UNIVERSITY OF CALIFORNIA, SAN DIEGO

Mapping a Wildfire: Mapping Practices, Authoritative Knowledge, and the Unpredictable Nature of Disaster

A dissertation submitted in partial satisfaction of the requirements for the degree Doctor of Philosophy

in

Communication (Science Studies)

by

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The Dissertation of Katrina Gooding Petersen is approved and it is acceptable in quality and form for publication on microfilm and electronically:

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ABSTRACT OF THE DISSERTATION

Mapping a Wildfire: Mapping Practices, Authoritative Knowledge, and the Unpredictable Nature of Disaster

by

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This dissertation examines the relationship between mapping a wildfire, production of knowledge about the wildfire, and general understandings of regional risk and disaster expertise. It takes as its starting point maps made during the 2007 wildfires, centering around a Google My Map made by an ad-hoc network that improvised their way through their mapmaking. It asks: how did making these maps under the duress of the disaster create a way of knowing the disaster that was valued by scientists, first responders, journalists, and the public alike? Why did an ad-hoc map gain the authority it did to describe the unfolding disaster? In approaching these questions, this

interdisciplinary project draws on science and technology studies, communication studies, visual culture studies, critical geography, and disaster studies to treat disasters as spatial practices rather than external features imposed upon spaces at specific times.

This project uses mixed-methods that look backwards and forwards, beyond the immediacy of the hazard being faced to understand how value and authority are attributed to the maps. To do so, it links historical methods of fire tracking and communication, social and technical wildfire mapping networks and practices from 2007, and imagined potentials, future expectations, and anticipated disasters as they have played out in disaster mapping since 2007. It also situates these practices within networks of actions that were human, technological, and environmental.

This project finds that how a disaster is made knowable shapes what is considered authoritative, conceptions of risk, and what qualifies as threat. It suggests that temporality is a primary organizer of uncertainty, accuracy, and thus a map's value. Only when representational practices remained flexible enough to incorporate local resources and changes over time yet were presented in stable and standard enough ways to share information between diverse groups were these practices able to establish authoritative stances in relation to general knowledge about the disasters. As importantly, this project argues that knowledge and expertise are distributed, something that, if acknowledged in mapmaking, can capture within a map some of the dynamism and multiplicity of meaning that exists within any disaster.

INTRODUCTION

This dissertation project examines the relationship between mapping a wildfire, production of knowledge about the wildfire, and general understandings of regional risk and disaster expertise. To do so, it takes as its starting point maps made during the 2007 wildfires, centering around a Google My Map made by an ad-hoc network that improvised their way through their mapmaking. These maps, especially the ad-hoc map, were grounded in new and untested mapping practices that have since taken hold as exemplars, signaling a new paradigm of communication and collaboration during disasters. The improvised practices necessary to make these maps suggested solutions to past problems in practices of shared meaning making during disasters. As importantly, the mapmaking brought together actors in unusual and unprecedented ways that opened up new paths for disaster planning and communication among a range of actors. How, then, did making these maps under the duress of the disaster create a way of knowing the disaster that was valued by scientists, first responders, journalists, and the public alike? Why did an ad-hoc map gain the authority it did to describe the unfolding disaster? In order to approach these questions, this project examines the socio-technical and material practices that went into making these wildfire disaster maps, it explores communication and collaboration in general during wildfires, and considers the production of new disaster mapping technologies. In answering these questions this project finds that how a disaster is made knowable shapes expertise, conceptions of risk, understandings of threats, and complicates the relationship between uncertainty and socio-technical context.

The original aim of this dissertation project was to understand why a singular, ad-hoc map made during the 2007 wildfires became popular and gained power as a tool for shared meaning-making between diverse actors. To begin with, I looked at how the map was made and how it differed from more traditional styles of disaster mapping. While this map remains a driving force in all four chapters, the overall project quickly transformed into something larger as I made a connection between disaster theory, science and technology studies, visual culture theory, and cultural geography: scholarship in all these areas demonstrate that the meaning of any object is bound to cultural-historical practices, practices that need to be examined through the interactions of people, technology, their environments, in action and in situ. Looking into this one map, then, required that I examine disaster mapping as a practice bound to larger cyclical processes that are a mixture of actions and expectations of the past, present, and imagined future.

Consequently, this dissertation looks at the mapping practices as grounded in a continuum, one where space and time extend beyond just the blazes of October 2007. It thus examines past practices of mapping and information sharing during wildfires in Southern California that built to the moment of the 2007 wildfires and made space for the adhoc map to emerge as a valued way of knowing. It delves into what happened with mapmaking during the 2007 wildfires to look into spatial knowledge production and the construction of expertise and risk. It also explores the disaster mapping practices in the years that followed to grasp how imagined potentials, future expectations, and anticipated disasters affect how these wildfires could be known.

Maps are common tools used in the event of a disaster. Over the last decade, they have become prominent forms of communication during disasters, especially by public-facing organizations. This is increasingly the case with the introduction of participatory-style mapping, mapping practices that are not top-down but instead draw on networks of actors and technologies that are often globally spread and include the affected public. Maps, in these contexts, are used both as sites of reference, moments of resistance, and as forms of reconstruction. They make it possible for groups involved in the response and recovery to quickly and visually manage a lot of information at once to identify places in need of aid, highlight the changed topography or ecology, and even help delimit what was lost. As objects and data, they can be readily shared between groups or at least act as bridges between a range of groups in the disaster. At least, this is frequently the logic expressed behind their use.

But these maps often start and end with the hazard at hand. Once the immediate threat to life or property is stabilized, the mapmaking dissipates. While the hazards that trigger a disaster can be defined in terms of their social, technological, and physical expanse and magnitude, a disaster itself unfolds as a result of the interaction of the social, technological, and natural over time and in specific locations (Davis 1999, Knowles 2011, Klinenberg 2002, Fortun 2001). In other words, the conditions that make the wildfire a disaster, rather than just flames, are grounded in how hazards interact with and interrupt--over time and space--everyday experiences, environmental relations, and social norms (Steinberg 2000, Oliver-Smith 2002, Hilgartner 2007).

Mapping disasters have to be treated, then, as situated practices that are simultaneously immediate to the moment and spread over long periods of time.

Focusing on the practices that surround the maps--the doing as well as the seeing--makes it possible to observe the relationship between actions within a space, cultural expectations, and the use of visual technologies in the production of meaning (Alac 2008; Vertesi 2008; Ingold 2007; Brown and Perry 2001; Goodwin 1995). Observations are organized through these situated interactions such that meaning is possible (Suchman 2000).

Approaching the ad-hoc map as situated representational practice, then, requires mixed methods capable of exploring past practices, present interactions, and future expectations. I draw on new methods in science and technology studies, as exemplified by Fortun's (2009) ethnography of open systems and Beaulieu's (2010) digital co-presence in order to look at disaster mapmaking as a form of situated knowledge production grounded in material and spatial practices. Together, Fortun and Beaulieu's methodologies make room for ethnographic techniques that bind the field not by physical location or time, but by the networks and interactions that create knowledge. In other words, the field of study is not bound by physical space or an isolated event but by interactions and relationships over space and time. This way of treating the space of an analysis is increasingly valuable as the production of knowledge becomes increasingly interdisciplinary and collaborative. Because the volatile nature of disaster causes much to be impromptu and largely undocumented, examining practices in this way makes it possible to approximate tacit and interactive elements of map production through interviews of actors involved with the 2007 maps, participant observation of present day disaster mapping practices, and textual analysis of related archival documents.

This dissertation project offers insight into the complex relationship between natural phenomena, cultural and political practices, knowledge of the environment, and potential action taken in response. It illustrates the creative work that takes many previously constructed ideas and produces a shared way of knowing and imagining. It offers insight into emergent notions expertise, risk, and boundaries through which future wildfires will be planned for and fought. In doing so, it aims to offer tools with which to unpack the assumptions behind democratic celebrations of participatory mapping and criticisms of government produced maps in ways that offer productive paths forward.

Disasters as Spatial Processes

A map, writes de Certeau (1984), "exhibits the (voracious) property that the geographical system has of being able to transform action into legibility, but in doing so it causes a way of being in the world to be forgotten" (97). Maps, by their very nature, distort what it is they represent, be it mathematically through the projection of round onto flat, be it temporally by flattening actions and movements into an object on a page, or culturally by centering a map on what is valued by the producers of that map (Harley 2001, 1989, Wood and Fels 2009). Maps are also like statistics: they can be made to speak in many different ways, especially as they turn dynamic processes into static representations (Monmonier 1996). Acts of mapping, rooted in accepted scientific practices and social values, are necessarily historically and culturally specific.

As such, maps are argumentative tools in the making of disaster knowledge more so than they are historical documentations of the facts of the event. They argue for

meaning and for the value of specific cultural and technological practices in relation to that meaning. Studies in visual culture of the environment, urban spaces, and medicine argue that an image's ability to represent a phenomena and the image's potential authority as a representation are bound to cultural interactiations and speicific egangements with the imaging technologies (Goodwin 1995, Nye 2003, Sturken 2007). For example, satellite images are mediated processes grounded in cultural assumptions that are part of an interactive process that shapes political consciousness and understanding of the environment (Jasanoff 2001). Similarly, the X-ray and MRI translate a set of conceptual relationships, through practice, into a visual object (Pasveer 1989, Cartwright 1995, Van Dijck 2005, Dumit 2004, Alač 2008). The power of any image to represent is not given in the form of the representation nor can it be separated from how we come to know the world (Cartwright 1995, Latour 1999, Beaulieu 2002). How a wildfire or disaster becomes known as it is mapped is not just through placemarks and lines; the meaning emerges as part of an ever-changing network of interactions, substitutions, and relationships between nature, society, and technology.

Maps are the materializations of those relationships. Studies in critical geography have argued that maps are part of cultural practices that include geographical imaginaries (Cosgrove 2008, Davis 1992), material forms and cultural values (Harley 2001), as well as contested histories and networks of practice (Harvey 1996, Kitchin and Dodge 2007, Wood and Fels 2009). In the final form a representation of a disaster takes, socio-technical networks and cultural expectations play an equal role to scientific debates about the hazard, political boundaries in its path, natural phenomena, and local understandings of the environmental context.

As scholarship on disasters has argued, every disaster is grounded in a specific history of social order and socio-technical cultures of practice, but because of their innate messiness disasters simultaneously bring into question previously accepted analytical categories and systems of classification (Klinenberg 2002, Fortun 2001, Vaughan 1996, Tironi 2014, Oliver-Smith 2002). As such, disasters make visible the complex and dynamic relationship between technoscience, expertise, personal experience, and institutions in the production of knowledge and risk (Knowles 2011, Frickel and Vincent 2011, Fortun 2001, Kuchinskaya 2013). Frickel (2008) argues that how these relationships are deployed creates what he calls 'knowledge gaps', gaps that often lead to uneven spreads of risk and resources. These relationships and gaps bring into question not just what it means to know the disaster, but also bring into question the normalized associations between practices of knowledge production, expertise, risk, uncertainty, and communication.

These questions make it hard to know what to include on a map, let alone how to map a space in crisis. But no disaster has easily defined ends to turn into a clear case study. No disaster exists in isolation from the ones that come before or after, as the past and potential futures help structure present understanding. While knowledge of a disaster is not a priori to the disaster, some of what is understood about a disaster does come prior to it, in anticipation of the future and memory of the past (Fortun 2000, Knowles 2011, Lakoff 2008, Michael 2014). This messiness in spatial and temporal practices problematizes attempts to make standards or systems of classification (Bowker and Star 2000), yet these are necessary features of any mapping practice in order to turn experience and action into code. The end result is a need to look beyond these

categories and nodes to the larger, situated networks and meshworks at play (Latour 1987, Ingold 2007).

Much literature in science and technology studies has explored how to follow such networks of interaction in order to understand how diverse actors – social, technological, and material -- work together across disciplinary boundaries, work for common goals, and share a common object of understanding (Latour 1987, Star and Griesemer 1989, Mitchell 2002, Turner 2006, Galison 1997, Mukerji 2009). Some theories focus on the space of interaction, some of the objects that help make the interaction possible, and some on the power and role of the individual nodes in shaping the networks. These theories all point to the value of the human, non-human, the local, and the immediate goals at hand in the final knowledge produced. They also point to the importance of the relationships between these elements to the value of the knowledge produced. For example, practices of witnessing, which establish authoritative knowledge and the potential to claim expertise, emerge from specific networks of interaction, networks that are restricted and appealed to in determining opinion from fact (Shapin and Schaffer 1985). But, to accept any claim to authoritative knowledge one must accept more than the legitimacy of the relationship between the claim about the issue and the issue itself, but also the legitimacy of the relationship between the network of knowledge and the object of that knowledge (MacKenzie 1990, Wynne 1992). Thus, the value of any knowledge is not in the knowledge itself but in the situated interactions within the network of production.

Even in situations where norms and common sense appear to be pushed aside by forces outside of our control, like wildfires burning in unprecedented manners,

knowledge production is situated in specific spaces and histories of interaction (Easthope and Mort 2014). Only in these traditions of extrapolation can temporal and spatial wholes be made from the parts presented in the maps (Ingold 2007). By examining the rhythms of action it becomes possible to see the interplay between old and new, standards and local that exist in the practices and form the basis for spatial knowledge production (Lefebvre and Régulier 1999). By looking at how these networks are situated in space and time it becomes possible see how the ways in which knowledge of a disaster, disaster expertise, even what's at risk and what's valued emerge from the situation and are never fully formed a-priori, never fully contained to the moment, and are never fully only imagined. The production of a disaster map and potentially valued knowledge of a disaster are a little bit of each.

Case Study

In October 2007, Southern California faced one of the largest wildfire events in its history. Within two days, thirteen separate wildfires were burning between Tijuana and Los Angeles, seven of them in San Diego County alone. It took almost twenty days to contain the wildfires. At least 1500 homes were destroyed and over 500,000 acres of land were burnt including 13% of San Diego County. Over 6000 firefighters from across the nation were deployed to help bring these fires under control. As the edges of the fires wandered unchecked, San Diego residents experienced the nation's largest ever evacuation due to wildfire (County of San Diego Office of Emergency Services 2007, California Department of Forestry and Fire Protection 2008). These fires were the most

intense and longest lasting in San Diego County recorded history (County of San Diego Office of Emergency Services 2007).

Not all wildfires are disasters, and initially these wildfires were simply flames burning an excess of dry tinder that needed management and bounding. But these flames quickly got out of control and started to threaten the delicate balance of land and livelihoods that make up the much of San Diego County. New fires kept igniting and resources for fighting them became thin which further facilitated their growth and spread. As these fires crept into difficult terrain and smoke thickened in the air, the fires became harder to pinpoint and track using people on the ground and forced the first responders and data gatherers to rely on non-visible technology in the air. With fires moving in their backyards many residents had to leave their homes, moving around the county in search of safety. At the same time, residents that were out of the way of the flames were affected by the air; they remained inside their homes in response to health concerns due to the decreased air quality. The fires impacted county infrastructures, from closed arterial highways fragmenting the residents facing the flames to the ability to maintain and transport clean water and electricity throughout the region. The wildfires became a disaster when the region experienced this mix of threatened human life, property, infrastructure, and natural ecology, combined with the gaps in knowledge produced by the flames' inaccessible locations as well as the lack of resources to control the flames. In other words, the differences between a wildfire and a disaster was in how the flames were implicated in the disruption and reconfiguration of everyday practices. As a result, this disaster posed a great challenge for fire officials, disaster responders,

and the news media as they worked to make sense of the scene, gather and share information about the fires, make contingency plans, and take actions.

The 2007 wildfires disaster manifested at a unique moment in disaster information management and mapping in San Diego. At the time, multiple styles of mapping interacted, each grounded in their own histories of practice. Maps became both vital tools of communication and means for making the fires knowable. Those who produced the maps, though, struggled to find ways to visually represent dynamic wildfires. In order to map this disaster, mapmakers drew upon new sources of data and networks of interaction. The introduction of new mapping technologies and expectations challenged conceptions of what it meant to know a disaster and what counted as relevant and appropriate knowledge of the situation. The results of their intersection were novel approaches to mapping which are presently being explored in San Diego.

At the time of the 2007 wildfires, despite recognition of mapping's potential and value, there was no established practice in place for collecting, sharing, or visually representing fire information on a map, neither between responding agencies nor between the agencies, media, and the public. Moreover, the region was still determining how to manage the increased need for inter-agency fire response, the increased ways in which the public could be affected, and the increasing variety of information sharing techniques (Office of State and Local Government Coordination and Preparedness. U.S Department of Homeland Security 2006). State and County fire review boards had already acknowledged that communication between institutions, with the media, and with the public needed improvement (County of San Diego Office of Emergency

Services 2007). But while San Diego County was making maps of the disaster right from the start, these maps were not being released to the public. When they were released to the media it was often with restrictions and delays. Consequently, those who needed the maps had to creatively improvise their own mapping techniques. By the end of the first week of the fires, many news media stations were producing their own maps and the county changed its policy to offer regular publically accessible map releases. In fact, some early forms of participatory disaster mapping began to appear.

With the range of maps it quickly became clear that no two groups agreed upon what elements should be included on a map of the wildfires. Multiple factors contributed to the differences amongst the groups. Mappers did not agree on what constituted the disaster; was it a disaster in terms of human property or was it a disaster in terms of lost ecosystems? In addition, the county was in the process of restructuring their emergency offices and communication networks (Scanlon 2008, County of San Diego Office of Emergency Services 2007). Furthermore, the meaning of a line on the map was still being worked out between responding agencies. The result was agencies interacting with drastically different assumptions about wildfire response and priorities. The intensity, urgency, and scale of the wildfires further stressed patterns of communication between responding agencies and with the general public also complicated these circumstances

One group, however, found that a mash-up Google map – based in My Maps, seemed to offer an ideal solution to the otherwise difficult problem of producing and circulating information in a time of unreliable infrastructure and constant change. This new technology allowed non-programmers to build, share, and update customized

Google maps. The map represented the collaboration between many different normally disconnected groups, including KPBS, Google, San Diego State University, California Department of Forestry and Fire Protection, San Diego County's Emergency Operation Center, SanGIS, NASA, U.S. Forest Service, local citizens, and a Taiwanese researcher. The network created did not exist prior to the mapping project; the group coalesced around the tool and the communication goal. This map drew on a range of data sources, many that would not normally stand as authoritative or as equal to scientific or government data, such as unconfirmed information from the public. The map was not consistent with a single community's conception of wildfires.

But that did not seem to stand in its way as an accepted representation of the situation. The map drew national attention, was linked to by the California Department of Forestry and Fire Protection, the Port of San Diego, and the California Governors webpage. It also caused a shift in disaster mapping practices throughout the county. The map's power as a relevant and valued representation of the disaster came from the socio-technological engagements – the practice of mapping. The production of the map required collaborative work that brought into conversation disparate ideas about what is relevant knowledge of the wildfires. This collaborative work involved the negotiation between scientists, politicians, firefighters, news media, and citizens on the ground. The work that went into making this makeshift wildfire map helped it take on as great of an authority as a representation of the wildfires as the maps produced using more authoritative means.

The impact of the wildfire mapping that took place in 2007 is still being established, but it has already influenced the shape of future mapping practices. For

example, acknowledging the success seen by the ad-hoc map during 2007, San Diego County is presently designing an online mapping interface to be included as part of their internal planning server. Even more closely related, the San Diego chapter of the American Red Cross soon after began designing a Google-based platform that is built to do—in a planned way—exactly what the ad-hoc group improvised: draw on a range of data sources from a range of agencies, including social media in order to communicate internally, with their partners, and with the public about a given disaster situation. These new practices all offer solutions to decades old problems of seeing a wildfire, knowing a disaster, and collaborating to share information about it.

The Chapters

This dissertation is divided into four chapters ordered in a way to offer a snapshot of the spatial processes that produce wildfire disasters and the representational practices that surround attempts to communicate about the disaster and align understandings. The first looks backwards, the middle two at 2007, and the last at present day – the early future of 2007. Together, they attempt to present the mapping practices within the larger spatial-temporal situation within which the disaster emerged.

Chapter 1 is a genealogy of communication and information sharing around wildfires in Southern California. It explores how problems within these practices influence the emergence of mapping as a communication and information practice during wildfires. Focusing on the role of memory and space in making sense of disasters, this chapter starts with wildfire data gathering and information sharing practices in the 1950s. It explores the uptake of aerial reconnaissance and the

establishment of new population movement patterns in the region that begin on the changing knowledge production and sharing practices around wildfires. It examines the shift from single-agency wildland fires that concentrated information gathering and sharing in the hands of responders on the ground to the emergence of multi-agency fires at the wildland-urban interface that relied on technological networks to get their jobs done. In doing so, it examines the relationship between the public and the first responders leading up to the 2007 wildfires, and the changing conceptions of witnessing the fires that emerge as a result of the continual conflicts between local and standard practices and between face-to-face and technological interactions.

The next two chapters pick up with the mapping practices during the 2007 wildfires. Chapter 2, looks at two of the maps used to communicate with the public about the wildfires: San Diego County's maps and the ad-hoc map produced using Google My Maps. It explores the practice of making both of these maps to understand the relationship between the process of map production and the process of making sense of a disaster. To do so, it focuses on how data is gathered, reconciled, and managed in both of the maps and the resulting decisions made about what gets included in the representations. The chapter argues that not only do the different practices of map production produce different spaces of disaster, they also produce different conceptions of accuracy, risk, uncertainty, and threat. The practices themselves make different knowledges valuable and authoritative.

Chapter 3 delves specifically into the ad-hoc map in order to understand why all the various groups involved in the production of this map participated, how they found value in the map, and what this means for expertise. It places the production of

expertise in a distributed practice, one where identifying what needs to be prepared for and known in advance is almost impossible, and one that challenges the traditional roles of democratic and managerial knowledge production. In doing so, it also expands on what it means to connect risk with expertise.

Chapter 4 looks at the anticipatory and imagined in the production of disaster knowledge and their roles in making sense of a present situation. It explores how temporality, in the form of memory, plans, anticipation, and exercises, shapes how the space of a disaster comes to be understood. It investigates the relationship between the immediacy of disaster mapping, speed of information sharing, and potentials seen in a given interaction, elements that were so vital to the shape the maps and networks took in the previous chapters but generally left unaddressed. To do so, this chapter explores the design and use of a present day disaster mapping platform by the San Diego Red Cross that emerged from the imaginings and future-looking that took place during the 2007 wildfires. It aims to understand how timelines and as timescales shape the spatial knowledge of a disaster produced, including what contributes to understandings of risk and order.

This project demonstrates how knowledge of the 2007 wildfires was not produced by a single way of knowing or through a top-down preset structure of information sharing, but emerged within complex, interactive, and contingent mapping practices. With each change in social interaction or technology used came changes in both expectations of what it means to be prepared for a wildfire as well as in the definition of a wildfire. Tracing the map as a practice made visible the relationships that

get materialized in how disasters are represented and made meaningful, including scientific debates and cultural interactions.

In doing so, it also complicates any attempt to write about disaster mapping by tracing any given classification scheme or following a specific disaster response agency. This project challenges the use of boundaries between public and government, experts and lay, local and universal, and even those who received aid and those who did not to make attributions of ignorance or invisibility. It further complicates any attempt to ascribe credit or blame for successes and failures to the new mapping technologies or the ability to network. While thinking of disasters as spatial practices brings together many forms of engagement with the world, this flexible definition makes it hard to determine how one might begin to understand how a given space is situated, how boundaries are drawn, how presence and absence are produced, or what distinguishes "here" from "there." It is a reminder that what needs to be asked of these maps when trying to understand why one thing was included and not another cannot end with questions about the mapmakers intentions alone. Instead, questions need to be asked about how the maps were made and to what effect.

CHAPTER 1
Witnessing, Mapping, and Collaboration in the Emergence of Wildfire Mapping Practices in Southern California

Introduction

Disasters are not events; they are processes situated in space and time. Understanding the shape a disaster, including related communication and representation patterns, takes involves looking at more than just the immediate situation. It requires examining the historical trends, local culture, and established practices within which the disaster is situated (Davis 1999, Oliver-Smith 2002, Knowles 2011). Even when the main focus is on understanding why a disaster map looked the way it did or had the power to act as fact, this involves exploring the relationships over time between landscape, humans, and technology, and between government, media, and the public. In this chapter, I argue that situating the mapping practices during the 2007 wildfires entails understanding more than just the maps and how they were made in 2007. It entails understanding the changing relationships between San Diego residents and the wildlands within which the fires began. It also entails tracing the development of techniques and technologies for gathering and sharing information between diverse groups during wildfires and examining changing expectations for local community and media involvement. From this understanding of how 2007 was situated in the accumulation of past practices and expectations, it then become possible begin unpacking why maps, and in particular an ad-hoc Google map, gained the authority they did during the 2007 wildfires.

When the 2007 wildfires struck Southern California, map use was transforming from one of following generic maps to one of personal map production. Maps were being increasingly used to share information with and between the public, often used in lieu of words. In general public use, Google My Maps was an integral part of this trend, making it possible to provide lines and points on a familiar map background, supplanting the need for verbal directions or descriptions. Google My Maps was taking the lead in online personal map tools, appearing embedded on an assortment of websites from Internet news stories pointing out landmarks to restaurants providing a link and personalized directions to their location. As a technology, it was slowly sneaking its way into everyday spatial practices. Within government business, maps were also becoming more prominent features of reports and communication. In these contexts, GIS was emerging as the common platform for the storing and exchange of data between departments and for including spatial information in government reports. GIS map data repositories were being coordinated through San Diego city, San Diego County, and California State, and new standards of protocol were being actively drafted. In addition, maps were already an established part of disaster information gathering. For over a century and a half, maps were hand drawn by fire observers in the field and fire behaviorists at wildfire base camps for use in coordinating first responder response and planning. Maps were also used in government incident reports filed after the main fire action was over to be kept as records of the event. Despite the prevalence of maps and their seeming position as the data representation of choice, the role of mapping in public communication and inter-agency collaboration in disaster response in general, or wildfire response more specifically, was yet to be determined.

The 2007 wildfires in San Diego ignited in the middle of a range of debates about how ways of engaging with the natural and social world relate to communication practices, shared knowledge, and authoritative stances. In order to explain why 2007, and why San Diego, saw the emergence of new disaster mapping practices, I find that what is really brought into question is what it meant to *witness* the fires. Witnessing wildfires, and thus establishing an authoritative culture within witnesses and a shared common understanding, required balancing local knowledge with standardized ideals, views on-the-ground with the views from above, and face-to-face communication with technologically-based networks. As a result, this chapter examines the cultures and practices of witnessing wildfires in Southern California since the 1950s, by looking at how groups involved with the wildfires communicated and collaborated with each other, how they introduced and used new technologies, and how they relied upon specific networks of interaction. To understand the situated character of mapping the 2007 San Diego wildfires, then, meant placing wildfire maps in relation to after-action reports, incident reports, memoranda of understanding, scientific and economic studies, internally circulated histories, training manuals, and planning documents.

Mapping and the Epistemology of Disaster

As a disaster emerges, it challenges the managerial, orderly vision of the social, political, and technical systems within which it is situated. This is especially the case as a disaster exposes and juxtaposes elements that are informal and formal: the official government response with the ad-hoc community networks, the standard procedures with the local improvisation, the formal representations with the individual story, the

planned with the immediate (Hilgartner 2007). Envisioning and establishing order involves bringing under control the material aspects of the disaster, like burning flames or damaged buildings, as well as the discursive aspects, such as what makes a map or how and when information is made public or how normalcy is communicated. It also means guiding how the concept of an *emergency* – something that implies an unpredictable, abnormal, and short-term nature of the phenomenon – relates to the ways disasters are situated in long-term dynamic relationships (Knowles 2011, Oliver-Smith 2002, Steinberg 2000, Calhoun 2004). These images of order have multiple effects: they blackbox the complexity from which that order is derived and they masks the systems through which our understanding of legitimacy, expertise, and hazards are constructed, making it possible to claim these as givens to be dealt with in specific ways.

While government officials, aid organizations, and affected communities members typically set reestablishing order as a fundamental priority after a hazard hits, what this means varies from group to group, has specific relationships to time, and balances the immediate moment with a history of action. Faith in a government's ability to manage a disaster is important to a vision of a sociotechnical world under control, to political legitimacy, and to maintaining any position of power and authority within that society (Hilgartner 2007). If one's ability to manage is questioned or challenged, one's power and potential expertise is as well.

Disasters are not events in which the natural world is at odds with the human world, but hazards transform into disasters precisely because of how the affected society's understanding of nature encourages specific relationships between people and land (Oliver-Smith, 2002). Rather than coming from outside of society, disasters mirror

social values so as to reveal patterns of risk built into the environmental and technological underpinnings of that society (Knowles, 2011). They are grounded in economic forces, ideologies, material and cultural practices, demographics, ecology, topography, all of which are interact differently in the face of a hazard (Davis 1999). Discord in social relations is expressed and exposed through material practices with the natural world and thus appear as contradictions in our understandings of the environment (Harvey 1996). These are frequently presented as a divide between nature and culture, a divide implicated in the causes and solutions attributed to a disaster (Oliver-Smith, 2002).[1]

The wildland-urban interface, the boundary between urban life and wildlands over which the 2007 wildfires traveled, represents one of these discords. Even its name stands as a symbol of the problems the boundary poses for San Diego and disasters. Living along the edge of the wildlands in Southern California can be less expensive than living in the cities, can act as an escape from the government restrictions on city spaces, or is where, provided the financial capacities, a person goes to have the space, the views, and the freedom associated with higher class living. At the same time, keeping the wildlands pristine is a value held as part of the American ideology related to freedom and power (Cronon 1996).[2] The clashes that result from these various meanings of the wildlands as they intermingle with the urban are expressed in the communication, collaboration, and representational challenges faced by the first

[1] Causal explanations that arise from such divide include blaming how market relations and human ethics ignore natural forces or how scientific methods impersonalize disasters (Oliver-Smith, 2002).

[2] Both of these ways of engaging with the wildlands, though, promote elite forms of engagement and are only possible is humans are kept outside of nature (Cronon, 1996).

responders in the field and the affected public when a disaster unfolds along this boundary space.

Oliver Smith (2002) argues that one way to think about this is to treat disasters as metonyms for larger dynamic systems. The 2007 firestorm, I argue, is a good example of a metonym for a disaster that encompassed the conflicts in technological, social, and natural constructions that brought the wildfires and their devastation into existence. As a disaster, the 2007 wildfires were one small piece of a larger history of ever-changing relations that influenced the form the fires took and what they made visible about the inner-workings of society and politics. The aim of this chapter is to uncover what some of those relations were and their interrelatedness with attempts to put information on and share information through maps.

Hazards that lead to disasters are part of everyday relations rather than exceptions to the rule. They are normal parts of society, so much so that it is unlikely that a system can be constructed so as to be completely disaster-free. Instead, as Perrow (1984) argues, thinking of disasters as normal suggests establishing coping mechanisms within a system that mitigate the effects and help maintain organizational structures. This switch in understanding parallels a shift from prevention to preparedness in planning, from an abnormal event that can be stopped to normal occurrences that need to be minimized. According to Lakoff (2008), prevention focuses on a specific event that might affect the population, bases decisions in risk calculations of past events, and usually requires only a single solution to be prepared for by the authorities. This relationship to disasters is grounded in the assumption that public education and extrapolations from the past can keep a disaster from entering the orderly system.

Preparedness, on the other hand, emphasizes mitigation and focuses on protecting the larger infrastructure and building a capacity to manage a range of circumstances. Instead of avoiding catastrophe, demonstrating preparedness approaches disasters as normal occurrences that will someday come. Either approach suggests different priorities for policy, different roles for the communities involved, and different standards in communication infrastructures between the local publics and the government.

In this way, disasters make it difficult to maintain any classifications systems or related standards. The work behind maintaining classifications affect the practices of information sharing as well as value systems (Bowker and Star 2000). If it is difficult, if not impossible, to follow a classification system if disasters constantly make room for questions about what defines the order of the everyday. In doing so, they make it possible for public spaces to be appropriated in new ways that disrupt norms and codes (Steinberg 2000). Leading into a wildfire there are often standards of protocol designed to enable and maintain formal order, such as standardized communication networks, terminology, and mapping systems, all of which get codified in routine messages for the public and for other agencies. However, public inquiries, which include media reporting, local community information requests, public hearings, and acts as simple as looking to the internet instead of television for news, serve as a mechanism by which to disrupt these classification schemes by creating their own collective narrative about the situation, pushing back on the official representations and discourse, and displaying the layers of messiness that a disaster reveals (Hilgartner 2007). Such disruptions to the order dissolve any stability to specific distinctions between formal and informal.

In this chapter, I argue that mapping, as a practice and episteme, lies in the middle of all of these issues. Maps standardize and codify social, environmental, and technological relations turning rules of society into the rules of the image (Harley 1989). But they are also tools by which a public can resist, tools by which the local practice and the specifics of the situation can be voiced (Scott 1998). During disasters maps act as standards for information gathering and questions for analysis and are intended to be efficient ways of expressing considerable amounts of information all at once. Producing maps makes comparison possible, between, for example, two maps of the same region made at different times or between two sections separated by a line on the same map, comparisons that are used to determine regions of concern (Monmonier 1996).
But to create maps also involves balancing the local situation that resists the standards, protocols, and timeliness intended by the use of maps, such as local terrains, technological practices, communication infrastructures, smoke, and unsafe flying conditions. The work done by the lines on the map reinforce power struggles, conceptions of authority, and rights (Harley 2001).

Mediating the world through models and materiality built into socio-technological practices, like mapmaking, forces an order upon the world that carries throughout the use of the technology. In doing so, it also creates a distance from the object of analysis (Masco 2006). This form of mediation suggests an objectivity that allows for a common perspective on the situation (Galison and Daston 2007). It creates a sense of virtual witnessing that enables the validation of the claims, the acceptance of the provided view, and the establishment of authoritative space and power (Shapin and

Schaffer 1985). These ordering mechanisms simultaneously draw boundaries to keep objects apart (viewer from fire, urban from rural, burnable from moist, expert from general public) and make possible connections despite physical distances that enable, in practice, an ideological structure to hold together a society that is physically fractured by both their distributions over land and by the disruptions they face as a result of the hazard. This chapter looks at the underlying practices and struggles surroundings witnessing and standardization that lead to the development and use of wildfire maps for disaster communication in Southern California, in order to see why during the 2007 wildfires the local voices and practices had the ability to challenge the governmental standards and procedures as well as why new forms of collaborative practices were sought.

Changing Populations, Changing Fire Information Practices

Southern California was no stranger to wildfires or the tenuous relationship between nature and humans displayed by the various shapes the wildfires take. This troubled relationship took its form in the challenges produced by the increase in and movement of people in the region the debates over what it meant to exist amidst flammable wildlands. It also took its form in the debates over how to gather information, including when technologies should be called upon and what limitations were attributed to human practices. As the multidimensional conflicts play out in how the environment and wildfires are known, they reveal some of the inner-workings of authoritative claims, the constructions of boundaries, and the complicated relationship between local practice and standard systems.

In Southern California, wildfires have historically materialized almost entirely within wildlands; these fires were remote, impacting very few people, structures, or roads. Flames, started primarily by lightning strikes, ignited on land managed by the Unites States Forest Service (USFS), National Park Service (NPS), Bureau of Land Management (BLM), Bureau of Indian Affairs (BIA), or California Division of Forestry (CDF), and mostly remained in those lands, making the fires federal or state issues rather that problems of counties or individual cities.[3] Until the 1940s, fires in these areas typically were of no threat to people living in the regions and therefore not of any grave concern for anything other than ecology (United States Forest Service 1968, Jones & Stokes Associates 1974). Managing these fires often meant observing the weather, the fire's path to make sure nothing of ecological or historical value was in danger, and then letting the fire burn itself out. The domains of responsibility were clear since the fires remained bounded by the wildlands. If collaboration was required it was typically with only one other group. Moreover, because of their remote nature, fire officials rarely had to provide more than minimal information to the general public, generally statistics and statuses.

Population growth in Southern California forced a change upon these practices and expectations in management and communication. The population doubled between 1930-1950 and almost doubled again during the 1950s. The increased population spread out from the cities into the forests, mountainous regions, and chaparral (United States Forest Service 1968, Jones & Stokes Associates 1974). In addition to rural residencies

[3] The CDF is now the California Department of Forestry and Fire Protection (CAL FIRE), a change that happened in 2006.

and new communities sprouting up in these traditionally wildfire-bound lands, these years also saw an increase in recreation and tourism in the wildland areas, including campers and campfires (California Division of Forestry 1973, Folkman 1979). During the same time period, there was an expansion in adjacent communities as well, bringing to the wildland areas power transmission lines, industrial activity, highways, gas and oil lines, and railroads lines (United States Forest Service 1968). In addition to the new range of potential fire starters unrelated to weather patterns that arrived with the movement of people over and on these lands, the increase in people and related infrastructure stressed the water supplies necessary for urban fire fighting, both within the communities infrastructures and in the general water basins (ibid.). The number of wildfires started to mount and the boundaries that had defined fire-fighting practices were becoming blurred and contested.

And, because of the movement of people, even if the fires remained in uninhabited regions, they could affect vital elements for those residing near by, like water supplies and resources for local economies. Southern California found itself in a unique position: a semi-arid climate, steep mountain topography, dense brush, combined with an ever-expanding variety of fire causing agents and a constantly changing relationship between people, infrastructure, political jurisdictions, and their surrounding ecology. And this was not just because of new people living in the region. In fact, it was more a cause of the movement of people through the region and the infrastructure required to maintain the people on the land.[4] Wildland fires began to take

[4] While there had been an initial rise, by the 1960s, the CDF reported that the number of fires started by the local residents remained relatively stable. Instead, the increases seemed to be

a new shape: larger, multiple fires burning at once, crossing any potential or cultural boundaries that divided residential from wildland. Distinguishing between these two classifications of land became so difficult that in the early 1960s the California Legislature established rules for the clearance of flammable vegetation around residential and commercial structures (California Division of Forestry 1973).

The blurred boundary meant the meeting of two realms of fire response. Urban style focused more on how fire moves into city and structures and fought using water to put out the flames. Forestry fire fighting tended to make decisions based on how a fire starts, weather, and topography, stopping the fire through drops of retardant and followed lines that limited the fires movement and let it burn itself out. City firefighting assumed adequate water, an assumption that could not be carried over to large or multiple fires. While single structure fires scattered throughout town did not affect water pressure for the fire fighters, in a large scale response, using water caused the water pressure drop throughout the region and rendered water use impractical. But spreading retardant in urban regions could be a health hazard and it was not possible to plow lines through private property (Butler 1976). A combined response could not rely on either method and necessitated the initiation of new and creative planning.

How these wildland fires were fought had to change just as their numbers and intensity started to increase. In 1956, San Diego County experienced the Inaja Fire, caused by a wildland resident who threw a match, burnt over 47,000 acres in the Cleveland National Forest, and took the lives of 11 firefighters. The high number of

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caused by the stresses that accompanied the population movement, such as increased industry, roads, power lines, dumps, and tourists (California Division of Forestry 1973).

deaths made this fire of particular public and media interest (United States Forest Service 1957). In 1961 was the Bel Air Fire that burned 484 homes, many of which were celebrity-owned and received much media attention (http://www.lafire.com/famous_fires/MajorIncident-index.htm). The Coyote Fire of 1964 was "disastrous" according to the State of California (California Division of Forestry 1973, 1). It burned 67,000 acres around Santa Barbara as well as over 100 homes (City of Santa Barbata Fire Department 2004). The fires in 1970 were particularly damaging, when the simultaneous Laguna Fire, Boulder Fire, Tecate Fire, Lilac Fire, and Theater Fire competed for the same resources (United States Forest Service 1970b; http://www.wildfirezone.org/community.asp?idno=2). All these fires pitted the various practices of the fighters and residents against each other.

These frictions in environmental understanding and practices were not innate to the boundary. They appeared because these boundaries were material expressions of conflict within society (Harvey 1996). Here, the conflict was between what was valued in the wildlands: the wildness of the space, the resources within the space, the cheapness and openness of the land, and the freedom of choice provided by the lifestyles associated with remoteness. Each value suggested a different focus for fire fighting protection: one involved letting the wildland stay as minimally interfered with as possible, the second involved stopping the burn cold so that nothing gets damaged, the third suggested a need for outside protection since those there will not have the finances to afford to protect themselves, and the last implied an each-for-their own strategy. The contrasting ideals were not judgments about whether humans were living harmoniously with nature, or whether the economic context was cause or effect, but

about the implications of how the interactions are interpreted (Oliver-Smith 2002). As these ideals and their related fire agencies interacted to a greater degree than ever before, new and unpredictable wildfires burn patterns emerged. New debates over decision making and over what materials should be used in the fire fighting process appeared. Just as importantly, they also appeared in the challenges in communication about the fires, with greater demands from the media and public for real-time information.

But throughout these initial changes in fire, population, and communication patterns, the primary method used by federal and state agencies to gather information for wildfires remained grounded in placing officers in the field. One of the earliest forms was the lookout. These were trained fire observers living for weeks at a time in towers on tall peaks or stands in remote areas whose main goal was to keep an eye out on the surrounding terrain, typically with 360-degree views. They mainly looked for smoke plumes arising out of the forest canopy and chaparral bush, but also assembled weather data, acted as a node in the communication networks, and sometimes aided with monitoring ground patrol and smoke movement (Zimmerman 1969). These towers were originally connected by telephone to dispatch during the day when the forest canopy was visible. At night, the telephones were routed through local community operators, affording the side-effect of local connections to the observers (Smith 1969). But by the mid 1940s, radios replaced the telephone because they did not require as much infrastructure on the ground (ibid.).[5]

[5] "By the end of the war due to the increased efficiency of radio along with the loss of several telephone lines from fire which would have required a very costly replacement project, telephone had now assumed a secondary roll in fire reporting and dispatching" (Source 12: 5).

Lookouts were complemented by scouts on the ground. The scouts were not a regular feature of forest fire monitoring, but would be called into service when lightning abounded or when Santa Ana conditions intensified (Zimmerman 1969). These scouts drove around with portable radio stations to report any findings that required immediate action to the lookout towers and local dispatchers. This practices involved technological and environmental cooperation. Depending on the terrain, the intended receiver needed to be within a certain distance of the mobile unit in order to receive the message, or the mobile unit had to travel to less disruptive topography.[6] The person on the other end also needed to be actively listening to get the message. The introduction of repeaters expanded the range and time within which a message would travel, but still would not solve all communication problems between field observers, dispatch, and local terrain.

For instance, the USFS report about the 1970 Laguna Fire in the Cleveland National Forest (United States Forest Service 1970b), noted that the fire was initially spotted by two deer hunters and reported to Forest Officers manning a hunter check point. The Forest Officers tried to reach the lookout tower by radio to call the dispatchers, but was unable, which delayed the response. They left their station to drive to the tower to give the message in person and continued to try to reach the tower on their mobile radio. But in this case, they were lucky: another officer in a different zone with a mobile radio unit happened to be on the same frequency and overheard the call. He took it upon himself to make sure the message was heard, but by a different lookout than the one the first two had tried to contact. The fire incident report noted this fortuity

[6] Flat terrain would allow for wider ranging radio waves. Mountainous or canyon terrain would limit the movement of the waves.

twice and commented on how this impromptu network saved time in the response and kept the fire size down. But networking people in towers and on the ground via radio still left many blind spots, especially in the canyon and mountain terrain particular to Southern California.[7] Disastrous wildfires emerged from these gaps; where human practice, technological capabilities, and environmental understandings did not align (Oliver-Smith 2002).

One potential and popular solution was the addition of air reconnaissance. The earliest reported air patrol was in California in 1919 as part of military defense, and the first aerial photography in fires was used in 1925, but as a whole this way of monitoring wildland fire in general did not take off until after World War II (Gray 1982, Zimmerman 1969). But it took off quickly. By 1967 there were over 200 state-owned fire detection aircraft in the country and just as many privately owned aircraft were contracted for this use (Zimmerman 1969). The aircraft could do what the lookouts, scouts, and radios could not: they could move above the terrain that limited the other forms of observation and information sharing. Aircraft moved to the smoky areas, got direct overhead views of the fire fighters and others potentially in danger even on mountains or in valleys, and acted as mobile nodes in communication (United States Forest Service 1970a). However, because they had to keep moving and could only monitor a small space over a short time aircraft could not fully replace the other methods of observing and collecting data. The scouts were more useful in areas with greater fire fuel and man-caused fires, since predicting these fires was less aligned with

[7] United States Forest Service (1970b), in the report on the Laguna Fire, notes that one of the reasons radios were needed in the first place to report this fire was because the fire started in the local lookout towers blind spot.

the weather and requires more continuous monitoring. The aircraft were more useful in monitoring mountainous areas and regions that deal primarily with lighting fires, since these were less accessible by foot or visible from a tower and could be predicted based on weather (Zimmerman 1969). Since many of the wildlands in Southern California dealt with both types of environments and fire sources, no single method of observation, human or technological, in air or on the ground, could work alone.

How the population encroached upon the wildlands and modified the local infrastructure further exacerbated the inability to keep the types of safety work separate. The appearance of new communities changed where the roads needed to be for the scouts to be effective. These changes brought more telephones, public and commercial radio networks, and local city fire agencies, all of which could keep their eyes on the canopy and competed with the lookout towers to be the first to report on fires (Smith 1969). In some places the residential areas infringed so much upon the lookouts' views that the towers had to move in order to still see, sometimes to lower terrain which limited visibility in other ways (ibid.). As scouts and lookouts became less effective in relation to the new patterns of land use, air reconnaissance increased in popularity, became the cheaper tool, and by the 1980s aircraft started to outright replace, instead of supplement, these "fixed detection networks" (Zimmerman 1969, iv).[8]

The traditional eye-witnessing practices of data gathering—on foot and in tower—started to be replaced by a more mobile, distant, and networked practice that prioritized the view from above rather than on the ground. At the same time, the public

[8] Lookout towers had higher costs of labor, materials, training, and administration" than planes (United States Forest Service 1970b, iv).

was making its voice heard, stepping up when the fire lookouts were too slow. In the process, this changed how both the public and the officials expected to see wildfires and thus what it meant to know them. In doing so, a new witnessing public was produced, changing who was involved in defining the fires as fact (Shapin 1984). The power the various physical and political positions produced to define the characteristics of a wildfire had implications for what was deemed necessary to know to make legitimate decisions about what to protect, what to communicate, and how. For example, one major change that came with these new forms of observation was a shift in priorities from protecting ecology, such as wildlife and watersheds, to lives and property (United States Forest Service 1970b).

It also meant a greater priority on communication as part of the wildfire process, not just on the management of land or residents. Now that fires involved multi-agency responses, the traditional information needs of a forestry fire fighter -- weather conditions, terrain, fuel, and fire perimeter – were insufficient. The responders also needed to know, among other things, potential lines of transport for the public not just their own resources, local communities and industry, local communication networks, recreational patterns, and public utilities infrastructures (Zimmerman 1969).

In addition to the new range of data to be collected during the fires, general regional data needed to be maintained prior to any fire in a way that was accessible to those who needed it as part of their fire response. They also needed to change their approach: stopping the fires before they spread instead of just limiting the spreads zones. To do so required knowledge about fire hot spots, areas neither safe for scouts nor typically visible from the fire's perimeter. Infrared imaging technology was added to

the aircraft to detect and map these hot spots and the technology quickly became considered vital to successful responses.[9] As fire protection shifted from controlled burns to stopping flames, information to be gathered and shared now included tracking movements of people and flames as well as environmental modeling.

By the mid 1990s, the region saw a move away from knowledge gained on the ground to a focus on the aerial, mobile, and technologically networked. Information gathering techniques stepped away from direct vision moving towards a greater reliance upon technologically mediated perspectives to see where humans could not. As wildfires became problems of human presence, these practices had the effect of removing the humans one-degree from the practice of protection and offered a technologically mediated objectivity that emphasized distance over proximity impersonalizing the process of knowing the wildfires (Galison and Daston 2007, Masco 2006). Doing so created a culture of virtual witnessing that enabled the fire agencies to retain their authoritative stance over the general public (Shapin and Schaffer 1985).

Sharing Information Between Agencies

By the 1970s, wildfires started to challenge the political boundaries between agencies grounded in the separation of nature from human. Fighting these fires was no longer a task that could be achieved by a single agency, but required communication and collaboration between various styles, scales, technologies, and cultures of practice.

[9] During the Chino Fire, a communication from the Fire Management Office to the Regional Forester praised the value of Forward Looking Infra Fire (FLIR) technology in seeing hot spots and recommended their widespread use (Kemble 1977). These sentiments were echoed in the after action reports from the 1993 Fire Surge (California Office of Emergency Services 1994).

While at first this was done primarily by different agencies with land management and conservation as their foci, in the later decades of the twentieth century, these interactions were increasingly between agencies with the same goal – fighting fires – but for whom that goal had completely differently meanings. Collaboration was a difficult prospect, and it contributed to questions about who is in charge, which standards of interaction should be followed, and what shape the final communication network should take.

In the mid-1970s, the CDF and the USFS acknowledged a need to improve fire hazard warning systems, evacuation plans and procedures, mutual aid plans between potential responding agencies, and communication practices (Folkman 1979, Firefighting Resources of California Organized for Potential Emergencies 1988). In response to this awareness, in 1977, the BLM, USFS, and the NPS finally updated their cooperative agreement from 1943 (United States Forest Service, National Park Service, and Bureau of Land Management 1977). The purpose of the agreement was to enhance cooperation, coordination, and public information related to fire management activities, to assure correlated action taken by all groups involved including those on adjacent land. But this agreement was not designed to override other agreements each agency had with local organizations and communities; these were to be followed before any larger coordination was requested and the standards established in the federal agreement came into play. While the aim of the agreement was to get all the federal agencies on the same page when they had to work together, it also set each agency up for two simultaneous directions of coordination, vertical and horizontal, that they had to make talk to each other in moments of extreme stress.

The FIRESCOPE project, authorized by state and federal governments, was started in 1972 in response to the damage caused by the coordination difficulties experienced during the 1970 Laguna Fire to encourage better collaboration and communication.[10] In the first few years it produced a variety of products aimed at just these issues, focusing on information sharing such as the Incident Command System (ICS), Multi-agency Coordination System, and the Information Management System, many of which are still used today (Firefighting Resources of California Organized for Potential Emergencies 1988).[11] It set the stage for information sharing procedures that relied on supportive technologies to be effective, but its practices were not implemented until the mid-1980s. In the late 1980s, the project's goals were revisited as a result of the realization that to have technologically-based common communication practices necessitated unforeseen technological support. New goals were established for the year 2000, including an initiative to create a common mapping system, a common technological framework, and the ability to have real-time access to maps (ibid.). While useful in its intentions, this project did not create change fast enough for the groups that needed to work together.

Since the results of these plans were so far off, in the 1970s and 1980s much of the information sharing and collaboration was done via radio networks, interactions at base camps, and printed maps.[12] Even with radio networks, practices that started to take

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[10] Firefighting Resources of Southern California Organized for Potential Emergencies

[11] San Diego County was not involved in the initial phases of this project, only southern California counties that had a fire department, which as a county, San Diego did not. San Diego only had (and still has) regional and city departments.

[12] The increased use of aircraft did not change many of these methods, simply changed the locations that needed to be reached by the radio channels.

hold twenty years prior, missed connections were still a common issue. Cities, counties, states, and federal response groups all had different frequencies assigned for specific purposes and owned different brands of equipment that themselves had different frequency capabilities. For decades after the initial attempt to align inter-agency practices, fire incident reports continued to mention the difficulties they had with radio communication that delayed response time, information sharing, and the production of a big picture of the situation.

For example, the Palm Springs Fire Department's report on the 1977 the Chino Fire noted that the different groups were so tied to their radio communication routines that they could not get on the same page throughout the entire incident:

> "I have a handi-talky and I tried that, but they said all of our engines operating up there were on white. You needed to free your routine…We have got four frequency capabilities on our units. 140-160. In all county units we have 5 frequencies. We have 3 frequencies in the county. We have overlooked that to a great extent" (Palm Spring Fire Department 1977, 4).

Because of the chaotic airwaves, they could not get a channel freed up for the division chiefs to use, nor could they get the corresponding groups from city and county on the same lines when needed. In some cases, this was blamed for the endangerment of fire fighters (United States Forest Service and California Department of Forestry and Fire Protection 1988, Angeles National Forest, California Department of Forestry and Fire Protection, and Los Angeles City Fire Department 1996). A similar cause, local fire agencies not monitoring the same radio frequencies as the state, was attributed to the death of a fire fighter and injury of others after the 1996 Calabasas Fire (Los Angeles City Fire Department, City of Glendale Fire Department, and County of Los Angeles

Fire Department 1997). Sometimes too many groups tried to use the same frequency and caused interference, a situation that remained common when managing multiple fires which required teams from other regions and states to help. For example during the Harmony fire in 1996:

> "Different agencies, even within the same city, were on different radios. There were only two local frequencies and two or three state frequencies; it was like putting hundreds of people on a party line. For one agency to talk to another, you had to go through dispatch, which was inundated with calls. Since you couldn't speak to others directly, you never knew if your message got through" (Campbell 1998, 19).

In another case, the California Office of Emergency Service (OES) report on the 1993 fire surge stated:

> "Strike teams from all over the state arrived and attempted to carry out tactical communications on their home frequencies -- which in some cases were also the frequencies assigned to other agencies in Southern California, thus creating harmful interference with the local agencies. This problem was compounded by an inclination of units to utilize the tone-coded squelch decoders in their radios so as to not have to listen to the "unwanted" local traffic" (California Office of Emergency Services 1994, 23).

This local traffic included both city and county teams as well as amateur radio operators from the local communities who monitored the fire and police radios. The public monitoring helped with fire response by acting as repeaters or by coordinating aid needs and offers (like during the Palomar Fire, see Palomar Amateur Radio Club 1987), but other times the government agencies tried to block them out with coded transmissions or scramblers, unintentionally also blocking out the other responding agencies as well (California Office of Emergency Services 1994). In conjunction with these procedural problems, radio faced general human error which came when "weary dispatchers received hard-to-decipher reports from out-of-breath firefighters" (Campbell 1998, 19).

Sharing information between fire and law enforcement was another issue entirely. They typically had physically separate base camps and separate communication procedures. But while fire agencies are the primary managers of the flames, law agencies are the primary managers of the general public, which meant these public-oriented agencies that were in charge of evacuations and road closures needed to know what was going on within a fire in order to properly perform their tasks. Agreements like CALCORD appeared in the early 1990s that set up a common frequency for such cross-agency communication (California Office of Emergency Services 2014). But even as these agreements were enacted, many of the responding groups remained unfamiliar with the plans or were not equipped--and are still not--with the necessary technology (United States Forest Service 1970b, California Office of Emergency Services 1994, United States Forest Service and California Department of Forestry and Fire Protection 1988, Angeles National Forest, California Department of Forestry and Fire Protection, and Los Angeles City Fire Department 1996). These issues were exacerbated by each agency not understanding other operating procedures or forms (California Office of Emergency Services 1994, Palm Spring Fire Department 1977). Even when the technology was aligned, the standards by which the groups internally interacted got in the way. Information management requires a classification system that can function as a boundary object, without that, then the order imposed by the classifications begins to unravel (Bowker and Star 2000).

One way the radio network problems were managed was by avoiding them all together: through co-location. Many reports stated that the operations worked only because the chiefs from the groups were in the same room, sharing a base camp.

Reports noted that that face-to-face discussions were vital to working coordination and were the main reason their response was successful in light of the technological and cultural issues between groups and liaisons present at each Chief's headquarters (Palm Spring Fire Department 1977, California Office of Emergency Services 1994). The reports continually cited two people in the same room working with the same objects as a way to bridge the gaps in classification and standards between agencies. In addition, training manuals encouraged face-to-face communication for bridging changes of command or when there was a complex message that needed to be communicated (California Department of Forestry and Fire Protection 1995). Summing up this need, the chief during the Harmony Fire explained:

> "If you can't communicate adequately in the field, you need face-to-face communication as if you were on a prehistoric battlefield. Without communications, everybody becomes a freelancer" (As quoted in Campbell 1998, 20).

Working face-to-face, while not as ideal to the chief as working within technological networks, is what made the orchestration of inter-agencies possible.

Face-to-face interactions were also encouraged when the information was to be restricted. The training manuals advocated for avoiding the use of technologically-bound communication methods that could be intercepted by other agencies or a curious public when it is preferred that the discussion is not overheard by the public, the media, dispatch, or what could potentially lead to a liability issue (California Department of Forestry and Fire Protection 1995, 282). Despite an expectation for radio communication as a way to connect the disparate and distant groups, it was clearly noted that it – or really any other technological means – could not replace two people in

the same room working together. While on the one hand technological practices were promoted as the best and most efficient temporal and financial means by which to gather and share information, in-person communication was proclaimed as the solution to the problems caused by these technologies and the (necessary but not quite existing) shared practices they required.

While designed to encourage the erasure of physical and cultural boundaries, radio communication procedures and technologies did exactly the opposite. Instead of enabling trading zones that allowed groups with different interpretations and interests to interact as they produced knowledge even as they seek that knowledge for their own purposes, the radios created technological misalignments and barriers (Galison 1997). Instead of being stabilizing elements in the coordination process, they encouraged disengagement and partitioning. Face-to-face interactions helped alleviate some of these cultural barriers, but in turn introduced physical boundaries to the knowledge produced. A person had to be in a specific place at a specific time to be privy to the information and the mutually agreed upon interpretation of the hazards being faced. Each method of communication produced a different potential ordering device, with them different ways of managing legitimacy and authority (Hilgartner 2007, Knowles 2011)

With FIRESCOPE, maps were formally encouraged as a way to enable this collaboration and mediate some of the troubled radio communication (Firefighting Resources of California Organized for Potential Emergencies 1988). While delivering maps often required someone traveling between sites, they offered a common object over which the inter-agency discussions could take place. They were already pervasive in wildfire response, even if in a variety of forms. Maps were drawn regularly in the

field by the firefighters on the front line, by the county and state emergency offices to compile the assorted individual reports received in the field for big picture planning, and by individual agencies to submit with their incident reports. They were used to help record information for decision making in the field, develop causal explanations after-the-fact by fire agencies and emergency offices, track movement of people and resources, to determine evacuation or security needs, and to determine agency responsibility along the different divisions of the fire perimeter. As newly designated communication tools designated to encourage crossing boundaries, maps were intended to help develop a shared picture between the groups involved.

Figure 1.1. A forest patrolman locating a forest fire from his lookout point, 1909. Source: Zimmerman, 1969, p. 1, U.S. Dept. of Agriculture.

How the maps were to be drawn to achieve this shared purpose, though, was not at all obvious. Maps on the front line and from the field were a practice that went back over a century (Figure 1.1). But they were not designed in ways conducive to being used beyond their site of origin. They were drawn in ways that required either an underlying map or an acknowledged relationship to a specific map, often just an 'x' on a regional scale map for interpretation.[13] The resulting map was frequently just a line on a generic grid, with no legend and with only minimal features to explain the context of the lines drawn (Figures 1.2 and 1.3). The maps drawn by the city, county, or state emergency offices for the larger regional planning did offer more physical references bringing the maps closer to stand-alone representations. However, the details that were included, the forms that went with the maps, nor the symbology could transfer between agencies without an attached explanation or a liaison to help interpret in person (Figures 1.4 and 1.5).

These representational and contextual issues were exacerbated by disagreement over what the drawn lines meant. Were the lines, as asked by the Palm Spring Fire Department (1977), to be treated as absolutes where any creep of an object from one side to another implied the introduction of a new agency and responsibility zone? Or were they flexible, offering the opportunity for some spillover before joint responses had to be established? Were regions of protection and hazard, as Millar (1976) asked, to be based on ownership, administrative lines, or topography?

[13] The forms within each agency did not change to any great extent from 1950-1998, the end of the period for which I was able to access them.

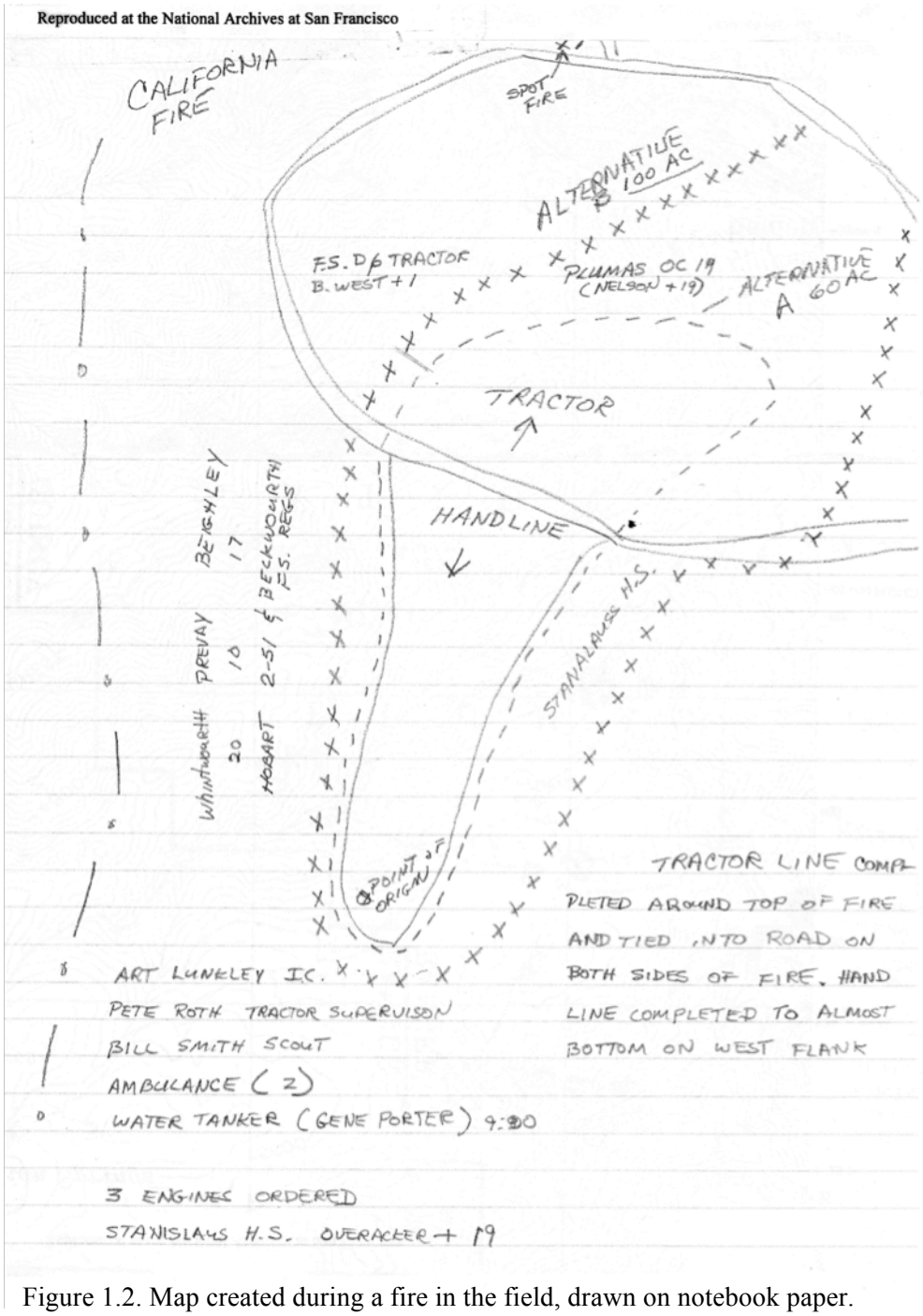


Figure 1.2. Map created during a fire in the field, drawn on notebook paper. Incident report map from the California Fire, 1984. Source: Historical Files Related to Fire Control 1963-1971; Records of the National Forest, Record Group 95; National Archive Building, San Francisco, CA.

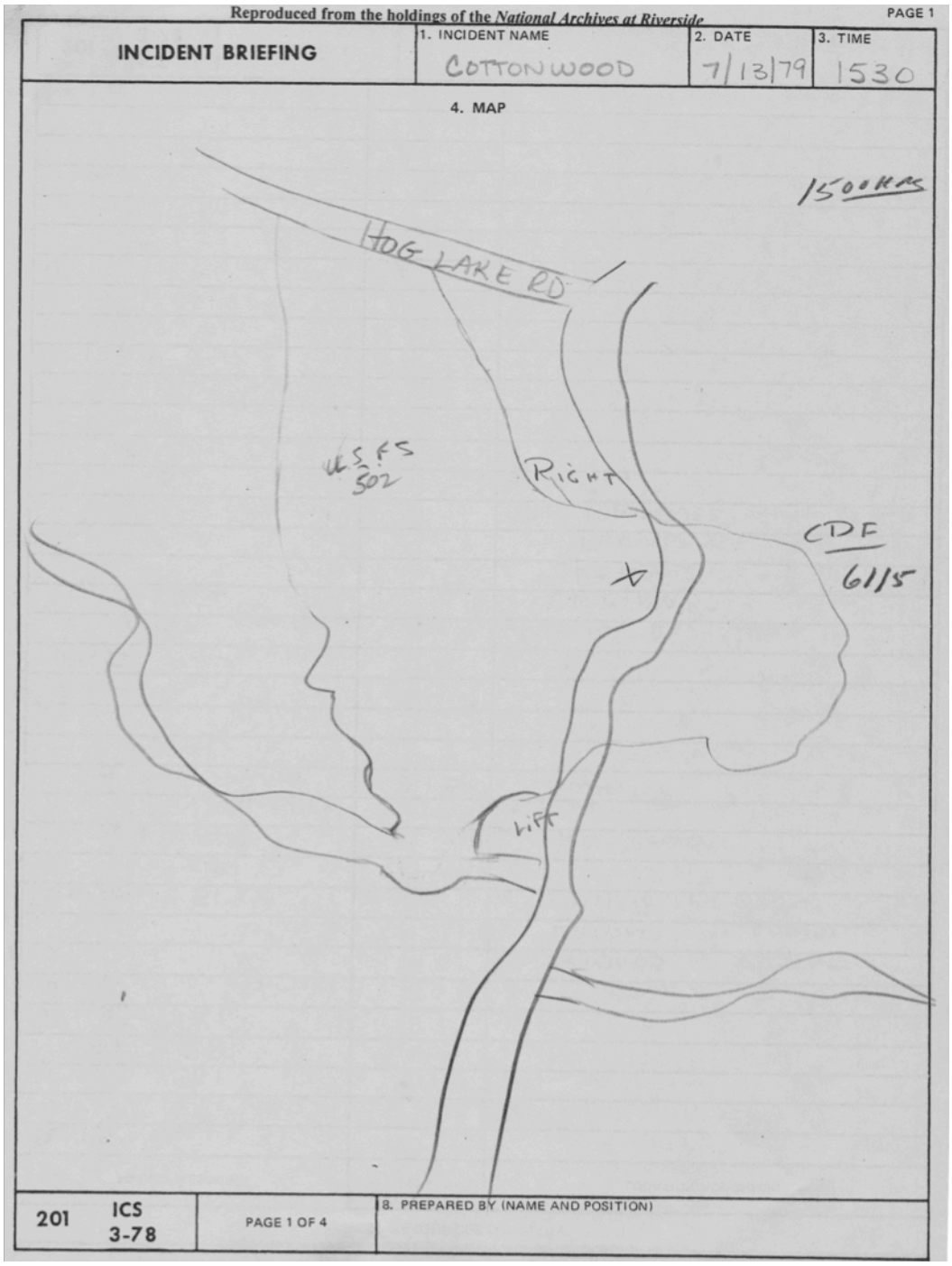


Figure 1.3. Map created during a fire in the field, drawn on field incident report form. Incident Report Map, Cottonwood Fire, 1979. Source: Fire Reports and Related Correspondence 1908-1998; San Bernardino National Forest, Records of the National Forest, Record Group 95; National Archive Building, Riverside, CA.

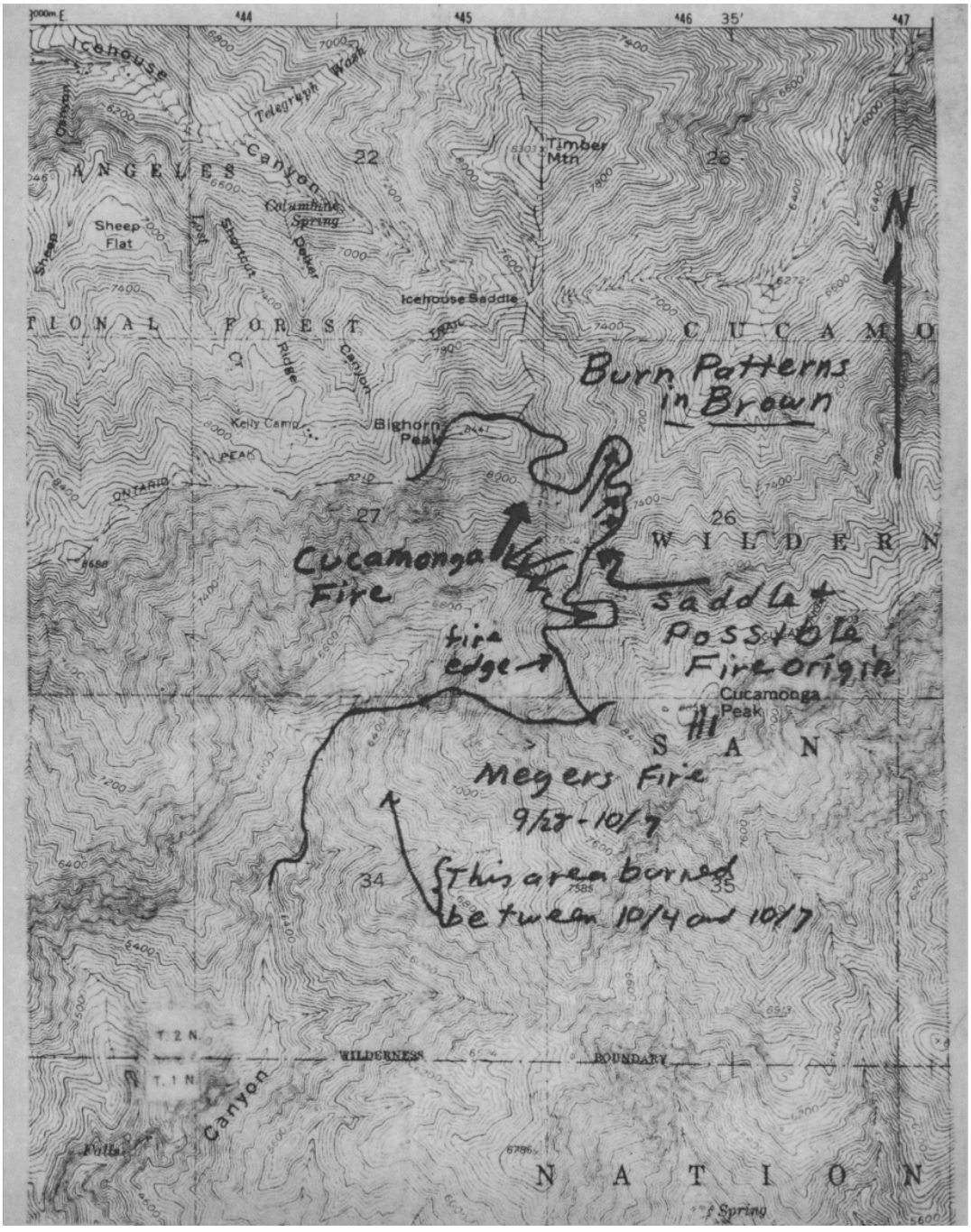


Figure 1.4. Map created for Burn Pattern Report. Shows fire movement and burn pattern over a week in relation to topography and potential fire origin. Cucamonga Fire, 1970. Source: United States Forest Service, 1970.

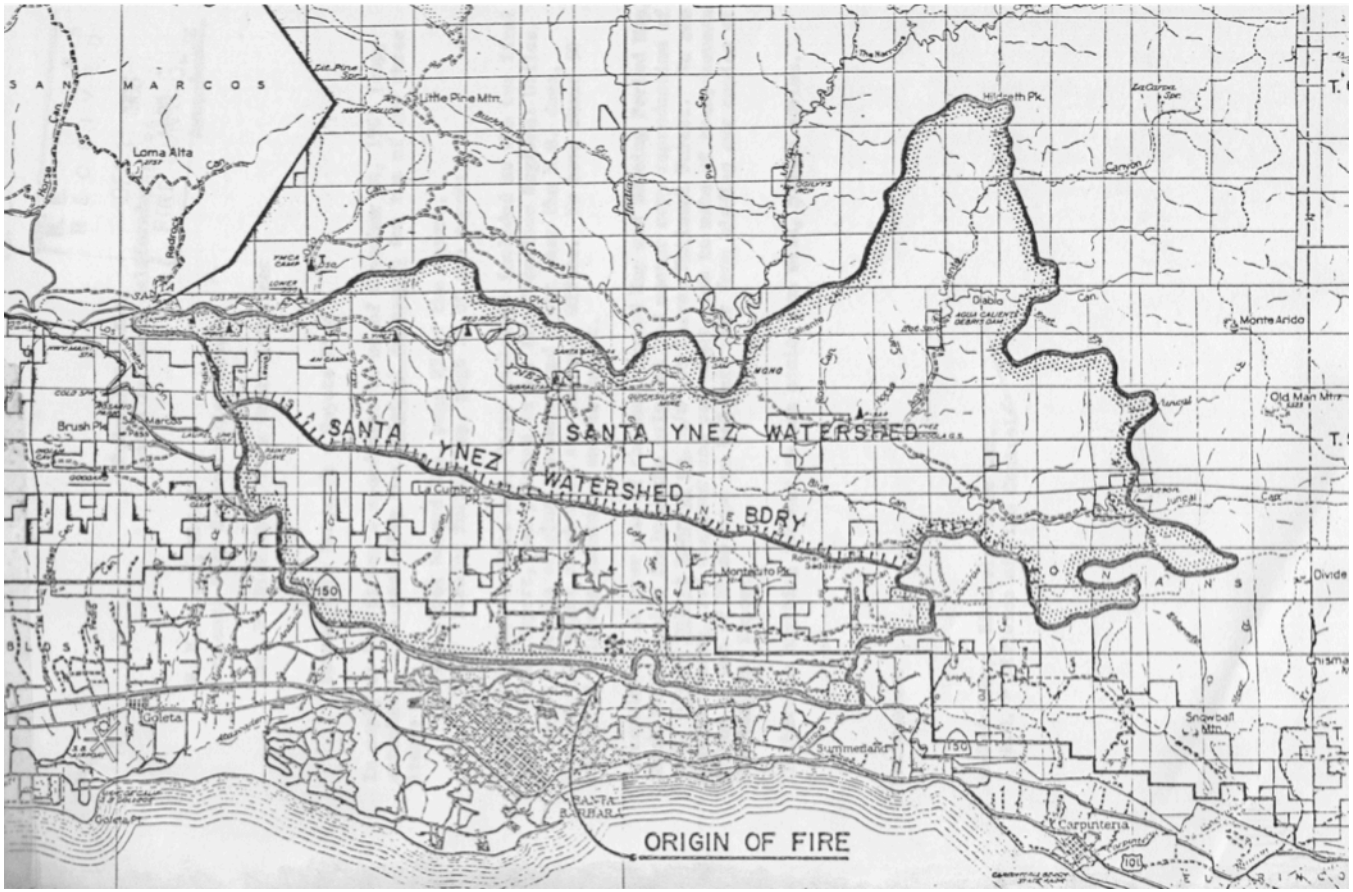


Figure 1.5. After Action Report Map. Shows fire perimeter, jurisdictional lines, watershed boundary, and fire origin. Coyote Fire, 1964. Source: Historical Files Related to Fire Control 1963-1971; Records of the National Forest, Record Group 95; National Archive Building, San Francisco, CA.

These interpretational issues reared their ugly heads in a survey in 1973 when California counties were asked to define fire hazard zones (California Division of Forestry 1973). The survey found that despite a statewide plan, there was a wide range of definitions, from defining hazards zone as all generic forest, brush, or grass areas to defining it in detailed and nuanced ways that were entirely county dependent. According to the survey, the state recommended that for administrative convenience, all fire hazardous areas be drawn on maps using infrastructure, such as roads, utility lines, streams, landmarks, so it is visible not just on a map but as a responder is walking through the space on the ground. But local agencies found that such details were difficult to obtain when dealing with private property scattered amongst wildlands. Overall, according to the survey, Southern California counties found this type of boundary drawing neither descriptively sufficient nor resolved issues of responsibility.

Such different stylistic and interpretational practices around maps were especially challenging when different teams would travel from one region to help fight fires in another, a common practice when the fires were large or multiple. Each team would have different ways of relating the lines on the map to the environment around them and develop totally different understandings of the hazard and its relationship to the fire situation they were facing. While the firefighters were trained to develop protection plans and priorities based on risk, hazard, and value, even the training sources and fire reports acknowledged these judgments were based on previous and local experience (United States Forest Service 1964, Zimmerman 1969, California Department of Forestry and Fire Protection 1995). The maps were placed in a

contradictory position, as both situated practices and as immutable mobiles (Latour 1987, Suchman 2007). While local knowledge was to be called upon interpret the situation, the situation was somehow supposed to be drawn in a standard, and thus culturally and physically mobile, way.

These same procedures for map sharing and interpretation had the side effect of separating into isolated practices map use and public communication. Map use, according to the training manuals, required face-to-face communication (California Department of Forestry and Fire Protection 1995). But face-to-face was the same type of communication encouraged when wanting to keep information from the public. Instead, it was greater inter-agency communication and coordination that was argued to benefit the public by speeding up response and making it possible to have more timely public updates (California Office of Emergency Services 1994). The methods that enabled coordination between those in the field created greater distance between what was going on at the scene of the fires and what the public could find out. For the public, these maps were not mobiles at all; they were cultural and temporal barriers.

As such, the maps used for collaboration in the field, for planning, and reports were engaged with and shared in such ways as to create spaces of authority. To know a map was to create a locally bound culture that would only be interpreted for public consumption after their vital role in defining aspects of the wildfire response was already complete. The ability to blackbox the messiness that is involved in the collaboration is one method of managing the disaster to maintain order (Hilgartner 2007). To manage a system is to close it from democratic decision making, limiting in whose hands authority can be held (Calhoun 2004). In addition, making the practices

invisible to the public assumes a public that does not offer any information to the system. But the public tends to assess quickly and take action, without waiting for outside help; there seems to be high local self-sufficiency and resilience in disasters (Knowles 2011). Keeping the public out does not necessarily keep the public disciplined. In fact, during disasters the public does not wait for order to be imposed, it makes its own (Tierney 2006, Steinberg 2000).

Making Information Public

Despite building barriers between them and the public, the officials in charge of battling the flames could not ignore the local communities or the media. The media asked questions, sometimes overwhelming the officials who themselves were still sorting the situation out. When the public needed to be evacuated or, at least, kept away from the roads being used by the first responders enough information needed to be provided that they heeded the instructions. By maintaining a distance between both official action and public information as well as between hazard and data gathering, the officials continued to form what it meant to witness. They were enacting a specific relationship to the production of authentic knowledge to establish their classification of the fire and its impacts as matter of fact (Shapin 1984). The public, though, did not always agree to this arrangement.

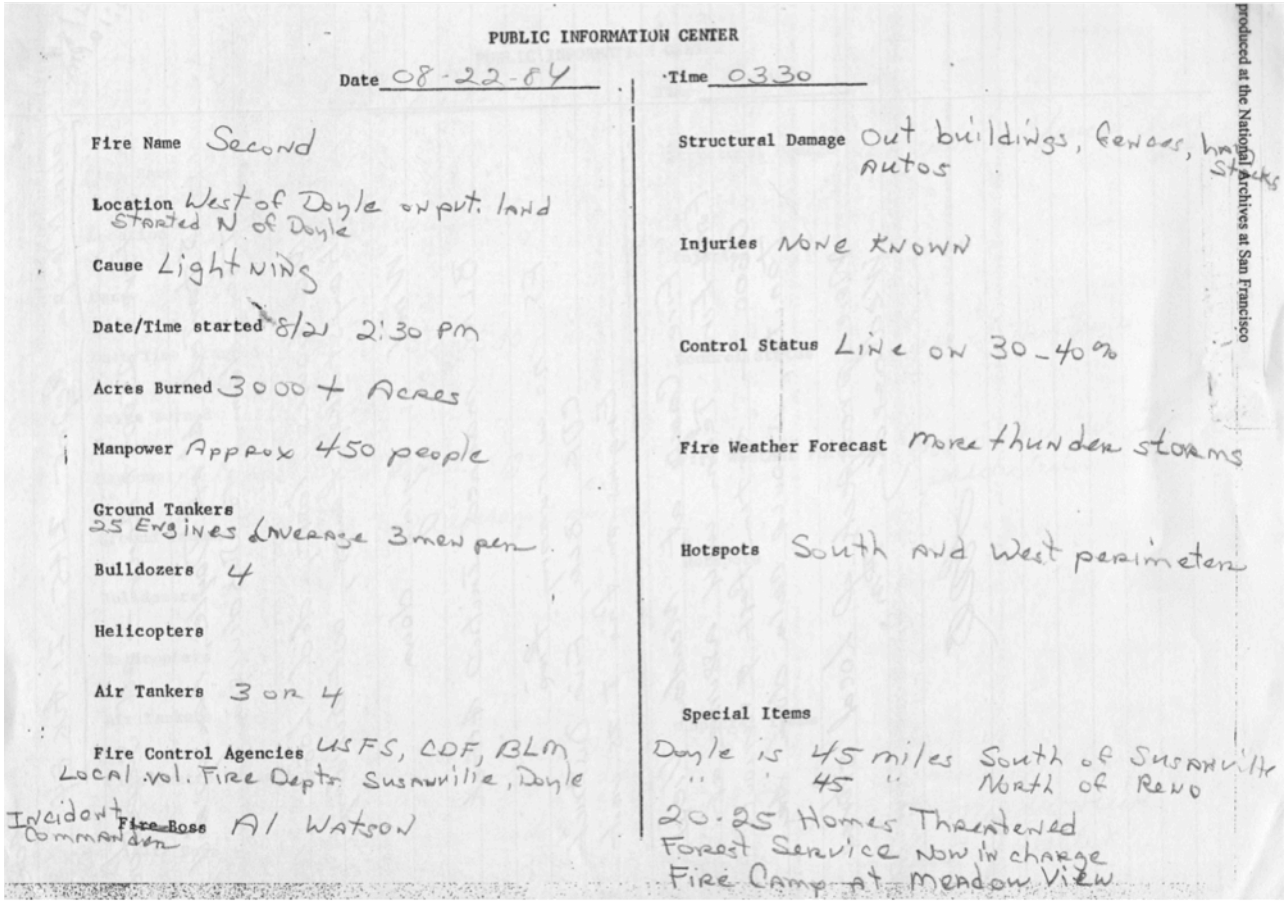
During the last decades of the 1900s, information left the fire commands and reached the public in at least three ways. First, the public got information through the mass media provided to them by the incident's public information officer. Second, as already mentioned, it was leaked out via technological means, most commonly radio

interception.[14] Third, the public was able to examine fire reports, such as pre-fire plans and after action reports, reports that frequently included maps and were created in times when there was no fire. Each of these methods provided a different type of information, a different relationship to the immediacy of the event, and asked the public to play very different roles within the event. They each encouraged a different relationship between the public, witnessing a fire, and the final knowledge produced, differences that created spaces of resistance (Harvey 1996). In these moments, the public made themselves visible as part of the communication process, not just passive recipients of information.

The most formalized method by which the first responders provided information to the public during a wildfire was through a public information officer (PIO). Included as one of the command personnel in FIRESCOPE's ICS, this role was designed to have a primary contact provide regular updates to the media about the emergency, information that was deemed relevant to the public that typically included regular updates about the general situation, what is being done by the fire fighters, and more specific community details like evacuations zones and burnt structures (Figure 1.). [15] Described in a 1977 memorandum of understanding between the BLM, USFS, and NPS, the role of the PIO was to make sure that:

> "the public will be notified of restrictions and closures through the news media. This notification will be handled by field units for local news releases and by concerned regional and state offices for press releases having more than local applicability. Joint media releases will be made whenever feasible" (United States Forest Service, National Park Service, and Bureau of Land Management 1977, 1).

[14] Operators like these still function today and are still incorporated into the response process.
[15] Positions of this type have been mentioned in the fire reports since the introduction of the telephone as part of response prior to World War II.



PUBLIC INFORMATION CENTER

Date 08-22-84 Time 0330

Fire Name Second

Location West of Doyle on pvt. land
Started N of Doyle

Cause Lightning

Date/Time started 8/21 2:30 PM

Acres Burned 3000 + Acres

Manpower Approx 450 people

Ground Tankers
25 Engines Average 3 men per

Bulldozers 4

Helicopters

Air Tankers 3 or 4

Fire Control Agencies USFS, CDF, BLM
Local vol. Fire Depts Susanville, Doyle

Incident Commander ~~Fire Boss~~ Al Watson

Structural Damage Out buildings, fences, hay stacks
autos

Injuries None known

Control Status Line on 30-40%

Fire Weather Forecast More thunder storms

Hotspots South and West perimeter

Special Items

Doyle is 45 miles South of Susanville
" 45 " North of Reno

20-25 Homes Threatened

Forest Service now in charge

Fire Camp at Meadow View

Figure 1.6. Example of a Joint PIO report. Second Fire, 1984. Source: Historical Files Related to Fire Control 1963-1971; Records of the National Forest, Record Group 95; National Archive Building, San Francisco, CA.

It was also the job of a PIO to mitigate rumors. While some information came to the public from local units that would best understand the local needs, much was streamlined and coordinated so a single, shared, message would be provided. Frequently, this position was connected to the local sheriff's office, the agency designated to manage the public.

The PIO was typically not co-located with the planners in the field and the information provided would come only at regular intervals, often delayed in relation to events. While many reports noted that being close together aided communication, collaboration, and generally the ability to grasp an overall view of what is going on, many of these same reports also noted that the PIOs were kept both separate physically and often organizationally from those involved in the response (Palm Spring Fire Department 1977, Campbell 1998). The PIO had to learn about the events themselves through the troubled technological networks that instigated much of the face-to-face communication. And, sometimes they had to move because of the loss of these communication lines, creating even greater distance between them and the information they needed to share (United States Forest Service 1970b). Even when based in the County Emergency Offices where much of the off-site activity takes place in a disaster, like a countywide response such as what occurred in 1993, the reports from these noted that the PIO should have been located at the command post or base camps where the fire fighting is being coordinated because information was too delayed (California Office of Emergency Services 1994). In how the PIO was positioned, wildfire response and public communication were not structured as integral one to the other.

Since the introduction of radio networks in wildfire response, amateur radio operators have often been brought into the response, even federal responses, through formal organizations like RACES (Radio Amateur Civil Emergency Service) or local groups like the Palomar Amateur Radio Club (PARC). The amateur radio groups could not be privy to all official communications and they were restricted to specific frequencies, a restriction that was in part dictated by the bands built in to the amateur radio's technology. The first responders had to be using one of these bands in order for it to be intercepted. The technological infrastructure behind these amateur radio groups was often used to enhance official communication lines when the official lines or technological nodes were insufficient or damaged, which offered the local communities within radio reach a glimpse up the information transmitted. For example, during the Palomar Fire of 1987, Animal Control used the PARC repeaters as they coordinated their response and were used for 9 days by the American Red Cross and fire agencies to coordinate their actions. During this time, the club reported getting calls from both ham and non-ham operators who were listening in to offer their resources and aid (Palomar Amateur Radio Club 1987).

Lastly, the public could find out about the fire after-the-fact through the release of pre-fire plans and after action reports. The reports, and the many maps included within them, were designed to act as facts of the fire, be it of the setting in which the fire took place, historical record of the effects of the flames themselves, or evidence of the logic for a response. The maps within them had to contain enough background information to act as evidence to justify the claims being made within the report about causality. But this did not mean uniformity. If, for example, the argument was about fire

spread in relationship to residential locations, then roads, houses, locations of firefighters and arrows depicting perimeter movement were often the only details included (Figure 1.5). If the goal was to report on the overall fire situation, then typically included on the map were the fire perimeters and any damage, highlighting any infrastructure or ecology that was affected (Figure 1.6). Overall, these reports provided a generalized overview constructed through a narrative, statistics, and maps.

The information provided to the public was either fragmentary or delayed. Gathering information through the technological communication networks, like radios, provided immediate information, but built into the public knowledge were the same issues complained about by the fire fighters who argued for the necessity of face-to-face communication, something not granted to the public. Waiting for information, through PIOs or reports, would offer more full snapshots, but would arrive in ways that excluded the local communities from decision making, including about how best to determine their own safety. In either case, what was provided was structured and planned, each report and map acting as what Monmonier (1996, 72) calls a "tool of persuasion" offering a specific view of the situation that has no innate connection to accuracy, but a view necessary to make cases about the validity of the priorities chosen and values expressed. These views, while seemingly all-encompassing, had the power to limit the types of questions asked about the given and future incidents (Monmonier 1996, Hilgartner 2007). They are metonyms, static pictures standing in for the larger disaster (Oliver-Smith 2002). But when treated as self-contained, they become arguments for the extent of the disaster, bounding the disaster as an event in time and

space, drawing political lines that include and exclude elements from the conversation as consequential to the history.

Local Community Involvement

The relationship between the public, their actions, and the need to fight fires was one of great stress. The public, because of their increased presence, became a common scapegoat for the existence of and damage caused by wildfires. Assumptions about the public not listening, panicking, and being without order are common amongst responding agencies despite being often only imagined (Tierney 2006, Knowles 2011). During the population expansion and increase in Southern California wildfires, the excuse of the misbehaving public was so strong an instinct that it was sometimes assumed at the onset of a fire that a resident or tourist caused the fire only to have to revoke this claim upon further analysis after the fire was out (United States Forest Service 1954a, 1970a). The public, in the mind of the officials, needed more education.

Studies that examined the increased wildfires and wildland population consistently touted public education as a primary missing ingredient in the safety net preventing wildfires. One study acknowledged that by the early 1970s most of the general public in Southern California understood that forest fires were to be things of concern, just that they did not know what this implied in terms of their role and therefore did not follow laws and safety recommendations (Task Force on California's Wildland Fire Problem 1972). In 1974, another report reiterated the same need for education, prescribing practically the same general educational instructions for high density communities, low density rural areas, recreational regions, power companies,

and industrial areas (Jones & Stokes Associates 1974). In 1979, the USFS, stated that this education needed to be for not just rural residents but also for urban users of wildlands to "fill serious gaps knowledge related to fire prevention…the aim is to change behavior" (Folkman 1979, 16). Overall, the type of education suggested went undifferentiated between groups. Everyone who was not a fire fighter needed to learn the same things for a region to be safe.

When there was differentiation, it was often to redistribute responsibility. For instance, in 1983 the USFS drew on research from the Pacific Southwest Experimental Station and recommended that one of the main ways to prevent wildfires was to educate homeowners to understand fire behavior and maintain proper landscape, making it increasingly their responsibility to know what was going on in order to properly prepare and respond (Radtke 1983). Yet again in 1993 the public was blamed for the profusion of damage. They were said to have ignored clear warnings and other official notices shrugging their responsibility in order to returning to their residences to assess the damage for themselves, actions that put themselves in the path of danger and clogged the few active roads being used to move first responder vehicles and supplies (California Office of Emergency Services 1994).

These views all came from a focus on prevention rather than preparedness (Lakoff 2008). Prevention of wildfires in Southern California focused on teaching the public in order to keep a disaster from starting in the first place. In this view, knowledge gaps lead to misbehavior, which in turn leads to the cause of a disaster. But, the public neither waits idly for information or to take action. Nor do they get into mischief unless a structure is imposed upon them. Rather, they actively seeks and creates their own way

of engaging with the situation, in most cases acting just as exemplary as the first responders in the field (Tierney 2006). Even a report for the California Department of Forestry acknowledged the blaming the public was an empty claim and declared that: "It is too easy to suggest that this is a community problem, because the interface is barely recognized, even by people who write environmental impact studies" (Butler 1976, 13). Just saying these fires were the result of public ignorance missed the larger picture. Southern California was dealing with multidimensional boundaries: those created to maintain a sphere of authority around the government officials and those that existed because of different understandings about the same lived space. The fires in this region required multidimensional solutions.

The local communities and the media did not just sit back and wait to be educated during a wildfire. Timeliness of public information was and remains a concern for the media and the public, and even government officials when they consider the public needs (California Office of Emergency Services 1994, County of San Diego Office of Emergency Services 2004, Palm Spring Fire Department 1977). This was especially pertinent as the public started to experience a general shift in approaches to disasters from prevention to preparedness, a shift that implied greater public and individual responsibility in the face of a disaster. The public and the media sought out new ways of learning about what was happening and what might occur and in doing so often acted in ways that did not align with the plans and expectations of the government officials, like when the disregarded established boundaries like road closures, air travel restrictions, and closed radio networks. Sometimes it meant that they sought information in ways that made sense based on their everyday practices but were not

considered in the larger procedures of the first responders. The transgressed lines made visible new ways of thinking about and communicating during fires.

For example, during the Harmony Fire in 1996, it was not clear to residents where they should look for information about the fire and the media was not providing information fast enough, especially as they were being evacuated. A large number of the local population turned to the Carlsbad public library, a regular source for community information, despite it having no more information about the fires than anyone else. A report summarizing the fiasco stated:

> "As residents evacuated and firefighters tried to save homes, many concerned citizens flocked to the Carlsbad libraries which, since they didn't close their doors until 9:00 pm, were the only city buildings normally open at night. Where was the fire headed? Were the roads passable? What areas were being evacuated? Where could people take/obtain emergency supplies? Questions abounded, but unfortunately, the library staff didn't have many of the answers" (Campbell 1998, 21).

The report acknowledged that police and fire officials needed to speed up the flow of information internally and externally. It commented that internal issues to the fire and police communication networks, including stressed phone and radio networks, made those dealing with the public have insufficient information to share. These issues prompted deliberation on how to construct public communication differently than simply a PIO with regular updates to the mass media. The report suggested that officials needed a greater awareness of what the local communities would want to know, especially in face of being asked to evacuate or to be responsible for their property. To do so, it proposed that any response should have a local official involved in the response and communication process that is connected to the everyday community information practices. The report further suggested that instead of relying only on mass media

communication, a constantly accessible information bank or call-in lines accessible to the public could be of great value (Campbell 1998, p. 58-63).

In another case, during the 1993 wildfires, the media violated boundaries that had been established by the government response, but in doing so revised future boundaries to include them. When discussing the role of the news media during the response, one of the after-action reports for these fires noted:

> "Opinion was somewhat mixed regarding the role of radio and TV media on incident coverage. Again, this varied by incident. In some cases, the media's ability to provide an airborne picture was of direct assistance to on-the-ground decision-makers. Several responders believed that airborne media should be used to provide information on the direction and probable fire spread for areas ahead of the fires. Another, more negative view, of the airborne media resulted from numerous violations of restricted airspace on some incidents. This caused some concern to Air Operations personnel because of interference and safety issues" (California Office of Emergency Services 1994, 8).

While it was well known that aerial reconnaissance and photography could be useful, the images and footage obtained by the media had previously been ignored, deemed inappropriate sources of knowledge. But the imagery obtained by the media during this fire, though it was procured in dangerous airspace and doing so it interfered with parts of the aerial firefighting, was found to be so useful to the first responders in the field to trigger a reassessment. Media presence is a given during a disaster, so the fire officials had to weigh what was of greater value: a separate information gathering process or a bringing in this wider range of data – which was often more immediate than their own—and expanding their network of communication and redefining their community of witnesses and notion of authority.

At other times the public involvement was more subtle than a blatant disregard for official expectations and rules. There did exist local arrangements that incorporated local community members directly into the response. But how the community acted on that involvement at times tested the authorized plans. Often, this was because the local would rely on their everyday use of technology. For example, during the 1954 East Tunnel Fire, a contracted aerial scout from the local community who brought along his Polaroid land camera. Using photography to capture aerial photographs was far from new, but because of the lengthy processing time for most photographs the images were not practical for real-time decision-making. But the popularity among the general public of the Polaroid that provided relatively instant images provoked change. Though the camera use was unsanctioned by the official response, the Special Report written after the fire stated:

> "This photography enabled the FCA who was reasonably familiar with the country, to proceed directly to the fire across a very hazardous country and pick the right ridge before dropping off the main divide. It also paid off in fixing the location of the fire had it developed into a sleeper" (United States Forest Service 1964, 2).

Because the contracted pilot was not limited to the official procedure, he was able to demonstrate the value of this new technology, which the report on the fire recommended get used in all fires as part of aerial reconnaissance practices.

In addition to the interventions in technology and practice, local knowledge continually held its ground against that produced by generalized, standardize, or technological means. For example, in a correspondence about the 1955 Lytle Creek fire in the Cajon Pass, the Forest Supervisor wrote:

> "Local empiric knowledge indicates that at the season of the year during which this fire occurred there is a short period of time usually one-half to an hour and a half occurring about sunset when the strong up-canyon winds which dominate the daily airflows die and a lull occurs which preceeds [sic] the normal nocturnal down-drifts. If this period of timing is missed it results in a delay in firing operations which often cannot be successfully conducted after humidity increases prevent clean burning out of lines" (United States Forest Service 1954b, 1).

In another case, a report from the East Tunnel Fire in 1964 stated:

> "Local experience of the Forest Dispatcher in this type of problem indicated heavy manning in keeping with the "plan for the worst probable" principle. Had reinforcements been lighter or skimped upon, control at relatively small size would have been much less likely" (United States Forest Service 1964, 2).

Local knowledge of the terrain, weather, and public expectations kept demonstrating itself to be integral to a successful wildfire response.

Standards and classifications are ordinarily invisible, but in these occasional moments of transgression, they are made visible and open to resistance. These moments offer glimpses of when a top down model neither facilitated the most effective response nor most efficient way of making the wildfires knowable. They are moments when the ad-hoc and personal practices intermixed with established conventions, demonstrating the always incomplete nature of such conventions when engaged in a specific moment and place (Bowker and Star 2000). Each of these cases of change was triggered by people outside of the official response stepping in and just doing their normal routine: going to the library to find information when needed, getting to the scene however necessary for the news, and simply carrying the technology one usually would. These transgressions into the information networks established by the official response were done for a shared reason: timeliness. Each actor made their own sense, their own

expectations for what order should involve, and they did not wait for the officials to tell them what those expectations should be. Steinberg (2000) argues that the public will almost always push back and appropriate their spaces in ways that disrupt norms and codes established by those in power. Here, the formal and the informal social and material practices met and challenged the managerial vision, and opened up the blackbox of authority in relation to the production of legitimacy and knowledge (Hilgartner 2007).

Classifications are often treated as though they offer a complete picture of the world, but there are always monsters and wild zones, objects that push back on the lines drawn (Bowker and Star 2000). Bowker and Star note that knowledge about what is useful at any given moment is embodied in social roles and the accompanying mundane practices. When different roles meet, these practices appear less mundane and the assumptions behind them can no longer be taken for granted, revealing these monsters and wild zones. These public actions did just this: they highlight the fact that as the fires move from flames to disasters, the affected communities, classified as outside or adjacent to the wildfire response, were actually were ingredients within the incident. While initially treated as monsters and wild zones in need of control and education, they demonstrated themselves to be integral and relevant.

GIS as a Communication Solution and the 2003 Fires

But that does not mean one should throw out classification systems all together, that every incident, that each agency should approach the wildfires on their own. Rather, these systems are what make shared action possible, especially as they move from the

conceptual to the material, becoming inscribed and affixed to things such that they become transportable (Bowker and Star 2000). As the need for collaboration, sharing, and mutually beneficial practices became increasingly pressing for an ever-widening range of groups during wildfires, maps – specifically GIS maps – turned into a go-to tool for bringing all the local variations into alignment.

By the time of the 2003 fires, the predecessor firestorm to the 2007 wildfires, two trends emerged in wildfire response and public communication.[16] First, technology and alterative forms of seeing, especially aerial views and infrared imaging, were deemed more efficient economically and temporally than scattered people positioned in the field. Second, the communication practices with the public – regularly scheduled updates given to the mass media for the reporting that had been sufficient when the fires were mostly contained within wildlands – did not satisfy the needs of the increasingly larger publics facing increasingly larger wildfires in their backyards. This was especially the case as multi-fire incidents occurred that impacted many different communities bringing into the same space different departments and agencies had to figure out how to work together. In addition, since during wildfires residents and responders were constantly on the move portable objects for communication were needed. The USGS suggested that such objects could even help create consistency at shift changes when the team in charge of information transitions (United States

[16] These wildfires were very similar to the ones from 2007: they occurred towards the end of October, throughout Southern California, affecting many heavily populated regions, some of the same ones from 2007, and took a similar amount of time get under control. Many of the same actors were involved in both fires and they were struggling still with many of the same issues. Some of the recommendations from the 2003 wildfires had barely had a chance to be drafted, yet implemented by the time of the 2007 fires.

Geological Survey 2005). GIS emerged as a way to alleviate all of these problems at once.

With the financial and temporal efficiency of remote sensing relatively accepted as fact it was increasingly incorporated into wildfire information gathering and sharing practices. GIS was integral to remote sensing, since the remote sensed data is most useful when combined with other layers for interpretation. For example, remote sensing provided heat signatures which made it possible to see through smoke, unmasking things like hot spots and vegetative reflectivity, and provided generalized data about surface properties such as potential flammability. Combining this information with GIS layers like fire history and topography, as well as GPS data from firefighters on the ground provided a level of detail to potential burn patterns that understanding the generalities of fire behavior alone could not (Jaiswal et al. 2002, Arroyo, Pascual, and Manzanera 2008). However, to provide such a technological vision for the hazard, schemas for fire risk needed to be designed and established prior to any data gathering and analysis; the data itself did not provide these definitions (Chuvieco et al. 2010, Hernandez-Leal, Arbelo, and Gonzalez-Calvo 2006).

Seeing GIS as a potential tool to provide quick yet critical information during wildfires, GIS maps were examined by both government funded research programs and incident reports. These programs and reports imagined GIS as a platform that could provide a common data format, combined commercial and civil communication infrastructures, and could become a common language through which to move information from fire camp to emergency operations center (Ambrosia et al. 1998,

Governor's Blue Ribbon fire Commission 2004).[17] The hope, though not stated in these words, was to incorporate GIS maps as boundary objects, objects to help balance categories and meanings, that could inhabit several communities of practice at once but remain plastic enough to adapt to local needs (Star and Griesemer 1989). The hopes shaped practice: by the late 1990s and early 2000s, GIS maps progressively crept into more parts of wildfire communication. Even Environmental Systems Research Institute, Inc., a popular producer of GIS software, started to design and promote their products specifically for use during wildfires (ESRI 2000).

During the 2003 fires, these ideas were tested. The value of GIS as part of the response was not fully realized prior to these fires nor did San Diego County or the City of San Diego have full-time on-call GIS staff. But during the 2003 fires, GIS was brought to the field by ESRI who provided local technological infrastructures at the Incident Command Posts necessary to compile and print GIS maps. These maps were used for fire perimeter mapping, identification of critical facilities, allocation of resources, and fire behavior modeling. City and County emergency offices throughout Southern California created GIS maps used during planning and public hearings. To fill in the expertise gaps, San Diego County drew on GIS support from agencies like Public Works as well as individuals from industry groups like SAIC and Pennant Alliance (County of San Diego Office of Emergency Services 2004). Many of the maps were

[17] Such as WILDFIRE, a disaster mitigation feasibility study started in 1997, demonstrated the feasibility of integrating civil and commercial communications and information technology to provide operational resources to firefighters attacking wildland fires (Ambrosia et al. 1998). These potentials were also being demonstrated in the field in disaster response. For instance during the 1993 wildfires, the pre-planned wired-telephone and radio communications both failed, so the fire agencies requested aid from the cellular industry with great success (California Office of Emergency Services 1994).

made available to the media, but only via a paid subscription web service (Theodore 2004).

Both the City and County of San Diego found GIS maps full of potential but not immediately effective. Their staff were not able to provide guidance as to their needs in relation to mapping, the San Diego Fire Department and County Public Works did not have enough staff nor the necessary software, equipment, or network expertise to manage all the technological and data problems encountered (City of San Diego Fire-Rescue Department 2004, County of San Diego Office of Emergency Services 2004). The County was also unable to acquire satellite GIS data to map the fire areas more effectively, even with a coordinated attempt on many governmental scales (County of San Diego Office of Emergency Services 2004). Despite these problems, GIS was deemed promising if given the proper ingredients. After the fires were over the City of San Diego wrote:

> "There needs to be a means of displaying graphically, using GIS, the extent of the Incident and any other relevant information. Appropriate resources and processes need to be included such that information is created once (at the ICP or a DOC), then is made available to the EOC" (Lee 2003, 3).

The visual and spatial format seemed right, the ability to have transportable standards a plus, but the local instantiations were insufficient.

But even with the inclusion of the GIS maps, the all the after action reports from the 2003 fires still declared that communication was a struggle during the majority of the incident response, especially between individual agencies and between the general command and the public. For example, it became clear that the urban and forestry agencies still did not agree about what a fire boundary meant (Governor's Blue Ribbon

fire Commission 2004). Should, for example, protection at the fire perimeter imply structural protection or perimeter control? The different interpretations not only impacted how resources were distributed both during and after the fires, but also got in the way of clear and effective communication with a public that lived on these boundaries. The maps were not acting as the hoped for boundary objects.

While a boundary object has different meanings for each group engaging with it, for it to maintain coherence across the intersecting groups it still need some form of shared classification scheme between groups -- some sort of shared structure -- to be recognizable as common (Star and Griesemer 1989). But this cannot be imposed upon the practice from the outside; it has to come from the practice. A boundary object emerges from durable cooperation, in practice, to act as a tool to resolve the anomalies that arise when a classification system becomes naturalized without imposing the schema from one community onto another (Bowker and Star 2000). These maps struggled to play that role, especially in relation to what it meant to work at the lines drawn on the maps.

Moreover, responding agencies still had incompatible communication networks and technologies that interfered with sharing the information needed from the ground for the GIS maps. Their ineffectiveness on mountainous terrain impeded communication between agencies, slowing down the movement of information to the public. FIRESCOPE was a good start to bring everyone into the same standards but it had not kept up with changing technologies and changing situational needs (Governor's Blue Ribbon fire Commission 2004). For example:

> "In some cases, firefighters found it necessary to carry three or four different radios, two extra batteries, a text capable pager and a cell phone, and had to check multiple frequencies and contend with busy signals in order to maintain communications and obtain needed information" (ibid, p. 52).

So many different communication paths and technologies were used that the commanders would often not know which ones to monitor. To alleviate some of these disconnects, the City of San Diego stated that they still needed to co-locate the various departmental commands "to insure a timely accurate exchange of information" and to gain a shared picture of the issues being faced (Lee 2003, 3). Even with new technologies, face-to-face communication was still the communication practice that guaranteed a shared picture. Over sixty years after fires along the wildland urban interface emerged as a potentially disastrous problem that needed managing, coordination was still a concern and a mystery.

GIS, as a potential solution to these communication, collaboration, and meaning making problems was an inter-agency solution, not one for communication with the public.[18] The public was not to be a part of this network via this exchange, even though the public and media kept demonstrating their value to the production of an overall picture of a wildfire. But this did not mean they were still classified out. In fact, the classification system that had long defined wildfire response and information gathering

[18] The state even went so far as to say that if there is a joint communication center formed, which is where the PIO would be located, it needs to be near the emergency operation center (Governor's Blue Ribbon fire Commission 2004). At the same time, though, the city complained about the physical proximity of the communication center to the disaster operations center, claiming "it was a security issue and impacted the DOC's functions (City of San Diego Fire-Rescue Department 2004, 23). Within the same reports once again contradictions emerged. While co-location was necessary for successful information sharing, the PIOs and their related publics need to be kept separate for the safety of all involved. Implied in these statements was that the public and their needs were not part of the primary disaster response.

was actively being modified to include the public to a greater degree. One of the new ideas that emerged after the 1993 wildfires, and partly codified in the existence of the Fire Safe Councils as a result of the 1996 California Fire Plan framework policy, was to include more community involvement in the strategic fire planning effort (United States Geological Survey 2005). The USGS, BLM, and USFS did a study during the 2003 wildfires in response to previous criticism by local communities that they did not receive appropriate or timely information from the responding agencies. They found that the public needs more and different types of information than traditionally offered (their information net is much wider than the mass media), including the ability to get real-time information, and that the mass media and official information seldom provided the kind of information residents found useful (United States Geological Survey 2005).

There were also recommendations to incorporate local knowledge to a greater degree. For example, the California Blue Ribbon Commission's report on the 2003 wildfires recommended that federal and state agencies do a better job of integrating local incident command team members because the teams in charge, typically federal or state, lack the knowledge of local fire protection planning efforts, area geography, fire behavior, and political boundaries. These gaps, they argued, could impact the effectiveness of fire suppression and efforts to provide the public information (Governor's Blue Ribbon fire Commission 2004) In addition to including the local knowledge, the city of San Diego's report reiterated the state's sentiment from the 1993 wildfires stating imagery from local media helicopters should be monitored and better used as a source for "live intelligence" for determining fire activity (City of San Diego

Fire-Rescue Department 2004, 23).

These moments demonstrate exactly how standards need to work if they are to act as collaborative tools. When producing knowledge, there exist protocols, sets of rational directions that are developed over time, that represent the culmination of experiments that have become standard method. This is part of the repetition that makes something accepted as matter of fact (Shapin 1984). Yet, while a procedure may be described in such a way that the chances of replication are increased, when put into practice it will become embedded with tacit knowledge and personal variation (Jordan and Lynch 1992). Often the expert cannot explain the procedure to the next person; they cannot separate personal touch from the necessary steps exhibiting the localized nature of the standardized practice. The local and the ad hoc are what make standards possible, they are not practices to be excluded from the development and implementation of standards (Bowker and Star 2000). For GIS maps to work as bridges between groups and information, they would have to balance these two ways of knowing.

Conclusion

Discussions around maps often circle around how the production of maps produces power over what is being mapped in symbolic and political terms. These analytical approaches focus on where and why lines are drawn on a map and how those lines delineate such things as inclusion, exclusion, objectivity, and normativity (Harley 2001, Monmonier 1996, Scott 1998). These issues appear throughout this history of wildfires in Southern California, particularly in relationship to the meaning of the boundaries drawn. The contentious debates regarding the meaning of the lines draw on

these fire maps as well as the cultural and political lines in practice reveal power struggles, struggles to manage order, liability, and responsibility. The struggles are also about how far over a given line a specific power can travel before it starts to infringe on another group's rights. As importantly, the debates over the lines drawn often were renegotiations of priorities and fighting styles, of what and who is included and excluded.

But drawing fire maps to alleviate problems in communication and collaboration did more than just reveal the struggles over power. They also made visible the debates between local versus standardized knowledge, the complex relationship to witnessing between proximity and distance, the authority granted by engaging through a technology or face-to-face, and the relationship between expectations and what unfolds. The incorporation of remote sensing and GIS technologies did add more and more models into the practice of knowing, and distanced witnessing from the citizens on the ground (Masco 2006, Shapin and Schaffer 1985). But these practices do not remove the local communities from the knowledge production process. In fact, the public kept sneaking back in every time they were classified out. It is precisely this distancing that created the need for increased public involvement and local knowledge. Greater public involvement also came with the shift to a preparedness framework.

Perhaps a shift in communication ideology is needed. In their analysis of the role of the public in communication practices during the Southern California wildfires of 2003, Gillette et al. (2007) write,

> "In the past, public information officers have been instructed on how to control the flow of information in a manner that benefits the organization

> responsible for wildfire suppression. In an open system, it is not possible to control the information, only contribute to its content" (para. 41).

But this neither implies a complete loss of control nor a completely democratic process. Someone has to decide what gets published and how it can spread. But those who get to make those decisions become part of a broader group who can influence how the lines around the information get drawn, which then can become more inclusive.

This tension between the local and the standard is not one that can be erased nor should it be avoided (Bowker and Star 2000). But in this history of wildfire information gathering and sharing, the tensions are never fully managed nor are the relationships fully stable. The GIS maps became, instead of boundary objects, moments where one system of classification was tested to see if it defined a form of success against the wildfires in way that produced a standard of knowledge production that was acceptable to those in the path of the flames. The 2007 wildfires ignite at this moment of when the bounds of mapmaking as communication, collaboration, and classification practices were being explored, experimented with, and appraised.

CHAPTER 2
Different Mapping Practices and the Production of Authority, Uncertainty, and Risk

Introduction

When the 2007 wildfires ignited in Southern California, San Diego was facing a crisis in disaster communication: in what format and via what technology should information be gathered and shared between first responder agencies and with the public. After the 2003 wildfires, fires of similar scale, magnitude, and geographical context to the 2007 fires, maps emerged as a solution. Maps could incorporate both GPS data from firefighters on the ground and satellite data from the air. Maps were sharable over digital networks or as paper printouts and could condense large amounts of information into a single picture, making them an ideal tool through which to encourage a shared picture of the situation or express the complexity of the moment. But maps, as a format, do not tell a mapmaker, data gatherer, or decision maker how to make them, what should be included in them, or how to turn image into spatial awareness. As a result, multiple different maps appeared on the scene. No two sets of maps looked the same; each offered their own version of the situation. That is, on the maps made by different groups, no fires had the same boundaries, no infrastructural elements and details included were the same, even the regions covered varied between the maps.

This chapter considers two attempts to make sense and share information about the 2007 wildfires through mapping. Specifically, I examine the production of maps created by San Diego County's Emergency Operations Center (EOC) and a Google My Map created by an ad-hoc group started by a public media outlet, KPBS, and San Diego State University (SDSU). This chapter asks: how did the different practices of mapping

these wildfires produce different spaces of disaster? What was at stake epistemically and politically in the various mapping strategies employed? I look at how producing these two maps shaped how the wildfires could be understood. I am interested in how what goes into making these maps has the power to delimit and define what is at risk, especially if there are different practices going on at the same time. I am most interested in the how socio-technical practices like our interactions with cartographies, satellite platforms, connectivity infrastructures, and scientific models of the environment are intertwined with how disasters come to be known, imagined, and acted upon. I argue that these different ways of disaster mapping had consequences for how priorities in planning and response were determined, what qualified as valued information, the authority of formal procedures, and even in what constituted the greatest threat. They also established different time scales for action.

Disasters bring into question previously accepted analytical categories or systems of classification and make it hard to know what to include on a map, let alone how to map a space in crisis. This messiness makes visible how the material pushes back on the social and political and problematizes attempts to make universal claims from single patterns of action. Focusing on these material practices make it possible to examine representations, like maps, that typically naturalize underlying cultural and historical relationships as if single, stable, shared, and a-priori (Harley 1989, Monmonier 1996). These material practices are integral to the production of knowledge (Lynch 1991, Alač 2008) and social organization (Suchman 2007).

In order to get at these material practices, I draw on a combination of interviews, ethnographic observations, scientific studies, and government reports. Because of the

volatile nature of disaster necessitated much to be impromptu and largely undocumented. I approximate these tacit and interactive elements of map production through interviews of actors involved with the maps, observation of their present day practices, and textual analysis of related documents. While these only approximations of the past practices, static snapshots of a dynamic practice, in order to piece together how the maps were made I focus on how technologies were engaged with, data was gathered, information deemed necessary, social networks and political infrastructures relied upon, and the maps used.

Data on the County mapping practices came from interviews and discussions with the cartographers in charge of the wildfire mapping at the San Diego Emergency Operations Center (EOC) and for the California Department of Forestry and Fire Protection (CALFIRE), field observers who helped map specific fires, geographers at SDSU, and a public information officer for San Diego County who managed the flow of information – including the maps – in and out of the County's EOC during the wildfires. Information as to priorities, procedures, and results was also drawn from textual analysis of government documents, including San Diego County's Geographical Information System (GIS) Standards of Protocol from before and after the fires, after action reports for the state, county, and City, burn area reports about the individual fires, City and County emergency and preparedness plans from before and after the fires, interagency reports on collaboration during and after the fires, the handbook for community wildfire protection plans, and San Diego Regional GIS Council's Meeting minutes.

Data on the ad-hoc group's mapping practice came from interviews with an editor, web designers, and web producer from KPBS in charge of the map and website, a Google employee who came down to help with the mapping, as well as the geographers from SDSU who also helped with this map.[1] The information about the ad-hoc groups mapping practices relies primarily on interviews, e-mails, and news reports about the map from the weeks around the disaster, since the group did not exist prior to the incident and thus had no specific plans written in advance.[2] The actors have since dispersed, so no after action reports or analyses were produced by the actors.

To contextualize both of these sets of data, I reconstruct ways of knowing wildfires in 2007, social and environmental values, and general inter-agency socio-technological interactions. To do so, I examined trends in scientific publications on the effectiveness of remote sensing and GIS for wildfire mapping and on the role of different data sources in knowing the ecology of Southern California and in wildfire response. I examined at plans for and reports on community preparedness for expectations of responsibility. To inform how all of this data fit together into active practices, I observed Incident Command Post meetings of the first responders who use the maps, participated in disaster drills at the County EOC and the SDSU visualization lab to better understand the flow of information in the government and community response, attended meetings of Volunteer Organizations Active in Disasters (VOAD), and toured GIS trailers like those that were on the front lines of the firefighting.

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[1] Some, though not all, of the geographers at SDSU helped provide data for both sets of maps.
[2] Two interviewees were willing to share some of their e-mail conversations from during the fires. However, though I could use these to inform my understanding, the information was provided with the caveat that the details had to remain confidential.

To begin my analysis, I discuss how mapping is a material practice that stabilizes specific conceptions of space, and how a space in flux, like that of a disaster, challenges this practice. I then analyze how, as necessitated by the wildfires, the two groups developed unique wildfire mapping practices, including techniques for gathering data, negotiating and representing boundaries, and accounting for constant change. Lastly, I explore how the two practices assembled different spatial elements to produce different values, priorities, and expectations and discuss the implications for response, risk, and how the wildfires gain meaning.

Mapping a Wildfire

Mapping a wildfire involves assembling diverse information, from local geography to the specifics of the emergency. Among this information are physical descriptions such as fire perimeter, active burn areas, and regions potentially in the path of the flames and smoke. It includes social information, like evacuated zones, locations of shelters, aid distribution centers, and road blockages. It includes political information, like jurisdictional boundaries or regions of responsibility. The objects on the map can include the status of the objects mapped (like whether a shelter is opened or full or if a burn zone is active) or focus on physical location (like marking the expanse of a fire perimeter that is near a dense suburb or crosses a tribal boundary). Once in map form, this information is used by a range of people, from the public trying to understand their relationship to the smoke in the air or the smoke they see off in the distance to the emergency managers and first responders trying to decide what they need to do next to protect the affected land, property, and people. However, which of these things gets

included in a map is neither obvious nor consistent, and the final products have implications for how the disaster is defined and acted upon.

Consider, for instance, how the fire perimeter for one of the fires, dubbed the Harris Fire, was drawn as it burnt through a less populated area to cross the San Diego County border into Mexico. The County maps showed the fire perimeter ending with a straight line along the border, ending the space of the disaster at the edge of the County's responsibility to protect, excluding a section of the people affected by the flames and smoke. The ad-hoc map traced the perimeter into Mexico presenting a fire disaster that maintained continuity in where the fire went and who it affected rather than whose land it was on or who had responsibility to fight it. By contrast, the County limited the perimeter on its maps because to represent more required the exchange of data over an international border, jumping multiple levels of jurisdiction and transforming the wildfires into a federal issue, changing the entire practice of response. Meanwhile, the ad-hoc group declared the straight line at the bottom of the County map artificial. In order to draw a fire perimeter that went over the border, the group worked with academic institutions that had access to the same satellite data as the County but were not bound by political limits. For them, it was a technological challenge grounded in social networking. These two ways of mapping the fire at the border place in juxtaposition the hierarchy of action (who is responsible) with the lived experience of the fires (who is affected). One suggests a priority of government response and protection of the region, whereas the other a priority of public understanding enabling residents to take their own actions.

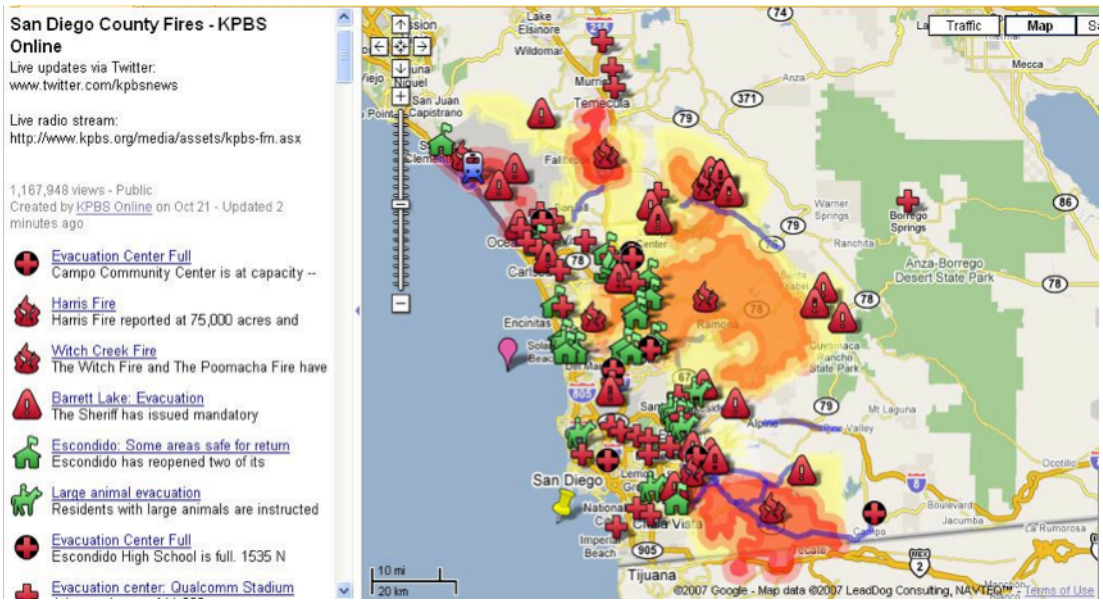

Figure 2.1. Screenshot of the ad-hoc group's Google My Map, day four of the wildfires. Source: Author.

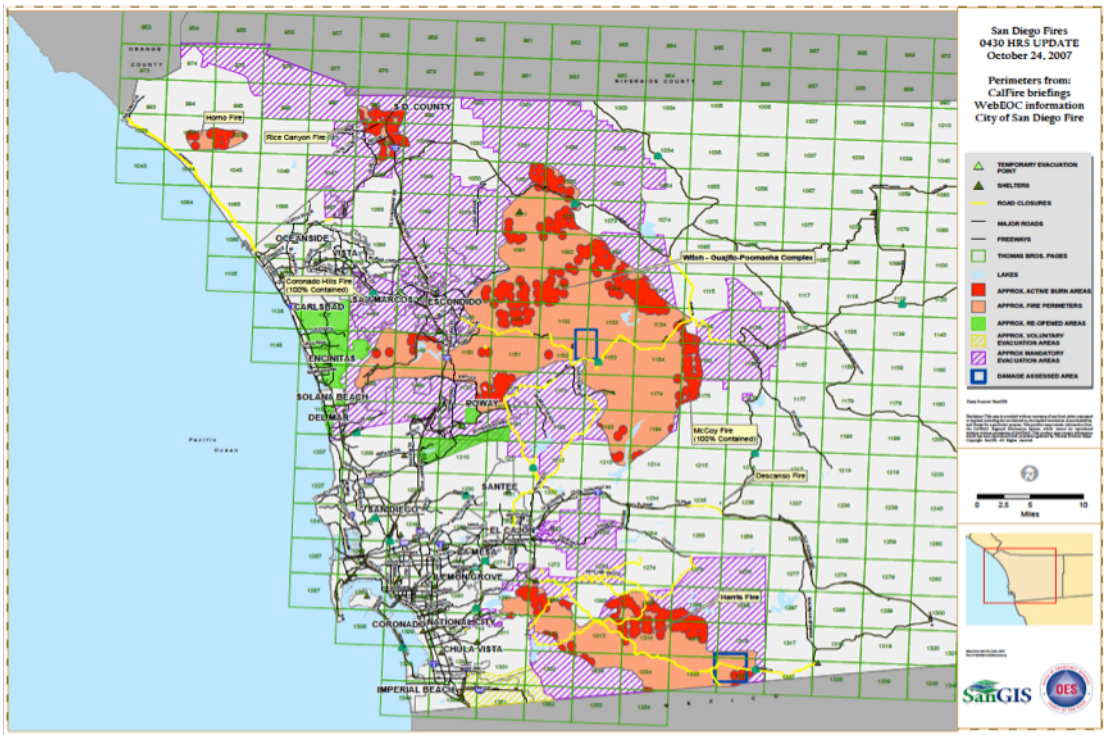

Figure 2.2. San Diego EOC PDF map of the wildfires, day three of the wildfires. Source: SanGIS.

While representational choices grounded in social interests and personal beliefs inform what gets included on a map and influence causal explanations (Koch 2011, Monmonier 1997), how a map produces the represented space is not determined by a map's technology, the physical world, nor the map-maker alone. Rather, technologies and their users co-produce each other, materially and in practice (Pinch and Bijker 1984, Woolgar 1991). As Latour (1999) writes, 'knowing the world and the knowing world are always performed in concert with each other' (30). Moreover, these practices are multiple, grounded in collective histories and future imaginaries, and are mutually constructed along with the artifacts and objects of those practices (Suchman 2000). As Sarah Whatmore (2002) argues, the question 'who has a say' ignores vital elements of the spatial practice, namely: how that say comes to be and how it gets turned into something that can be represented.

Practices that both make and make sense of visual representations are situated in histories and socio-technical networks. They are bound to assemblages of technologies, bodies, and everyday practices (Alač 2008, Lynch 1994). The form and intensity a disaster will take and how it will be visually represented are shaped in some measure by how and where we build houses, who lives in those neighborhoods, communication infrastructures, data gathering technologies, as well as the underlying geology (Davis 1999, Wood and Fels 2009). The distribution of responsibility, what is deemed proper aid and recovery, and who's voice will be given the authority to speak are influenced by assumptions of what is at stake, preferences for types of data, mapping software used, the direction of a given satellite, and the physical landscape (Fortun 2001, Klinenberg 2002, Barrios 2011). The introduction of new representational forms and practices,

especially when normal patterns of action are under duress, has the potential to destabilize existing relationships and shift power relations.

As such, disasters make visible the complex and dynamic relationship between technoscience, expertise, personal experience, and institutions in the production of knowledge and risk (Knowles 2011, Frickel and Vincent 2011, Fortun 2001). Frickel (2008) argues that how these relationships are deployed creates what he calls 'knowledge gaps', gaps that often lead to uneven spreads of risk and resources. Beck (1992), as he discusses new forms of risk, suggests that in these moments society seeks ways to distinguish the bad. For Beck, this is no longer a purely technoscientific project or a project of the state, but one that has to manage both the private individual as a new dimension of the political and the multiple forms of competing knowledge at play.

These issues came to the fore during the wildfires. For instance, this meant managing County responsibility, local community protection plans, and the insistence on personal defensible space. Each of these held wildfire risk within different scales, temporalities, and bounds. The fires hit a location where all these elements clash – the wildland-urban interface. As the flames affected this land, government, private, individual, public, natural all hybridize into the risk being faced. But it is not clear what shape that risk really takes.

As maps become common tools to aid in the communication process during disasters, they also become ways to locate these bads – these risks – and as ways to try to align and demonstrate these multiple ways of knowing. However what gets included in a wildfire map is neither obvious nor consistent. This is especially the case when the

mapping takes place under extreme pressure and when the technology used in making the maps cannot keep up with the constantly changing burning space.

This chapter considers how our engagements with the material world--be it the burning flames or the satellite capabilities--push back on political and cultural forces to help shape how we ascribe meaning to a disaster. Artifacts and systems of engagement are inseparable; one cannot isolate an object from the practices that produce it. Even in situations where norms and common sense appear to be pushed aside by forces outside of our control, like wildfires burning in unprecedented manners, knowledge production is situated (Easthope and Mort 2014). The material and political objects of a disaster are multiple and emerge during the disaster, not prior to it (Tironi 2014). With this in mind, this chapter examines how the practices of mapping relate to the production of knowledge and authority to help explain how wildfires become disasters with specific shapes for which society needs to plan and respond. By looking at map making as form of situated knowledge production grounded in material practices rather just looking at maps as artifacts or analytical tools, I look to how these practices produce specific ways of understanding disaster and politics of action.

Drawing the San Diego County's Fire Maps

When the wildfires began in October 2007, San Diego County had just finalized its disaster GIS standards of protocol, but it had never been implemented, tested, or communicated with other agencies (County of San Diego Office of Emergency Services 2007). Learning from their successes during the 2003 wildfires the County wrote plans to include GIS as part of the wildfire response to enable a visual common operating

pictures (COP), situational awareness, as well as more efficient sharing of information to and from and workers in the field (County of San Diego Office of Emergency Services 2007, 2004). COPs are shared representation of all that is important in a disaster that is used by all actors responding to the disaster to coordinate their actions and were a common practice in disaster response.[3] But having them in visual form was relatively new and enabled by the increasingly common use of GIS for data storage and analysis by government agencies in San Diego.[4] While GIS has been used for decades by the various agencies in the County, there had not been any standards for data sharing beyond the common data layers produced by SanGIS (Hardwick 2007). One major aim of the protocol beyond encouraging collaboration and shared information was to have the County act as the central mapping source, disseminating information out from there to other agencies, including state and City entities (County of San Diego Geographic Information Systems 2008).

These maps were drawn such that they could be used to balance an understanding of a fire's current and potential threats, as aids to risk analysis, cost, and efficiency in response, and as tools for interagency communication (National Interagency Fire Center 2007). The County produced maps of the fires every six to twelve hours as part of their internal decision-making and for use by first responders in the field. Drawn in ArcGIS, the mapping software encouraged data integration but required specialized training. Because of the necessary skillsets, they were drawn by a

[3] Despite its name, different institutions or networks of actors can each have their own COP.
[4] According to a survey taken in 2006 by the San Diego Regional GIS Council, ArcGIS was the only common software system/platform used by all County agencies, other than Microsoft Windows (Hardwick 2007).

team of 4 or 5 that worked 12 hours shifts throughout the entire week of the fires. Every time the County updated their data they produced a distinct map, which often included new stylistic features because of changing representational needs. However, the maps were consistently drawn to be comparable to each other and to regularly maintained maps, such as regional burn histories, population densities, and wind patterns.[5] The maps were released to the media after they were transformed into pdfs and only after the necessary decisions were made using them, sometimes 24 hours after they were produced (County of San Diego Geographic Information Systems 2008, County of San Diego Office of Emergency Services 2007). While not initially released to the public, versions of the pdf maps of the flames were placed online for public access partway through the week. As these maps were made, they constructed a disaster that was unfolding at the edges of jurisdictional boundaries, along the lines of hierarchical structures, and tied to prior ways of engaging with the space of San Diego.

The data they used was maintained by a variety of agencies through the County, in a variety of forms, and updated at different points in time. Some of it was gathered prior to any incident as part of an individual agency's regular overview. For instance, Caltrans already had maps of the County roads, SanGIS maintained map layers of the jurisdictional boundaries and property plots, California Energy Commission had locations of their power lines, and the San Diego Red Cross had address lists for their potential shelters. This data was gathered with the foresight that it might be useful at

[5] For example, knowing the fuel history -- where a region had burnt in previous fires -- helped fire fighters guess where the 2007 fires would burn. If an area had recently burnt, even if it was in the middle of a larger 2007 fire perimeter, it would likely be left unscorched (Wildland Fire Lessons Learned Center 2007).

some point in the future, often from a lesson learned in a previous disaster. Some of the information was produced automatically during the incident itself. The Reverse 9-1-1 calls were documented, providing lists of addresses that were evacuated and weather and wind automatically came from the National Weather Service. However, there was some information that could only be gathered once the incident had begun, from GPS on foot and helicopter, paper and pencil on the ground, radio communication, aerial photography, and Landsat and MODIS satellites in the air.[6] This information required an understanding of the San Diego terrain, fire behavior, response needs, and community emergency plans.

This part of what got included in the map was dependent upon the situation, including the topography that was burning, the communities threatened, the groups responding, and the cartographers' social networks. Consequently, the County mapmakers harnessed a variety of data gathering techniques and technologies to accomplish their task. During the first day of the fires, their maps consisted of fire perimeters overlaying basic infrastructure – the minimal needed to help first responders identify threats – primarily drawing on data gathered by teams fighting the fires. Though detailed, this data was limited to the regions visited by the firefighters and was only received by the mapmakers every twelve hours.[7] To help extrapolate between points, the mapmakers listened to fire radio for landmarks to pinpoint and drove around the burn area to get information firsthand.

As the fires progressed, the maps accounted for an increasing number of features

[6] Assuming these will be explained in chapter 1. If not, add explanation here.
[7] At the change of firefighting shifts.

to help contain the flames and to coordinate the larger response and manage the displaced public. Much of what was included was requested by the workers in the County Emergency Office who were often liaisons to external agencies or organizations involved in the response.[8] In some cases, this involved overlaying already existing maps, such as jurisdictional boundaries for national forest service areas and Indian reservations. Other elements came verbally from the EOC, like locations for local assistance and road closures, and were added as the job of the responders changed from fighting the fires to managing a continually displaced public.[9] The mapmakers also refined the fire perimeters to better reflect the nuances of the situation. To do so, they incorporated eyewitness reports and GPS data about offensive lines created to limit where the fire went as well as burn area flyovers. But these sources were inconsistent and routes were limited by wind, smoke, and debris. After about two days, the mapmakers incorporated data derived from satellites and thermal photography. This data, though less detailed and always delayed compared to the movement of the fires, was consistent and offered expansive snapshots of the situation.

County: Balancing Precision and Accuracy to Manage Uncertainty

As the County worked on their maps, limiting uncertainty in their data stood at the center of many of the decisions they made about what to include. But reconciling all these data forms was not an easy task, and often involved mapmakers interpreting

[8] Among these people, though, were no tribal representatives; they did not have a seat in the EOC.

[9] This became increasingly important as multiple shelters wound up in the line of the flames requiring the already evacuated to either shelter in place with fire around them or to pick up and move.

through their culture of map use. The data sources varied in resolution, scale, subjectivity, and spread – features that had to be resolved in order to create a continuous polygon representing a fire perimeter, let alone a whole map of a disaster. For example, data gathered from remote sensing technology were valuable at large spatial and temporal scales but could not take into account high variability and fine scales. Data gathered from the field observers were fine-grained cross-sections but limited in scope (Hudak et al. 2007). These two scales could not characterize each other and required specific working knowledge of both data gathering and interpreting techniques in order to be combined (Chuvieco et al. 2007).

Moreover, some of the data contradicted each other and forced the mapmakers to choose between sources. For instance, a fire mapper noted:

> I knew where the origin was. I also know that the purple part of this map is wrong. Here's another thing: never believe these [points to fire perimeter]. I'm telling you not to believe mine. I just did a project in a GIS class looking at the origins of fires. So I got all the data, I started looking at it. Well that fire didn't start there [points to origin on map]. That fire didn't start there [points to another]. But I mean some of them are like, okay, there the fire started because the helicopter hit a power line. Well, you can argue all you want but it's got to be on the power line somewhere. So at any rate, this fire never moved ten feet in the easterly direction from when it started (Field Fire Mapper 2012).

The official fire propagation map derived from satellite data depicted the fire moving east, but he knew better. While thermal satellite data provided a wide-sweeping view and provided distinct lines between temperatures, even if the lines were a bit wide a fuzzy, what these lines meant was not always certain. The boundary between what was hot and not offer clear notions of what had *not* been affected. But what happened within the heat signature could be many different things: flames, ashes, smoke. Declaring what

had been affected often required the mapmakers to look beyond the distinction between the colors, comparing what they saw on the paper with what they knew from their experiences in the field.

This same type of mapping logic was used when it came to demarcating the fire and the U.S.- Mexico border. Describing how he mapped the Harris Fire, the field mapmaker said:

> I was at the origin so I knew where that was. So I'd take my little GPS out, push the button and then as I drive down here, push the button. Come down in here someplace, push the button and I could look up there and say okay, I know where that mountain top is. And the border is obviously a…Actually that line turned out to be…most of the time the border is really a boundary since nothing is below the line. It's all white just like this map is (Field Fire Mapper 2012).

To inform his interpretation resolve the dilemmas, he depended on what he saw with his own eyes and what he knew from prior similar situations (such as other fires at the border). General extrapolations from personal experience were often more accurate than the precise lines from thermal imagery.

Some information arrived in ways difficult to map as a result of the translations required for it to be shared. For instance, responders in the field relied on visual references, but they had to deliver that information over the phone, verbally. Confusion was a common result, especially when those words were trying to describe bounding boxes on the map, but in shorthand.

> When the incident command post would call for an evacuation, sometimes they would say, we need to evacuate north of Del Dios Highway and south of this and east of this. And, the mapmakers would look at the map and Del Dios Highway would look like a snake. It'd go south and north and west and east and it just…What do you mean north of this highway? Because it's all over the map (County PIO 2011).

The mapmakers struggled to turn the words into shapes. The directional data designed to orient the mapmaker had no shared meaning without some point of reference off the map. But because they were co-located with their audience, the mappers had a unique way of managing this confusion. They were able to take away the technological and data barriers to help get to the root of some communication problems. This often involved printing out drafts of the maps or grabbing preprinted ones and walking over to the people who were providing information that did not make sense.

> Because the, you know the text and the verbiage that was coming in wasn't anything that we could actually physically map. So we'd give them, we went and bought a whole bunch of Thomas Brothers guides and we're like freaking draw us what you're talking about because what you're saying isn't making sense. And then they started realizing well it goes, oh you're right. Like that doesn't make a box. And we're like okay, okay, okay, you know go talk to your deputies, figure all of this out (GIS specialist at County 1 2011).

However resolvable, the mapmakers often had to delay plotting the data until they confirmed specific spatial interpretations and visual relationships.

Not only were the data potentially contradictory and difficult to translate spatially, they often arrived in irreconcilable forms. Despite the pervasiveness of ArcGIS, five other, grandfathered-in, real-time mapping platforms were still used by various agencies involved in the response (Holt 2008). For example:

> The one thing now that is a limitation is that there is, well, currently in San Diego anyway, there's no way to get the map that I drew in, say, reverse 911 to show up as a layer in GIS. Whether that's through some kind of service or downloaded as a GIS layer or feature class or whatever, there's no way to get that one database to talk to the other database (County PIO 2011).

Running all of this data through GIS encouraged cooperation between agencies, but it put together mappers who were not all trained in the same information gathering

systems and who relied on different terminologies and analytical criteria regarding situational awareness and damage assessment (County of San Diego 2007). Compiling data from these platforms was difficult. Mapmakers either redrew the data from one map onto another or printed out the maps to compare side-by-side. Moreover, they had to decide if redrawing the data was more valuable than the time the task took.

The County also had to manage precision and accuracy in data in how the data was presented to their varied users. For example, they changed the way they drew the fire perimeters because their audience was working with incorrect assumptions (everything red = burnt). To compensate for these types of misinterpretations and facilitate map use and communication, the County mapmakers decided to include more detail and to get more precise in their representations. Over time they made a variety of modifications trying to balance their users' interpretations and the presentation of accurate burns, including adding shading, hot spots, and outlining the perimeters rather than filling them in (Figure 2.3). They also added the gridlines from the Thomas Brothers brand of paper maps. Adding this design feature that represented something separate from how the disaster was unfolding on the ground increased the value of the maps for the first responders and field observers because they used this brand of map to determine regions of responsibility.[10] These details increased the usefulness of the maps to help determine which jurisdiction was facing the majority threat and should be put in charge of the unified command.

[10] This sentiment of increased value was reiterated by multiple reports (The San Diego Foundation 2008, Wildland Fire Lessons Learned Center 2007). In addition, the news media saw this value and took advantage of these gridlines in their own reporting.

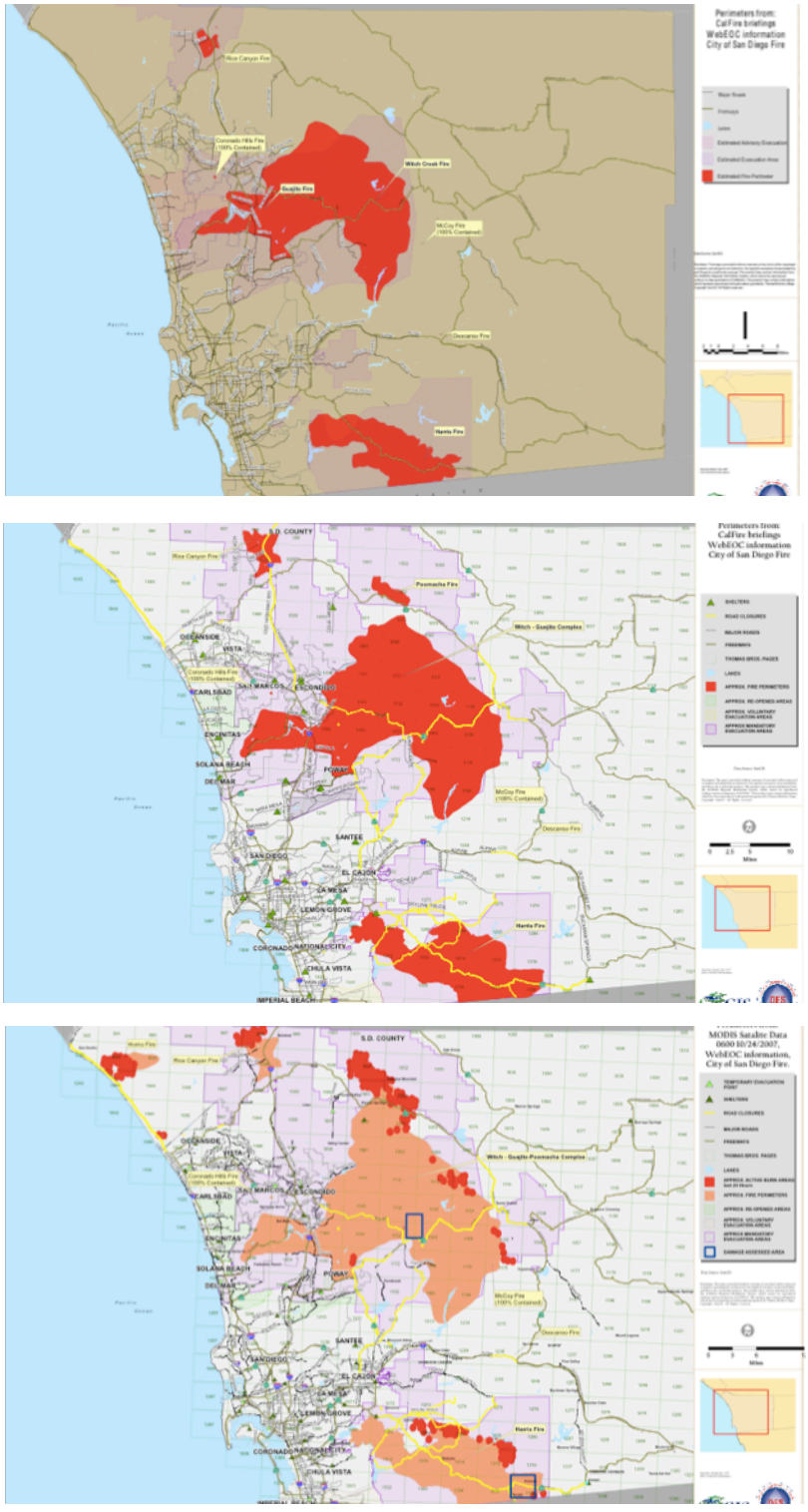

Figure 2.3. Progression of the County maps, showing the shifts in perimeter style, details, coloring, and shading that occurred. These maps cover a 36-hour period. Source: SanGIS.

The County mapmakers faced so many requests to put information on their maps that they risked making the maps illegible. They had to negotiate assumptions about map users while trying to dictate what makes a good map. But in doing so, they probably learned as much about mapmaking as they were trying to teach their users about map reading.

> We learned a lot in how to color a map properly for everybody. So we first started with a tan background. Then somebody came and they said "hey when I display your map on my big screen it doesn't look good…And I said excuse me? I think you should change the background color. I got slightly upset and then realized, all right, whatever. So we turned it to gray in the background. Then we realized that having the fires colored in wasn't good because people couldn't see what was behind the fire perimeter. So we turned it to that outline. We thought everything was good to go, and then afterwards we found that if you're color blind you can't see the difference between green and purple. And I felt really bad. So now we know and so next time we will not use green and purple to do the, but in reality it was the only colors left that weren't on the map yet. You know what I'm saying? Like we had used red, we had used yellow (GIS specialist at County 2 2011).

They had been adding colors as they went, choosing a new color with each new feature. In traditional mapmaking, colors were arbitrary yet balanced–each object has a color from a different section of the color wheel than its neighbor so they can be easily distinguished. Since much of their audience was not fully planned in advance, they did not account for a few color blind people involved in the planning and did not know that the colors they picked had to look good on a projection screen. To change one color meant they had to change all the colors, in effect changing the entire system of representation and asking users to once again learn to read the maps.

There were moments, however, when features were removed from the maps. This was especially the case when the maps were released to the public. Because this

release was not a part of the initial plans, discussions had to happen mid-disaster to consider the implications of that act.

> And so the director had a brief discussion with the policy group and they said yeah sure, release it, I mean this isn't secret information…we wouldn't be putting out where the hazardous materials are, we wouldn't be putting out where critical infrastructure was. We were just putting out: okay here's the area that's evacuated, here's where the fire is that we know about, here's your shelter locations. Here is, you know, the stuff the public needs to know (GIS specialist at County 1 2011).

While not secret, doing so was not politically popular with all responders.

> And there's a hesitancy on the part, the fire guys have always kept these things close to their vest (Field Fire Mapper 2012).

Many of the people gathering the data wanted to hold it close as a buffer for the sake of public liability. So, the County predetermined what qualified as essential public information. This helped them avoid revealing information that would place the County in a position of liability, for example, making it harder for the public to question the County's priorities in response. This also helped control public behavior, discouraging personal interpretations that might contradict evacuation orders.

Transposing data onto the map in ways that reduced uncertainty was more than a technological act. It required the mapmakers to negotiate the relative values of accuracy, details, and timeliness. However, what the priorities were for each of these categories remained open for interpretation.

> Q: So the people who are determining priority do they have a set of rules by which they determine those priorities?
>
> A: No, not really because it didn't really require one. It kind of became obvious after a while. It was amazing that, that in order to teach somebody that position we thought we had to go through you know, create priorities and this is what you're looking for. And if you see this let somebody know. And it turned out not to be the case. It was very

> apparent when things were important that came through, that basically we just instructed them if you see something unique and new let us know. And that was kind of the, the one rule that they had. So it was very simple and really worked (County PIO 2011).

Determining what became visible ended up being about what was different, new, novel, and instinctual. This process relied on common sense grounded in a specific culture of community engagement, one that was neither written down nor repeatable. But this reliance upon instinct had its problems for the mappers. How an actor thought about a specific region on the map or even how they talked about the area would affect what was expected from a map. For example, when someone said City of San Diego, a user could think of downtown San Diego, La Jolla (which is fifteen miles north of downtown), or Rancho Bernardo (which is thirty miles away from downtown). If each actor had to place a pushpin onto the center of 'San Diego' they would put them in different locations and would make sense of the relationships presented differently.

To reduce uncertainty and encourage shared meaning, the mapmakers had to address experiential understandings. The GIS specialists spent almost as much time mitigating map use patterns as they did figuring out how to make the maps. In one exchange, a GIS specialist noted:

> Not just, well not just the scale but that number. So the entire San Diego isn't 70 miles away, the entire San Diego isn't 20 miles away so we've had to do a lot of explaining to emergency managers, and public safety about how the maps work and how you can properly read the maps and how you can properly use them (GIS specialist at County 1 2011).

Potential variation in understanding was not limited to the public or government officials. Even the mapping specialists from different spatial disciplines had different cultures of reading mapped data. This became apparent when the County mapmakers

tried to map wind direction:

> And they go: the wind is at 70 degrees. So we put the little arrow pointing to 70 degrees and someone comes by, that's totally not right. And so we had to flip it and we were like well, why didn't someone mention like that to us? No one thought to mention that (GIS specialist at County 2 2011).

Wind is named by the direction it comes from, not the direction it is going to. Making sure wind was mapped and interpreted in a consistent manner was very important to any agreed upon analysis of the significance of the fire perimeters, hot spots, and fire movement for decision-making or priority setting in the response.

For the County, uncertainty emerged from how the data were interpreted in order to be drawn by both them and their audiences. Managing uncertainty was necessary in order to maintain an authoritative and valued position for those that engaged with these maps. In how they mapped, the County declared flexibility in interpretation an impediment to sustained socio-technological connections and social organization. They tried to reduce this uncertainty by relying on their culture of map use. They continually modified and included more features on their fire maps to make them valuable across socio-political lines prominent in non-disaster times, increasing the maps' authority as firefighting tools. They removed features to maintain a specific social order. In the end, putting a variety of actors on the same page was more important than establishing consistency in data representation. In doing so, they defined a type of risk that existed in relation to uncertainty in mapping practices rather than lived experience in face of the flames.

County: Drawing Lines While Crossing Boundaries

The County wildfire maps were turning into a means by which to align actions in the space of the wildfires. But in addition to the data, as the County tried to map the movement of the fires over land in a way that enabled a shared understanding of the unfolding disaster, the jurisdictional boundaries pushed back. San Diego had no centralized fire department; each City had its own, eighteen in total. In addition, the County is divided by state forests and bureau of land management regions (state responsibility), national parks (federal responsibility), and Indian reservations (sovereign responsibility). It is bordered to the north by military bases and to the south by Mexico (Figure 2.4). Where each fire fell in relation to these lines changed who fought it and managed the information about it, a determination that was difficult, variable, and often entailed careful negotiations (California Department of Forestry and Fire Protection, United States Forest Service, and The Governor's Office of Emergency Services 2008).

This complexity was exemplified when two fires, the larger Witch fire and smaller Poomacha fire, merged over wildland and urban spaces:

> Fire mapper: It's burning in the forest it will be a forest service fire. It's burning down in private lands which is the state responsibility. Poomacha wound up being a fed team. The Witch Fire was 50/50…started out as a fed team and then it became a state team and then they split in half with another fed team.
>
> Q: How'd that work?
>
> Fire mapper: Terrible, but…
>
> Q: But how'd it go from federal back down to state?
>
> Fire mapper: Well, it's not down.

> Q: Oh?
>
> Fire mapper: They're equal or at least the state thinks they're equal. But it depends on who owns the land. So the Witch Fire started and it was mostly burning Forest Service when it started, and then when it started burning mostly private lands it got into Rancho Santa Fe and down into Escondido and all that, then it became a state. The whole east end of it was a fed team, the west end of it was a state team (Field Fire Mapper 2012).

In the end, the merged fire included three different authorities, with six teams total: state (California Department of Forestry and Fire Protection), federal (United States Forest Service), and regional (Heartland Fire Zone).[11] Also involved were the California

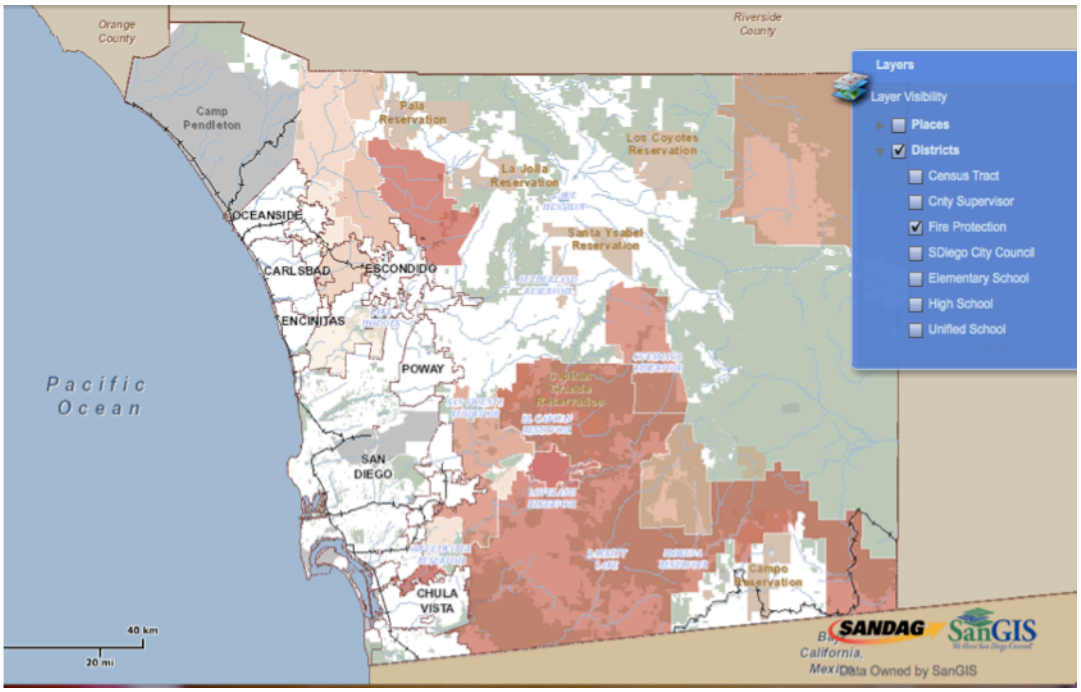

Figure 2.4. Fire protection jurisdictions in San Diego County. Source: SanGIS.

[11] Teams were coordinated under a unified command created for each fire, physically based at an incident command post, situated along an edge of the burn area and headed by a fire chief or police commander. For each fire there was staff in charge of operations, logistics, plans, and intelligence, and in some cases a mapmaker trained in GIS. Twice a day, with the shift change in response teams, the ICPs held debriefings that relied on maps based on field data. Those maps were then sent to the County Emergency Operation Center for their response planning (California Department of Forestry and Fire Protection, United States Forest Service, and The Governor's Office of Emergency Services 2008).

Highway Patrol, San Diego County Sheriff, San Diego Red Cross, Animal Control, San Diego Police Department, Escondido Police Department, San Diego Gas & Electric, Bureau of Indian Affairs, Bureau of Land Management, Department of Corrections and Rehabilitation, and various local fire agencies (California Department of Forestry and Fire Protection 2007). The work of negotiating responsibility placed different levels of responsibility as equals and juxtaposed different styles of firefighting, each with their own priorities and interests to protect. The authorities, though, often worked in isolation. Red Cross workers, often put in the middle as they supported the needs of the groups involved, described such experiences like this:

> In many cases -- I've seen quite a few recently -- they say they are a unified command but PD [police department], Fire, and Sheriff don't actually talk to each other (Red Cross Worker 1 2012).

> Incident commanders' view of the disaster is like this [makes blinders around his eyes with this hands]. They might not even know what is going on around them (Red Cross Worker 2 2013).

The various authorities either had no time or interest in coordinating outside their immediate responsibility.

To overcome some of these formal limitations and barriers, the mapmakers appealed to their socio-technological networks. As one of the County GIS specialists described:

> Really what happens is I call to get imagery…I know somebody at USGS for the State of California. I know that person. I have their email address. I have their cell phone number. I call them up. I say, hey here's our situation, what imagery do you have available? Is there anything coming out? And that started a whole email chain of all the fires in California at that time and we were getting, what, 20, 30 messages a day (GIS specialist at County 1 2011).

Names in the mapmakers cell phone lists and who they trusted for information were just as important as the protocols and standards for mapping. This was even the case when it came to successfully sharing data that was supposed to be shared according to the protocols. To share the information with the cartographers, the data gatherers had to know how to get around the security on the cartographers servers.

> County GIS Specialist: And we had to put the zip and zap list together because some people had -- like SDSU can't receive zip files. So you had to rename the zip file to a zap file and then they could receive it.
>
> Q: Why can't you receive zip files?
>
> County GIS Specialist: Because IT people are worried about viruses (GIS specialist at County 1 2011).

Unless they told you, in person, to rename the file, your data would not get through. These informal networks were frequently used to fill in the gaps in data accessibility that were created by the formal boundaries. This was especially the case when it came to mapping around the border with Mexico, which was a delicate barrier to manage for the County. The County PIO (2011) stated:

> And that is a very difficult part, because we are two countries meeting at that line. At the local government level we have no right to communicate, talk, work with anybody in Mexico. It has to go through the state department at the federal level, so state department to state department.

He continued:

> We can't even do anything. That's not to say we don't. Because we have relationships. So we, over the years, have shared things, shared equipment, taught classes. For example environmental health, the Hazmat Team, will go and train the firefighters in Mexico and we can communicate. We have duty officers that can communicate kind of off the record, I guess you'd say. But as far as coordinating at an EOC level, or higher government level, it's not allowed until you get to the federal government.

Many informal relationships exist between the border communities, but remain social or technological, neither officially documented nor openly displayed to the public.[12] This informal networking counterbalanced the official classifications and procedures when producing representations of the unfolding disaster.

Landscapes, even natural environments, are culturally constructed ways of engaging with the world, grounded in histories of labor practices, imagined travels, and urban experiences (Cronon 1996, Weaver 1996, Wood and Fels 2009). Consequently, the power to represent and the power to organize are not to be found in the people alone, but in the hybrid formations that tie together society, technology, and nature (Spirn 1996, Gandy 2002). As the mapmakers tried to delimit the disaster in terms of what was represented on the map and who was responsible for taking action, the hybrid nature of the space pushed back.

For the County, mapping the disaster meant creating and maintaining relationships outside of the lines on a map, while simultaneously focusing on drawing those lines accurately. The intricate relationship between the formal and informal required to produce these maps reveals a multiplicity of spaces that push past categories that structured daily life in San Diego. The boundaries to be drawn could not be constrained within a single scale of action. Plotting lines on the maps initiated interactions between different scales of power and response, creating a friction in proper response between local action, cultures of practice, and international relations (Tsing 2005). But to focus on already existing categories of difference – such as U.S. versus

[12] Consequently, it often appears to the public as if the border relations are being neglected and the people living near its edges ignored by the responders. This issue became a popular topic after the 2007 fires.

Mexico, City versus state, or public versus private – reifies preconceived notions of a space (Rose 1993). Instead of looking at economics, politics, and labor relations, these mapmakers had to look to the in-betweens and alternative imaginations of the space in order to map the disaster (Thrift and Amin 2002, Whatmore 2002).

County: Managing Change Over Time

With ArcGIS integrated as a common platform throughout the County's response, compatible maps emerged from the field as they were made instead of individualized hand drawn maps that remained at their sites of origin (County of San Diego Geographic Information Systems 2008).[13] The ability to compare information between maps offered responders an unprecedented level of hazard analysis and fire prediction (County of San Diego Office of Emergency Services 2007). For the disparate and physically scattered groups of actors involved, corresponding maps enabled a shared vision of disaster and the possibility for a shared culture of engagement that previously was not possible through wildfire maps (Goodwin 1995).

But there was a tradeoff. Mapping in GIS, though more networked, required extra time for production. As one of the fire mappers noted when asked if any specific requests were made of him as he mapped:

> Hurry up. And you know I probably would have had it done faster, if I'd have just drawn it on a topo map and printed it. But I wouldn't be able to send it to anyone (Field Fire Mapper 2012).

[13] There were GIS trailers with wireless capabilities that mapmakers drove to the ICPs to map onsite instead of mapping only through indirect communication channels.

It is easier to draw by hand, but drawings on scraps of paper can neither be shared nor easily made into overlays for other information. The delay did not stop there. The pdfs created for disseminating the maps were so large that the internet traffic to download the files crashed the County's servers, adding to the time between what was being mapped and what was on the map (County of San Diego Office of Emergency Services 2007). GIS brought responders closer together in action, but simultaneously created temporal distance between representation and experience.

The County amplified this gap in time by strategically holding back information. For example, they withheld news about a subsiding fire so information about a new evacuation zone would not be overshadowed. Their rationale was one of public safety: they needed the roads clear from people returning home so evacuees could leave. As the County mapmakers maintained the maps in the past, they incorporated into the representations features that showed how they wanted the general public to act at present.

As the County mappers made their maps, they also found that keeping the data current took a backseat to reconciling the various data at hand. The data varied in terms of resolution, spread, and scale, as well as in terms of time. For example when determining how to draw their fire perimeters they gathered data about past burn to know where a fire would likely go, present GPS data being sent from the field, and the location of offensive perimeters being created by the firefighters to limit the fire's future movements. Creating one polygon from all of these meant treating past, present, and future as equal (Figure 2.5). The data gatherers and fire fighters understood this

Figure 2.5. Fire perimeter map drawn for a briefing at an incident command post. The different styles of lines within the perimeter represent if the line is past, present, or future, a distinction that gets erased when put on the County maps. Source: Author.

temporally calculated nature of wildfire mapping. The Field Fire Mapper (2012) said:

> Field Mapper: Everybody knows that.
>
> Q: Everybody knows it?
>
> Field Mapper: What it's really telling you is that you're sitting back here, and you think it's here [points to a spot on the map] and someone walks in with a map that shows it here [points to a different spot], and then it's just useful for predicting where it's going to go.

He then described the use of maps as this:

> First off, it's planning tool…By the time this briefing is held this map is wrong. And in fact it's very wrong probably. And a lot of times they'll go in there and stick the map on the wall and somebody will bring their pen and go, now it's here, now it's here, now it's here. So it's dynamic.

The maps were intended for prediction, not an accurate representation of the disaster; they were relational not merely representational. They included elements of where the fires could be and where they had been. To arrive at the present or an impression of the future, the maps had to be analytically connected to other previously mapped data.[14]

But these features of the maps were far from self-explanatory to someone not familiar with reading maps relationally. According to the County, the media and public treated the maps as literal.

> They would take these and go, oh, okay we're on page whatever and they'd open the Thomas Brothers page, and go it looks like half of this page is burnt. If you're in this half...So our PIOs [public information officers] had to call very quickly and say no, no, that's not what a fire perimeter is. It doesn't mean every single house inside this gigantic polygon that is on a countywide map is burned (GIS specialist at County 1 2011).
>
> The media would zoom in, okay let's look at that street. If you're on that side of the street, you're okay. But if you're on this side of the street,

[14] Including maps of the same fire, structures in the fire's path, historical burns, and weather patterns.

> you're not. We had to call them up and say don't do that. Because it is just kind of a wide line of where we think the fire perimeter is. So there's no zooming. Don't zoom in and don't give people a false sense of security (County PIO 2011).

The maps were being treated the same as a Google map, not how the County intended. When the maps were released to the public, the GIS specialists had to, in their words, include 'a detailed description of what it's saying.'

How these maps were drawn and used demonstrates that time is more than something stamped in the key. For the County, including past and future, not just what was happening at present, was necessary to depict disaster over space. Knowledge of the disaster emerged through associations and expectations in time. Fortun (2001) argues that how time is delimited in the description of given to a disaster shapes its form just as much as tracking its movement over space. Their mapping practice made it possible to plan future action and predict the extent of the disaster, whereas treating a map as stand-alone would have turned it into a description of the present to be challenged for accuracy and detail.

Drawing the Ad-Hoc Fire My Map

One local media news station, KPBS, started a map of its own. It was a single, continually updated, map drawn in Google My Maps. My Maps, new in 2007, was designed for non-cartographers to create simple overlays on top of the already familiar Google map background.[15] It was assembled by an ad-hoc group of actors, including

[15] This was a feature SDSU needed in order to translate their more technical information into a publically accessible form. While some of the data required geographical expertise, the mapping software did not.

some Internet news programmers and geographers, all of whom were learning the platforms capabilities as they went along. Like the County, these mapmakers worked long shifts often only sleeping a couple hours each night as they balanced their regular work with this volunteer work. The constant work was necessary, since My Maps was continuously accessible even while being modified, so users assumed it displayed the most up to date information.[16]

This map emerged in response to the media's difficulty getting information from the County in visual form and in a timely manner. It also emerged when the County was increasingly calling for common training through the federal Incident Command System for all first responders, including cartographers, to create a common language, while simultaneously asking cities in the Wildland-Urban Interface (WUI) to develop individualized wildfire preparedness plans (County of San Diego Office of Emergency Services 2004, Society for American Foresters 2004). These plans asked for communities at risk for wildfires to bring localized knowledge of community values and definitions of risk, and even the boundary for the WUI. They further encouraged each community to develop their own maps for planning purposes. The My Maps platform was thus advantageous for the public concerned with *their* community or *their* house because users were not limited to orienting themselves to the county as a whole; they could center on or zoom in to any point, like their residence, to personalize their perspective and continually track their position as the fires moved around them. Like

[16] Except for a twelve-hour period when the frequency of updates crashed Google's My Map server. But even then, my interviewees from KPBS commented how the public still called in assuming up to date and accurate information.

the plans the communities were encouraged to create, this map was able to be personalized to address local concerns.

Similar to the County maps, this map utilized a wide range of sources. But rather than struggle for compatibility, their network of data coalesced around its variety. KPBS worked with geographers at SDSU to mimic the lines from the County maps, but also to solicit other sources to bring those traced lines more up-to-date. Over the week of the fires, this map became so popular it received over five million hits.[17] Assembling this map produced a disaster unfolding through local experiences, with expectations for those affected to participate in the response, and focused on the immediacy of the moment. While the County maps provided a starting point for this ad-hoc mapping project making this map not a true alternative mapping practice, the production of this ad-hoc map pushed back on the County mapping practice and on its definition of the disaster.

These mapmakers were not bound to the hierarchical rules of the County, so they could take advantage of SDSU's relationships with other academic institutions and federal institutions, like NASA, to access their infrastructures of research satellites, remote sensors, and unmanned airplanes. They also relied on people who were well connected to events on the ground, such as Red Cross volunteers or the affected public, to provide details about evacuations, burnt houses, road closures, and other information pointing to the lived experience of the fires. While the County mapmakers relied on their own experiences to interpret their data, the makers of this ad-hoc fire map

[17] Google provided this estimate to KPBS because the official counter was turned off to accommodate the high volume of traffic.

benefited from interpretation from all sources. All of these sources were used to try to bring the always behind-in-time fire perimeters up-to-date to offer a map of the present situation.

While both the County and ad-hoc map changed over time, how and why they did were based largely on their engagements with the capacities of their technologies and social networks. Since they were using different technologies, the changes were not of the same type, leading to different forms of uncertainty being drawn into and produced by the maps. For the County the uncertainty that emerged was one that juxtaposed precision and accuracy. For the ad-hoc group the uncertainty that emerged was one that juxtaposed government versus the individual.

Ad-Hoc: Managing Uncertainty by Drawing In the Public

The ad-hoc map did not try to bring all the users into a single-sighted action plan. Rather, it took its shape based on its users, technologies, and sources for data. With no plan of action or standards of practice written in advance, with no clear idea of who and what should be involved when and how, the work that went into making this map took its form simultaneously with the map. Instead of politics as the starting point in shaping the form of the map, this map was largely structured around timing and access to technologies.

However flexible, Google My Maps was not the most capable program. The mapmakers struggled with its predefined features intended to simplify cartographic practice, finding these features limited how much and what could be put onto the map, dampening the mapmakers' ability to visually express detailed location and status.

> It was like there's a fire and there's a fire icon so there's a fire icon on the map. But the icon doesn't really tell you where it is; it's just generally in that area (Web Producer 2008).

A dot in the middle of an entire burn area does not provide much information about an evolving fire scene. Moreover, the limited number of icons forced the mapmakers to get creative and write explanation into the map, something abnormal for a traditional map.[18] The limited number of items allowed at any single time caused the map to crash multiple times when the mapmakers tried adding one too many things. On top of that, the system allowed only a single login per personalized map, forcing the crew of mappers to wait turns to upload their information or draw on the map.

In 2007, Google My Maps had practically no compatible data forms, making it difficult to relate it to other representations. Whereas the County relied on the technology to combine data layers, those working in My Maps had to do that layering by hand, repeating much of the work already done. For example:

> We started taking the MODIS imagery, converting it to the GIS format, detecting the perimeter, overlaying it on top of Google, and tracing the perimeter so to update the Google My Maps (Geography Graduate Student at SDSU 2008).

But this took time.

> The problem was that we would work for one or two hours on an image and then while we were in the process of converting it to GIS to publish it to Google Maps maybe another data set, another image came through. And so automatically we had new information but we were still publishing the previous data (GIS student at SDSU 2011).

[18] The software was designed to have pop up layers appear so that the verbal information could be directly connected to each icon, instead of in a separate statement accompanying the map as a whole. A few days in to the fires, they found time to finally develop icons of their own.

While they might receive this data automatically, the work involved in making it compatible often delayed the ability of the mappers to even get to the data, let alone to map it.

At the same time as they were managing the timing of the data, data resolution turned out to be a problem for these mappers. For the Ad-hoc group, dealing with the uncertainty of the satellite images involved balancing the technology with the public lived experience. Whereas the County cartographers could rely on a culture of mapping and map use to develop tools for how to handle data that came in broad strokes about a region rather than specifics about a location, the mappers for the Google fire map had neither the experts in the technology nor in disaster response standing between their map and the users to help explain how to interpret the maps. How the data became lines was not a straightforward process. In my interview with (GIS student at SDSU 2011)

> GIS student: They probably told you that MODIS has one kilometer resolution?
>
> Q: Yes.
>
> GIS student: So you kind of learn how the fire moves and like how to map it because the MODIS data is pixels. So a pixel square is not like a line. So you kind of have to go with your instinct sometimes and that's what we did, but then we overestimated, we over mapped.

What can seem like a clear line on a thermal satellite image could represent the heat flow of the flames rather than the flames themselves. Different materials on the ground have different reflectivity, at different times of day, and with different weather conditions (Kolden and Weisberg 2007).[19] How to interpret the data is not obvious,

[19] For example, if the data were gathered with GPS by foot or helicopter, the cartographer using that data has to account for difficult terrain and unburned islands that the data gatherer was

even if it is already in a visual form and even if you are already used to managing that data on a day-to-day basis. Turning satellite data into a fire perimeter is far from as simple as tracing the edge between two different colors on an image.[20] They had to estimate even more and run the data through increasingly diverse software, increasing the variability within the map (Figure 2.6).

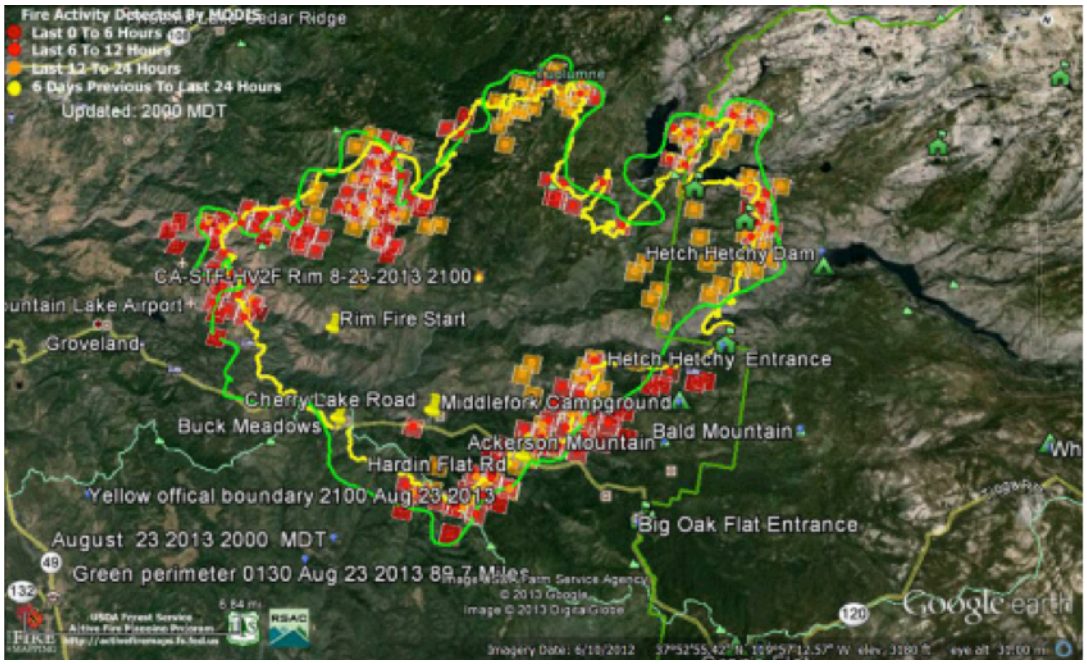

Figure 2.6. A fire perimeter drawn from MODIS satellite data. The lines are drawn by extrapolating from the variation in the pixels. Sournce: CALFIRE.

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unable to get to. If the data is derived from remote sensing, then the cartographers have to account for vegetation, soil, sun angle, weather, dense trees, all of which interact differently depending on the terrain and the satellite used (Kolden and Weisberg 2007).

[20] In discussing this more with GIS student at SDSU (2011), he pointed out the multitude of software needed to make the different types of images work together:

Q: Yes so did all the data, does it come in similar forms like do all satellite data…?

GIS Student: No, different forms. Different projections, different size and way of handling so we used a bunch of different software to, to deliver…

Q: What do you remember?

GIS student: arcGIS, Global Mapper, and ENVI, among others.

Additionally, by only having specialty knowledge in the technology rather than the personal data gathering, they did not have the ability to understand the disconnect(s) between the data gathered by the County and the data from the satellites, making it hard to know how accurate a map would be that combined both (Kolden and Weisberg 2007). Since this ad-hoc group relied on technological networks to get its data, they could not say if a line they were drawing was actively moving or dying down. Any consistency in the process came from who was doing it rather than how it was done or what program was used. The ad-hoc group of mapmakers creatively aligned the data through their practice of mapping, rather than aligning their practice to a specific standard or culture.

To amend their technological interpretations and how the users engaged with the maps, they used data from the public. Because the map was available to the public and connected to a public radio station where the public could call in and offer experiences and observations, this relationship provided a set of single data points that refined, and often corrected, more official sources.

> There was another situation in which we overestimated the fire over a freeway. We started receiving calls from listeners saying the fire had not jumped over the freeway. So at that point we modified the map because that was the most recent information we had from the ground. Our overestimation was also possibly because of the different resolution that we were working with (GIS student at SDSU 2011).
>
> If some guy's calling from his car and we say this is what we heard, we don't know if it's true. I wasn't waiting for some government official to confirm things. We were just working with what was flowing in (Web Developer 2008).
>
> The shelters, we would update it when we would hear that something was full. The official list wouldn't be updated yet, but someone would call up on the radio and say we're full…and it would get updated on the

> map. We got a couple of calls from people saying your map says the shelter in Imperial Valley is taking such and such but we can't take that, and we would have to go and correct it (Online News Editor 2008).

The data from the public complimented other sources in terms of time, location, and condition. In some cases the information was rumors supplied as fact. Despite the risk of repeating incorrect information -- something the County could not ignore for the sake of liability -- this participation provided overall up-to-date information for the ad-hoc fire map.

Rather than train the public to engage with the map in a specific way, these mapmakers incorporated the public into the production of the map as a data source bringing their expectations into the representation. To manage the uncertainty built into the technologies they were using, the ad-hoc mapmakers had to balance government approved accounts and scientific models with public knowledge of the events. In working this way to keep their map current, they incorporated into the maps another type of risk – the risk of just plain being wrong and losing credibility because they mapped a rumor.

This does not necessarily mean this map was any less authoritative or objective; it could even be considered more so than one produced by inflexible rules. Authority is contingent upon the variables within the network of knowledge, not some pre-imposed structure (Wynne 1992). Objectivity also changes depending on the cultural context of knowledge production (Galison and Daston 2007). For example, in some contexts (such as the science laboratory) standardization creates credibility, yet in other contexts (like disaster response) too much standardization can deny important local differences and culture. The success of this ad-hoc fire map, despite all of its limitations and

contradictions, demonstrated the value of locally contingent ways of knowing and doing rather than de-contextualized rules of behavior (Jordan and Lynch 1992, Suchman 2007, 2000). For this scattered network of interaction, variation in practice was necessary for any representational standards to work from one situation to the next.

Ad-Hoc: Mapping Networks Instead of Lines

Unlike the specific roles and protocols, categories, and organization that drove the design of the County maps, those working on the ad-hoc map had neither an assumed hierarchy of responsibility nor predetermined set of roles and skills. These different approaches were partly responsible for the different treatments of the Mexican, or U.S.-Mexican border on the maps:

> [KPBS] had a map to say there is the perimeter. There was actually a person that made the decision that we are going to do Mexico. And then because they did it and then in the County they said, oh, you're right, we need to do that. And that was [Head of San Diego County's EOC JIC] pounding on people's heads and they're going, yeah, but it's not in our jurisdiction, the rules…it's not our problem. And him going, but it really could be our problem (Visualization Specialist at SDSU 2011).

The County struggled to address unique issues of the specific space and situation, acknowledging in their after action report, for example, that following a fire beyond the County's borders needed to be a priority for future disaster mapping (County of San Diego Office of Emergency Services 2007). But the network around the ad-hoc map was versatile enough that it could address new developments and unexpected obstacles by involving different actors and technologies. The malleable structure of the socio-technical network involved with the ad-hoc map was as dynamic as the wildfires themselves, constructing through this practice a hybrid space (rather than wrangling a

hybrid space into a bounded representation). It also encouraged a different way of engaging with the diverse data sources.

> But say instead of trying to put everything into the same format, the same standard…there's enough utilities that are going around so that if you just do something consistently that's probably the wiser thing (Visualization Specialist at SDSU 2011).

By mapping consistently rather than through standards for compatibility, a wider range of data opened up to these mapmakers. As a result, the production of the ad-hoc map highlighted and showcased the networking, using the networks as its guidelines instead of a-priori regulations. The scale of the institutional action did not matter, only the ability to share data.

Another unique data source these mapmakers had access to because of their networking NASA's unmanned aerial vehicles (UAV), the Ikhana, that could both see through the smoke with high resolution thermal imaging and provide the images within 20 minutes rather than 12 to 24 hours.[21] While the tests were being conducted in the County, none of the of the partners involved were County level, so this data source was not initially included in the data pool for the County maps.[22] But that did not matter to the ad-hoc mappers: as soon as they got permission to fly during the fires, they saw its potential, started using the data (Figure 2.7 and 2.8).

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[21] It could provide data within 20 minutes of gathering it, fully interpreted, and in a format ready to be mapped, no waiting hours for the data, as required by traditional satellite imagery. It also provided much higher resolution data than the satellites (10-meter imagery compared to 250-meter). This new data format, though untested, provided the ability to have close to real-time and detailed data.

[22] This UAV was part of a joint research project by SDSU, NASA, and the US Forest Service to see how high resolution thermal imaging, a form of imaging that could see through smoke, could be useful during wildfires. While very useful in providing immediate data, it only provided a swath of data along a line of flight rather than regionally as would a satellite.

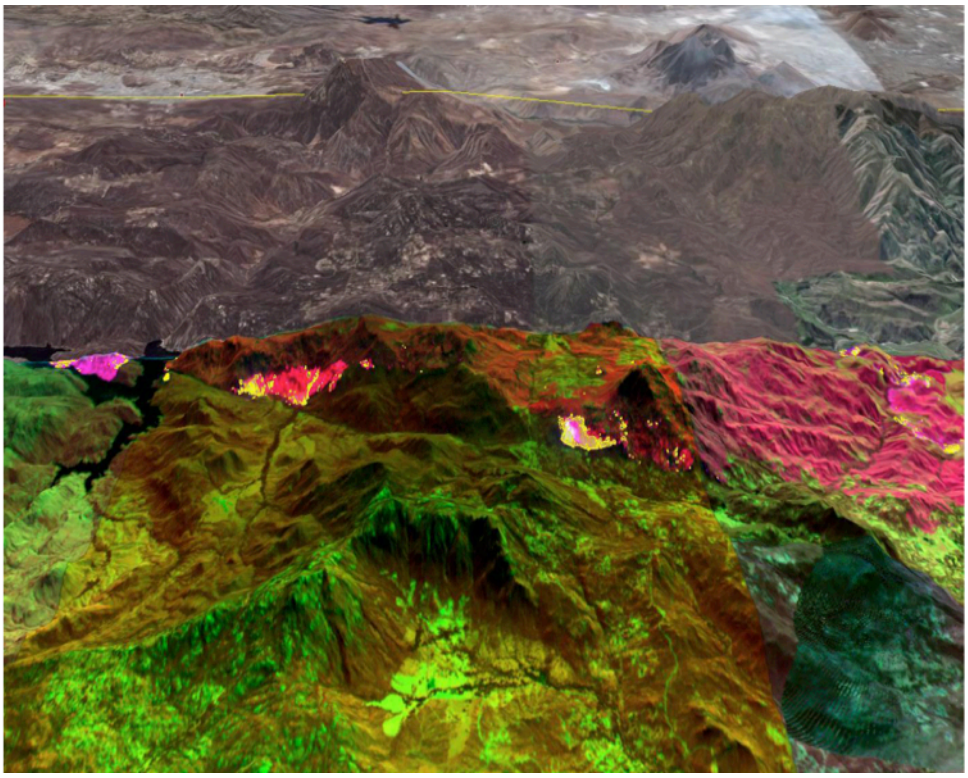

Figure 2.7. Data of the Harris Fire from the Ikhana looking south towards the US-Mexico border that is drawn as a yellow line near the top of the image. Notice the zone with no data. Source: NASA.

Figure 2.8. County EOC displaying the newly adopted data from the Ikhana. On the left-most screen it is possible to see the lines of flight on the map. Source NASA.

SDSU then went to the County to offer it to them. At first the County said no: this was not in their jurisdiction and, they argued, it is never good practice to change practice mid-disaster – that itself is a risk (Visualization Specialist at SDSU 2011). Only after seeing the ease and speed with which this data source merged onto maps was the County convinced that this new technology was worth modifying procedure for and incorporating themselves (County PIO 2011).

This technology, while it brought with it immediacy, introduced a new boundary to negotiate with the flames: airspace. While not bound by the limits of the landscape, fire perimeters, or transportation infrastructure, the UAV was limited by the rules of the air, which changed how the other lines were understood. According to the Visualization Specialist at SDSU (2011):

> So NASA is asking should we fly over Malibu? But with the predator you have a limited amount of where you're going to go, what are you going to do? How high is it, what air space do you have to fly through? How do you get there? Do you fly around LAX? Do you fly off shore? Those were all concerns.

Negotiating how the plane could travel had implications for which fires were deemed important.[23] He continued:

> They were saying, oh, the Witch Fire is the big one, but the Harris Fire which was right on the border they were going, ohhhh, we can't go close to the border because there is the international boundary that's 10 miles and we don't want to be within 20 miles because we don't want to be anywhere close to getting State Department smacked for doing something that's the U.S. spying on Mexico.

Though the fire along the border had less people and structures immediately in its path than the other fires that were burning at the same time, because it was not representable

[23] Though the social relationships that surmounted hierarchical boundaries were already in place when the 2007 fires ignited, the political relationships and boundaries still required negotiations.

with this new technology and because of the immediacy and availability of this new data, this fire became a greater threat. The Ikhana data divided the land and fires in ways that required new forms of interpretation and extrapolation to read between the lines and fill in the space. Rather than maintaining the status quo and discussing the disaster in terms of what could burn or how prominent or visible the potential destruction, this new practice of data gathering changed what issues were discussed, how danger was perceived, and what should be prioritized in response. It opened up the conversation about what criteria should be used to determine the greatest threat. Instead of public visibility, size, or what was in the fire's path, threat became about lack of information.

Rather than map the space of the wildfires by transforming and classifying the phenomena into data in a standard way, this group of ad-hoc mapmakers worked with translations in their practice to represent the disaster. Though the mapmakers did not all adopt the same understanding of the wildfires, even their most mundane practices demonstrated how both the space and lived experience of the disaster were hybrids of technology, humans, and land (Michael 2002). Examining the maps through practice makes it hard to discern which elements were included because of a decision made by a mapmaker, a result of technology, or a circumstance of the physical environment, making it hard to separate human from non-human (Latour 1987).

Though difficult to plan for, networks like this can help make visible what expert practices or political structures fail to see (Barrios 2011, Frickel and Vincent 2011, Weischelgartner and Breviere 2011). In this case, this network grounded in material practice exposed new boundaries to negotiate and transcended others, in the

process changing the fundamental nature of the threat, constituting priorities in response, and creating different criteria by which the disaster would be understood and characterized.

Ad-Hoc: Balancing Consistency In Time Over Thoroughness In Space

The ad-hoc mappers did not have that same responsibility as the County to manage response or liability, and saw as their goal to provide the public the most complete, relevant, and up-to-date picture as possible about the wildfires. The County mapmakers and responders focused on the dynamic nature the disaster and created movement through interactions with and comparisons between the maps. They presented the present-time as part of this interactive process. However, the modifiable nature of Google My Maps meant the ad-hoc mappers could keep up with the changing space in the map itself.

Limited neither by technology nor liability, with no need to delay information any further, the ad-hoc group of mapmakers focused on representing the status of the elements being mapped.

> The strength of the KPBS news side was that they were keeping track of the opening and closing of certain areas for evacuation and things such as the capacities and the reports on capacities of evacuation centers, things like that. Not just location update on time related data (Geography Graduate Student at SDSU 2008).

However, location and status, though intimately related, are very different questions that require very different engagements with temporality and representation.

By gathering most of their data about fire location from remote sensing technologies, these mappers could not comment on the status of the lines they were

drawing. A fire might have been under control but not contained, or a decision to let a section burn and move might have been one of safety rather than one of lack of control or information (National Interagency Fire Center 2007). These underlying firefighting practices and ways of defining threat about the burn area are discussed with the maps when in use, but impossible to discern from remote sensed images despite the ability of this data to provide more detailed perimeters (Kolden and Weisberg 2007). By relying on technological networks, this group could not make any comment about the status of the physical burn, only the social aspects in relation to the burn.

In the end, to work with the data gathering techniques at hand, in order to provide the most up-to-date overall map, this team sacrificed the ability to make the specific details perfectly accurate. For example:

> I would try to always do the most recent one, maybe skipping some of the previous updates that were high resolution. I might do the MODIS that was just released four hours ago that is lower resolution than DigitalGlobe that was one day ago just because that's the best information for the current situation. Later I might go back and reuse the DigitalGlobe to draw a finer perimeter of how the fire was at that time...But for us the most recent one was the most important (GIS student at SDSU 2011).

Rather than older data of higher resolution, they worked with less detailed but more recent data.

In addition to omitting pixels, they omitted elements, even if deemed important, in order to continuously offer status information. Sometimes this was because of limitations in the software. For example, My Maps had a limited number of data points that could be active at any given time, forcing the mapmakers to simplify their

representation and decide what was absolutely essential. At other times it was because there was no consistent source of information.

> If your house wasn't on fire but there was a lot of smoke and you wanted to know the evacuation area…they released that in Thomas guide grid numbers, which is a box shape, or they would say Northern Rancho Penasquitos is evacuated. Where's the line from north and south? The fire didn't follow grid lines. That was really hard and we really wanted to be able to notify. I think towards the end we took it off, the last days, because it was basically everything, and it was shifting and hard to keep up with (Web Developer 2008).
>
> Road closures, those came and went, and it was hard to maintain because it was changing so fast. Specific exit and entrance points (Web Producer 2008).
>
> The road closure information, there wasn't a good regular source for that. Caltrans didn't have a map that we could reference. We gave up on the roads after a while (Online News Editor 2008).
>
> There were lines that were tracking roads, but they were just using up a bunch of our potential data. It was limited to 200 things, so we ended up tossing them completely (Web Developer 2008).

The mapmakers did not want to display incomplete information that could potentially mislead users who assume a level of completeness, in space and time, to the map. Not being able to consistently represent a type of information was worse, they decided, than not representing them at all. To produce a glimpse of 'what's happening now' in this disaster, they chose as their epistemic priorities consistency in time over thoroughness in space.

Drawing Maps, Drafting Priorities

Both these maps struggled to keep pace with the situation. The mappers were working under great stress and struggling to stay well informed about the flames and reconcile all the data sources coming their way. Because of the different underlying

technologies and networks at play in making these maps, the County and the ad-hoc maps ended up coping with and representing the dynamism of the incident differently and to different affects.

The value of using maps to communicate information about the wildfires was clear by the end of the week when most of the fires had been contained. They were tools the public information officers from various institutions could use to express to their audience what was going on (City of San Diego 2007, County of San Diego Office of Emergency Services 2007, National Interagency Fire Center 2007, U.S. Department of Education 2008). However useful, mapping constantly changing phenomena was a challenge no matter how quick or where the data came from, because the mapping needs were in constant flux. The same reports that praised the existence of maps simultaneously acknowledged that what needed to be included was neither clear nor consistent which impeded their use as representations in public communications.

Even a fully automated system would not be able to keep up with the wildfires because it could not modify what kinds of information were included on the map, only update the elements that were determined prior to the incident to be important. In 2007, this would have meant that evacuation zones would not have been included on the map as part of the disaster, one thing that many of the after action reports have stated as being invaluable to an effective response (County of San Diego Office of Emergency Services 2007, City of San Diego 2007). Those zones were added by request of some responders in the EOC that engaged with the maps (GIS specialist at County 2 2011). They were surprised and pleased, though, at how useful those mapped polygons made

the maps for their planned audiences of County responders and, especially, their unplanned public audience.

The two sets of maps produced different views of the disaster, and demonstrated that mapping these fires had components that were impossible to predefine. Producing the maps in turn produced either a space of experience or a space of action, depictions of location or depictions of progression -- very different ideas of what was important to know and what was essential to considering during and after a catastrophe. But as these institutional practices were materialized in space they created boundaries. With boundaries like these always come relative positions to a space, some of belonging while others of alienation. Lines of inclusion and exclusion, of what gets counted and what is forgotten, matter greatly in a natural disaster. It can mean the difference between who does and does not get a phone call notifying them of evacuation for threat of fire or which side of a street gets firefighter first.

The County focused on predicting the disaster's path while the ad-hoc map focused on describing the disaster's present. The sense of what will come was a necessary way of knowing disaster for those fighting it, but was difficult to comprehend and accept for those living through it, often requiring an expert to mediate its meaning. Consequently, the County mapping practice centralized meaning, made sharing across the space of the fire possible, and created a common vision for how the maps' users were to engage with the wildfires. Its focus on aligning actors made it possible to have group action with responders all working towards the same priorities and the public acting in a coordinated manner. This mapping practice drew its authority from its ability to connect to normative social structures and systems of classification from non-disaster

times. It defined clear roles for and maintained distinctions between the groups as it drew boundary after boundary, layer after layer. Such aligning made disaster planning easier to do in the abstract, but both struggled to see other possible perspectives that could prevent future fires from becoming disasters and required the mapmakers to cross boundaries, and rely on the informal and undocumented in order to follow the lines drawn. This practice made the unplanned and individual less visible. Doing so reinforced pre-existing social divides in how responses are organized and missed some of what was unique about the specific disaster space. The result is that what goes into making the maps and what is decided with the maps did not follow the same rules.

The ad-hoc map looked in-the-moment, focused less on boundaries and predetermined lists of elements, and instead represented what emerged from the messy situation, making space for the unexpected and otherwise marginalized aspects of the disaster. It organized its practice by distributing power over its network, hybridizing data formats, sources, people, land, and technology through practice, aligning goals rather than meaning. It accounted for local experience and incorporated into its form through user participation rather than training its users to engage with the map in a specific, top-down, manner. Drawing its values and priorities from the production process itself, it seemed to take no sides or value no specific social position over another. It made this easier by focusing on the immediacy and continuity of information rather than its completeness or accuracy. However, in trade, this practice erased entire categories of action or experience as well as removed the map from any temporal relations. This map's authority emerged from its ability to account for the exceptional and individual. In doing so, it makes space for the atypical and assumes individual

responsibility but at the cost of common action, shared meaning, or connecting present decisions to past events and future potentials. Doing so both ignores how social structure influences how a disaster unfolds and makes it possible to claim an end to the disaster when the map ends, limiting claims of responsibility and potentially challenging future requests for aid.

The two maps carry with them different assumptions about the public's relation to disaster response. The County, in its top-down build, is very focused on the first responders who are the people on the front lines fighting the fires, taking care of the displaced, or addressing medical emergencies. However, the general public, especially those nearby but not immediately affected, are completely left out of their picture, both in their ability to engage with the maps as intended and in being represented within the map. But the public does not just wait for action, they are proactive and help each other; they do not fall into disorder unless there is a hierarchy imposed, rather they create a new order (Tierney, Bevc, and Kuligowski 2006). The flexibility of the ad-hoc fire map, whether intentional or not, was built in a way to accommodate this type of public engagement during the disaster. Such assumptions built into these maps as communication tools can influence organizational and government response, as well as public acceptance of their claimed authority.

The maps demonstrated a contradiction that seems to be built into expectations of responsibility and response in San Diego. Community Wildfire Protection Plans are designed for collaborative work and are lead to a certain degree by federal Incident Command System definitions and procedures, they ask communities to create their own risk maps and even their own definitions of risk that consider their specific community

values. In addition, people living at WUI were increasingly being asked to think about creating their own defensible space and building with defensible materials, conditions, according to the field mappers I talked with, firefighters seem to take into account when prioritizing at the scene (Fieldnotes 26 August 2011, Field Fire Mapper 2012). In addition, the City had to act independently at times, but relying upon the County maps meant delaying information as they recreated the maps in their system focusing on areas of interest to the City. This lowered the value of the maps for them in developing situational awareness and in decision making, and in the end the City itself did not end up using the fire perimeter data as a base for their decisions (City of San Diego 2007). At the same time, the State and County were being asked to pass on their priorities through their collaborations with the local communities and public in general. While the County was mandated with the protection of what was in its borders and thus needed to maintain some control over information to complete its job, communities and individuals were also being tasked with their own self-protection.

Yet these maps were not pure alternatives to each other. The ad-hoc map was grounded in the County map as a starting layer of information. If that layer had not existed for the first couple days of the fire, the ad-hoc map would neither have been able to exist nor been able to focus on presenting the immediacy of the situation. In turn, the County map modified goals, priorities, and technological practices in response to the existence and practices employed in the production of the ad-hoc map. For instance, it would not have been released to the public had the ad-hoc map not existed. Nor would the mapmakers have modified procedure mid-disaster to incorporate the Ikhana data if there had not been another map that focused on representing present

rather than predicting the future. In fact, while the ad-hoc map was designed in response to the inadequacy of the information coming from the County for the media's communication goals, it also became a way for the County to justify their own inadequacies: instead of the County fighting the ad-hoc map's existence in order to maintain control over the information the public was receiving, they realized the map's presence was to their advantage. In their after action report, the County said so much when they wrote that this map "helped alleviate some of the traffic on the overloaded County website" (County of San Diego 2007, 16). The maps forms emerged through their mutual interactions; neither way of representing disaster existed in isolation from the other.

Conclusion

The making of both sets of maps demonstrates how there is no clear line to draw between nature and society – between flame and disaster (Wood and Fels 2009). Representing the situation required the interaction of natural phenomena, social structures, and technological mediations. While many of the preparedness plans account for human ignorance of nature or human manipulation of nature, they perpetuate false assumptions about how disasters work (Oliver-Smith 2002, Hilgartner 2007). No category of knowledge or socio-technical practice works entirely to eliminate uncertainty and risk. Here we see interacting in uneven ways with the disaster: technology, personal experience, levels of detail, precision, accuracy, timing, and consistency. Yet no single category offers a complete solution or even a solution in a consistent way to respond to the uncertainty built into the nature of disaster mapping. In

fact, some technological uses brought some categories or risk into question while others introduced entirely new categories. Preparedness and response plans need to be modified to include these hybrid relations rather than lay blame along a spectrum between two distinct ends. These plans need to be rethought, regardless of the shape of the response and attributions of responsibility, in terms of the hybridity that pushed back on both sets of maps.

While many studies have pointed out that different affected groups construct a disaster differently (Hoffman and Oliver-Smith 2002, Henderson 2011), this chapter shows that even when the groups overlap or are working together, different constructions can still emerge. While both maps relied on much of the same data, social networks, and cultural understandings of the space, the actual mapping practices constructed very different disasters and potentials for response. In both cases, the practices highlighted the importance of accounting for material influences such as the physical world, the technologies used, and types of data gathered, not just social or cultural, on how a specific understanding of a disaster gains authority to represent the situation. As participatory maps are increasingly used as tools to contest official reports of risk and patterns of aide, understanding how they are made is vital to understanding how they are contesting the official reports, not just what in the official reports they are contesting. Stopping the conversation at ‘what’ basically offers two sides with no way to see why they each do what they do and why they see what they see as important.

Taking a step back and looking at the socio-technical practices both offers a chance to critically engage with one’s own assumptions about society and risk but also makes it possible to see why some risks get prioritized over another. Instead of asking

‘why was this map incomplete?’ and placing risk in its gaps it becomes more productive to ask ‘what was its goal and how does risk derive from that?’ In many cases, it is more complicated than simply political bias (even if political bias is also involved). Knowing how the risks emerge as visible can take us one step closer to understanding how to manage them.

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CHAPTER 3
Tracing Expertise and Risk as Distributed Practice

Introduction

The ad-hoc fire-map developed for the 2007 wildfires described in the previous chapter was designed in response to the obstacles faced by official communication pathways. Yet, this makeshift wildfire map became one of the most highly referenced maps of the wildfires (if not *the* most highly referenced map), receiving over five million official hits during the first week of the fires.[1] Unlike other wildfire maps produced at the time, this map ultimately drew national attention and was linked to by the California Department of Forestry and Fire Protection, the Port of San Diego, and the California Governor's webpage (Google Maps 2008). Achieving this status, however, was no easy feat: the map was produced neither by an official response team nor by any traditional team of map designers. Those involved with the map were comprised of a group of actors that normally did not work together and who engaged with unfamiliar technologies that were often incompatible, all while trying to piece together different conceptions of what was important to know about a wildfire. These actors also took cues *from* the public instead of simply giving cues *to* the public. It was exactly these distributed and often-contradictory interactions that helped shape this particular map while also assuming the same kind of authoritative status as those representations produced by more conventional means. This chapter traces how the ad-hoc map gained authority to challenge county maps as well as how it exposed very

[1] The official counter said over a million hits, but it was turned off for a couple days during the wildfires to increase website functionality. Google informed KPBS that the visitors to the map the week of the fire, based on their server traffic, was more like 5 million.

different notions of disaster and disaster communication established by two different mapping practices.

Much of the literature that examines environmental disasters looks only at questions of risk management, expertise, and politics that lead up to a given disaster, such as the extent of the damage and/or the success (or lack thereof) of the response (Beck 1994, Steinberg 2000, Rajan 2001, Vale and Campanella 2005, Roberts 2010). But asking only these types of questions leaves unaddressed the types of knowledges used to make these plans and how practices of communication during disasters can influence what types of knowledge are considered legitimate in the future. Why, one might ask, were standard mapping practices insufficient for all affected under the duress of these wildfires? In this chapter, I demonstrate how the complex relationships that constituted the practices of representing the 2007 wildfires on the ad-hoc Google map made those involved re-think communication networks and re-envision scientific and technological infrastructures. Only by understanding these processes, much of which were undefined by standard practices, can this wildfire map's value as a legitimate representation of the wildfires be understood. More importantly, I posit that valued forms of knowledge regarding the wildfires were not determined *a priori* to the wildfires or map, but came into being along with the map.

To understand how diverse actors and technologies mapped the wildfires and came to value the result as a legitimate way of knowing, I ground my exploration in theories from visual culture studies, critical geography, and science and technology studies that show the interrelations between forms of representation and networks of knowledge production. In the process I characterize map-making as a messy, distributed

network of knowledge production in which expertise emerges from in-betweens rather than defined boundaries. Finally, I consider the implications of treating the production of the wildfire map in order to plan for future wildfires in relation to standards and risk management. Examining the map as a network of human and technological interactions, I suggest, offers new perspectives on how we understand epistemologically what it means to know a natural phenomenon.

In order to get at these more tacit, undocumented, and interactive elements of the process of map production, I draw upon informal interviews of geographers, journalists, and computer programmers who were key actors involved in the production of the 2007 wildfire map. While some traces of the mapping practices exist in the digital drafts, much was impromptu, done with scattered e-mails long since deleted, and went largely undocumented. The networks and interactions that created the knowledge and shared meaning of the wildfires can be approximated through interviews and textual analysis.[2] I also conducted interviews between six months and a year after the wildfires, in which I asked questions about motivations, engagements with the various technologies, connection to the larger network, and conceptions of what information was necessary to map the wildfires. I asked how these individuals became involved in order to understand how the authority of the map rested on different voices at different moments. Additionally, I analyzed government and scientific documents regarding the

[2] New methods in science and technology studies, as exemplified by ethnography of open systems (Fortun 2009) and digital co-presence as an approach to fieldwork (Beaulieu 2010), propose ethnographic techniques that bound the field site not by physical location or time, but by the networks and interactions that create knowledge. They define the field not as a place or container for action but a set of interactions and relationships. Such methods are important as knowledge of nature moves from disciplinary lab work to consensus and collaborative work.

wildfires to help construct the larger landscape of cultural and political conceptions of fire, preparedness, and response in which the 2007 wildfires emerged. None of these texts are transparent or obvious sites of meaning-making; but by analyzing them we can establish the possibilities of how wildfires can be understood as well as how the production of the wildfire map might help us better comprehend the production of expertise about future environmental disasters.

Drawing Maps, Trusting Knowledge

Natural phenomena are not prior to knowledge, but come into being through social and technological practices that make physical processes knowable in the first place. For instance, what we often identify as "natural" landscapes are culturally constructed ways of engaging with the world, grounded in a history of labor practices, photographic aesthetics, and imagined travels (Cronon 1996, Spirn 1996, Weaver 1996, Gandy 2002, Mitchell 2002). Moreover, what it means to be natural is constructed through cultural processes. For example, "Roads," writes Anthropologist Cory Hayden, "do not just offer up flora in this relatively passive way; they can also, as numerous ecologists will attest, *produce* distinctive kinds of plants" (Hayden 2003, 175 italics original). Building each new road, emblematic of cultural engagements, produces new understandings and categorizations of nature. Sometimes the natural process produced is beyond sensory perception and requires technologial mediation to become knowable. For instance, in order to see nuclear reactions, scientists had to create technological and physical boundaries between them and the explosions (Masco 2006). By the time they could accurately observe the components of the nuclei in this interaction, the scientists

were multiple times removed from the objects they were seeing. This is also the case when the phenomenon is so large it cannot be grasped from a single physical or technological perspective, like a wildfire. Instead, these process are always mediated by cultural and scientifici models of technological interaction. Each new practice brings about new conceptions of natural phenomena and appropriate ways to know those phenomena.

An image's ability to represent a natural phenomenon and the image's potential authority as a representation are also bound to these practices (Goodwin 1995, Sandweiss 2002, Nye 2003, Sturken 2007). For example, satellite images of the Earth are mediated processes grounded in cultural assumptions. They are one element in an interactive process that helps shape political consciousness and understanding of the environment (Jasanoff 2001). Similarly, the X-ray and MRI are not representations that make the invisible body visible; instead they translate a set of relationships, through practice, into a visual object (Pasveer 1989, Cartwright 1995, Van Dijck 2005, Alač 2008). How a wildfire is understood through any given map is not just through placemarks on a landscape; it emerges as part of an ever-changing network of interactions, substitutions, and relationships in which nature, social worlds, and the surrounding knowledge all produce each other.

To be sure, nature is never simply a cultural fabrication; but neither does it exist outside of larger socio-technological relationships. And maps, one could argue, are the materializations of those relationships, not merely representations of objects in space. Critical geography studies have argued that maps are part of cultural practices that include geographical imaginaries (Cosgrove 2008, Davis 1992), material forms

(Monmonier 1996), cultural values (Harley 1989), contested histories (Wood 1992), as well as networks of practice (Wood and Fels 2009, Kitchin and Dodge 2007, Harvey 1996). These theories suggest that socio-technical networks and interactions as well as cultural expectations play as strong a role in representing nature as scientific debates, imaging technologies, environmental boundaries, and predicted movements of natural phenomena.

Science and technology studies scholars have found that trust or acceptance of any given knowledge emerges in these interactions. These relationships have been described as acknowledged scientific expertise (Collins and Evans 2007), as democratic processes that mitigate between expert and public (Bocking 2004, Jasanoff 2010), as social constructions of needs which defines a solution and thus an expert (Pinch and Bijker 1984). The problematic nature of these interactions have also been noted by scholars exploring the interactions of local differences with global knowledge (Tsing 2005), of specific knowledge with universal claims (Choy 2011), or of the work required for grassroots social movements to be heard as legitimate (Hess 2007). But in all cases, to accept a claim as authoritative one must accept the legitimacy of the relationship between the claim about the issue and the issue itself, between the network of knowledge and the object of that knowledge (MacKenzie 1990, Wynne 1992, Dumit 2004). As that claim becomes accepted as legitimate, the work of these diverse groups at the boundaries becomes naturalized.[3] Thus, the value of any knowledge is to be found in interactions between these diverse actors that produce and use the knowledge not in

[3] This naturalization is another reason to explore a map created in a situation where the norms of exchange become visible so as to see the activity, not just the product, of legitimation.

the knowledge itself. In other words, focusing on the interactions that produced this wildfire map make visible the how the knowledge produced by the ad-hoc mapping becomes legitimate across the diverse communities involved it its production.

The cartographic exists within a socio-cultural history in which it is common to treat maps, satellite imagery, and aerial photographs as realistic and reliable depictions of the lived-in landscape (Harley 1989, Cosgrove 2008). However, the power of any image to represent is not given in the form of the representation nor can it be separated from how we come to know the world (Cartwright 1995, Latour 1999, Beaulieu 2002). For example, critical geographer David Harvey (2006) argues that when we focus on the dynamic dialectics that produce geographical objects of knowledge we can develop richer understandings of the environment the objects represent. In other words, the relationship between what we come to know by engaging with visual technologies like maps and what we know through daily life is grounded in multiple intertwined forms of knowledge, forms that change along with the larger socio-technical networks. Consequently, in order to gain insight into what kind of knowledge of the wildfires was valued by the groups involved, in this chapter I focus on the interactive design process of the map, rather than the map and its connection to its object of representation.

However, the difficulty with developing and maintaining a shared understanding of a situation "is not just a matter of monitoring a course of events but of establishing their significance" (Suchman 2007, 56). Finding moments where the norms of policy, representation, and social interaction do not work, such as a controversy or a disaster, make it possible to analytically denaturalize and examine these mapping practices in ways that make it possible to see how meaning and value become established (Shapin

and Schaffer 1985, Pinch 1994). In these moments it becomes possible to see the dynamics of power in action, especially in how radically different communities come to agree upon or contest a given piece of knowledge. By examining this mapping practice developed during and for use in the 2007 wildfires, this chapter pushes questions of disaster management and scientific expertise to include the invisible relationships and improvisational tactics that took shape in order to better understand how diverse voices, often non-authoritative ones, become part of the collective knowledge of a disaster.[4] Such an exploration also makes it possible to consider the implication of mapping decisions for what it means to have standards for knowledge and for future disaster response.

Some scholars have argued that increased engagement with technological networks and mediation leads to a disconnection from reality (for example, see the edited volume by Sorkin 1992). These arguments range from how representations of cities turn those cities into machines of fantasy, how simulated environments like malls construct false senses of public space, to how nostalgic histories of architecture produce disconnects from some more real history. However, these arguments romanticize distinctions that are less about exploring what the representations are and do and more about constructing ideological conversations about what reality and forms of experience should be.[5] Such arguments treat representations and technologies as outside of norms of knowing the world and everyday practice, with no regard to the cultural and

[4] Following the lead of scholars such as Fortun (2001), Tsing (2005), Choy (2011).
[5] Communication scholar Jennifer Light (1999: 124) argues that thinking of representation and the world as other than mutually shaping each other is to "risk falling into the technological determinist trap…postmodern pessimism."

historical nature of those norms (Hayles 1996, Light 1999). Considering technological mediations, such as maps, as always already part of how we come to know the world, then, is a way to avoid such traps of treating them as lenses that offer up a partial world.

Tracing the Map as Practice

As seen in Chapter 2, at the time of the 2007 wildfires, there was no established practice in place for collecting, sharing, or visually representing fire information on a map, and no two groups responding to the disaster agreed upon what elements should be included on those maps. Part of this is because they did not agree on what constituted the disaster. Was it a disaster in terms of human property or was it a disaster in terms of lost ecosystems? Was it a disaster in terms of public damage or in terms of government lack of control? Each question implies different socio-environmental relationships, conceptions of what constitutes the threat of fire, and communication needs. The 2007 wildfires did not make this any easier with their placement at the wildland-urban interface, at regions that varied in terms of class and race structure, in terms of population density, and in terms of natural resources.

The State of California acknowledged these challenges and, in 2005, began a review process of their fire protection plan focusing specifically on Southern California fire prevention (California Department of Forestry and Fire Protection 2010). The County of San Diego also began restructuring its emergency offices and communication networks (Scanlon 2008, County of San Diego Office of Emergency Services 2007). However, by October 2007, no new formal policies had been written on how and what to communicate, and agencies were interacting with drastically different assumptions

about wildfire response and priorities. In the past, much of the official data was not presented on a map, but arrived as grid numbers from the Thomas Guide, a popular map brand, even though, as one of the wildfire map designers noted, "the fire didn't follow the grid lines" (Web Producer 2008). Moreover, the intensity, urgency, and scale of the wildfires further stressed patterns of communication between responding agencies and with the general public. In 2007, these communication practices were largely structured around possibilities for sharing, shaping how a map (and the group that made it) gained validity and the power to speak as well as what was included in the mapping practice.

The official maps of the fire being produced by the San Diego emergency office were put into circulation within responding agencies, and partway through the fires were released to the public. However accurate, these maps had a few features that made sharing a problem. It took 12 to 24 hours to produce them so that by the time they were available for use the wildfires situation had long since changed and even the city of San Diego acknowledged that the delay meant the fire perimeters were not useful for decision making (City of San Diego 2007). The maps were produced at a regional scale, and thus not as useful to people on the ground trying to determine the status of their local neighborhoods (Online News Editor 2008). Lastly, the files were so large and the county infrastructure unprepared for sharing, that the traffic downloading the maps crashed the county servers, slowing down access (GIS specialist at County 1 2011). Timeliness and regionality are features deemed important since much of the local response, especially during the first 48 hours, was being carried out by local volunteer organizations without waiting either for the external government response or in lieu of a government agency (County of San Diego Geographic Information Systems 2008, City

of San Diego 2007). San Diego is structured around a response system that includes government agencies, the American Red Cross, Community Emergency Response Teams (CERTs), and public and private organizations including religious groups and large corporate store chains, each with their own mandate.[6] The use of these different groups is written into disaster plans; there is an expectation that they will stand up and fill in for what the government cannot do either due to timing, liability, lack of resources or socio-cultural challenges (City of San Diego 2007). Maps that need to be waited for and that do not scale well to the local are not useful in the right way and the right time for these groups. Consequently, in 2007 many groups who needed maps creatively improvised their own mapping techniques to account for movement of the fires, people, the constantly changing environmental conditions throughout Southern California, and their assumptions about public communication needs.[7] Among these was the ad-hoc Google My Map.

Despite being a rudimentary Google My Map, tracing county information inaccurately, and producing a different – if related – notion of disaster, the production of this map also produced a new understanding of expertise, one that stands in-between standards and local, situated knowledges. Picking up from where the conversation ended in chapter 2 about authority in relation to this map, this chapter turns to the socio-technical networks that stabilize and naturalize these representational relationships in ways that produce not just a new understanding of disaster but a new way of thinking

[6] such as the San Diego VOAD, sdvoad.org, or the San Diego interfaith disaster council, http://www.sdinterfaithdisastercouncil.com

[7] Other than the KPBS map, there were similarly updated maps created by, for example, the San Diego Union Tribune, LA Times, MSNBC, and San Diego CBS 8.

about expertise and what needs to be and can be set up to aid in the production of knowledge prior to a given disaster. It traces the network of interaction that made it possible to gather the different data forms, process them into information, and display them on a map that made this specific way of understanding the wildfires possible.

Because it was not planned, much of the work and collaboration that went into the ad-hoc wildfire map was grounded in real-time contingencies. Describing the situation, one person stated:

> Everything kind of came together at the same time, and it's funny because when I talk to people they all have a slightly different version of how it all came together. It's kind of bizarre (Online News Editor 2008).

Another observed that:

> The map was a series of compromises and we never got it quite right (Geography Graduate Student at SDSU 2008).

But in the process of figuring out what to do, the ad-hoc group found that the introduction of new mapping technologies and expectations they brought to the wildfire mapping practice challenged not just how wildfire maps were made but also how legitimate knowledge of the wildfires were constructed in the moment.

Google My Maps was the mapping platform of choice because the team at KPBS had recently completed another reporting project using a Google My Map and decided to continue with that format for this event since it had been popular among their online users. In many respects, the wildfire map looked like any other Google map: it was made up of different color polygons and pre-programmed icons. Scrolling through the legend on the right hand side of the map, a user could click on an item and watch as the map centered on that point on the map and a window opened with detailed written

information (in the form of a speech bubble) overtop the main map view.[8] This digital format made it possible for the map to be continually updated in order to track the movement of the fires, making the fires more dynamic than possible with a photograph or pdf map alone, bringing immediacy and movement to the fires in a unique way for their users.

This movement, while unique to this format, was very limited also by the format. Partially this was because of how this team had to retrace all the information from the county maps due to the incompatible mapping programs. Because of how the software was set up, the KPBS team had to "sketchily" draw the elements by hand (Geography Graduate Student at SDSU 2008). They outlined fires and designated areas under evacuation by using polygonal shapes. They marked points of interest, such as evacuation centers and animal shelters with icons. Each time the KPBS team had to update the information, which they did as often as every ten minutes, they added or revised points to the existing map (Web Producer 2008). But the Google My Maps had a maximum number of items and updates that could be included in a single map; these maps were meant to display static rather than dynamic information. Two days into the production of this map, the team drawing the map hit this limit and could no longer update their information (Geography Graduate Student at SDSU 2008). This was a relative number of points on the map at a given time; once they realized they had reached the maximum number of points, they had to go back and start deleting objects

[8] For example, if a user clicked on the legend referring to a specific fire, the polygon of the fire would become the center of the map and in the window would be information about how the fire started, how many fireman were actively working, how many acres were burnt and what percentage the fire was contained.

on the map in order to add anything new. As they worked out the software glitch and their plan of action, the map effectively froze for over 24 hours, unable to be updated (Web Developer 2008).

With the frozen updates unbeknownst to casual Internet users, the wildfire map became so popular on these days that KPBS received over thirty times its regular traffic the first day (Glaser 2007).[9] These hits were coming from all over the country and represented a user size that KPBS was unprepared for both in terms of information sought as well as server capacity.[10] To keep the map up and running, KPBS had to simplify the rest of their website to increase user capacity. Paired with this redesign, they decided to increase user capacity by removing the embedded map from their website and simply linking to Google's own page (Web Developer 2008). As the visits to the map increased with these modification, this wildfire map experienced the largest number of users ever in a single day for a Google My Map and quickly overloaded the Google My Map server. Now, both the map updates and the map server were frozen. Google engineers

> …were up all night trying to figure out how to handle the load because their servers were overloaded from traffic to our Google map…they actually thought they were under a denial of service attack and then they looked into it and discovered that there was this map (Online News Editor 2008).

[9] On a personal note, I was part of this traffic, using this map throughout the wildfires as I tried to understand how they were moving around me, I did notice that there was a period in which they had not changed on the map. I simply assumed that the fire situation was holding stable and never once questioned the lack of change or attributed it to a technological issue.
[10] The actual number of users is unknown, since, as Online News Editor (2008) notes in the interview, the viewer counter was disabled for a while during the first week of the wildfires.

But while these crashes were going on, KPBS found their users were still treating the map as real-time and had no way of letting them know about when it was last updated on the map itself (Web Producer 2008). KPBS realized they did not have the technical knowledge or skills to assemble this data, even if they had the skills in relation to gathering the information.

How the help arrived and joined in to the ad-hoc nature of the map is unclear. According to KPBS, as they tried to contact Google for help, they happened to get a call from the Visualization Lab at San Diego State University (SDSU); they had someone from Google with them and wanted to know if they could help (Online News Editor 2008). According to one person from SDSU, they were already working with people from Google Earth who wanted to get their information to the public, so one of them went across the street to the KPBS building and tried to call and literally knock on their door but got no answer only to have KPBS call them requesting help with their map a short while later (Visualization Specialist at SDSU 2011). According to another from SDSU, KPBS contacted them because after seeing their maps online they realized there were people working on mapping in their neighboring building and tried to get connected for help. SDSU said they asked Google for help a couple days into the week when the map froze (GIS student at SDSU 2011). Google offered to send people to help with the map (not just those working on Google Earth imagery that were already onsite) after they found the map struggling on their system and deemed it important enough to intervene (Google Engineer 2012). They sent an advertisement engineer who lived in Southern California and could actually get to SDSU to be onsite to help not with the mapping itself but with the networking needed for the mapping to happen. Whatever the

actual start was, the end result was a team working onsite at SDSU and even more actors networked online but physically scattered over distances with the sole aim of keeping this map running, maintaining its functionality, and helping it remain popular.

When SDSU joined in, they already had a few projects going of their own. One of the main actors from SDSU, a geography student, had already been working on mapping the fire perimeters on his own time since as a student he had access to much of the satellite imagery. His work even released him from his normal responsibilities so he could focus on his intiative (GIS student at SDSU 2011). But all this work was on his home computer so he called one of the professors at SDSU and offered to share his work. This professor had started his own mapping initiative, map.sdsu.edu, which he had done in 2003 during the last big fires in San Diego and he incorporated this student into a volunteer group of about ten geography students and faculty members to map the fires with GIS (GIS specialist at SDSU 2008). The group worked primarily to write computer programs to compile different GIS datasets to create new ways of visualizing the fire, such as combining geo-referenced aerial photos with GIS landscape data. The SDSU wildfire website was primarily a list of various GIS images to describe the fire, each resource a project of interest to one of the graduate students or professors involved. However, GIS is not readily accessible to non-geographers and their website was not receiving nearly the traffic they wanted and they were already looking for ways to connect to more popular mapping formats. Moreover, the traffic they were receiving was more than the website's server could handle. By the time KPBS asked them for help, they were already looking into new physical infrastructural possibilities for sharing and posting public information (Visualization Specialist at SDSU 2011).

The team at SDSU brought new sources of information and technologies to the wildfire map. Because the SDSU team had a student working in the GIS office at the EOC, they received all of the data compiled by the office before anyone else would get it (GIS specialist at SDSU 2008). They also leveraged their relationships with some of the private satellite providers, like GeoEye and DigiGlobe, to receive the raw data from their images at no cost and in a timely manner (GIS student at SDSU 2011). This also meant the data was available to SDSU for free, which was not the case for other people requesting it. SDSU also leveraged their relationship with NASA and convinced the scientists there to reduce the processing time of images collected from satellite from 24 hours to three (GIS specialist at SDSU 2008).

While there were two Google Earth people already onsite at SDSU to help SDSU with their project, they were not knowledgeable with Google My Maps. When Google offered help with the Wildfire Map, they put out a plea to local workers who could be onsite, which meant that Google was not going to provide a mapper in person because their mappers were located in either Northern California or Sydney, Australia. The help they were sending was a cultural one – someone who could arrive onsite within hours and who knew the culture at Google and knew how to seek out help from Google employees. They were also sending someone who could provide access to a proprietary and expanded beta version of My Maps but that would help the ad-hoc team attain their goals (GIS student at SDSU 2011).[11] The worker who was sent down described his role like this:

[11] This involved, though, signatures on a privacy clause, an action that involved quite an e-mail back and forth between all the parties involved as they tried to determine who had to sign it.

> I was passing back and forth mostly technical questions – number of points that could go on the map. Map was basically crashing because there were too many fires…evacuation centers, locations, the software wasn't designed for this purpose. It was designed for individuals or companies to do a few annotations on the map. But when it hit 100, 1000s, it started to crash (Google Engineer 2012).

At another point, he stated his role this way:

> Google is a very open place and it was a lot smaller then, everything is open and we can go and find anyone doing the projects, so I just looked for the people working on the project. Everyone was eager to help (Google Engineer 2012).

Overall, he helped them find people and translate the problems in a way that was manageable for the Google workers to tackle, including rerouting the map on their server and rewriting some of the mapping software. He himself did nothing directly to the map or the software.

KPBS and SDSU both brought to the network the idea of using a map for communicating with the public information about the wildfires, but KPBS had the audience that SDSU did not have. KPBS also had knowledge and experience with the general public in San Diego and understood to a certain degree how the map would be engaged with as well as a general interest in human interests. SDSU, though, had the mapping skills and connections to other individuals and organizations for mapping data (such as workers at the County and NASA) that KPBS did not have. One of the people from KPBS describe the relationship saying that SDSU had much better capabilities with the fire perimeters but no information or interest in relation to the evacuation details and wanted to get that from KPBS (Online News Editor 2008). Google brought with it the proprietary technology and the engineering knowhow to help make the My Maps software do what it was not designed to do and keep the map technically

functioning. While each group brought a piece of the puzzle, this ad-hoc, ever changing, group had its work cut out for it.

As these actors and technologies interacted, part of the work involved in mapping the wildfires was based in managing representational technology and information access. As Google tried to address issues faced by the freezes, they had to revamp their system so that the wildfire map could be continuously modified because mapping the wildfires asked the software to do something for which it was not designed (Geography Graduate Student at SDSU 2008, Google Engineer 2012). They increased their server capacity, designed new icons for the fires, restructured the menu to be more user-friendly under such information load, and added time stamps. They worked out a way that the update process itself would not interfere with the functionality of the map, so that the mappers could update the map then post the updates online instead of modifying the map while people were trying to access it which caused trouble for the users (Google Engineer 2012). They even "white listed" the map so that it could behave separately from other My Maps in an attempt to increase the number of points on the map (ibid.). According to one of the people from KPBS:

> they provide a modified URL that was supposed to force the map to show more than 200…it was supposed to allow 1000 items, but it didn't work as far as we could tell (Online News Editor 2008).

To make this change Google required KPBS to link to a new location. This meant rerouting all of their users who were likely refreshing bookmarked links. Somehow, they had to figure out how to update this link on the home computers as well as their map (e-mail correspondences between SDSU, Google, and KPBS).

But many of the features needed for the map to stop crashing required Google to make changes throughout their entire mapping system. For example,

> To do the timestamps they actually turned them on across all My-Maps…if you looked at them that week they all got timestamps because of our map (Online News Editor 2008).

Increasing the number of points on the maps would mean they had to let them be increased on all maps, asking for a completely different scale of server capacity. As a result, they could not just make any change to help this map work because it would have ramifications through their system. For example, simply increasing the number of points allowed for the map in general (which would have worked better than the modified URL for KPBS) would have meant all maps could increase the number of points increasing exponentially the requirements on the servers.

KPBS had to similarly decline the ability to get information mapped more quickly in order to maintain user access. Google and SDSU were already working with Google Earth, and offered to use that instead of Google maps, turning the sketchily and slowly drawn fire perimeters into quick and accurate processes.[12] In fact, while My Maps froze, Google Earth kept working. But, KPBS expressed concern that this would alienate some users who did not have the ability to run Google Earth on their computers (e-mail correspondences between SDSU, Google, and KPBS). They had to balance the need to provide information with the technological capabilities of their audience, two features that kept tending towards opposition.

[12] Google Earth, while somehwat similar to My Maps, was set up to compile data directly from GIS and the two platforms could not directly speak one to the other.

Part of the process involved in making the maps was to build the infrastructure. The map not only challenged the software capabilities but also pushed beyond their limits the physical network that links people to the data. As the servers failed, if they could not boost the capacity of what they had, they needed to reroute their data. Doing so either involved changing the URL, literally rerouting traffic with an electronic version of a railroad switch, or creating a proxy server, using the original server simply as a bouncer to a new server that was directly linked by a dedicated fiber (Visualization Specialist at SDSU 2011). Google tried the former. SDSU tried the latter. SDSU coordinated with Calit2 on UCSD's campus, an institution with which at least two members of the team from SDSU had affiliation, to host both SDSU's fire mapping and KPBS' website in order to increase both sites responsiveness (California Institute for Telecommunications and Information Technology 2007).

Much of what went into making this wildfire map had nothing to do with evaluating data. It revolved around managing software capabilities; specifically the ability to scale. One of the reasons why KPBS needed so many points on the map was because it was trying to be detailed as users zoomed in. This was already a difficult process when they were trying to trace lines from county maps and satellite imagery onto the My Map. These sources represented their data at regional scales that do not align with the capabilities of a Google map that allows users to zoom in to see their block. One of the map designers involved said:

> It was impossible to be totally accurate, because you could zoom all the way down to your house and say 'where's the line?' We were literally just slapping it in like finger paint because that's all we could do (Web Producer 2008).

This problem sparked a whole chain of questions in regards to how to map, because no one had tried to do it to such a degree with My Maps before (Google Engineer 2012).[13] Other than causing KPBS to use a different hosting site on Google, the software required conversion of the lines to a specific map projection, not the same as being used by the county or the satellite imagery, so tracing was not as simple as copying a line (GIS student at SDSU 2011). Google uses a relative of the Mercator Projection, which distorts the globe at the poles. But while it distorts the land at the poles when zoomed out, when zoomed in makes the roads on those same distorted lands meet at the same angles someone would experience if on the ground.[14] Drawing at the two different scales, regional or that of a block, required specific experience and knowledge in both wildfire mapping and geographic theory.

Savvy home computer users called not only to provide information but also to complain that, for instance, their house was shown on the map as within the fire perimeter when it was not. It was in trying to reconcile the scaling of the My Map with the data they were receiving that the mappers began to realize the inadequacy of their official data sources and technologies, and how these were at odds with the kinds of details they were getting from their users.

By incorporating users as data sources it also made them aware of another issue: if users could not figure out the map's user interface, they would not find the information they needed or be able to provide useful information. Since the platform

[13] Throughout my interview with the Google advertising engineer who came down to SDSU, he continually stated how each new change was triggered by the scaling SDSU and KPBS were trying to do.

[14] For example, roads that meet at a right angle on the ground continue to meet at a right angle in the map. (https://productforums.google.com/forum/#!topic/maps/A2ygEJ5eG-o)

has been designed for points in the tens rather than the thousands, the key bar was designed to be a simple list, each new pointed added to the bottom of the list. If the list were longer than a computer screen, then the user would have to scroll down the key bar to see the bottom (Geography Graduate Student at SDSU 2008). For this map that was trying to represent dynamic information, this meant the most recent updates were off the screen. Additionally, with a small number of points there is no need to organize information in any way, each point can stand as equal. But with the amount of data this team was working with they wanted to categorize the type of points to create a shorter list with sub-menus, or at least flip the order of the list from newest to oldest. This project ended up taking up much of the energy of the mappers and drove much of their interactions (ibid.).

Then there was pure coincidence. The SDSU team had the opportunity to collaborate with the director of Taiwan's satellite information distribution center, a former SDSU research fellow. He had access to data from the high resolution Taiwanese satellite FORMOSA that, because he had been at SDSU the previous summer, was still pointed at San Diego. According to the GIS specialist at SDSU (2008), when the Taiwanese scholar heard about the fires he started to send over data from that satellite that could be incorporated into their maps. Thus, SDSU had the only high resolution and recent satellite images from before the fires, which they were able to use to interpret the burn areas. SDSU also had already been working with NASA's Ikhana doing experiments in wildland fire monitoring and it was Google who processed the data from the plane (Visualization Specialist at SDSU 2011). Had this fire been anywhere else, even just Los Angeles and not San Diego, these sources of data would

likely have not been incorporated. Had KPBS not started a Google map, but chosen to work in another mapping system, the Ikhana data would not have been usable in Google's maps in the same way

The burning flames themselves were part of these interactions. For example, one reason these maps became so important to the fire officials is that the amount of smoke and the scattered nature of the fires made many traditional methods of surveillance, such as aerial photography from planes, impossible.[15] The Ikhana became of value not just because of the timing of the data (since the Google Map spent much time frozen or slow) but because it had newer technology that could see through the smoke in ways many of the actors here had never before seen (Visualization Specialist at SDSU 2011). Also, as the firefighters began to contain the fires and the weather shifted to bring in moist air to dampen the flames, the innovation and interactions stopped mid-step. Multiple interviewees were frustrated that much of the work never got incorporated because the threat dissipated. For example:

> By the time we got things set up for them, the fires had died down, things weren't being updated any more (Geography Graduate Student at SDSU 2008).
>
> But by the time everything was solved the fires were dying (Google Engineer 2012).

Some of details of the map that tied this group together never surfaced in the final product, including the redesigned key bar. As the immediacy of the disaster dissipated, so did the ties in the network. Without the flames, the map lost its value.

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[15] There were planes in the air gathering data on spectrums of light not impeded by the smoky blanket, but the data from these planes required a certain amount of processing time and provided the information more slowly than the map designers needed to keep up with the movement of the fires.

In the end, to make this wildfire map, the network expanded as the map designers began to collect information from citizens on the ground, geographers at their computers, as well as the first responders at the front lines to balance out the satellites and cameras in the air with the immediacy, detail, and limitations of the Google technology. Neither nature, the people doing the mapping, nor the technology alone could represent the wildfires on this map.

The Map as Distributed Expertise

These technological, institutional, and social interactions demonstrate that there was no single person, technology, or environmental factor that was in control of the mapping practice. Each node in the network had to look beyond how they would traditionally treat the fires as a phenomenon for representation or communication in order for the interactions and mapping practice to keep moving forward. Each actor made the others maneuver in relation to them. The mapping practice gained legitimacy because each element offered a solution to a problem of another actor; because each gained something from working together that they couldn't have working alone. Any description of the wildfires or the mapping practice grounded in political, technological, or social arrangements alone would be incomplete (Mitchell 2002).

The need to look beyond traditional boundaries of interaction and knowledge production in order to achieve one's goals can be seen throughout the production of this wildfire map. KPBS had the structure in place to acknowledge public needs but they did not have the technical skills to modify the map for those needs. Although KPBS initiated this particular map, the idea of a map as the proper tool for expressing and

making sense of San Diego wildfires had long since been practiced by geographers at SDSU, the County EOC, and first responders in the field. Though SDSU had their own maps, they neither had as large of an audience nor the server capacity to be a widespread communication tool and were looking for ways to connect to more popular mapping formats. Google was both interested in improving and promoting the mapping software for disaster response in general and saw reasons to work with these groups. The mapping technologies pushed back, with their conflicting scales of data, user patterns and expectations, and server needs. The infrastructure connecting people to technology also required rerouting of access and movement of data in response to how the map was being made and to how it was being used. The flames themselves constrained the mapping practice. Each made the designers move in unforeseen directions to find the greatest mapping potential.

The need to look beyond traditional boundaries can also be seen in the need to accommodate rather than modify different ideas of what it means to be connected to others within the group. While a government-based emergency response plan had strict rules about who to talk to, when and how, this group was making it up based on each node in the network. For example, for KPBS, to be connected prior to this map meant being physically plugged in:

> One day, for example, they came down here with their laptop. It turns out their laptops don't have network interface cards for wireless. Because they're in a building they plug everything in. So they came down here and we're trying to get them to get on the wireless here. And it doesn't work. And so we spent a couple hours trying to figure out why they can't get any of their laptops on the wireless. Everybody else can. And it turns out they're missing the card (Visualization Specialist at SDSU 2011).

They saved money when buying their computers at a time when wireless was just getting started by omitting the wireless card. They were already set up for wired connections and were continuing that trend until they had to take their work and walk it to a new building to share with someone else. For SDSU, being connected was about being able to make a phone call to get access to data or skills. They knew workers in the county so could gain access to their data (GIS student at SDSU 2011, GIS specialist at SDSU 2008). They were already working with people at NASA and Google so could get them working together to make the data from the Ikhana available (Visualization Specialist at SDSU 2011). They had contacts to call when they needed help with remote sensing interpretation or KML programming.

> I called [geography graduate student] because I worked with him before and I knew that he could do certain things… Yes, I had to, to reach this other student [another fellow student] to help me deal with the satellite image because he's a remote sensing guy so he would know more…. I didn't really have to kind of scout or ask everybody what they could do. I kind of knew who could do what and I put them to do the task that I needed (GIS student at SDSU 2011).

Google worked with a connectivity that was designed around a mix of onsite and long distance networking to bring into conversation local issues and internationally localized skill sets.

Moreover, the ad-hoc wildfire map had no central point through which the design process or network had to travel. This is demonstrated, in part, by my difficulty identifying potential interviewees – no single person stood out as the most important person. It is further evidenced by the nature of my communication with each person I contacted: each consistently told me to contact someone else they thought was just as or

more important to understanding the KPBS Google Maps, would not take credit for their work, or described how others were needed in order for the problems to be solved.

> It was like a war room. It was a very good experience, everybody came together and everybody was willing to work and collaborate and problem solve. No finger pointing….we worked around the clock almost…It was a very positive experience (Google Engineer 2012).

> And probably a lot of it is that people really realize they aren't an expert. Like the people at KPBS, they are not math people. They, but they're going, we're trying to do this and we may have done a crummy job to start with but it's an effort and then the Google people going let me help you. But they had the courage to start where no other station did (Visualization Specialist at SDSU 2011).

> [GIS student] was just talking with them, networking with people and he kind of got talking with KPBS…. I hadn't had a ton of experience, but there was a guy from Google there. It was more or less me, [GIS specialist] and a guy from Google just working (Geography Graduate Student at SDSU 2008).

> We were mapping to the best of our ability but to get someone with more technical ability…and more bodies, I was just trying to get more bodies. That's how I met [GIS specialist]. [Viz Lab] walked us up to the geography department and introduced us to him and [GIS student], who then ended up helping us to do the fire perimeters (Online News Editor 2008).

Each individual described themselves as just a gear in the machine; as a human being managed by a technology and an event, as a carrier of some knowledge, but not enough. What makes up knowledge of the wildfires cannot be placed in a single location.

Much literature in science and technology studies has explored how to follow such networks of interaction in order to understand how diverse actors – social, technological, and material -- come together to communicate across disciplinary boundaries, work for common goals, and share a common object of understanding (Latour 1987, Star and Griesemer 1989, Mitchell 2002, Turner 2006, Galison 1997, Mukerji 2009). Though the form these interactions take is far from agreed upon, these

scholars argue that a common goal underlies the interactions and any potential trust in the knowledge produced, even if the goal is understood and expressed differently by the various actors involved. Many of these theories, though, only account for one or two aspects of a given interaction, such as the space of exchange or shared object of understanding.[16] Communication scholar Fred Turner (2006) devises the concept of a network forum as a way to account for multiple aspects of networked interactions in a single model of knowledge production. A network forum is a situation in which members of different communities come together around a single goal to exchange ideas, synthesize new frameworks for knowledge production, and create forms of legitimacy that draw on each other's expertise. This is a process of interaction through which heterogeneity is preserved as each group maintains its own identity. It is a series of local moments of coordination in the middle of global differences. Most importantly, Turner argues, work within a network forum is not centered on creating individual ways of knowing; rather, work within the network is centered on imagining new technological possibilities and creating legitimacy for one's own contribution to the whole. It is not about what knowledge is produced, but what kinds of relationships can

[16] For instance, Star and Griesemer (1989) propose boundary objects to bridge different social worlds and help create working arrangements that satisfy needs of all groups at once, but focuses only on the plasticity and robustness of the shared objects of exchange rather than the practices and activity that produce and maintain them. Galison (1997)develops the concept of trading zones, another theory that looks at such networks of knowledge exchange. The concept of trading zones switches the focus from objects to the interactions that create transdisciplinary spaces where both communication and knowledge production are possible. In trading zones, terms from various fields are reframed for common exchange languages to be made. But the theory leaves unexplained how legitimacy emerges.

be leveraged in order to support the validity of that knowledge and the practices that produced it.

The network of interaction that formed around this wildfire map in response to the 2007 wildfires seems to be grounded in these types of exchanges, where creation and maintenance of validity was a greater focus than the resulting types of knowledge produced. For the designers at KPBS, their goal was to provide timely information to their audience in a familiar format. Describing the initial inspiration, one of the Online News Editors said, "What do people want to know: where is the fire. How will they know it: a map!" But to reach that goal the team quickly realized they needed more skills and knowledge than they had. In order for their map to be legitimate in the eyes of their audience, they needed the expertise of those around them. Being in the network made SDSU's work more publicly visible, advancing the goals of the GIS group to make the potentials of GIS mapping more prominent to the public and public officials. The GIS Specialist at SDSU (2008) stated,

> In general my goal is to make people, especially decision makers, understand the value of GIS so when they are making decisions in the future, like evacuations or relocation of fire fighters or resources, they can utilize those technologies, and the general public can access the same information as the decision makers.

Google hoped the modifications of their professional practices and the networking possibilities would help them gain greater popularity and get funding for future projects.[17]

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[17] Google has continued to design its maps to be usable in different crisis situations. They even produced multiple advertisements for the use of Google My Maps, with the wildfire map as their prime example. For example, see video: http://maps.google.com/help/maps/casestudies/video.html#kpbs.

> In 2007 we were eager to help but were not prepared. This actually got us prepared, helped Google understand what the limitations were (Google Engineer 2012).

For Google, the map was about technological innovation and promotion; what it represented did not matter, rather what was important was how it could represent in ways that work for large audiences. While the goals did not match, each fulfilled a gap in another group's goals.

But in the process of creating these relationships of legitimacy exchange, the individual actors came together for a common goal that became larger than the individual goals: to represent the wildfires disaster on a publically accessible map. What makes up the knowledge of the wildfires that emerged as a result of these representational practices, just like knowledge of any natural phenomenon, cannot be placed in a single location. Communication scholar Chandra Mukerji (2009) describes this as a kind of collaborative intelligence, as a form of distributed cognition. In distributed cognition, how we know the world around us is mapped onto the situated interactions – in the moment – between people, things, and their physical environment (Hutchins 1995). We cannot trace authoritative knowledge from beginning to end, in a single individual, or through an isolated aspect of social life (such as economic goals or political values). The value of any knowledge is to be found in the interactions between the groups that produce and use the knowledge not in the knowledge itself. Even claims to expertise stand at the intersection of all elements in these networks (Giere and Moffatt 2003). To put it another way, knowledge is always socially-technically distributed (Woolgar 1991) .

The Google wildfire map was not just a case of blurred boundaries or hybrid knowledges, but was a case of distributed expertise. Each group needed skills, practices, and data potentials from the others to make the map work. No one type of knowledge, no one community's conception of appropriate data, made it possible to represent the fires on this single map. As a result of the collaborations needed for the practice of representation, the map's power as a relevant representation of the disaster came from the social and technological engagements – the practice of mapping and its event-based structure. The legitimacy of any knowledge that emerged was grounded in the relationship between actors as they actively negotiated their individual ways of knowing to represent the object of knowledge. It had less to do with what the data was or where it came from than how it was part of the interactions.

Imagining the Next Wildfire

How the distributed expertise that emerged with the network that formed to represent the 2007 wildfires will shape the way the next big wildfire is imagined and understood to unfold. In other words, the production of the map produced new kinds of politics, rationalities, and social interactions, which in turn produce the next response. These imaginings can include future potential in the form of new technologies, new networks of interaction, and new needs for response.

For instance, until the 2003 wildfires – the largest wildfires in Southern California prior to the 2007 wildfires – fires, in general, were understood as either threats to wildlands or urban spaces as opposed to spaces of human-nature interaction. According to the GIS specialist at SDSU interviewed (2008), as a result of this

understanding, during the early days of the 2003 wildfires San Diego County's GIS practitioners were sent home; they were seen as non-essential personnel in combating the wildfires. However, the 2003 blazes exposed how wildfire behavior and response is inseparable from the interplay of environmental and social conditions (County of San Diego Office of Emergency Services 2004). The GIS Specialist noted that after the local government saw the value of maps created by a group of GIS volunteers in 2003 for rescue workers and news media, the government changed its policies to include GIS technicians, and the practice of mapping, as equally vital to wildfire response as other emergency staff. The practices in relation to the 2003 wildfires produced a new way of imagining wildfires in San Diego, an image that for the wildfires of 2007 put the flames in conversation with more than just potential fuel, but also city roads and urban planning practices.

New imaginations of the next wildfire and response can also be seen as a result of the connections and exchanges made during the production of the 2007 Google wildfire map. Throughout the interviews, the designers of the map were imagining ways to maintain, rebuild, and expand their ad-hoc interactions for the future. For example:

> There's a lot of networking and infrastructure related things that need to be set in place and worked through before hand, preparation for something like this, in order to make it to work well (Geography Graduate Student at SDSU 2008).

> I think our ideal world situation would be we don't have to create the map. There would be a mash-up where each agency responsible for shelters, roads, fires would be updating one central map and that would be available to the public (Online News Editor 2008).

> I'd love to have a more wiki-ish discussion board, where you don't have to go through so much to post the information, where the user doesn't have to go through us (Web Developer 2008).

> Most of the exchange of data was going through mailing lists or lists of people through emails. And there were a lot of troubles with like big files and not everybody being included on the list. So having a place online where you could put the files was really like I guess it was real important at that moment (GIS student at SDSU 2011).

> I felt that we built that between EOC, us and other actors, we kind of built this new set of procedures and lesson learned that we, they eventually implemented in the future and I implemented later in Europe (GIS student at SDSU 2011).

> Two of the guys involved went on to work on disaster response for Google, turning this into a larger career project for Google (Google Engineer 2012).

None of these potentials were seen in previous arrangements of actors during earlier fires, nor would they necessarily have made sense in the context of the earlier events. Each new arrangement makes possible new practices of mapping and new forms of knowledge valuation. Fire response and representation is now imagined by these actors as linkages in distributed networks rather than actions grounded in a central base**.**

Sometimes, though, these imaginings can be so powerful as to gain equal or greater legitimacy as actual experience. MacKenzie (1990) found that people often defend the imaginings of a technological potential as the most credible way of knowing a natural phenomenon. The ad-hoc network designing the wildfire map found that such imaginings, in part, shaped their mapping practices. Users, based on previous experience with Google maps, were imagining the ability to represent wildfires to the scale of a meter, since that is the case for general Google maps. The designers found that users had "an expectation of accuracy that even the county wouldn't necessarily be able to maintain" (Online News Editor 2008). One of the designers noted when discussing users zooming in, "we wrote it in, if you clicked it, *estimated* fire perimeter

or *estimated* evacuation zone. But people's reactions were to the visual information" (Geography Graduate Student at SDSU 2008, emphasis added). In this case, the test of accuracy had nothing to do with how the data was gathered, where it came from, or how scientific the process was determined to be. It had to do with what the users imagined the technological potential to be, how they imagined the visual connected to the world outside of the image on their screen. These imaginations of potential, in turn, become part of the interactions that shape the legitimacy of a given representational practice.

The relationship between the networks of practice and the future imaginations of that practice is important to consider when determining what kind of expertise is needed for response to a disaster. How we even imagine expertise to exist influences how we look for and evaluate the resulting knowledge and practices. For example, according to environmental studies scholar Rajan (2001), any disaster is missing expertise when the production of risk is not counter-balanced by a centralized set of expertise to understand or mitigate the risk. Missing expertise, he argues, results when the unknowns outweigh those who have the power to know; it results when society is missing the priorities to build appropriate expertise. To identify such gaps in knowledge production, Rajan looks at the social structure in place in a given society. He argues that in risky situations, what is missing is often an infrastructure to effectively respond to a disaster. If expertise and knowledge are imagined as static, then holes can be found.

But if imagined as active, holes and their solutions are harder to pinpoint. To see failure – a gap, something missing, something gone wrong – is to focus on and critique standards and abstractions of practices (Michael 2014). If knowledge production is treated as distributed over an emergent infrastructure of material and social interactions

and not prior to a given disaster, then missing expertise means missing links in the network of practice that forms in response to that disaster. Treating expertise as distributed means seeing a given expertise that materialized to identify and address problems that would have otherwise gone without solution as "a concentration and reorganization of knowledge rather than an introduction of expertise where none had been in use before" (Mitchell 2002, 41). With this in mind, if the networks arise only during disasters, then what is expertise exists only at specific moments and during specific formation around specific events and technology. What is missing changes each time any elements of the network or representational practice change, including the imagined potentials and the disaster itself.

The kind of network that came into existence for the wildfire map is not one that could have been positioned before hand by looking at the structure of society. The type of network seen here can often exist in the background, invisible, in the everyday practices before or after the event. Moreover, the network was ad-hoc and fleeting; this exact form of distributed expertise is not guaranteed to come into fruition in the same way during the next disaster. New representational and communication technologies could emerge along with new ways of engaging with old technologies. Different practices of data gathering could gain authority. Expectations, audience, city infrastructure, urban planning, and fuel maintenance practices could all change. Furthermore, wildfire behavior is not well modeled and the potential risks are not well understood, leading to more unknowns in the network (Bowman et al. 2009). The present structure of interaction, and thus present links, cannot be expected to hold for the future. In order to account for these future potentials, present planning needs to

accommodate the ad-hoc and sometimes fleeting nature of this mapping practice. Imagining what it means to know the next wildfire, in part, means imagining the next shape the practice of mapping will take.

Planning, Standards, and Risk In Light of Constant Change

An intimate relationship exists between expertise and risk and plans. Expertise is tied directly to imaginations of future disasters (Knowles 2011). This imagination is not just what form the threat takes, but who is involved and what issues are considered pressing. From these imaginations emerge plans – within them standards for action – as well as what is deemed at risk. But, as Knowles documents, this is a slow, consensus driven process that often leads to broad-based conclusions. The need for immediate information often conflicts with this traditional development of disaster expertise. This traditional formulation, Knowles suggests, is not so helpful for making decisions in the moment or for accommodating for local contingencies by local responders, policy makers, or the public. What, though, does this type of distributed expertise and imaginings mean for disaster planning? How is it possible to design standards of practice or develop conception of risk management? How do you identify what might need to be planned for and known if part of the expertise to manage it comes in the moment?

Typical disaster planning, based in government response, is built around two things: learning from previous responses and creating new protocols for future disasters, both similar and unknown. These lead to the writing of documents (such as after action reports, standards of protocol, or communication plans) that spell out how different

agencies involved in a disaster response engage internally, with each other, and with non-governmental organizations like religious groups or private businesses that provide aid resources. These documents form the basis for training and exercises and shape the expected practice for the next time around.

For example, prior to the 2007 wildfires, the San Diego communication plan (Office of State and Local Government Coordination and Preparedness. U.S Department of Homeland Security 2006) emphasized the importance of uniform response protocols between agencies and all scales of response. This included when specific communication channels and gateways should be used, how chains of command proceed with phone calls, how data is shared and stored, what technologies are used to make sure they are compatible. The plans proposed a movement towards the federal Incident Command System (ICS) to encourage shared meaning in language and a common understanding of action. The California State communication plan published immediately after the fires (California Department of Forestry and Fire Protection, United States Forest Service, and The Governor's Office of Emergency Services 2008) states that each scale of plan should not stand to replace any other and should not take precedence over each other, but that they each remain as separate documents. It acknowledges that any maintenance of a plan requires not just procedures but an ongoing awareness of technology in different regions and agencies, but wants a statewide standard.

The 2007 wildfire after action reports from the city of San Diego stated that new standards are required as a result of the slow-down of data sharing on the county servers because of the number of people trying to access the maps. The recommendation was to

"develop a Standard Operating Procedure (SOP) to train and instruct GIS technicians regarding potential computer network conditions to ensure continual mapping support" (City of San Diego 2007, 39). Instead of writing flexibility into the system, these plans and reports encouraged shared procedures, predefined problem solving, and expectations for a common dictionary of terms and data interpretation (Harrald and Jefferson 2007). Overall, the aim of inter-agency and inter-group communication is to create a shared situational awareness. This is the ability to be aware of one's surrounding situation with an understanding of the relative importance of each element of that situation.[18] The picture is dynamic and what information is required to create it depends on decision-making goals.

The problem with standards is that no two institutions have the same ones. This is partly because no two groups need to make the same decisions when it comes to their roles in disaster response. When the situation calls for coordinated action between institutions, the result is not conflicting standards but also different understandings of what constitutes the 'same' action. 'Sameness', in this respect, is grounded in individual goals and plans rather than universal standards (Suchman 2007). Such discord becomes exaggerated when part of a wildfire falls under state jurisdiction, the state brings in its own teams, teams that typically come from outside of the region.

> So they'd fly in this management team once the fire was going, from Washington State they'd fly them in, drop them in, okay. You're managing the fire. And they do a great job but the only thing they're missing is they don't know the terrain. They don't have the experience that a local firefighter would. So they're trying to maybe eventually fill

[18] This is an idea taken from the military that has increasingly infiltrated not just US disaster planning but international disaster planning (Harrald and Jefferson 2007, Wood et al. 2012).

> that gap a little bit. That local knowledge plus the experience of being on these giant management teams (Field Fire Mapper 2012).

Not only do these teams work with different standards for wildfire fighting (and thus what data is relevant and how to gather that data), but they also come with different cultures of relating to the land. What could be assumed common knowledge for a San Diegan can't be for a firefighter from Oregon. The Visualization Specialist at SDSU (2011) described the end result like this:

> Because people are going you know the joke about the great part of standards is there is so many of them. Means that there are no standards.

Standards are enacted differently from place to place, group to group, person to person. These actors are acknowledging what Suchman (2007) argues: a collection of procedures does not equal intelligence or expertise.

Instructions have meaning through interaction, not through clear writing. It is in practice that these documents get legitimated and become knowledge and together, in specific social and material situations form expertise. To maintain an idea of distributed expertise requires building situated action into standard knowledge and plans. Situated action is the idea that every course of action depends on the material and social circumstances (Suchman 2007). The consequence of the idea of situated action, according to Suchman, is that interaction and communication must have both a sensitivity to local circumstances and resources to problem solve, which involves some level of prediction of needs. In part, this is what made the ad-hoc network that formed around the My Map so successful at claiming authority. Their work was grounded in both flexibility and imagination, balancing the specifics of the wildfires and the technology at hand with the standards for data sharing and infrastructure management.

They grounded their decisions about how to communicate about the disaster with each other and the public in the resources available.

However, this does not stand in opposition to standards, plans, nor abstract structures used to guide future action. Rather, structure is a product of situated action not a foundation for it. Successful interactions around plans, standards, protocols, and official terminology, treat them not as blueprints for action but resources for situated action (Wood, Büscher, and Ramirez 2012). They are a balance of improvisation and automation. Design work, be it technological or procedural, should be located – physically, temporally, and within a network of interaction – and treated as always partial (Suchman 2002). A collaborative or shared system of meaning making is not about isolated packages that happen to talk together but about the production of new forms of material practice.

No single expert category or technological practice can define and manage all risk, be it scientific or applied, public or private. Knowles (2011) argues that this is in part because expertise in disasters is more like a consensus, grounded in contentious agreements about what should be and how it should be protected. Each time a new actor or group is introduced to the consensus process, the goals of mitigating disasters change. For example, the incorporation of urban planners brought into the conversation about fire mitigation things like order, light, clean water, and transportation to what had previously been about architectural structures and ecosystems. In addition, different actors are involved in different phases of the response. The City of San Diego acknowledged this in the after action report for the 2007 wildfires, stating:

"The complex system of resourcing, planning, training, exercising,

> outreach and coordination with local governments and nongovernmental organizations, tribal, state and Federal agencies must be constantly nurtured, updated, maintained, adjusted and practiced. The realization must be accepted that because of its location the City of San Diego will be on its own for the first 48 to 72 hours of a catastrophic event and therefore must be self-reliant and self-sufficient" (City of San Diego 2007, 3).

It is not about 'who' determines if data is relevant or meaningful but how the distributed system selects these qualities. Moreover, any planning needs to account for new skills and expectations that emerge within the public from the introduction and inclusion of new technologies and the related "cartographic literacy" (Liu and Palen 2010, 88). When both government agencies and the public were included in these interactions, planning had to balance technical and social expertise, two features which worked together to form the basis of risk (Zeiderman 2012). However rudimentary in form, it created a participatory approach which, according to Jasanoff (2010), grasps risks in a way that expert managers cannot see, what she terms "expert governance" rather than "expert management" (36). This form of interaction acknowledges the government's relationship with the public in a democratic society rather than one of a manager in an organization. A manager works from top-down as they act in charge of a system while democratic society functions from bottom-up, drawing its strength by "aggregating communal knowledge and experience" (ibid., 30). This switches the problem of shared information from one of standard goals and definitions, where bias becomes the contextual problem, to one of ensuring consistency, integration, and accommodation in the situation.

Coordination between agencies is emergent within an event and depends on the ability to flexibly assemble, through improvisation, people, technology, and resources

(Wood, Büscher, and Ramirez 2012). Technologies, on the one hand, open up collaborative potentials by linking together people and technologies over physical distances and offering a common place to store information (rather than a bunch of post-it notes covering a walls in different rooms). But these same technologies can shut down other vital parts of this collaboration. Standards technological practices often erase the social from these interactions, introducing new barriers to the interactions. What are the most efficient technologies and tools for a situation emerges from the event, from the situation and the collaborative acts around them (Pettersson, Randall, and Helgeson 2004). Technologies cannot and should not be designed to replicate these emergent properties but can be used to provide solutions in terms of "time, ambiguities encountered and resolved, resources used" (ibid., 151).

However, a side effect of increased variety of actors and sources for making sense of a disaster makes it harder and harder to define and predict what the threats are and where the risks are located. The problems of the potential disaster became increasingly harder to define, in turn making it harder to determine whose responsibility it is to identify and respond to risks and whose voices should be listened to. This is partly because each expert group looks at a different aspect, and is able to test for different aspects of a given risk. One looks at the human aspects, another at the natural aspects, another at the technological or structural aspects. Consequently, Knowles argues that turning expertise from knowledge to action requires innovative organization forms, forms that usually cross and redraw disciplinary and scalar boundaries.

Conclusion

The problem of mapping the 2007 wildfires to provide information for journalists, rescue workers, and the public turned out to be much more than the problem of geographically representing the position of flames or evacuation zones. The practice of mapping required negotiations between diverse actors, technologies, infrastructures, and the physical environment. As part of this practice, each actor had to expand their definitions, priorities, and expectations, working outside of their conventional way of engaging with the world around them for representation and communication. The representational practice could not rely on a single type of knowledge or technological practice in order to maintain its legitimacy. Just like the fires, the collaborative and situated work needed for the practice of representation was dynamic and continuously evolved as the situation required.

The distributed network that formed around the production of the wildfire map only came to fruition during the event and will likely never be manifested the same way twice. The links that did exist prior to the wildfires are the kinds that are easily overlooked when only the large structures of society, culture, and power are examined. But it is through these links, through the interactions across boundaries that knowledge emerged and the claims they made became accepted as legitimate. Each element involved, including the flames themselves, shaped the communication needs and solutions. Yet, the wildfire map that was produced in the 2007 San Diego wildfires was greater than any individual actor could produce alone.

Looking at any individual element of the network – the fires, the technology of representation, the map designers – cannot explain the authority and expertise the map

came to represent. Rather, the affinities and interactions of those involved exceed the grasp of any one entity involved. The actors did not look for any particular kind of knowledge, but focused instead of the relationships possible that support the validity of that knowledge. In the process, the practice of representing the 2007 wildfires produced more than a new kind of map; it produced new expectations of what is knowable, new notions of disaster preparedness, new forms of legitimation, and new techniques for representing disaster. Through ad hoc interactions, the map's many builders harnessed a powerful but fleeting distributed expertise that was only partially materialized in the map they created.

The practice of representing any given disaster is in part predictive. Present practice is shaped by future imagination and future imagination draws on present practice. Examining the production of a map during disaster revealed some of the cultural imaginaries that shape wildfire response. It also highlighted how the 2007 wildfire mapping and response was contingent upon the imagined futures emerging from the previous wildfires. The distributed nature of the expertise produced through the practice of mapping is bound neither to space nor time. These imaginations, past and present, are equally folded into present and future practice.

Tracing expertise in this way requires a different sort of planning and risk analysis that acknowledges the distributed nature of how we come to know the world. It means looking at disasters not as events that are outside of the norms of society, but that exist within a given society's daily practice and cultural history. This way of thinking about disasters introduces new tensions to the norms of wildfire mapping and response by offering an alternative to official pathways, as well as both technical and lay

conceptions of data. It challenges how we identify expertise and what it means to produce a legitimate representation.

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CHAPTER 4
Mapping Disasters In/Over/Through Time

Introduction

In my final chapter, I examine how the concept of time is built into the practice of participatory disaster mapping. No disaster is bound to just the immediacy of the hazard nor to a single understanding of time, and so no map of a disaster has meaning just within those moments. To understand how this broader temporal perspective was constituent of the mapmaking practice during the 2007 wildfires, this chapter tries to put time back into the mapped space. Ingold (2007, 102) argues that the formation of knowledge cannot be entirely detached from the dynamics of movement. To understand the role of that movement--of time--in the production of knowledge about a space under duress, this chapter turns explores how to map a disaster in, over, and through time.

Which temporal scales get highlighted and foregrounded in the production of disaster maps affect priorities and strategies for compiling and managing information. But, when there are multiple different voices being brought together into a single map, how do the different understandings of temporality interplay in how the disaster gets understood? Chapter 2 demonstrated that the temporality (looking in-the-moment or looking forward) built into the individual disaster map shaped not only the possible definitions of accuracy and uncertainty that emerged but the potential uses of the maps in making sense of the disaster. Chapter 3 pointed to how time and urgency affected the shape the networks took when making disaster maps, again affecting the knowledge produced as well as conceptions of expertise and risk. But so far these explorations of time have been comparative, looking at how each map took on a specific sense of

disaster time and its effects. Since no disaster exists only as an isolated point on a timeline, this chapter turns to how these temporalities affect each other in the design and use of disaster mapping practices and the resulting knowledge produced to better understand how their interplay shaped the mapping that took place in 2007.

Specifically, this chapter examines the production and deployment of a present day disaster mapping system by the San Diego Red Cross (SDARC) that was directly inspired by the ad-hoc map and informational needs from the 2007 wildfires. But temporality is not something for which someone can be a spectator, only a participant (Ingold 2000, 196). Focusing ethnographically on these practices highlights how engagements with the world are what make a space relevant and meaningful. In this light, to experience firsthand what goes into making these disaster maps and to see the tacit and improvised actions that make up the practice of mapping, this chapter draws on two years of participant observation of disaster mapping. During this time, I was one of the volunteer mappers and information analysts at the SDARC, mapping during real and mock disasters, attending planning meetings, and observing people within SDARC's network working with the technology.

In order to look at the relationship between time and space in disaster mapping, I begin by examining the role of time in how a disaster becomes knowable in general. After explaining how the mapping platform works I examine how it tries to establish a new spatial practice in four specific ways. First I look at how this mapping practice evokes the maps from the 2007 wildfires and their effect on the imaginative potentials of this new system. Then, I examine the role plans play in the temporalities inscribed in the mapping practice. I continue by exploring how exercises using simulated disasters

structure specific practices that carry through and shape the temporal expectations during real disasters. Last, I take up cases of mapping with this platform during actual wildfires and disasters to see how the socio-technological networks push back on the temporal expectations that were built into the practice.

I find that when multiple temporalities inter-mesh during the mapping practice, at times the mappers used imaginary and anticipatory structures to manage the temporalities. At other times the technical and social practices needed to bring the information together overshadowed the temporalities and their individual importance. The end result was the condensing of time into beats, into individual moments and nodes in time, instead of a meshwork of flows over time (Ingold 2007). The result established a form of knowledge production that placed disasters in a temporal structure that, while larger than the immediate moment, could be spotty and selective in ways that limited how the environment and effects of the hazard could be known. In exchange, though, a dynamism resulted from the interactions of the discordant temporalities, one that made the mapmakers aware of the instability and mutability of space facing disaster, creating a sense of movement and change vital to the knowledge of space but difficult to capture in a static map.

The Importance of Time in Making Sense of Disasters

The temporality of disasters and crises has been well established as an important issue. Time is one way that actors involved with the disaster structure and make sense of the situation as it unfolds (Bergmann, Egner, and Wulf 2012). The temporal patterns help define the elements that get made the focus of these experiences (Lefebvre and

Régulier 1999). But each temporality enables a different spatial practice offering a different picture of the disaster (Lefebvre 1991). Disasters do not have a single time over which to change or in which to be up-to-date. For example, there is the immediacy of victim needs, the future expectations that inform present practices, and the look to historical experiences for insight into the affected space. Some of the mapped information changes every fifteen minutes while other data changes over weeks or even months. Even the first 24 hours is marked by a different set of needs relative to the following 48 hours, which involve more analysis and prediction. No disaster has easily defined ends to turn into a clear case study – no disaster exists in isolation from the ones that come before or after, as the past and potential futures help structure present understanding. Immediacy of the moment, historical cycles, and everyday patterns of life are all temporal rhythms within which the space of the disaster comes to life.

Which timescales are or are not included in the political considerations of causes and effects of a disaster have a direct effect on how assistance is distributed, who or what gets blamed, and what is considered a loss (Fortun 2000, Frickel 2008, Clancey 2006). Different cultural, class, and gendered understandings of what recovery and normal life look like suggest different timelines for disaster management (Superstorm Research Lab 2013, Ruwanpura 2008). Scholars examining climate change and health pandemics as a long-term crises discuss how such issues require different media practices than more immediate and visible disasters, like hurricanes or wildfires (Cartwright 2013, Sachsman 1996). These studies suggest that different time frames are made more or less visible through different representational practices. Overall, the time frames involved in any given disaster response are prioritized based on who holds

power or authority. Only by using these relative terms can a normative time scale exist for any given disasters. This chapter extends these lines of research to ask not just why there are differences or the effects of each individual temporality, but how such competing temporal representations of disaster interplay.

Just as importantly, much of what is understood about a disaster comes prior to the actual disaster – based in memory and anticipation. In looking to what might be next, disaster planners are trying to get at what needs to be done to alleviate the impact of these inevitable, but in a not entirely predictable, occurrences (Lakoff 2008). This anticipation can be in the form of extrapolations and calculations drawn from historical experience or cultural imaginaries used to stand in for the relevant qualities of unknown potential futures (Weart 2012, Lakoff 2008, Masco 2008). As we enact these memories and anticipations we do what Fortun (2000) terms "anteriorizing the future" (189).[1] These enactments are point to a unique problem of preparedness: building a system that can last and resist but remain relevant over time and through change (Tironi 2014). However, doing so shifts attention away from actual disasters to what happens before them, decoupling the preparedness from the events, focusing any analysis on the imagination of a disaster and the consequences assumed by those doing the imagining--not the actual disasters (Weszkalnys 2014). The measure for developing and enacting

[1] Fortun (2000) writes: "Tracking the ways historical perspective is built into law, policy, bureaucratic initiative, civic action and commercial endeavor was an important part of the project. Most important was the effort to understand how response to the Bhopal disaster has anteriorized the future – through legal precedents and the structure of rehabilitation schemes, but also more subtly by establishing what counts as adequate description, explanation and social response in the wake of disaster, and determining how the past should be encountered" (189). The definition of justice and rehabilitation for the Bhopal disaster, about which she writes, was based on a specific way of thinking about health as a medical problem rather than health as a social problem within a larger network of interaction.

any spatial practice in the present emerges in part from time outside of the majority of action during a disaster.

New media and communication technologies bring to the fore questions about the relationship between time and space. How temporality is interconnected with knowledge of disasters becomes increasingly pertinent with the introduction of new digital communication technologies, like participatory disaster mapping platforms, that are used to gather and share information over physical distances and boundaries. Some scholars initially lamented the loss of time from space because of the result of such digital technologies (Bauman 2000, Castells 2000). These arguments claimed that global logics and flows of sharing information overpowered local senses of place, standardizing and generalizing space into a single, timeless whole.[2] They argue that where routines once tied space to time, now new technologies have made this connection irrelevant. From these perspectives, what were once many individual affairs become collective ones, changing what practices define the little space there is. However, these arguments only serve as reminders of the value of looking for how time does exist in the spatial practices in relation to these technologies (Massey 2005).

As new technologies get incorporated into everyday practices, spatial practices take new forms. They are no longer limited to bound places but can found in the networks and flows (Massey 2005, Hajer and Reijndorp 2001, Moores 2004). If space is thought of as bounded physically, time will disappear from theory. If space is thought of as produced through practices and rhythms, time will appear as flexible and multiple,

[2] Bauman (2000) writes, "in the software universe, space may be traversed, literally, in 'no time'; the difference between 'far away' and 'down here' is cancelled. And so space counts little, or does not count at all" (177).

made up of experiences (emphasis on the layered plural) not objects on a map (Lefebvre and Régulier 1999).[3] Any understanding of speed and scale is contingent upon the rhythms in question (Adey 2006, MacKenzie 2002). Only in these relative terms can a normative time scale exist for disasters, a recovery cycle, or a social process. In the previous chapters, zooming in spatially revealed different types of risks and threats in relation to the wildfires. In this chapter, zooming in temporally introduces a new set of issues and lines that have to be negotiated when drawing a shared picture of a disaster.

Immediacy of the moment, historical cycles, future expectations, and everyday patterns of life are all temporal rhythms within which the space of the disaster comes to life, and all come to head in the San Diego Red Cross's disaster mapping platform. To examine how these multiple temporalities are merged in the design and use of maps on this platform requires looking past the maps, archived documents, and interviews. Understanding how time structures knowledge of disasters requires looking in situ (Bergmann et al. 2012).[4]

While gestures, words, drawings, and exclamations help define the overall spaces, thereby setting the stage for the definition, legitimation, and communication of objects of knowledge in relation to that space, these modes of communication and representation simultaneously abstract that space (Barthes 1983). As de Certeau (1984)

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[3] Considering only categories of analysis instead of practices merely reifies the categories rather than acknowledging new practices of space-making or how old practice continue but play out in different physical places.

[4] As visual representations are made and made sense of, they are situated in histories and socio-technical networks. They are bound to assemblages of technologies, bodies, and everyday practices (Alač 2008, Lynch 1994). How temporality is incorporated into the digital maps, then, is also to be found in these assemblages. Observations are organized through these situated interactions such that meaning is possible (Suchman 2000, Alač 2011).

has argued, it is not possible to visualize agency or tactics, only strategies and generalities that flatten the multivalent nature of experiencing and producing space.[5] Instead, examining the practices that surround the maps ethnographically--the doing not just the seeing--makes it possible to observe the relationship between actions within a space, cultural expectations, and the use of visual technologies in the production of meaning (Alač 2008, Vertesi 2008, Brown and Perry 2001, Goodwin 1995).[6] Only in these traditions of extrapolation can temporal and spatial wholes be made from the parts presented in the maps (Ingold 2007). By examining the rhythms of action it becomes possible to see the fluid interplay between old and new, repetitiveness and novelty, that exist in everyday routines and form the basis for spatial knowledge production (Lefebvre and Régulier 1999, Lefebvre 2004, Kitchin and Dodge 2007).

Mapping After the 2007 Wildfires

The San Diego Red Cross (SDARC) was entangled with many of the information and communication networks during the 2007 wildfires. Drawing inspiration from successful ad-hoc mapping during the 2007 wildfires and the failures they saw in 2003 during hurricane Katrina because of a lack of shared picture, the SDARC has begun to design and implement a participatory-style disaster mapping

[5] de Certeau (1984) writes, "It is true that the operations of walking on can be traced on city maps in such a way as to transcribe their paths (here well-trodden, there very faint) and their trajectories (going this way and not that). But these thick or thin curves only refer, like words, to the absence of what has passed by" (97). This form of representational tracing misses the acts themselves, making singular a polyvalent space; it makes invisible the operations that made it possible.

[6] These methods follow the tradition of laboratory studies in Science and Technology Studies, where researchers observed scientists in action in their labs to understand how practice became inscription and scientific fact (Latour and Woolgar 1979, Knorr-Cetina 1981).

system based in Google Maps and ArcGIS. This map draws on many of the features from the 2007 ad-hoc map, including many imagined individually but never fully brought to fruition. It has an organized key bar with sub-menus. It acts as an archive and data wiki to store regional information that is gathered between hazards, but is useful during disaster response. It automates and tries to make routine inter-agency data exchange (Figures 4.1 and 4.2).

The SDARC's mapping system intends to produce what they call 'actionable information' and a shared picture of the event called the 'common operating picture'. It combines information from volunteers in the field, the news media, the county/city emergency offices, private utilities and corporations, public and government agencies, and the affected public. In a room known as The Chapter Disaster Operating Center (CDOC) the map is used to: document what is known at present, record historical data (volunteer homes, evacuation centers, past food sources), aid informal prediction (what needs to be prepared for two days out), and inform real-time action. By aligning information and technologies, the use of the map aims to coordinate the people behind the information through a (assumed) shared understanding of the constantly changing situation (Hinrich et al. 2013). The systems is partly automated, collecting layers and information from other institutions, and partly incident specific, relying on a mix of volunteers with diverse levels of training in mapping and information analysis.

In 2007, one of the major issues that appeared in both the archival and interview data was the time it took to align data, automatically putting the maps at a temporal disadvantage with respect to the changing wildfire situation. Since 2007, however, some compatibility has been worked out between ArcGIS and Google alleviating this major

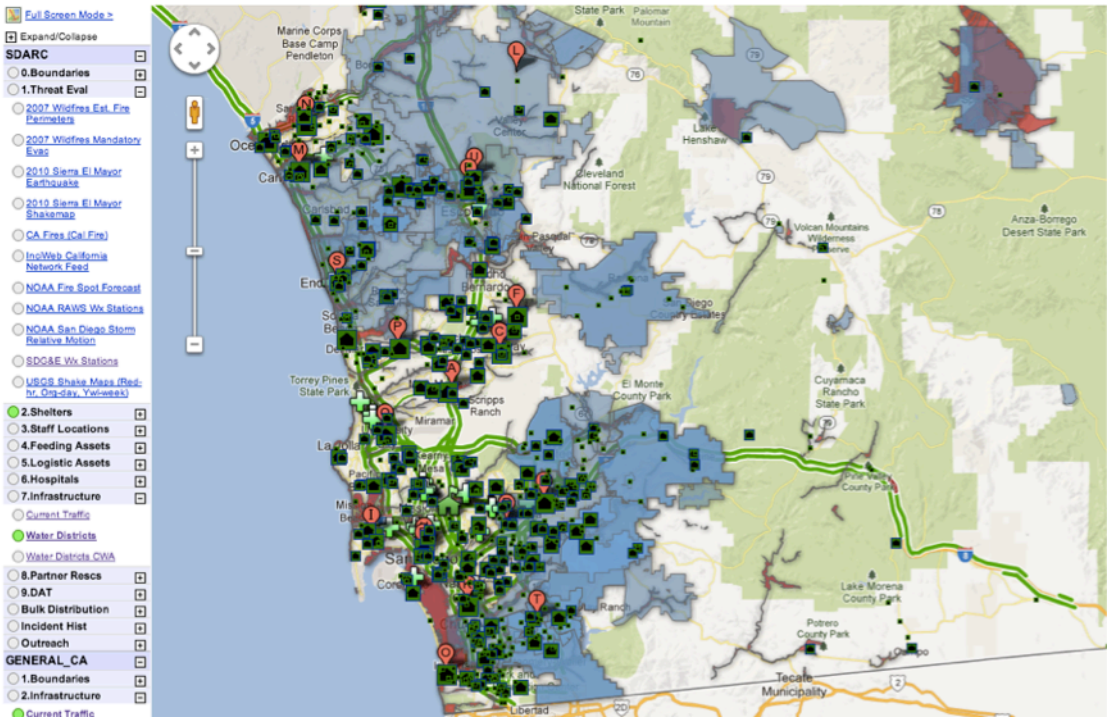

Figure 4.1. Screenshot of the San Diego Red Cross Mapping System, with many active layers displayed. Source SDARC. Copyright permissions granted.

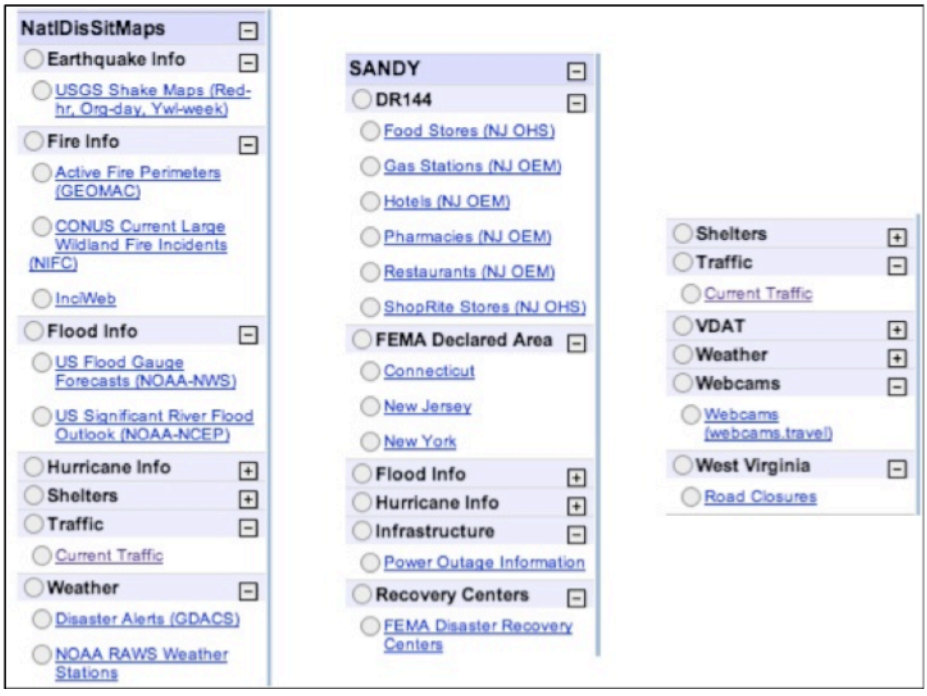

Figure 4.2. The menu showing the different layers and sources built into the mapping system. Source: SDARC. Copyright permissions granted.

data sharing and management problem. More importantly, SDARC has been designing their mapping system to be able to handle various different data forms as they create data partnerships in advance. When they set out to design the system, SDARC, with the help of a consulting group, started with widgets from iGoogle, combined them with Google's beta Fusion Tables (a geocoding spreadsheet program) and Google's My Places. Using My Places makes it possible to draw by hand while using Fusion Tables makes it possible to have the system translate verbal and written information into mappable objects rather than relying on individual mappers to do that translation. In addition, they designed this in such a way that remains ArcGIS compatible so that GIS layers can be imported rather than traced. This way, the software itself is already designed to encourage the data networking and consistency required in a disaster mapping practice. As a whole, the SDARC is attempting to design a system that does not rely on local or contingent interactions, but can create a network like the one from 2007 in any place at any time with minimal work once a disaster strikes.

The mapmakers are expected to learn the basics of the software through group classes and online training. Much of the training takes place by participating in either large-scale exercises or small-scale real-time responses. While the training primarily focuses on the skills required to draw items on the map, SDARC also realizes that there needs to be some level of information analysis training that goes along with the mapping practice. However, this is a feature that is being actively developed, as there is still an internal debate over how much analysis should be done by the mappers in relation to how much mapping should be done.

Developing Everyday Spatial Practice and the Exceptional Disaster

By connecting all the potential data sources socially and technologically, the Red Cross is attempting to produce a spatial practice. Spatial practices, as proposed by Lefebvre (1991), are the spatial patterns of everyday life that reinforce routine and encourage normalization that are crucial for social cohesion. They are where individual action and shared purpose meet in the form of organized and regular activity.[7] This requires incorporating the map into daily routine in a way that structures daily activities (or produces a structure within the daily activities). But practice is not just about regular phone calls or learning to use a technological system. Practice is a system that structures your daily activities or a structure that emerges from your daily activities rather than something that is only organized for a special occasion. While disasters are never outside of the given social structure, they are also not everyday occurrences. They force people to act on the exceptional as they try to bring life back into a routine, quite often a routine that is modified and has new meaning from prior to the disaster (Michael 2014). Built into disaster maps is a need to reconcile these two issues: the exceptional nature of disasters and the everyday patterns required for the production of a spatial practice. Looking from either rhythmic perspective suggests different objects and elements to prioritize in the map and in management practices (Adey 2006). These patterns are (both temporally and in practice) tangential rather than oppositional (Michael 2014). Figuring out how to bring them into the everyday can require some creativity and planning.

[7] Spatial practices emphasize agency yet objectifies these subjective spaces in the material structure of a given space, turning daily regimen into ideological practices.

Mapping Over Time, Connecting Past to Future

Since the 2007 fires in San Diego, new mapping forms similar to the ad-hoc map have become increasingly prominent throughout disaster response and communication in San Diego. This follows an international trend to include maps as part of the disaster communication toolset. Locally, geographers at San Diego State University have continued to explore new ways of combining GIS data with other, more publically available maps. They also have taken the lead in conducting regional and global disaster response exercises that test and sustain technological networks (e.g. X24, www.inrelief.org). Google, listing the 2007 California wildfires as their second ever crisis response—the first in the list since continually providing mapping services during disasters—has since spawned a crisis mapping section, keeping a collection of crisis maps produced using Google products. They have been promoting and designing their maps to be friendly for crisis response (http://www.google.org/crisismap/weather_and_events; http://www.google.org/crisisresponse/). KPBS wanted to continue the success of their wildfire map in connecting with their audience and has since created permanent relationships with local institutions who offer to be on-call to help with future mapping needs (Online News Editor 2011). Even San Diego County has added mapping software to its online emergency services bulletin board so responders can see the information visually and spatially in real-time without having to wait for one of the GIS maps to be printed out and brought to them. The county has also strengthened their ties with the geographers and homeland security researchers at SDSU. All of these new technologies and networks aim to continue and improve upon the ability to have

continuously up-to-date maps during crisis response, aimed at increasing both the effective communication and expertise associated with their maps.

But, as Suchman (Suchman 2007, 97) notes, the relevancy of an action is connected to any prior events that can be tied to the immediate environment, no matter how far away or long ago. When I was being introduced to this new mapping system, the power of the past to inform future imaginaries in the present became clear. The Red Cross was activity promoting its potentials to institutions and community groups they wanted to partner with. To do so, they needed some way to show its capabilities. For that they used the data layers from the maps made during the 2007 wildfires, much of the data put together by the 2007 ad-hoc network. For instance, when the system was ready to be publically unveiled, they set up the big screens on the walls in the room with the example of the 2007 fires in order to impress upon their audience the potential of this new systems. And, for each of the tours of the CDOC I observed, over twenty, they also pulled up the data layers from the 2007 wildfires (Figure 4.3). This was the case even if the screens were in use for an active response. The present fires did not hold the same imaginary potential as the 2007 fires, so instead of demonstrating how the system was being used at present, they showed the past to demonstrate how it could be used in the future. Mapping the 2007 fires matters greatly to the success of this system, the same way mapping and sharing information during the 1993 and 2003 fires mattered to what happened in 2007.

The references to the 2007 wildfires offer a trajectory from the successes of the ad-hoc map to demonstrate what following that line of practice can potentially offer. It draws on the past to create its imagined present and future potential. The 2007 wildfires

Figure 4.3. The CDOC, the central room where information is gathered and decisions are made for active disaster response, showing the large screen that can display the mapping work being done. Source: SDARC. Copyright permissions granted.

also offer something none of the two years of mapping I did there could: it was an experience shared by the majority of the region that highlights the urgency for what they are doing and leaves behind gapping questions about the effectiveness, speed, and coordination of communication and response (San Diego County 2007; City of San Diego 2007). These fires also summon the issues that accompany a large-scale disaster: something that is difficult to coordinate, hard to pinpoint into a single causal explanation, and challenging to grasp in totality. The map, on the other hand, was designed for coordination, identifying causes, and creating a common operating picture. When the future cannot be predicted and planned through historical statistics,

referencing singular events can focus preparedness to offer a sense of security (Lakoff 2008).

The references to 2007 did not just end with the tours. They were consistently appealed to in my discussions with internal decisions makers. In talking about the potential effectiveness of the maps, one referenced the communication at the Harris Fire, for which she was an Incident Commander, describing how each team in charge of responding to a specific section of the fire thought they knew it all, but the never had the whole picture, and what the different teams thought they knew would often contradict each other. The Incident Commander's decisions would often upset the teams because of these disconnects (Fieldnotes June 19 2013). In another example, an activity lead referenced the Witch Fire when arguing for the ability to have very quick information flow. In 2007, shelters had to move suddenly because the wind shifted directions. So, he argued, the ability to provide information within minutes, something this mapping platform hopes to do, is an absolute necessity (Fieldnotes, June 11 2013). In fact, very few disasters other than Katrina and Sandy were referenced when promoting and designing the mapping system.

The maps of 2007 act now as images. As such, they are part of the present space, bridged over time in order to simultaneously build a collective memory with which to draw and construct an imagined geography upon which to orient oneself and act (Sturken 2007, Boyer 2003). But these images are fragments of stories, journeys, and incidents from which the 2007 maps resulted. They no longer describe the world in the making but a ready-made world (de Certeau 1984, Latour 1987). These images have the ability to shape expectations of what to see and what to know and to define the space

before it is even visited. They create a structure through which the next space gets analyzed.

Starting with another disaster has a twofold effect. Comparing disasters often offers insight into where to look for damage and change while simultaneously making it possible to perpetuate myths (Dienst 2006, Tierney, Bevc, and Kuligowski 2006) (Dienst 2006; Tierney et al 2006). Seeing resemblances between two different disasters, or a disaster and a potential future can make visible what is historically significant or who the disaster affects the most, not just who is most visible. It gives the viewers, users, and designers of this system a starting point to work from and priorities around which to organize their plans. But resemblances are arguments, arguments for what is really at stake in a disaster. Piggybacking one disaster onto another risks conflating different causes and distinct remedies (Dienst 2006). Referencing different elements from a space's past produces different notions of what is relevant knowledge and what knowledge is lost (Frickel 2008). The maps of the 2007 fires cannot be appealed to as precedent without carrying this baggage with them. Their memory became a justification and organizing clause for the setup of the present day mapping system. They also became the future potential, the imaginary future that has yet to come.

Designing Time Through Plans

As the system has been deployed and designed, three different time scales emerged in relationship to planning: long term strategy, short-term initiation, and externally expected time. Each scale requires a unique set of data types, information analysis, and certainty to be built into the items that get mapped.

Planning that looks out days, even weeks, is written into the mapping platform's mandate (Hinrich et al. 2013). Early on in the design, the chief disaster operator at the SDARC asked: *Are you making sure our priority is to gather the information the section chiefs need to design their long-term strategies?* (Fieldnotes June 11 2013).[8] The long-term picture was one of the main priorities of those using the map, enabling them to look out two days instead of just a couple hours. In the process, snapshots of the maps get included with the twice daily reports that get filed about the present response and are used to help determine long term funding, volunteer distribution, and disaster assessment. These types of decisions require that the map is used as a starting point that makes it possible to combine present knowledge with future potentials, very similar to the way San Diego County drew its maps in 2007.

These predictions are needed if shelters are to be placed in safe locations, but shelters cannot wait days, let alone twelve hours to open. When the Red Cross gets asked to open a shelter, it has about two hours to ascertain enough about a situation to determine where it should be in order to allow other agencies to act and for volunteers to be mobilized. *I discussed with sheltering today about how the mapping was useful to them. One of the staff leads asked if we had a plan for how to deploy mappers in the event of a large-scale disaster that really required mapping. I had to admit I did not know of one. His reply took me by surprise: if we did not have a way to get mappers working within minutes of a fire, for example, then the map would become immediately useless and never be touched. He said that the sheltering team often made decisions as they drove out to the evacuation zones and could not wait for the mappers to drive in to*

[8] Exerpts from fieldnotes are in italics to denote their status as description rather than analysis.

their stations in the CDOC in order to have a useful map (Fieldnotes March 6 2013). In fact, the time is so short in some cases that it had initially escaped the eyes of the mappers and their planning.

These are both times internal to the Red Cross. But since this was a networked map, they also had to manage the temporal expectations of those they worked with, which rarely aligned with how long it took the Red Cross to do things. One of the liaisons to the county government and agencies who acted as a communication line between the County and SDARC acknowledged*: he was worried that the focus on the map was going to make people forget that the Red Cross is always managing the two hours it takes for them to ascertain enough about the situation to begin to offer aid and the minutes within which answers are requested about our actions from the government* (Fieldnotes August 8 2013). In most cases, external partners wanted answers within fifteen minutes of a request. Such awareness of other people's temporal needs and expectations had to be included in any internal plans.

While these all require a level of prediction built into the information provided on the map, the ability to consider two hours or two days requires competing concepts of data relevancy and priorities. Providing information within fifteen minutes suggests mappers not question in detail the information about the situation, simply provide it in one place. It also suggests looking to known sources to reduce risk and uncertainty. To provide information that looks two hours ahead, mappers must ask about what is happening now (such as where a fire is) and what might be in danger of failing (such as a road or water supply). This suggests reaching out to new areas to try to identify those unknowns. To provide information that looks days in advance mappers must verify the

accuracy of the sources and understand how that accuracy might change over time. For example, while a fire perimeter might be accurate at present, the further away the map gets temporally from when the perimeter was drawn, the accuracy decreases.

These relationships between information and time -- some faster, some slower, some long-term, some short-term -- are placed into conflict in the map as practice. While intimately related, asking for short-term stability versus long-term change requires different work of the data. The former asks for a map of present risk, the latter a map of predicted-change-over-time. They require a level of prediction built into the information provided on the map, but each differently affects how those objects are implicated in the stress and urgency of the constantly changing moment. Each flow has a unique speed and timing that is relative to spatial formation (MacKenzie 2002, Adey 2006). Each flow often cause friction as it interacts with other flows (Hannam, Sheller, and Urry 2006, Tsing 2005).

The ability to record an absolute space – the basis of this disaster mapping platform as a co-ordinate system – made it possible to see space and time as relative in specific ways (Thrift 2004).[9] The relative points produced by the rhythms of each information request bring into question different elements of the map and makes different features stand out as uncertain or irrelevant. When the movements that comprise the meshwork of space become differentiated each enact power in a different way (Adey 2006). Many of these temporal issues had to do with the spatial scale of the response; they only became visible and valid at specific scales of action or

[9] Thrift (2004) argues that the emergence of qualculation in effect makes visible new ways of experiencing and engaging with space and time.

representation.[10]

One of the information analysts tried to alleviate some of this friction by developing a layered timeline that could be followed based on the time from the start of the disaster to see what kind of information would be needed. It included the daily rhythms of reporting that cycled anew each day. It included the variations in activity between day one and day three. It included any planned or foreseeable time to intake information from the outside or provide information back out. But this timeline remained as a draft, never fully brought into production or use. Where past, present, and future could be collapsed to specific effects to manage (and produce) different types of uncertainty, representing these timescales in a way that manages them produced a different set of issues. Though this collapsing of time enabled the mappers to see the relationship between the speeds at which they needed to consider information, a timeline like this offered another imaginary rhythm. No disaster is scheduled in this way, even if there will always be briefings at 8am and 8pm. Shelter and aid requests cannot be predicted nor timed. Nor can the sudden need to provide disaster assessment. Even the natural forces do not follow such an orderly schedule. Wildfires do not even follow the same patterns month after month (Johnson and Balice 2006).

The data making up the map is not what is brought into question by the different temporal practices. What comes into question is what is expected of the data and how it connects to the social problems introduced by the various temporal requests (Fiore-

[10] In discussing Lefebvre's production of space, Janzen (2002) notes, "Lefebvre's three part framework - spatial practices, representations of space and representational spaces - thematizes the contradictory possibilities of the "everyday" and the scales at which these might be understood" (97).

Silfvast and Neff 2013). Overall, the different groups involved in this map understand the data in the same way – the data is not acting as a boundary object with interpretive flexibility (Star and Griesemer 1989). A shelter location is a shelter location, a road closure a road closure, a floodplain a floodplain. What matters is how these elements meet in answering the questions asked of them by the different temporal requests. What is different is how the data are put into use by each group, what contexts of analysis are mobilized within the data, and what questions in relation to uncertainty are asked of the data. In these examples, one group wants to know from the data if a specific location will remain stable for the next day, while another group wants to know how things overall will change over the next week.

Exercising to Look Forward

The challenge intensifies when the basis for this new form of cartographic design is one of approximation and anticipation. Since 2007 there has not been another large-scale disaster in San Diego County like those wildfires. The system has been deployed along with Red Cross staff and volunteers to help with Hurricane Sandy, the Oklahoma and Illinois tornados, and even wildfires in other regions in California. But in these uses, the requests of the map have been limited and the audience small. As a result, how the platform will work and what role it will play in making sense of a disaster to come is still being worked out. In place of actual disasters, stands-in have been a primary method by which mappers can learn and create the system, which means the San Diego Red Cross has had to rely on exercises to help develop and incorporate the mapping practices as part of daily routine. But these exercises pose a challenge to

learning the rhythms that produce the unfolding space and time. Exercises act as common approximations, especially when there is not a historical precedent from which to calculate hazard patterns and risks. But exercises function on their own timing. In addition, they shift the focus from prevention to preparedness, which helps create a generalized expertise through imaginative enactment of potential situations (Lakoff 2008).

It was almost 3:00pm and the head of County mass care was getting quite frustrated with us. My teammates and I from the San Diego Red Cross were acting like sitting ducks just waiting for that phone to ring. We were at the San Diego County Emergency Operation Center for an all day disaster exercise – a hypothetical flood of the San Diego River – and I was one of three volunteers sent to act as government liaisons. It was our job to maintain the information flow between the county and the Red Cross mappers and to help get some of the decisions started using the maps. But when it came to which shelters to open, we were simply conduits with no power to do anything but continue to pick up the phone.

In the span of about ten minutes we were asked four times by the head of mass care at the county if the Red Cross headquarters had approved shelters. Then about ten minutes after that she came again asking if, at least, we knew what sites they were debating over so the county could begin making their plans that are contingent upon those decisions. She emphasized the urgency on two counts: 1) any emergency cannot wait this long for shelters to open; and 2) they needed shelter locations for the exercise to demonstrate a functioning network of information flow and other groups participating in the exercise needed to know those locations in order to play their part.

By not having those locations, we were holding up the exercise and there was less than 45 minutes left to complete the day's goals.

Figure 4.4. Photograph of the action at the County EOC during the Raging Waters exercise. Source: Author.

We were frustrated, too. We tried to explain that every time we called we got a different person and none of them seemed to have an answer. Each time we called we requested a call back in ten minutes. Not once did we get that call. So my two partners and I decided to take action into our own hands. If we could not get the information over the phone, we could at least see what was being put on the map. We pulled up the Red Cross disaster map, clicked on the flood perimeter, evacuations zones and potential shelters. There were quite a few shelter possibilities and though we were not trained in what to consider when opening a shelter, we started to debate the virtues of opening up

one big one or two smaller ones. That is when I noticed there was a flood plain layer that could be turned on. I clicked it. With all those layers up only about five shelter locations steered clear of the water's potential path. Within minutes of starting, we pick two: one north and one south of the river, out of the floodplains, deciding it was not practical to expect to send evacuees across a flooding river. "That was so easy!" one of my partners declared. "What in the world is going on at headquarters? Does no one there today know how to use the map?"

When we got back to the Red Cross headquarters at the end of the exercise, a meeting was called. The chairs in the Red Cross's Disaster Operation Center were filled with the exercise participants. Almost everyone within my earshot was in a conversation expressing their frustration at how things went over at the county emergency offices. I sat in amazement. What do you mean what was wrong with us? You could not respond in any reasonable timeframe, I thought. What happened that things went so sour? The meeting was called by the Disaster Lead to find out where the disconnect was. Jumping on his question, the Red Cross staff that helped the county design the exercise responded quickly. She explained that the urgency of the questions we were asked at EOC clashed with the timing of the decisions made back at SDARC headquarters. In the end, it became clear to her (and she confirmed via a phone call at the end of the day) that in the drill there were two different assumed times at play – the County was functioning on a condensed timescale where four hours equaled one day, the Red Cross on a more conventional timescale where one hour equaled one hour. Whereas in the four hours the county tried to cover the main tasks that would occur in a

twenty-four hour period, in those same four hours the Red Cross covered what they would normally do in four hours (Fieldnotes December 12 2012).

While the SDARC's map still stood at the center of our ability to make a decision about where to place the shelters in the exercise, it did not encourage a shared understanding or communication between the actors with the appropriate information for such a decision. Though this disconnect emerged in the context of an exercise, it makes visible what happens when the different temporalities of action surrounding disaster maps clash. A shared sense of a space, urgency, and priorities in a disaster is difficult to establish if the considerations of time are not the same. This is because space is a practice, one that is grounded in time (Kitchin and Dodge 2007). In this case, how time was built into the actions for which the map was used directly affected the ability of the different groups involved in making the maps to share information, communicate productively, and build trust for future endeavors. The incongruous timescales and concepts of urgency over which event unfolded constrained our ability as mapmakers to develop the trust and coordination required for future relationships, despite both parties working towards the same general goal. Creating any consistent understanding or shared practice to carry from one disaster to the next becomes difficult if there are misaligned temporal understandings and expectations.

In another instance, during one of the countywide disaster exercises, developing a consistent spatial practice got lost in the need to manage timing. The exercise, called Golden Guardian, was the first time their new mapping system was deployed on a large scale. Until then, there had been scripted training sessions and small examples to work from, but none of them possessed the urgency and confusion of an event designed to

mimic some of the problems faced during a real countywide disaster.[11] This simulated disaster was a preparedness practice for a large earthquake (7.8), with a range of ramifications, like aftershocks that did not seem to follow fault logic, a resulting unstable nuclear plant, broken bridges, and a threatened dam.[12] That exercise was the first time I was assigned to sit in the threat analysis chair in the mapping room.

This is an actual seat in the small glassed-in room off to the side of the rest of the disaster operations center that can be shut out from all the noise, called the Situation Cell, but also a position of power in which it was my responsibility to determine what threats were valid and important to SDARC's operations and thus what to map. The room has three computers, five monitors and chairs, three phones and desks, and walls of televisions and whiteboards (Figure 4.5). The desks all border each other with the computers facing in. When sitting in one chair it is possible to see the other mappers but not their screens. Each computer is a separate station with a specific goal. One is for threat analysis (my chair that day), another for critical infrastructure, and the life sustaining elements. Between the three of us stationed in the room, we were all to gather information for the same map, one focusing where the danger is and will be, one on what's been damaged, and the last on who else is doing what and needs what that is involved with the response. The pressure was intense as we tried to balance getting ahold of a situation that, even in the exercise, was constantly changing and failed to meet the needs of the different groups within the SDARC.

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[11] This is an added challenge since in my time at SDARC I sat in on many conversation about what defines a disaster and when would the mapping team be activated? Never once was a clear line drawn around these issues.

[12] The aim was to simulate a catastrophic earthquake on the San Andreas Fault, followed by two local quakes one on the San Jacinto Fault and one on the Rose Canyon Fault.

Figure 4.5. The author at work in the mapping room during Golden Guardian disaster exercise in May 2012. Source: SDARC. Copyright permissions granted.

9:22 am: *Having never sat in that seat before I was given a quick primer from SDARC staff who typically does it. My instructions were to analyze the information coming our way, identify gaps, and determine the conditions that were acceptable for the information to be placed on the map. I pulled up the county bulletin board and realized I had no clue what criteria to use as a filter. I asked my teammates what other sources I should look at and what types of items I should be looking for compared to them. The answers I got back were vague. Basically, it was explained to me that I was to look for anything that might affect where people can go and anything that explained the severity of the situation. I walked over to each computer to see what they were doing, and they each seemed to have the same screens pulled up: the county bulletin board (WebEOC) and the map. So I sat back down and pulled those up and started to read up on the situation.*

10:26 am: We were told we needed to produce three maps in the next hour and a half for the noon briefing meeting so planning for the next 24 hours could begin: 1) an updated threat map for two regions that were hit by different earthquakes; 2) a map of our current assets in use; and 3) and impact map showing what utilities, and city infrastructure like sewage and bridges that were impacted. Feeling a bit overwhelmed by three requests at once I started to look for any information about the affected regions by skimming through the last couple hours of the county bulletin board.

11:05 am: I had barely started to determine what information I should be collecting when I was asked by another chief to identify areas of significant damage in El Cajon, La Mesa, and Carlsbad. They needed the analysis (and preferably maps to help explain why) within 15 minutes so they could determine how many people might need temporary places to go and what general areas they could start establishing those safe places. I decided to go with the second request first, since they were on a bigger time crunch – I figured that being fifteen minutes late for a longer term planning meeting would cause less harm then being fifteen minutes late for a decision that needs to take place within the next hour about the safety of the public.

12:05 pm: When I did not have the information in time for the noon meeting the Job Director in charge of operation came in wondering what was going on. I explained to him the two competing requests and my logic for the order. He said that my main purpose was to serve the chiefs and the bigger picture planning, so his map should have been priority. But I was confused because a chief had made the second request and we, as mappers, had been trained to develop its use so that it became the first go-to source of information for all activities so that they were all working from the same picture.

12:30pm: I would bring up what I found and another mapper said they had already logged it or vice versa. There seemed to be a bit of an overlap between all three of our jobs. We started to discuss if we needed to rethink how our positions were defined. We were all going to the same two or three sources. And despite that, we were behind on mapping. One of the mappers suggested that for the sake of the data available to us for the exercise, it would make more sense to divide the work differently than original designed. One would focus on the actual mapping (we assigned that to the one with the most experience with the system), the other two of us would split the sources and just gather what seemed useful overall and pool the information together. I set to the task of copying and pasting what I was finding into a Google document to share with the now designated mapmaker.

1:00pm: No one from outside our glassed-in room seemed to be calling us or asking us questions. From what we could tell, no one was consulting the map. We were doing our best to get information on it as past as possible, but that also meant we weren't really checking on the information. When I left the room that morning my questions were to ask the people in planning if I was providing information in a useful format and what they needed that I was missing. I never once double-checked on the quality of the information I was grabbing off of the online emergency bulletin boards. On top of that, we were being corrected by people from outside our room. I had just finished gathering information about a broken dam and its flood plain when a chief entered and asked why. He explained that the broken dam, despite being stated on WebEOC by a credible source turned out to be a rumor. This cannot help the maps credibility amongst our new users at the SDARC (Fieldnotes May 2012).

We found ourselves struggling to follow the categories given to our assignments in relation to the map. We were slowed down by the planning process, unable to keep up with the exercise or the mapping practice. In both these examples, the method chosen to speed things up during the exercises was to divide the work differently and redefine our roles; it was to reclassify the needs. But this affected how the map was made and used. Those with information no longer knew who to go to with new information, nor of whom they should ask questions. Information sharing slowed down. We worked with the information that was readily available online and immediate, rather than seeking out new sources. It became difficult to make any claims about the importance of information on the maps. There was no shared practice to structure priorities, goals, or relative values. Developing a consistent practice got lost in the need to manage timing.

By speeding up the actions around the map, rather than encouraging networking, the work around the map also isolated. As we sat in our glassed in room, we worked with the information that is readily available on our computer screens. This had the side effect of making transfer of information one-way.[13] As mapmakers we kept gathering data, but we conferred neither with the sources nor those using it. This type of networked relationship takes time, especially when trying to build into the analysis a structure that will enable new and repeatable habits to be formed. Without such

[13] As a result, despite the constant introduction of new sources that were compatible in terms of data and form, these sources often took second stage to already established reliable sources. Overall, the mapmakers looked for the old sources in new places. Instead of calling CALFIRE, for example, they followed their twitter feed. Never once over the two days of the exercise was the phone picked up by one of the mappers to follow up on any information with the agencies participating in the exercise. As mappers, we asked fewer questions that shape how the information comes or even what the best form was to plot it on the map.

interrelationships with the world outside the mapping, it became difficult to make any claims about the importance of information on the map. The mapmakers prioritized work in ways that agreed with their logics rather than the goals or bigger picture of the responders. Just because everyone is doing the same thing at the same time does not mean they are connected (Lefebvre and Régulier 1999).

The exercises also highlighted the fact that exercises are never conducted with the same temporality as a real-world disaster. First, when a real disaster is declared, shifts are twelve hours long, with minimal breaks and support. As soon as a worker arrives onsite they would be put to work with minimal preparation. In an exercise, frequently the participants sit around and wait for the initial set up and briefing, taking the time to make sure all the communication paths are working. Exercises are usually over within six hours each day including a nice long lunch break (with catered food provided). Exercises last one or two days; disasters are not clean cut like that. The rhythm to the day–what kind of information or visual is needed when–is condensed and produces a sense of urgency unique to its schedule.

These exercises form a prominent component in the development of the representational design practice of the maps. The imaginaries being used to create the generalized knowledge engage with time in specific ways. While exercises create opportunities to practice the technology and network links, their anticipatory temporal structures construct spatial strategies that are disconnected from institutional goals or everyday cultural practices. But as decisions start to get made based on the temporalities experience during the exercises, they become part of the normalized routine that structures the production of spatial practice. In the process, they influence what gets

dealt with in the practice of mapping, what kinds of analysis are required, and what becomes acceptable to leave out for the sake of time.

These imagined disasters are powerful forces that stand in for both memory and conceptions of safety, creating their own culture of inquiry and priority (Masco 2008).[14] Knowledge of disasters and approaches to risk analysis emerge from the discontinuities in time present in the exercises rather than the material interactions in the world, relying on those disconnects to help structure relevancy and strategies. Enacting creates knowledge about collective life "not through the regular processes of population or society, but through the uncertain interaction of potential catastrophes with the existing elements of collective life" (Collier 2008, 244). Actions in the space of the map become synchronized and coordinated with this imaginary time, creating a meshwork that does not share the same patterns outside of this anticipatory temporality.

Becoming isolated turned our practice into a nodal one. Each node is ideally connected to the others through a networked structured by the technology and the disaster, but each node functions on its own. This model is actually similar to modern cartography whose goal is to locate points, places, or lines that each have removed from them the movements that made them significant. Ingold (2007) describes this type of relationship as one of 'occupation'. This relationship to space, he argues, is one where practice builds up from points that are then collected and integrated into an assembly used to approximate the space. He counters this way of engaging with space with a

[14] "Thus, by rehearsing nuclear war in the imagination or via civil defense, one does not master the event or its aftermath. Rather, one domesticates an image of a postnuclear world that "stands in" for the inevitable failure of the imagination to be able to conceive of the end" (Masco 2008, 382).

notion of 'habitation', a practice that cuts across the points and recognizes the relationship between the movement on the surface with the points defined. To map habitation is to weave together the different narrative styles that exist within the surface -- the different rhythms and movements -- into a single tapestry. It is much more complicated than simply plotting points on a grid. It requires more than just categorizing fragments in relation to each other but focusing on the work that brings everything together (Lefebvre and Régulier 1999). It is more like the practice of combining a set of individual drawings made by people describing how to get from point A to point B, each likely only useful for their specific goals and means. Instead of a network, this practice creates a meshwork that interweaves different paths to be traveled (Ingold 2007).[15] How these temporalities affect daily practice can be found in the interactions between these maps (be it keeping up with things happening two hours out, trying to speed up how the map was drawn, or coordinating actions over time). The incongruent experiences between the different timings and urgenciers of the requests for information and the disconnect between the mappers and their data sources demonstrate the extreme challenge involved in keeping temporal movements in the traces made on the page. Instead, the production of this mapping platform asked mappers to design a new form of cartography based on a blend of occupation and habitation, on geographical places and lived experience.

[15] Ingold (2007) borrows this idea of meshwork from Lefebvre. It also aligns with the idea, in STS, that networks or cyborgs are not answers to problems but rather analytical tool to help find the answers. Using the notion of networks as maps: "there is no way explicitly to articulate the relative weight or scale at which different processes are implicated in cyborg subjectivity or hybrid quasiobjectivity" (Janzen 2002, 99).

Applying These Temporalities to Present Action

So, what happens when these planned and anticipated rhythms meet with real disaster response? As the mapping platform was incorporated into an increasing number of disaster responses, the multiple temporalities at play interfered with the structure of the network necessary for the mapping platform to work. First, anticipatory patterns of action did not align with the everyday practices of those involved. Second, the networks of actors that were available rarely matched the expected networks, challenging the time over which actions could occur.

As a way to gain experience with the map and finesse its system, working on disasters outside of San Diego county is a relatively common way to get more partners on board and to have more opportunities for the mapping volunteers to get to know the system in practice. In fact, the majority of the disasters I mapped as a volunteer to gain experience with the platform were outside of San Diego. While this increased the opportunity for experience outside of exercises and increased the range of data sources available to incorporate (in an actual disaster sources like news media, twitter feeds, local fire agencies all come into action), it also introduced into the system new expectations of the data and new technological challenges which had effects on the relationship between temporality, structure, and action. These issues were front and center when two of us were called in to help create a map for the response to the Springs Fire in Ventura County in the spring of 2013 (Figure 4.6).

When I arrived, my fellow mapper was already hard at work. Despite our presence, our lead was looking frazzled and tired. She had just hung up the phone and had an unusually unpleasant look on her face. Since early morning, she had been

making phone calls to her previously arranged contacts in the fire departments trying to get GIS fire perimeters. Apparently, though map files were arriving in a timely manner, they were all pdfs rather than the raw GIS data required by this mapping system. She walked over to another team member and asked them if they had the contact information for someone she met recently at a disaster exercise. She said that he was likely to be getting the same information in GIS format and hoped he would forward it to her. She got his voicemail. Since it was an active fire, everyone was probably focused on working on their maps rather than picking up their phones.

For much of this time I was sitting with the other mapper waiting to be told what to do because without the perimeters the rest of the data would not be useful. While we waited we stared at the TV news that was up on the big screen in the room. It was a scene, from a helicopter, of cows running in a pasture from smoke and flames. We all started to root for the cows, completely mesmerized by the TV, momentarily ignoring our task at hand. Suddenly, the lead mapper instructed me to hold off putting anything on the map and instead scour the news to find out anything about animal shelters taking relocated animals, large or small.

I started with the online news for the TV channel we had just been watching, figuring they would likely have put some information about how to evacuate large animals if they were focusing their cameras on cows. No luck. I then tried the public television station, knowing from my past experience their priority on putting out as much disaster information as possible. There I found a blog for the fire that listed details for two shelters. From there it was a pretty easy mapping job. I found the shelters websites based on the names, city, and phone number of each location. I then

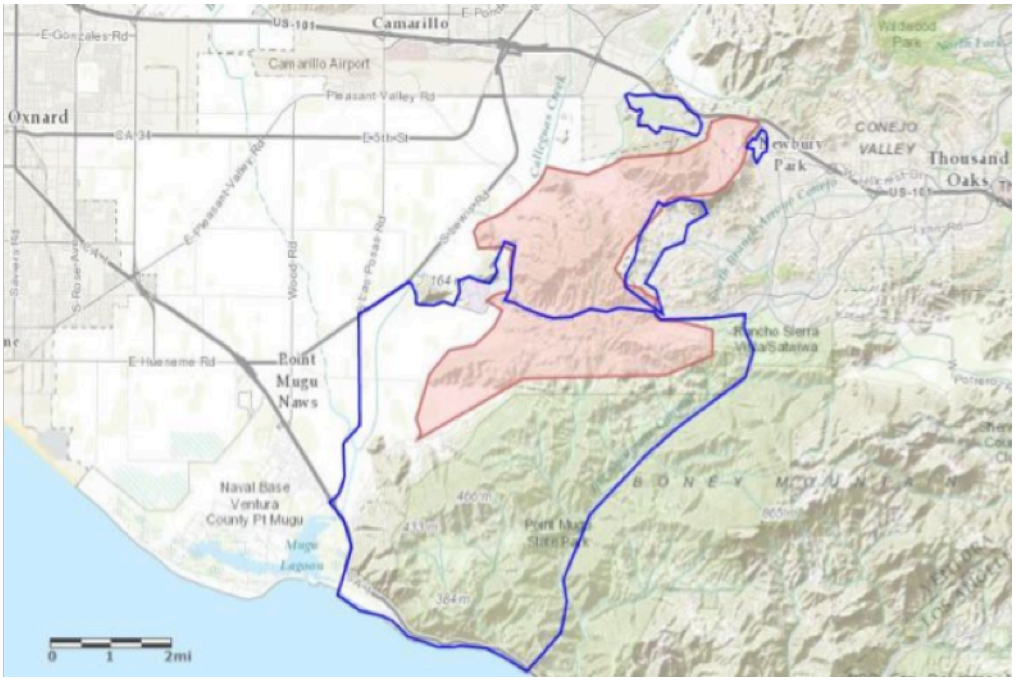

Figure 4.6. Lower Image: The PDF map sent to the Red Cross with the fire and evacuation perimeters. Source: Ventura County Fire Department. Upper Image: Our tracings up on the big screens in the CDOC. Source: Author. Copyright permissions granted.

created a new My Places map, searched for each address, and dropped pins on those spots. All I needed to do was input the information into the bubble. But I could not figure out how to add in new descriptive text. The lead was once again on the phone, so I had to wait for her to get off to ask for her help. When she did come over to help, she informed me that from My Places I could not adjust the text fields in a pop-up bubble, only fill in the preexisting fields. That meant I had to start over using Fusion Tables.[16] *My fellow mapper had a fusion table template already started, so I opened it, resaved, and entered in my data into the boxes. About 15 minutes later I e-mailed the layer to the lead and yelled across the room to tell her so she could upload it as a new layer on our map.*

She then looked at the clock and told me that she was giving up on the GIS layers for the time being. It was close to lunch break at the county offices so it could be hours before she could try reaching the mappers over there again. My new task was to trace the perimeters. She told me I could find the most up to date map on the fire agency's website. I repositioned myself at a computer with two screen and pulled up the website on one screen and Google maps on another so I could work with them side by side. The map was relatively straightforward, not too many twists and turns, but I wanted to zoom in anyways to draw in as much detail as possible each section. But the zoom function did not work. Nor did the scroll. The fire map was frozen. I reloaded it in a different browser, but it was still frozen. I then pulled out my personal laptop, a mac instead of a pc, to see if that would help. It did. I worked from these two different

[16] Which is a mix between Excel and geocoding software that allows a user to enter in addresses into the spreadsheet, along with related verbal information, which automatically converts them into lat/longs and rows within the related pop-up bubble of information on the map.

computers to begin tracing the fire and evacuation lines. It was a bit challenging as the screen were different sizes and at different angles, but doable. This was funny, since GIS is the primary method of mapping (and was the way this map I was looking at was created) and ArcGIS (the most common software – pervasive as Windows) does not work for Macs, only PCs. Yet, something about this webpage, not the map, required a different browser.

*I had gotten through three sides of the main polygon when I discovered another problem. The roads on the fire agency's maps did not exist on the Google map. I was using the roads as my reference points to know when to make twists and turns in my perimeter. I zoomed in on the Google map to see if the roads would show up at a different scale but to no avail. I instead zoomed back out to get the full picture to make my judgment by common proportion rather than common reference point. I asked my partner to take a look and see if she agreed with my line. When all was said and done, I was told I was quicker than they expected and it was a good job. This was over an hour later, over 3 hours after I showed up. I couldn't help but wonder how many times I would have to repeat this process over the span of this fire (*Fieldnotes May 2013*).*

In the exercises and planning, the practice had been built around looking forward in various ways. But exercises and plans create abstract patterns derived from times outside the lived rhythms.[17] Here, as in many cases, mapping ended up being about working with what we had rather than what we expected.[18] In this case, we were

[17] For a detailed discussion of the ways in which abstraction of disaster temporality can occur, see Michael (2014).

[18] In the end, it took another full day for the first GIS perimeter data to arrive. In the meantime, this process had to be repeated. My acts were organized around getting the technology to work

working with established everyday practices that were overpowering the new, potential, practices that are required for the predictive and anticipatory rhythms to function. These exhibited themselves in, among other things, the sharing of the PDFs. While this disaster was outside of San Diego County, it was not an unknown network for the mapping platform: much networking had already gone on to create contacts for information and for potential future users of the maps, including with the fire agencies. But despite the existing social relationship, pdf are how the fire agencies share information with outside agencies, and it appears the Red Cross got lumped into that category. Sharing the GIS layers that were the base of the pdfs was not a priority to those mapping the fire perimeter (even if they expected the Red Cross to step in and support their work with only short lead times). Once again, we were isolated as a result of the strength of everyday practices.

The mapping practice was also structured by the timing made possible by the technology rather than by the goals behind the technologies use in the first place. The difficulties putting the proper data into the pop up bubbles on the map was one instance. While the information was readily available, it took it longer to get it onto the map because the information required changing how the map was drawn in order for the information bubble to be customized. In another instance, the need to switch brands of computers when looking at a pre-drawn map slowed down the mapping process. In another case, it was the distraction of the television screens. In other words, not only

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so I could move an inscription from one system to another in the quickest possible way, rather than asking questions about the inscribed space. Never once did I ask questions about if a source was trusted, accurate, timely, or necessary. Instead, our focus was on the questions to ask of the data and technology to make for the quickest possible compilation.

does the uncertainty and variability of a disaster and the multiplicities of everyday life make coordinating the various speeds required for the mapping practice into a schedule near impossible, so, too, do the tools and technologies used. In the design of the mapping platform, continuity over time was placed in juxtaposition with network stability. In order to maintain some continuity in action using the technologies, the stability of the network was challenged. In order to strengthen the technological network, the timing had to change.

The focus on anticipatory and predictive temporalities led to a disconnect in practice when it came to deploying the map in disaster situations. Futures, and related preparedness practices, are enacted through the assemblage of specific styles, practices, and logics (Anderson 2010). The problem is that these end up being generic as-ifs played out through technological means. If the aim of preparedness, or looking towards the future, is to limit the impact of the disaster on valued aspects of everyday life (Deville, Guggenheim, and Hrdličková 2014, Lakoff 2008), then the generic cannot envision or enact the complexities and situatedness of everyday life. The focus on the present situation shifts the focus from that of preparedness -- from abstract patterns and patterns seen from before and after the event -- to the lived rhythms (Deville, Guggenheim, and Hrdličková 2014, Weszkalnys 2014).

Such disconnects become especially visible when we engaged with disasters outside of San Diego. The focus on the speed of information needed for some of the decisions being made with the maps often meant that the mappers worked far from the

action.[19] The more people mapping, the faster information was represented on the map, and our San Diego team was more experienced than any other team, so we were often called in to speed things up. One of these times was during Hurricane Sandy (Figure 4.7). I was put on a task to get the tribal boundaries for New York by one of the San Diego volunteers who was deployed there to lead part of the response. This made perfect sense to me, since San Diego has over twenty tribes, they are sovereign nations, and need to be engaged with differently than other regions within the state, so knowing where they are can shape a region's response. This was supposed to be a quick addition to the map that would help the people in the field that afternoon as they drove around working on need assessments.

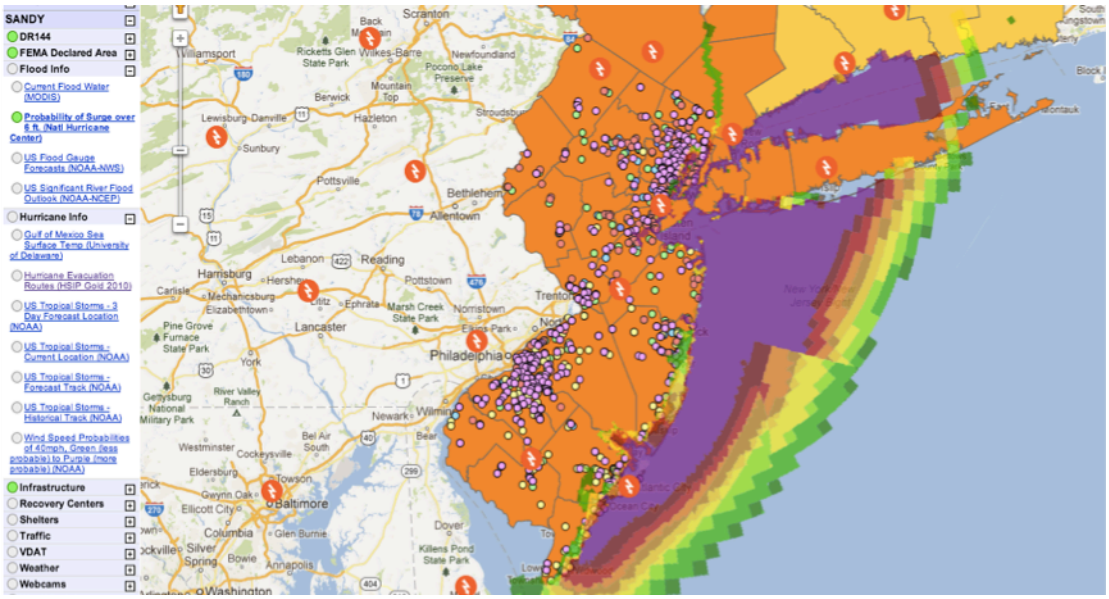

Figure 4.7: SDARC Map of Hurricane Sandy, showing some of the data layers assembled by the San Diego Team. Source SDARC. Copyright permissions granted.

[19] In a couple cases this meant working from home for me and the other mappers. This meant that the work I was doing was even further disconnected from the situation, since by working at home I was on my schedule and my pace, focusing on new pieces of information on my schedule rather than someone else's.

After two hours of searching I sent the lead mapper an e-mail telling her that I had not found any specific data, only what looked like a hand drawn map of the vague location of tribes over a certain population. There was not even boundary information on the federal office for tribal relations website. The best I found was a historic language site that had information about the regional tribes, but the information was primarily verbal (Fieldnotes October 2012).

Managing time also meant managing regional and institutional differences. For example, the tribal areas in New York seem to have a less visible political profile because we could not readily locate that information. The San Diego volunteers had to regularly focus on managing political boundaries the New York responders did not seem to consider important. Ignoring these differences for the sake of speed can lead to a misunderstanding of what needs work and what was lost (Henderson 2011), increasing the disconnect between recovery timelines (Superstorm Research Lab 2013, Fortun 2000).[20] In addition, cultural difference in expectations for what and how data should be represented is grounded in institutional goals. The Red Cross' goal was to provide aid in politically acceptable ways, while that of the Tribal Affairs Office was to manage their population. This use and design of the technology did not take into account the different data valences, in effect masking different regional cultural expectations, presumptions about the other groups involved, and different goals in map use that were vital to the structure of the space.

Exercises and plans produce formal representations designed to establish

[20] In her study of the failed recovery plans in New Orleans after Hurricane Katrina, Henderson compares maps of valuable infrastructure prior to the disaster drawn by FEMA and those drawn by community members. She finds that they place entirely different elements on the maps.

specific forms of expertise and decision-making (Kuchinskaya 2013). But they are often politically bound and miss local knowledge, despite being necessary for successful techno-scientific decision-making. The risks defined are not always easily accessible by or acceptable to those living through the situations.[21] But while technoscientific expertise ignores local specifics often with the problem of the local communities not accepting the defined risks, local knowledges are often presented in formats incompatible with the type of analysis needed to manage and monitor risk. The coordination between these two, argues Kuchinskaya (2013), requires specialized, rather than generalized, expertise, and an infrastructure that can balance standards and detailed descriptions – quite similar to the balancing of occupation and habitation, nodes and lines.

Discussion

This chapter has charted a few competing relationships to temporality within the disaster mapping platform. These relationships emerge through planning, exercises, and real-time experience all of which inform both the design and the use of the mapping platform. Much was built into the mapping practice based in anticipation of what might come. In these cases the timing of specific response goals was used to structure the map design and use, despite the existence of different anticipatory and predictive speeds. By contrast, when engaging with real-world disasters, the timing of technological

[21] This is not to imply that local knowledge is superior to global or that there is a hierarchy to universal and regional claims. This is a debate still being played out in STS scholarship and is on that again and again demonstrates that while those in power often miss details of those on the ground, neither knowledge is more or less complete (see, for example, Choy 2011, Tsing 2005, Hayden 2003).

capabilities grounded the practice of mapping. These different temporalities each have their own sense of uncertainty attached to them – be it managing the unknowns of the present moment, trying to grasp how the situation might shift, who might be able to provide necessary data and in what format, or whether the standards of operation mesh with local cultural expectations. In the end, For SDARC, time structured the shape the map took, though often not in the intended way. Managing the incongruencies between various temporalities or the technological capabilities often took priority over managing and maintaining a shared picture. The different temporalities present make it difficult to identify priorities in knowledge or action.

This mapping practice affected how knowledge of a disaster was approached: it removed the need to go through specific experts, opened up access to a greater population but at the cost of consistency in resolution, temporality, and even the visual form of the spatial information. Yet, by putting these differences in conversation with each other it created the potential to open up new discourses through the necessary acts of interpretation. Within this messiness, with no specific order to fall back on, social norms became more visible and space--both metaphorically and physically--got created for new forms of engagement and cultural self-awareness.

It simultaneously tried to coax voices into alignment by placing them into the shared technology. Such a vision of a well-ordered and manageable sociotechnical system is critical to political legitimacy of information (Hilgartner 2007). It is in this order that expertise can be identified, authority claimed, and morals defined. As it aimed for order, the mapping practice's relationship to temporality challenged such a vision. While offering the ability to adapt to new situations and account for unpredicted

and local needs, it made it difficult to maintain specific patterns of representation or interaction within the network as new questions were constantly getting introduced. Moreover, putting together the various voices could create a contest to control how causal and moral responsibility for a disaster are framed. The different temporalities present in both the data and the forms of interaction made it difficult to identify priorities in knowledge, objects of blame, or what was appropriately included and excluded. Because of the conflicting goals, intentions, and expectations at work within the layers, displaying more and different data did not necessarily produce more knowledge or a more accurate immediate picture of a disaster.

But as these temporalities get merged together, they had the effect of masking the flows within each temporality. This masking was neither a political move nor an intentional one. It happened the same way two sine waves of different frequencies played at the same time will reinforce each other to constructively and destructively make a beat (to borrow an idea from wave theory). What is left will be individual nodes that mark the points where the waves resonated in specific ways. In wave dynamics this interference caused by two waves is called ‘beating.’ What is left is a rhythm, while the different speeds and temporalities that make up the rhythm get erased, despite being integral to the final structure of the remaining points and movements in the space.

The discord between different temporalities that merge within this disaster map demonstrate the importance of acknowledging the two ways of engaging with space set out by Ingold: occupation and habitation. While his discussion is very much a theoretical exploration, it has direct implications for examining the relationship between the planning that goes into the mapping platform and how the platform is put to use.

While occupation is grounded in networks and nodes which was structurally and conceptually how the mapping platform was designed, how the platform was used was more like habitation, a meshwork of lines each with their own power, where the end points of those lines are less important than how the lines interact and meet.

This suggests the distinctions that drive the various cycles in disaster management— prevention, protection, mitigation, response and recovery—are the generic beats that get left behind. Planning based on these points and not how they come to exist will miss out both on local experience and knowledge as well as the various rhythms that make up a lived space. At the same time, understanding that these will be the larger rhythms within which the motions work can help offer a scaffolding for any spatial understanding of the situation. While this collapsing of action is problematic for those with different temporal expectations who rely upon the maps to inform and manage their various goals, it also has a benefit. By removing some of the distinction between the various bureaucratically defined stages of disaster response, the system accentuates the ways in which disasters are part of normal routine rather than abnormal or exceptional events that act upon the normal. They challenge any clear cut representation of when one stage ends and another begins.

This brings us back to the problem, set out in the introduction, of how to build something that lasts and resists while accounting for change (Deville, Guggenheim, and Hrdličková 2014, Tironi 2014). How do you balance anticipation, prediction, and an uncertain and inconsistent present? What is built based on looking forward will always fall short in the present unless there is a way to combine the formalized and descriptive natures of knowledge, to connect the network of nodes to the meshwork that brings

them to life in action. One way to think about this is to consider spatiality as an aspect of network stability not the result of network stability (Law and Mol 2001). The network of actors and meshwork of practices does not come prior to the space in which they occur or of which they are trying to make sense, they are emergent in the concrete practices (Michael 2014). Nor does the space come first only to push back on the elements being considered in any analysis. Consequently, holding relations constant will likely erode continuity.[22] Law and Mol (2001) suggest, instead, thinking about time and space together in order to overcome the challenges that derive from standards, stable facts, and networks, in the form of a "topology of fluidity" (Law and Mol 2001, 12). This concept pushes the notion of meshworks beyond the thing that can simply encompass multiple lived perspectives and actions, but to one that manages gradual change rather than demanding invariance. To think otherwise, they argue, is to base continuity on discontinuity, or in the terms of the examples here, to base stability and consistency on the disconnect created by preparedness between present and future rather than the path that moves actors back and forth between the different types of temporalities.

But, this does not mean that these temporalities are incompatible; that anticipatory, predictive, present, faster, slower have to conflict. As Thrift (2004) points out, the world is always known through a constant flow of practices, which are always to a certain degree, future-oriented. Temporality is about moving forward, no matter to what degree or how far. In this light, preparedness does not stand in opposition to

[22] See also Jordan and Lynch (1992) and Bowker and Star (2000) for discussions about the relationship between standardization and consistency over space and time.

present action. “Rules, structures and rehearsals are not the antithesis of improvisation; on the contrary, they can provide strong scaffolding for it” (Wood et al. 2012, 359). To put it metaphorically, while a double pendulum may lead to chaotic and unpredictable movement, the specific movements of each pendulum are completely calculable and predictable and are the basis for how the double pendulum moves. But they need to be treated as scaffolding that makes it possible to build, not the building itself. As one movement adapts to the other, it becomes impossible to predict the result. But it also makes it possible for this practice to adapt and change to the ever-changing situation around it, where a clearly structured mapping practice would try to align the situation around it to its mapping practice.[23]

In the exercises and planning, the timing of knowledge production became the focus rather than the aid by which a bigger picture could become known. The various times became fragments, isolated nodes that lose track of the meshwork that brought them all to life and put them in movement in relation to each other. If plans are made based on the individual pendulums, then the plans will be misaligned with the larger chaotic movement over time, challenging any attempt at social cohesion around the combined practices. Understanding how temporalities structure meaning offers the opportunity to capture the disaster as lived and with its own rhythms. It opens the possibility to build into the disaster management cycle adaptive practices and multi-perspective views. In fact, looking at these different temporalities can offer a way to see the world in flux rather than as stable patterns that become destabilized.

[23] Think of this like the mismatch between the circadian rhythm and the earth’s rotation. One is 23.5 hours, the other 24 hours. While it causes problems in creating a single picture of the ecological cycle, it also is what scientists think allows for human adaptability to new situations.

Putting this in conversation with 2007 it becomes possible to suggest another answer to the question of why those maps gained the authority and traction they did. It was, in part, because the ad-hoc map allowed the mapmakers and users to imagine these present day projects, like the one at SDARC, as well as new forms of interaction, communication, and data management during the disaster response. It was also in part because the flaws and disconnects in the ad-hoc mapping process – many of the same flaws seen in the SDARC map, are what made it possible to see dynamism, despite being only a snapshot of a moment.

CONCLUSION

This dissertation research examined the production of maps created during the 2007 San Diego wildfires and looked at how these maps were situated in spatial and temporal practices that extended beyond the main week of the flames. By considering how these maps were made, the aim was to explore how it might be possible to bring together diverse actors, technologies, conceptions of city life, and understandings of the natural environment in ways that create for mutually valuable knowledge for diverse actors, including scientists, first responders, journalists, and the public. The project also aimed to develop an understanding of how representations of disasters are interconnected to the material world, local environments, data formats, and socio-technical infrastructures.

To do so, this project drew on social science literature on disasters that has established the importance of treating disasters as spatial processes that emerge over time, not external features that are imposed upon a space at a specific time. These temporal relations within a disaster needed to be accounted for in order to understand the construction of risk and liability (Knowles 2011, Fortun 2000), the establishment of environmental impacts (Oliver-Smith 2002), how various elements are implicated in the cause of a disaster (Davis 1999), and how a disaster mirrors social values (Calhoun 2004, Knowles 2011). Considering disasters in this way suggested that the disaster maps needed to be analyzed as more than just descriptions of events or arguments for power, but as entry points into the larger practices of knowledge production. The maps were not to be treated as representations of a single moment in time, despite their

timestamps, but as snapshots of practices that flattened many different moments in and speeds of time. Moreover, these theories required methods that looked backwards and forwards, beyond the immediacy of the hazard being faced. Following this argument, this project sought to answer not only questions about the relationship between making maps of wildfires and knowledge of the wildfires, but how this process is entwined with the socio-technical networks of action that make the mapping possible. It also sought to explore the networks as actions over time and examine what that meant for the creation of shared meaning and common objects of communication.

To trace the mapping practices from 2007, then, this research linked ongoing social and technical wildfire mapping networks, historical methods of fire tracking and communication, and cultural imaginations of future wildfires. This project situated practices of disaster map production within networks of actions that were human, technological, and environmental. This involved looking at the how the actions and decisions made in 2007 connected to the larger relationship between information sharing and wildfire response that had been established in the last fifty years. It also meant exploring how anticipation and expectations of wildfires and disasters in general affected the form the mapping took. In accomplishing these tasks, this interdisciplinary project challenged conceptions space, both in terms of ethnographic methods as well as in terms of looking at representations of a given space de-coupled from time.

Tracing these networks revealed a type of authoritative knowledge production that was malleable, fluid, and distributed. Who was involved in the mapping, how data was gathered and shared, what technologies were used to draw the maps, and the accessibility of the burning land all shaped how the disaster came to be known and what

was considered appropriate knowledge of a threat. New mapping technologies were regularly introduced to meet new communication needs, previously identified problems, and to balance present practice with imagined futures. The socio-technical interactions were consistently challenged by environmental factors, data practices, and cultural understandings of lines and categories. Topography, smoke, and changes in population distribution were equally implicated in the construction of what counted as authoritative knowledge as satellites, GPS, previous experience, and networking practices. In light of all of these elements, face-to-face interactions held their value as a means by which to coordinate meaning, especially since actors assembling data for the same map consistently did not even define 'disaster' in the same way. As the ingredients changed, so too did the practices. Each different practice of representation delimited different risks that needed to be managed and controlled. Each different network of interaction produced different ways of knowing the disaster. Together these spatial elements shaped what it meant to know a wildfire and what it meant to establish authority within those ways of knowing.

In the end, there was no one-size-fits-all way of making wildfires knowable, managing information needs, or even following the rules and boundaries established as part of a response. Each new interaction introduced new and unpredictable questions about the burning space the needed to be dealt with. This made it difficult for many of the maps of the wildfires to be used by the general public or to be separated from their context of production, despite such cultural mobility being a goal for all the maps. No single network formation or representation held stable, even throughout the wildfires. Instead, meaning and value were distributed among these elements as they interacted.

This realization pushed the concept of networks of practice beyond one that considers the role of each node or object in the final knowledge produced to one that focuses on the relationships between the nodes, in situ. Focusing on these meshworks revealed that only when representational practices remained flexible enough to incorporate local resources and changes over time yet were presented in stable enough ways to share information between diverse groups were these practices able to establish authoritative stances in relation to general knowledge about the disasters. As importantly, this study showed how when practices acknowledged (knowingly or not) the distributed nature of meaning it became possible to also capture within a map some of the dynamism and multiplicity of meaning that exist within any disaster.

Overall, making wildfire maps useable and meaningful to a wide-ranging audience (from first responders to the general public) required the reconciliation of everyday cultures of map use, scientific knowledge, and disaster response practices. This was often achieved by a nuanced interplay between local and standard practices, especially in relation to personal interactions (which created a proximity in space but distance in time) and visualizing technologies (which created a distance in space but proximity in time). Mapping practices that were valued in a shared way required balancing the practices on-the-ground and practices that could move beyond a given space or fire. These practices also balanced the immediacy of a disaster with the expectations previously built of how a disaster and response will and should unfold.

One way to achieve this reconciliation between the local and the standard can come from imagining new possibilities for accuracy. Focusing on a similarly shared sense of accuracy (like the 2007 ad-hoc map's focus on consistency) rather than a

shared sense of meaning for each line (as attempted by the County maps) can allow the various data valances to continue to exist while also making it possible to adapt protocol to the new representational, communication, and response needs. To a large degree, how these balances are managed determines what counts as authoritative and in what form expertise emerges.

One of the reasons the ad-hoc map was able to bring people together when other maps could not was because it allowed these changes and variations in practice, meanings, and data management. The practice of making this map acknowledged a range of understandings and perspectives that were involved in the wildfires, making the map accessible to a variety of actors. In the map's design, it created a delicate, but productive, balance between local with standard practices, produced a distributed expertise that could manage the ever-changing conceptions of risk, and valued consistency in time over cohesion in meaning.

Overall, mapping the space of a wildfire disaster turned out to be an issue of mapping changes over time. Looking at mapping as a practice made visible how no wildfire map contained data from only a single moment in time; they all relied, to some degree, on flattening past, present, and future expectations. This happened in short timescales, like a single day, as data about past burns and fuel patterns, present fire lines, and future fire boundaries being set up were merged into a single fire perimeter. It also happened over decades, when challenges in communication and information sharing from years past defined what was to be expected of maps in the future which in turn delimited what kind of mapping took place at present. As a result, there was no consistency between groups as to how they tracked wildfires (or disasters in general) as

they unfolded, how they connected the wildfires to planning or recovery efforts, or how they connected what they were mapping to cultural expectations and experiences in the landscape. In the end, two main types of accuracy seemed to emerge as a result of this, accuracies that were not necessarily connected to each other: accuracy in the present moment and accuracy of future predictions. In other words, time became one of the main qualifiers of accuracy and value, more than politics, liability, technology, or social status.

Another way in which time impacted the mapping practice was that the immediacy of disasters did not allow for the normal reconciliation of data of different forms or data of different spatial and temporal resolutions. The time needed to do this work could not keep up with the changing situation and forced all mapmakers to break from plans and improvise. Moreover, in all cases, the mapmaking process changed over time – over hours, days, and months – as new data sources and technologies are incorporated into the representation process. Consequently, expectations of disaster maps have to be different than expectations of maps made in non-disaster times, since the practices that produce one are not accessible or acceptable when producing the other.

This way of approaching expertise, authority, and valued knowledge complicates discussions that juxtapose democratic, participatory, and managerial knowledge production. These conversations often pit a public against a government or a local community against a larger industrial complex. They do so by focusing on the socio-political need to maintain power through managerial order, an order that abstracts and erases individual experience and local culture. But when the technological,

environmental, and communication practices are added back in to the conversation, the distinctions become harder to maintain. The results of this dissertation are a reminder that knowledge is distributed; it is not just people and technologies that hold knowledge, but the environment does as well.

Understanding the creative work behind and implications of collaborative practice for the knowledge produced can greatly change the landscape of debate around what these maps do. For example, participatory mapping is often called into action when local communities feel underrepresented by or excluded from the communications of the official response. But, in many cases (including the 2007 wildfires) the participatory model of disaster mapping involves networks spread globally, each with their own culture of map use, with little face-to-face interactions to confirm shared meaning. These practices rely on technology for links between data sources and divide the mapping by pre-defined skills rather than prior experience with disasters or the affected community. When data from people on the ground does exist it often goes unchecked for the sake of time and need. These representational practices make it possible to see what is often missed but also makes it difficult to see how each particular map connects to the affected space beyond the moments drawn. Government maps, on the other hand, are often accused of being based in practices that are designed to impose order and control the public. But these mapping practices (as seen in the County's practice in 2007) can have people on the ground seeing for themselves what is happening around them and making decisions based on the immediate situation and previous experiences in the region. And, despite the goal of order, even these maps

must manage a range of cultures internal to any official response. Both types of practices have ties to the local and affected communities; both rely on standards and specific ways of defining order.

Looking at practices rather than politics or objects, though, suggests that the questions should be asked are not about the relationship to power of the mapmakers themselves or the technologies they use but about how their meshwork of interactions balances the various elements at hand. Instead of assuming that maps showing different objects are oppositional or exclusionary, questions should be asked about how and why they were made. This should include questions about if the goals, conceptions of accuracy, and temporal relations are even comparable. Overall, more questions need to be asked about the connection between how disasters are talked about and represented to the way the material world and the local environments push back on the methods that produced these forms of communication. These questions should be asked of different types of disasters, such as hurricanes and earthquakes, to help tease out the role of the natural environment and data gathering and modeling practices in the overall production of knowledge of disasters.

These results also have two direct implications for future analyses of disasters, disaster maps, and communication during disasters. First, this project demonstrated that any approach to questions revolving around disaster knowledge production has to consider methodologically what studies of disasters are exploring theoretically. Any methods for studying disasters cannot just look at a disaster and its immediate after-affects to understand why different understandings of the situation are coming to a head or to understand why a response took the form it did. The methods developed for this

project are one potential approach among many – and imperfect ones at that -- but they do offer a way to bring into the study of disasters the space in action, the movement of the people or the things, and the changes over time (including time yet to come) that are so important to shaping those movements. Second, to think about the importance of time in how a disaster is understood requires writing about a disaster in a way that moves beyond linear time (how time was largely represented in this dissertation) to write disasters as cyclical and folding spatial processes.

These results are important to consider as more and new types of mapping start to compete and collide during disaster response. As new mapping software allows for the combination of maps from different sources and new data gathering technologies allow for more immediate representation, those engaged in communicating through these maps (either to each other or to the public) need to consider how time, accuracy, liability, and values are drawn into the maps. Just because the software languages can talk does not mean the combined data is representing the same spatial and temporal understandings of the disaster. Nor does it mean that these networks offer a greater or better connection to the cultural and environmental spaces being represented, even if they do open up new conversations as a result of their differences and potential for dynamism. It is especially important to consider how these elements are incorporated into maps as they are increasingly drawn upon as tools for public engagement.

This project was designed to open conversations about the role of these more immediate and multi-authored representations of real-time events in constructing specific ways of understanding the unfolding disasters. The results indicate a need for fluidity in response structure and methods, planning practices that consider the

uniqueness of the cultural as well as physical landscape, and an awareness that expertise and authority are influenced by who you talk to, what technologies you use, where you are located, and what timing is being addressed. They create a framework of questions to be asked by those involved in disaster response as they represent information to be shared between agencies and with the public.

Taken as a whole, this project contributes to the literature in communication and science and technology studies that explore environmental issues, social problems, or the role of visual representations in knowledge production, to require new forms of inquiry that look beyond the immediate vicinity of the action. This project extends the emerging body of literature making the spatial turn, both in objects of study and in analytical practices. It also pushes the limits of much network theory in STS, expanding this work to include issues of the environment and temporality, not just socio-technological relationality.

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