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Mapping Disaster

Tracing the 2007 San Diego Wildfires as Distributed Practice

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Mapping Disaster
Tracing the 2007 San Diego Wildfires as Distributed Practice

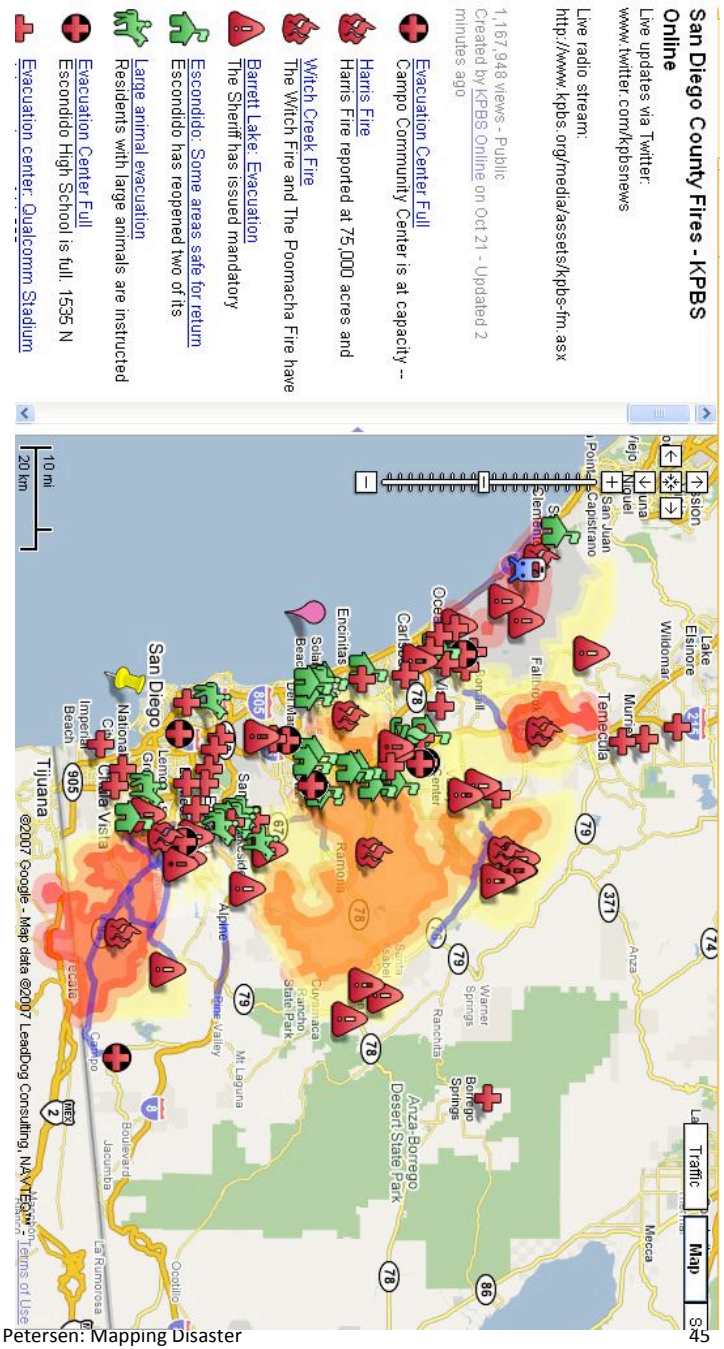
Katrina Petersen

This article examines the production of a highly referenced yet unofficial Google map made during the 2007 wildfires in Southern California to track the unfolding disaster in order to explore how, under duress of disaster, diverse actors and technologies interact to produce mutually legitimate ways of knowing that disaster. Drawing on informal interviews of key actors in the production of the map as well as textual analysis of government and scientific documents regarding the wildfires, I explore the improvisational practices that took shape in order to better understand how diverse voices, often non-authoritative ones, become part of the collective knowledge of that disaster. Engaging with visual culture studies, critical geography and science and technology studies, I expand upon the complexity of the relationship between representation and world, and argue that no single person, technology, or environmental factor was in control of the mapping practice. I find that the legitimacy and value of the map is to be found in the ad-hoc and often problematic interactions that produced the map, where wildfire expertise is not located in a specific training or position in society, but distributed over the network of interactions. Analyzing the relationship between representational practice and knowledge in this way, I argue, can help make visible how valued forms of knowledge were not determined a priori to the wildfires or map, but came into being along with the map.

Introduction

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. It took almost twenty days to contain them. At least fifteen hundred homes were destroyed and over five hundred thousand acres of land were burnt, including thirteen percent of San Diego County (California Department of Forestry and Fire Prevention 2008). Enough land burned at once for the smoke to be visible from space (NASA 2007). During that time, San Diego experienced the nation's largest ever evacuation of residents due to wildfire (County of San Diego 2007). Developing ways to represent and visualize these wildfires posed a great challenge for fire officials, disaster responders, and news reporters as they worked to gather and share information about the unfolding situation. Maps became both vital tools of communication and techniques for making the fires knowable, even as the activity of disaster mapping made visible the impromptu and situated nature of the practices that produced the maps. This article examines the production of one of the unofficial maps made during the 2007 wildfires in order to explore how, under duress of disaster, diverse actors and technologies interact to produce mutually legitimate ways of knowing that disaster.

Specifically, I focus on a Google map designed by an ad-hoc network of actors in response to the obstacles faced by official communication pathways. This makeshift wildfire map became a highly referenced map of the wildfires, receiving over one million hits during the first week of the fires. 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 Governors webpage (Google Maps 2008). But achieving this status was no easy feat. The map was not produced by an official response team, or any traditional team of designers for that matter; rather the designers of this map were a group of people that normally did not work together, engaging with unfamiliar technologies that were often incompatible, all the while trying to piece together different conceptions of what is important to know about a wildfire. It was exactly these distributed and often problematic interactions that helped this particular map



***Screenshot** of the Google wildfire map, day 4 of the wildfires*

assume the same kind of authoritative status as those representations produced by more traditionally authoritative means.

Much of the literature focusing on environmental disasters looks only at questions of risk management, expertise, and politics that lead up to a given disaster, both in terms of damage extents and success (or lack there of) of response (Beck 1994, Steinberg 2000, Rajan 2001, Vale & Campanella 2005, Roberts 2010). But just asking these types of questions leaves unaddressed the types of knowledge 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, did standard mapping practices fail under the duress of the wildfires? In this paper, I demonstrate how the complex relationships that constituted the practices of representing the 2007 wildfires on the Google map made those involved rethink communication networks, cross disciplinary boundaries, and reenvision scientific and technological infrastructures. I argue that it is through these processes, much of which were undefined by standard practices, that this wildfire map's value as a legitimate representation of the wildfires can 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.

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 2001). 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 (2005) argues that when we focus on the dynamic dialectics that produce geographical objects of knowledge we can develop richer understandings of the environment the object represents. 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, I focus on the interactive design process of the map, rather than the map and its connection to its object of representation.

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 (Shapin & 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 a map produced during and for use in a wildfire, this paper aspires to move beyond disaster management or discourses of 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, becomes part of the collective knowledge of that disaster.[1] Such an exploration also makes it possible to consider the implications of mapping decisions for future disaster response.

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 regarding the relationship between representation, knowledge, and the networks of production. I then trace interactions between the diverse actors involved in the production of the map, including technologies and conceptions of wildfire, in order to understand how the map gained the authoritative stance across boundaries that it did. In the process I find a messy, distributed network of knowledge production, where expertise emerges from the in-betweens. Finally, I consider the implications of treating the production of the wildfire map in this way for planning for future wildfires. 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.

[1] Following the lead of scholars such as Fortun (2001) and Tsing (2005).

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] 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 that were key actors involved in the production of the 2007 wildfire map. In these interviews, conducted between six months and a year after the wildfires, 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 also 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 wildfires to help construct the larger landscape of cultural and political conceptions of fire, preparedness, and response in which the 2007 wildfires emerged. These texts, however, are not transparent histories, but sites of meaning-making that not only help establish the possibilities of how wildfires can be understood, but also how the production of

[2] New methods in science and technology studies, as exemplified by Fortun (2009; ethnography of open systems) and Beaulieu (2010; digital co-presence as an approach to fieldwork) 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.

this wildfire map might help us better comprehend the production of knowledge about future environmental disasters.

Producing Ways of Knowing the Wildfires

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, to 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 than constructing ideological conversations about what reality and forms of experience should be.[3] Such arguments treat representations and technologies as outside of norms of knowing the world and everyday practice, with no regard to the cultural and 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.

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 Cori 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. In order to see nuclear reactions, scientists had to create technological and physical boundaries between themselves 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. Each new cultural practice brings about new conceptions of natural phenomena and appropriate ways to know those phenomena.

An image's ability to represent natural phenomena 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, Dumit 2004, Alac 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

[3] 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."

geography studies have argued that maps are part of cultural practices that includes geographical imaginaries (Cosgrove 2008, Davis 1992), material forms (Monmonier 1996), cultural values (Harley 1989), contested histories (Wood 1992), as well as networks of practice (Harvey 1996, Hajer & Reijndorp 2001, MacEachren 2002, Massey 2005, Kitchen & Dodge 2007, Wood & Fels 2009). 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 writing on the environment specifically have found that trust or acceptance of any given knowledge emerges in these interactions. These relationships have been described as acknowledged scientific expertise (Collins & Evans 2007), as democratic processes that mitigate between scientists and the lay public (Bocking 2004), as social constructions of needs for which the knowledge is a solution (Pinch & Bijker 1984), as the erasure of local differences (Tsing 2005), or as the hard work of 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 (see also MacKenzie 1990, Wynne 1992, Dumit 2004). As that claim becomes accepted as legitimate, the work of these diverse groups at the boundaries becomes naturalized.[4] Thus, the value of any knowledge is to be found in interactions between the diverse actors that produce and use the knowledge not in the knowledge itself. In other words, focusing on the interactions in the times of duress that produced this wildfire map is vital to understanding how the map – a particular way of knowing – becomes legitimate across the diverse communities involved it its production.

[4] 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.

Tracing the Map as Practice

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. San Diego County had drafted mapping standards but they had never been implemented, tested, or communicated with other agencies (County of San Diego 2007). As a result, 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? One reason for this uncertain definition was based in an increasing trend for residents of San Diego to push the boundaries of urban life to the edges of wildlands. This move brought into conversation and conflict two conceptions of fire response, one grounded in city life and the other in forestry practices (California Department of Forestry and Fire Protection 2010). With theses changes in environmental relationships came changes in the threat of fire and communication needs.

The State of California acknowledged these changes and, in 2005, began a review process of their fire protection plan focusing specifically on Southern California fire prevention. The County of San Diego also began restructuring their emergency offices and communication networks (Scanlon 2008, County of San Diego 2007). However, by October 2007, no new formal policies had been written on how and what to communicate, and different 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 fires didn’t follow the grid lines” (Web Producer). Moreover, the intensity, urgency, and scale of the wildfires further stressed patterns of communication between responding agencies and with the general public.

There were official maps of the fire being produced by the San Diego emergency office and NASA scientists. However accurate, these maps had a few features that made sharing and timelines a problem. It took 24 hours to produce them so that by the time they were available for use the wildfires situation had long since changed (Bigelow 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 neighborhood (Online News Editor). Lastly, the files were so large that the traffic downloading the maps crashed the county servers (California Institute for Telecommunications and Information Technology 2007). Consequently, those who needed the maps had to creatively improvise their own mapping techniques to account for movement of the fires, people, and the constantly changing environmental conditions throughout Southern California.

A few unofficial maps emerged during the disaster as news broadcasters in the San Diego greater metropolitan region struggled with ways to visually display information about the fires on a timescale that coordinated with the behavior of the fires. One ad-hoc group, however, found that a Google My Map – an interactive program that lets non-programmers build, share, and update customized Google maps – offered a solution to the otherwise difficult problem of circulating information in a time of unreliable infrastructure and looming ramifications of disaster. On the map, the designers mimicked the lines from the government maps for the fire perimeters, and added in evacuation areas, road closures, evacuation centers, aid stations, and any other information from the fire fighters and users who were at the scenes (Online News Editor).

The designers of the Google wildfire map initiated their work out of an information and technological necessity and much of their collaboration 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).

Another observed that:

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

But in the process of figuring out what to do, the introduction of new mapping technologies and expectations to the mapping practice challenged how wildfire maps were made as well as how legitimate knowledge of the wildfires were constructed in the moment.

A team at KPBS, a local public media station, had recently completed another reporting project using a Google My Map, and decided to continue with that format for this event. 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 centers on that point on the map and a window opens with detailed written information (in the form of a speech bubble) overtop the main map view.[5] The 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 alone.

As the KPBS web team received data from government emergency offices (EOC) and California fire officials, they added them to the map. But the data were not geo-coded in a manner that was compatible with the programming of Google maps. Because of how the software was set up, the KPBS team has to "sketchily" draw the ele-

[5] 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.

ments by hand (Geography Graduate Student). 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). Yet, doing so they quickly ran into another limitation of the Google My Maps software. 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. The team drawing the map had hit this limit and could no longer update their information (Geography Graduate Student).

Despite this software glitch unbeknownst to casual Internet users, the wildfire map became so popular that KPBS received over thirty times its regular traffic the first day (Glaser 2007). 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.[6] 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. 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).

As KPBS tried to contact Google for help, they happened to get a call from the Visualization Lab at San Diego State University (SDSU); the lab had someone from Google with them and wanted to know if they could help.

Recognizing the popularity of this map, Google revamped their system so that the wildfire map could be continuously modified (Geography Graduate Student). 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 (GIS Specialist). But, to do any of these changes for the wildfire map, Google had to make the 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).

Google continued to modify their maps based on the recommendations of these KPBS online staff members for months after the wildfire event was over (Geography Graduate Student).

The maps this network received from the San Diego County Emergency Office (EOC), from which they were tracing the fire perimeters, presented their data at a different scale than the capabilities of a Google map. Google maps allow users to zoom in to see their block. The EOC maps, however, provided information at a regional scale, a limitation of the MODIS satellite platform gathering the data. 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).

[6] The actual number of users is unknown, since, as one of the Online News Editors notes, the viewer counter was disabled for a while during the first week of the wildfires.

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 (Online News Editor). But because users called in, this mapping practice was able to gather more detailed, though localized, data than others in existence at the time.

The map designers began to realize the inadequacy of their official data sources and how these were at odds with the kinds of details they were getting from their users. One web producer stated that his team discussed,

> …what we should put on and what we shouldn't, and we decided if we just sourced it people could digest the information however they want. If some guys 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 Producer).

In addition, other information that was a priority for the news media, such as locations of burning houses or evacuation shelters, was not gathered by these technologies. One of the GIS specialists involved in the mapping put it,

> Satellite images are just images, they do not have roads, highways and streets information, so we need to combine, overlay them together so we know exactly where the wildfires happen.

One of the Online News Editors added:

> The official list [of evacuation centers] wouldn't be updated yet, but someone would call up on the radio and say "we're full", and it would go out of the twitter feed, 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 on and correct it.

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

One of the members of this network from SDSU had his own mapping initiative, map.sdsu.edu, and had already put to work a volunteer group of about ten geography students and faculty members to map the fires with GIS. 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. According to one of the GIS specialists, their website was not receiving nearly the traffic they wanted and they were already looking for ways to connect to more popular mapping formats.

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 did. 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 it to reduce the processing time of images collected via satellite from 24 hours to three (GIS Specialist).

Then there was pure coincidence. The SDSU team had the opportunity to collaborate with the director of Taiwan's satellite infor-

mation distribution center, a former SDSU research fellow. He had access to data from the high resolution Taiwanese satellite FORMOSA which, because he had been at SDSU the previous summer, was still pointed at San Diego. According to one of the GIS specialists, 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.

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 method of surveillance, such as aerial photography from planes, impossible.[7] 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 midstep. As the immediacy of the disaster dissipated, so did the ties in the network. One of the interviewees was frustrated that much of the work never got incorporated because the threat dissipated: "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). Without the flames, the map lost its value.

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 it would traditionally treat the fires as a phenomenon for representation or communication. Each

[7] 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.

actor made the others maneuver in relation to it. The mapping practice gained legitimacy because each element offered a solution to a problem in another; 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 incorporate audience 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 was started years before them by SDSU. 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. Each made the designers move in unforeseen directions to find the greatest mapping potential. While the wildfires were made knowable by the mapping practices, the practices were constrained by the state of the flames.

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 2007; Mukerji 2009). Though the form these interactions take is far from agreed upon, these scholars argue that a common goal under-

lies 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.[8] 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 when 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 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 legitimacy

[8] For instance, Star and Griesemer's (1989) boundary object bridges different social worlds and helps 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's (1997) trading zones, another theory that looks at such networks of knowledge exchange, 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.

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. One of the GIS Specialists 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.[9] 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.

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

[9] 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

on a 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). 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 & 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 is grounded in the relationship between actors as they actively negotiate 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 past experience and space of a given disaster is represented, and thus how it is encountered in the present, directly affects future imaginings for aid, rehabilitation, and communication needs (Fortun 2001). If, for example, the disaster is understood as an act of god, then those that respond to and plan for it will look at different elements and draw different conclusions than if the disaster is thought to be grounded in social processes (Klinenberg 2002). This means that 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 one of the GIS specialists interviewed, 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 2003). 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).

> 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).

> 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).

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 than 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 users, the designers found, had "an expectation of accuracy that even the county wouldn't necessarily be able to maintain" (Online News Editor). One of the designers noted, "we wrote it in, if you clicked it [zoomed in too far], *estimated* fire perimeter or *estimated* evacuation zone. But people's reactions were to the visual information" (Geography Graduate Student, 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. 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 response 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 is imagined as static, then holes can be found.

But if imagined as active, holes and their solutions are harder to pinpoint. If knowledge production is imagined as distributed over that infrastructure 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 changes, 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 beforehand 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.

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. The practice of mapping required negotiations between diverse actors, technologies, conceptions of space, priorities in disaster, and the physical environment. As part of this practice, each actor had to expand their definitions 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 on 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. Treating the practice of representation as dynamic and distributed challenges how we identify expertise and what it means to produce a legitimate representation.

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