

# WellWatch: reflections on designing digital media for multi-sited para-ethnography

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## Abstract

WellWatch was a webtool designed to create a collaborative space for communities and academics to monitor, study, and respond more effectively to the emerging shale gas industry. This article reflects on the successes and failures of the first iteration of WellWatch for academic research and its community of non-academic participants. For academics, this tool succeeded in gathering rich narratives of the personal experiences of people living amidst natural gas development. These narratives, from multiple locations, provide insight into structural patterns associated with this industry. They gave a lens into social processes emerging from and responding to these structures. Taken together, these narratives help define next steps for research. WellWatch also proved useful for non-academics, primarily impacted landowners from Colorado and Pennsylvania. It helped landowners manage problems of individual isolation by networking them with other landowners and providing useful information about how to manage and resolve problems. It also furnished data to the people affected that they could use in their own advocacy, with potentially important effects. The tool also helped non-profit advocacy groups in assisting with networking and with sharing best practices. Based on this review of WellWatch, the article proposes a method for further developing collaborative ethnographic and community-based research through networked digital media.

**Key words:** citizen science, community based participatory research, digital ethnography, hydraulic fracturing para-ethnography, multi-sited ethnography

## Résumé

WellWatch était un outil Web conçu pour créer un espace de collaboration pour les communautés et les universitaires à suivre, étudier, et de répondre plus efficacement à l'industrie émergent du gaz de schiste. Cet article se penche sur les succès et les échecs de la première itération de WellWatch pour la recherche universitaire et la communauté des participants non universitaires. Pour les chercheurs, cet outil a réussi à recueillir des récits riches des expériences personnelles des personnes vivant au milieu de développement du gaz naturel. Ces récits, à partir de plusieurs endroits, donnent un aperçu des schémas structurels associés à cette industrie. Ils ont donné un objectif dans les processus sociaux émergents de, et à répondre à, ces structures. Pris ensemble, ces récits permettent de définir les prochaines étapes de la recherche. WellWatch s'est également avéré utile pour les communautés, et les propriétaires fonciers touchés principalement du Colorado et la Pennsylvanie. Il a aidé les propriétaires à gérer les problèmes de l'isolement individuel par leur mise en réseau avec d'autres propriétaires fonciers et fournir des informations utiles sur la façon de gérer et de résoudre les problèmes. Il a également fourni des données sur les personnes touchées qu'ils pourraient utiliser dans leur propre défense, avec des effets potentiellement importants. L'outil a également aidé les groupes à but non lucratif pour aider à la mise en réseau et le partage des meilleures pratiques. Sur la base de cet avis de WellWatch, l'article propose une méthode pour développer la recherche ethnographique et communautaire de collaboration à travers les médias numériques en réseau.

**Mots clés:** la science citoyenne, sur la base de recherche communautaire participative, l'ethnographie numérique, para- ethnographie de la fracturation hydraulique, l'ethnographie multi-site

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## Resumen

Well Watch fue una herramienta web diseñada para crear un espacio de colaboración para comunidades y académicos para monitorear, estudiar y responder a la industria emergente de gas de esquisto más efectivamente. Este artículo reflexiona sobre los éxitos y fracasos de la primera iteración del WellWatch tanto para la investigación académica como para su comunidad de participantes no académicos. Para los académicos, esta herramienta logró reunir relatos ricos sobre las experiencias personales de personas que viven en medio de la explotación del gas natural. Estas narrativas de diferentes localidades proveen información sobre los patrones estructurales asociados con esta industria y dieron una mirada a los procesos sociales que emergen de y responden a esas estructuras. En su conjunto estas narrativas ayudan a definir los próximos pasos de la investigación. WellWatch también resultó ser útil para los no académicos, principalmente dueños de tierras afectados de Colorado y Pensilvania. Ayudo a los propietarios de tierras a gestionar los problemas individuales de aislamiento generando redes junto a otros propietarios y proporcionándoles información útil acerca de cómo manejar y resolver problemas. De igual manera entregó información a personas afectadas por su propia defensa, la cual pudo tener profundos efectos políticos y emocionales en los individuos involucrados. La herramienta también ayudo a organizaciones de defensa sin fines de lucro mediante la creación de redes de contacto y el intercambio de mejores prácticas. En base a esta revisión de WellWatch, el artículo propone un método para desarrollar aun más la investigación etnográfica colaborativa al igual que la investigación comunitaria a través de los medios digitales en red.

**Palabras claves:** Ciencia ciudadana, investigación participativa basada en la comunidad, etnografía digital, fractura hidráulica para-etnográfica, etnografía multi localizada.

## 1. Introduction

I don't open my windows in the summer, it is like a flume of toxins blow in from the South West, and smell is very thick here... I have plastic on the window. I can't risk a garden, I can't sit on the deck, I drink bottled water. The fumes were really bad a month ago. I called Company X and complained, and one of their employees, the liaison, told me that a lot of the fumes around where I lived were coming from Company Y's wells. The liaison said that Company X 'maybe' would put afterburners in on their future wells. The neighbors down the road had high-end horses, and there were reported problems with the births - the people moved out. The neighbor across the road gets royalties and moved to Florida. When the fumes were really bad a few years ago you could see a funnel cone shape of fumes from the deck. I am very ill - I have been threatened with eviction if I 'talk and make trouble'. I don't know what is going to happen. My former Doc. who worked at the Rifle hospital told me there were lots of alarming, unaccounted-for illness around here - and he advised me 'to get out of Dodge'... he is gone now from the hospital...away from gas development areas.

WellWatch report from Colorado in February 2011.<sup>2</sup>

Human experiences, like those described above, are the frontline of changing technical, economic and social conditions. The quote was recorded on WellWatch in 2011, a period of intense natural gas development in Colorado. WellWatch was an online tool where homeowners, living in the midst of gas development, could describe and share their experiences supported by photos, videos and other documents, and then map and tag them by issue area, location, time, and companies involved (Song 2011). Through WellWatch, people could find others with similar experiences and contact them (Song 2011). ExtrAct, a research group at MIT, co-directed by author Dr. Wylie, developed WellWatch. Second author Dr. Len Albright was not involved in the design and development of WellWatch. Prof. Albright's review of

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<sup>2</sup> All quotes are from WellWatch reports, they have been anonymized and corrected for misspellings. We have not corrected for grammar.

WellWatch reports and co-authorship of this article adds the perspective of a social scientist not involved in the design and development of the site.

For impacted landowners, a combination of isolation, impenetrable and unresponsive bureaucratic systems, and tangled webs of corporate sub-contracting, leasing and ownership, can make living through gas booms a tumultuous, hazardous and confusing experience (Perry 2011, 2012; Wylie 2011). Policy debates about hydraulic fracturing are often limited to an analysis of the safety of the act of fracking a well (Perry 2011). This compartmentalization does not account for the overall impacts of the practice for communities on the ground (Bamburger and Olwald 2012, 2013; Perry 2012; Wylie 2011). Communities describe the multifaceted experience of living with hazards including: truck traffic destroying roads, spills of waste water, chemical spills and smells, redirection or consumption of water, problems of animals drinking from waste pits, and spillover from waste pits in heavy rains (Clarren 2006; Perry 2011; Wylie 2011). These impacts extend throughout the supply chain, from communities who are experiencing booms in the mining of the sand used in fracturing, to communities where waste materials are being processed (Korfmacher *et al.* 2013).

As articles in this special issue argue, gas patch communities, like inhabitants of other areas of mineral extraction, are largely incapable of shaping the structure of gas development (Hudgens and Moore 2014; Mercer *et al.* 2014; Simonelli 2014; Willow 2014; Willow and Wylie 2014). They lack the information and the medium to follow and participate in shaping structures that are changing their physical, social, and legal environments. Government agencies tasked to monitor and shape the industry are under-resourced, technically under-developed, overwhelmed and without an infrastructure capable of monitoring such a distributed and chaotic system (OGAP 2012). Additionally, bureaucracies, as they are presently configured, are not necessarily built to identify, track, and address the negative environmental, social, and human health implications of the gas industry.

The technical and political infrastructure associated with this industry makes it hard to study the issue at community level in a holistic fashion. Available data are poorly organized for understanding the multifaceted, complex conditions this industry creates on the ground (Bishop 2013; Korfmacher 2013; Maule *et al.* 2013; Wylie 2011). Data on wells are available by state rather than by geographic formation or by company. Most state databases are hard to use, and do not take comments or data from the public, other than complaints (Perry 2011; Wylie 2011). Hence, it is not possible to study complaints and issues across states or by a particular company. It is also not possible to study emerging issues by geological formations or watersheds through state or federal agencies. Therefore, data are presently gathered in a way that makes it hard to recognize patterns in emerging problems (Wylie 2011).

This lack of technical infrastructure can be contrasted to the technical sophistication of this industry, which through close relationships with top-flight engineering universities, has developed extraordinary sensory power for detecting oil and gas deposits and remarkable infrastructures for extracting, transporting and refining fossil fuels (Wylie 2011). Comparable sciences for studying the results of this process from chemicals to social impacts are under-developed, uncoordinated, and decoupled from effective political action or technical development.

Journalism is tasked with generating and amplifying stories such as those above, but does not offer tools to empower citizens to share their own stories and analyze them to reveal structural relationships. Similarly, statistical analysis in social science can pinpoint trends and patterns, but strips data of cultural and human context and relies on access to data that can be difficult to obtain. Furthermore results of academic research lag or fail to reach frontline communities (Allen 2003; Brown 1997). Ethnographic studies and oral storytelling communicate new experiences, but even when digitized, their wider implications are often limited by the failure to link and compare across geographic or thematic cases (Marcus 1995). In contrast, emerging social media tools allow for the development of networked ethnographies through the facilitation of networked storytelling. This article argues through its reflection on WellWatch and the shale gas industry that social scientists can play a key role in shaping digital media to enable networked narrative approaches to industrial monitoring and to academic analysis.

WellWatch was a methodological intervention, intended to address some of informational and technical asymmetries between communities and the natural gas industry. As the other articles in this section have argued, this industry's connection to regulatory agencies, through neoliberal policies and discourses that foster natural gas development, tend to exclude even middle class communities with social capital from

shaping its development (see Mercer *et al.* 2014; Willow 2014). WellWatch intervened in this space as a form of "critical making" (Ratto 2011). Critical making is an emerging method of in practice research in Science and Technology Studies that uses media tactically to express academic arguments through art and design (Da Costa 2008; Ratto 2011; Thompson 2004; Wylie *et al.* 2014).<sup>3</sup> Building from academic critiques like those provided in this special issue, and needs expressed by communities and non-governmental organizations, WellWatch was designed as a space for networking communities and gathering information useful to both landowners and academics. The platform intended to counter frontier development processes that obscure the experiences of surface owners who bear the industry's externalities, which are vital to understanding the lived experience of natural gas extraction (Hudgins and Poole 2014; Willow 2014).

Following a brief background, we discuss the results of WellWatch for academics and discuss it as a fusion of multi-sited ethnography and para-ethnographic practices suited to the grassroots study of the oil and gas industry. Second we reflect on the usefulness of the website for communities and individuals, arguing that such networked online databases provide a methodological framework for responsive community-based academic research (Marcus 1995, 2000b; Minkler and Wallerstein 2008). Third we reflect on social and technical infrastructure issues that made the site prone to spam attacks, which eventually caused it to crash in the Fall of 2012. Crippled by spam attacks, much of the website's data was irretrievably lost. The material reviewed in this article was recovered from the Way Back Machine, an online internet archive, and the records of WellWatch contributors. We conclude with a discussion of redesigning WellWatch and its promise as a platform for community-based participatory research, which connects academic findings with goals of advocacy and social change (Minkler and Wallerstein 2008).

## 2. Brief history of WellWatch

WellWatch was developed by an interdisciplinary research group, ExtrAct at MIT's Center for Future Civic Media (c4fcm), funded by the Knight Journalism Foundation's News Challenge Grant (Csikszentmihalyi *et al.* 2007). ExtrAct aimed to identify civic problems posed by oil and gas extraction that might be addressed by new media information sharing tools. The project was co-founded and directed by Sara Wylie and c4fcm's director Chris Csikszentmihalyi in 2008. ExtrAct developed following Wylie's ethnographic research in Colorado with The Endocrine Disruption Exchange (TEDX) a small non-profit research organization lead by Theo Colborn. Colborn, a founder of the field of endocrine disruption, developed TEDX to archive all the available research on chemicals that disrupt human biological development through acting like hormones. TEDX provides researchers, policy makers and NGOs with up-to-date summaries of Endocrine Disruption research.<sup>4</sup> Working with TEDX to develop the first database of chemicals used in hydraulic fracturing and their health effects underscored for Wylie and her collaborators the need for new informatic systems designed for communities and academics to better study this industry from the grassroots.

The oil and gas industry is one of the world's most technically sophisticated industries and it works on a global scale. Schlumberger, one of the three major hydraulic fracturing companies, has the world's largest seismic imaging fleet and its own chemical company (Reed 2008). It has its own satellite network and supercomputing hubs to develop seismic images of the Earth's subsurface. These representations are shared in virtual reality suites accessible from offices in New York, Tokyo and Paris, far removed from the well sites (Business Wire 2001-2003; Wylie 2011). Their central office borders on MIT's campus, a location that fits with the company's larger strategy, namely to develop its workforce and to support Research and Development that is beneficial to its mission through connection to the world's premier science and engineering centers (Innovation Quarterly 2008; MIT News 1999; Tuz 2004).

In contrast, communities of landowners impacted by oil and gas extraction have comparatively little access to technologies or academic centers. Compared to the technical sophistication of this industry with its

<sup>3</sup> WellWatch was strongly influenced by Tactical Media and the emerging concept of Critical Making that builds upon the possibilities of new media. There is insufficient space in this article to reflect on the connection to and significance of the project for STS, Critical Making or New Media. Wylie (2011) describes the process of developing WellWatch as a mode of "STS in Practice" in which STS focuses on making criticism through media other than the written word.

<sup>4</sup> TEDX website: <http://endocrinedisruption.org/about-tedx/about>.

powers to generate and process vast quantities of data, public information systems are impoverished. Industry exemptions from the United States Clean Air Act and Safe Drinking Water Act forestall regulatory data-gathering on air pollution around individual wells or collection of information on chemicals used in fracturing (Lustgarten 2008; Maule *et al.* 2013; Nijhuis 2006; Urbina 2011a). WellWatch attempted to intervene in the technical and informational asymmetries between this industry and impacted landowners by developing closer relationships between communities and academics to actively employ ethnographic insights in the design of free, open source tools for communities and community organizations (Graeber 2004).

The WellWatch research group included an artist, an anthropologist of science and technology, non-profit organizations, impacted landowners and programmers. Based on ethnographic research the group designed and pilot-tested online tools for communities experiencing the boom in shale gas extraction. *ExtrAct* resulted in the development of three websites: *Landman Report Card*, *News Positioning System* and *WellWatch*.<sup>5</sup> Each of the websites offered communities and researchers new ways to share and aggregate information. *Landman Report Card* enabled community-to-community education on the industry representatives ("landmen") who research mineral rights and make mineral and surface lease agreements. This web service allowed landowners to share their stories, providing transparency and a more open market in leasing for landowners. *News Positioning System*, a website for geographically locating news articles and other information, enabled small community organizations to build their own online archives of news about the industry and share them with other small community organizations. The goal of this tool was to develop a much more fine-grained and geographically located view of news about the industry. The final tool, *WellWatch*, was only developed in prototype, and built on both of these systems. It integrated data from Ohio, Texas, Pennsylvania, Colorado and New York State into a searchable open layers map. As the site was a wiki, users could add stories, notes and complaints about particular facilities as well as generate their own pages (MIT Labcast 2009; Palfrey and Bracy 2011; Wylie 2011).

WellWatch, was first released in the Fall of 2010 (for pilot testing primarily in Colorado). It was advertised more broadly during January of 2011 and it was online until the fall of 2012. Persistent spam attacks made the site hard to sustain and cause it to crash in the fall of 2012. For example, one landowner's story about her illness was modified over thirty times by multiple IP addresses in the course of a single day. It is unclear what caused the destruction of the site and whether or not it was purposeful. However, in its time the online site became a rich resource for scholars and communities. The prototype for the website received over 200 reports from our three trial states – Colorado, New York, and Pennsylvania – and served data on nearly one million wells. WellWatch was most successful when there was a particularly invested individual who was able to act as an advocate for the project as is a common pattern in the toxics movement and in community based participatory research (Allen 200; Brown 2007; Minkler and Wallerstein 2008).

Tara Meixsell from Newcastle CO, became such an advocate in Garfield County Colorado. She was drawn into oil and gas issues through the story of a co-worker who developed very rare neurological illnesses coincident with gas development in her area of Colorado. This friend and coworker, whose health declined precipitously, asked Tara to write up her story as Tara had previously written historical fiction about their region. Following her friend's story led Tara deep into the lives of landowners in her area who felt their health and environment had been impacted by the boom in gas extraction (Meixsell 2010). Tara worked tirelessly to document their stories and worked with landowners whose computer experience extended to email, to share their stories through WellWatch. In doing so she helped create a physical and virtual network of landowners experiencing issues with gas extraction. Tara's work is a mode of non-professional ethnography or oral history, an effort to capture and reflect the lived experiences of those in her social network.

Through participating in the WellWatch project, landowners in Texas and Pennsylvania found people in Colorado with similar health impacts. Individuals used WellWatch as a diary of their illnesses and exposures, to document skin problems in their children, as well as to document spills and their impacts. A

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<sup>5</sup> Landman Report Card (LRC) The site was publicly released January of 2010. <http://www.landmanreportcard.com/>. News Positioning System (NPS): released in its initial version in the summer of 2010. <http://www.newspositioning.com>. WellWatch: the website is no longer online as described in this piece. Here is a YouTube video documenting the prototype of WellWatch: <http://www.youtube.com/watch?v=-LopQWM-t6s>

letter written by a physician on behalf of families about illnesses they experienced was shared through the interface. Two law firms used data from the system in their research. ExtrAct's tools have been covered in the *New York Times*, the *Columbia Journalism Review*, Reuters, and local newspapers (Colson 2010; Santo 2011; Song 2011; Urbina and McGinty 2011).

### 3. WellWatch as a structure for recursive publics

WellWatch was developed on an open source media-wiki platform, the same platform used in Wikipedia. This meant that users could freely start accounts on WellWatch and begin developing their own material. ExtrAct provided two background layers of data to which users could contribute, data on the location of wells, along with their state identification numbers, and available records on their owners and operators. On the front page, users could enter an address and find available well data close to that address. They could then click on facilities and add notes or complaints. Users could develop tags to categorize their comments, and upload images, documents or videos to supplement their text. Users' comments were compiled on the homepage by their tags, so users could read each other's content (Figure 1, 2). They could also contact each other through a chat feature and be alerted to others reading their posts or commenting on them. The site was also designed so users could provide each other with useful information that was not related to a particular well. In each state where WellWatch operated, users developed informational wiki pages to provide contact information for relevant state and local agencies and officials, as well as active community organizations in those regions. Community organizations could make their own wiki-pages. The intent was that the site could become self-sustaining by its users as a "recursive public," as Kelty describes, in which participants are aware of and able to modify the structure that brings them together (Kelty 2008).

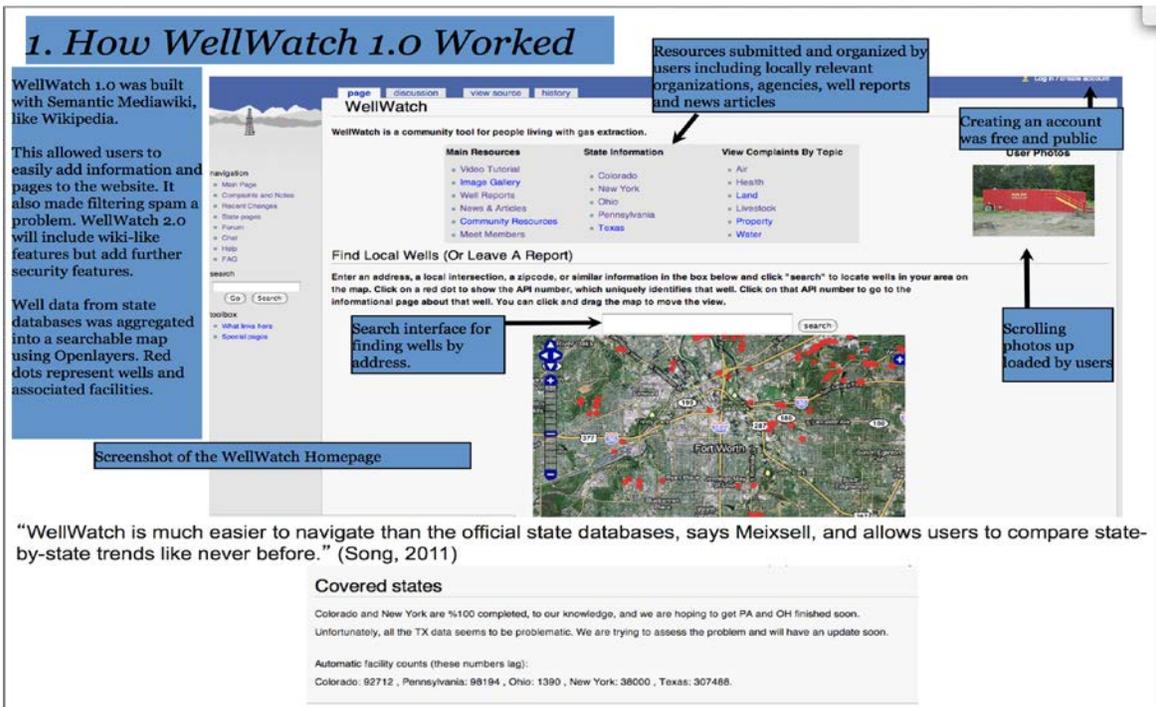


Figure 1: How WellWatch worked. This is an annotated screen shot of the WellWatch website.

Kelty developed this concept based on his study of open source, free software communities (2008). In his analysis, Kelty saw these communities thrive and challenge modernist concepts of *public*, in that participants are not ignorant of the structures that bring them together. Rather, communities of coders collaboratively write software down to the version control software that enables integration of multiple

author's work. Inherently, open source projects can be copied and modified by downstream developers who are recursively able to modify and develop the project. This awareness and ability to access to modify and contest the infrastructure described by Kelty, starkly contrasts with the lived experience of residents in the shale gas extraction areas, where surface owners are often structurally excluded (Perry 2011; Perry 2012; Perry 2013; Wylie 2011). In fact, one of the major findings for academics that analyzed the stories entered on WellWatch has been the lack of recursive public processes for shaping the trajectory of shale gas extraction.

Many of the stories on WellWatch describe the exhaustion and frustration on the part of landowners as they attempt to address their concerns about how gas extraction is proceeding on their own property, from the many years it takes to address a chemical spill to the lack of response to critical health conditions. This lack of surface owner control is a by-product of the industry's modular structure, where operating through leasing and sub-contractual relationships limits liability between corporations (Appel 2011). Surface owner exclusion is further developed through the industry's enclaving practices, the physical and temporal separation of sites and infrastructure for oil and gas extraction from the surrounding social, economic and physical landscapes. Off-shore drilling exemplifies enclaving, where the industry achieves the development of its own extra-territorial spaces (Appel 2011; Helmreich 2009). It reduces effective state and local oversight of and participation in extractive processes (Bowker 1994; Ferguson 2005; Watts 2005). WellWatch attempted to intervene by providing a mechanism for isolated landowners to report problems and share knowledge across geographic areas. As a method and platform, WellWatch "enacts" this critique by attempting to build an academic and community-based research structure that connects critique to structural change.

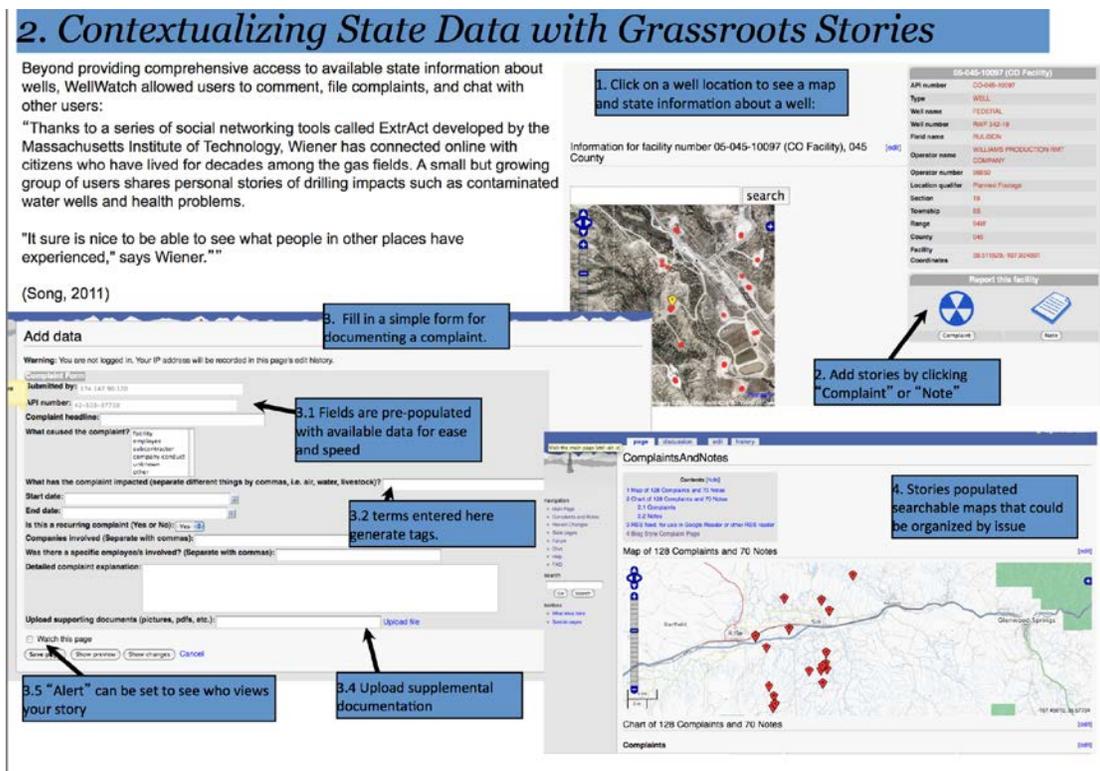


Figure 2: Contextualizing State data with grassroots stories. The sequential screen shots in this image shows how user data was added to WellWatch.

#### 4. WellWatch as a tool for multi-site, para-ethnography

Unlike other Digital Anthropology projects, which take the culture of using digital tools as their object of study (Miller 2012), WellWatch leveraged digital media to improve anthropological study of large-scale industries. WellWatch was in effect a tool for multi-sited ethnography, the study of complex systematic

relationships between physical locations (Marcus 2000). The central benefit of multi-sited ethnography is its ability to clarify relationships formed where structural processes tend to obscure and decouple them. Marcus argues ethnographic analysis is useful "...in cases where relationships or connections between sites are indeed not clear, the discovery and discussion of which are precisely in fact the main problem..." (Marcus 2000: 16). This multi-sited approach has been used to follow objects, scientific facts, supply chains and social movements (Dumit 2004; Fortun 2001; Juris 2008; Marcus 2000).

Multi-sited ethnography has traditionally relied on the single ethnographer to travel between sites to study and make apparent their interconnection, but "multi-sited research is designed around chains, paths, threads, conjunctions, or juxtapositions of locations in which the ethnographer establishes some form of literal, physical presence, with an explicit, posited logic of association or connection among sites that in fact defines the argument of the ethnography" (Marcus 1995: 105). Inspired by this, WellWatch offered a digital platform for uncovering and helping to forge more recursive relationships between sites and communities previously isolated by virtue of technical, informational and political structures. WellWatch proved effective as a tool for informing ethnographic research in that it raises questions about these links and processes.

Additionally, through networking academics and communities, WellWatch enabled an open process of para-ethnography. Para-ethnography "...proposes an analytical relationship in which we and our subjects—keenly reflexive subjects—can experiment collaboratively with the conventions of ethnographic inquiry" (Marcus 2000). Through para-sites, constructed meeting places external to the traditional "field" such as invited conferences, participants and researchers discuss problems collectively to propose new sets of questions and answers as they inform each other. Para-ethnography ideally enables both the community and anthropologists to engage in a reflection process that changes their perception of the object of inquiry. WellWatch, particularly in its co-development between academics, non-profits and community members, became an ongoing para-site in which users and developers of the site reflected on industry development in different physical locations, and environmental justice issues expressed by WellWatch users. Empowering users to recognize their experiences as being shared and structurally produced para-ethnographically, shifted users perceptions and opened new terrains for collective action.

Anthropologists are now discussing developing WellWatch 2.0. They would work with local advocates to generate ethnographic fieldnotes and encourage research participants to network with each other via Wellwatch.

## 5. How WellWatch has been useful for researchers

The following sections provide a presentation of data and analysis reported on WellWatch and gathered by local advocates. WellWatch was effective in providing ethnographic narratives, documenting social structure, uncovering social process and social change, and generating avenues and sites for future research.

### *WellWatch hosted ethnographically rich personal narratives*

People told their stories on WellWatch in accessible and candid ways that allows for systematic observation. For instance, these two stories were submitted from two landowners in Colorado who visited a well site as part of a *New York Times* article on the impacts of gas extraction in their neighborhood:

I went to the location and met with a group in front of a well pad by a resident's home, we were about 300 feet or less from the wellpad that is just off the road. The fumes being emitted from the tank (and afterburner) were visible (wavy distortion lines going up into the air). The chimney was making a ping-ping rhythmic noise as the metal was heated and the air was cold. I have an extremely compromised sense of smell, and did not detect fume odors at that time although another chemically sensitive individual who has had over exposure to fumes did smell odors immediately after arriving at the location...That night at 2 a.m. I woke up coughing and felt unable to breathe. I had an excruciating headache, I took Afrin to attempt to relieve the symptoms - when I blew my nose there was no colored or thick discharge, just a watery run off and blood on the tissue each time I blew. My respiration problems continued to be severe. I

would lose my breath just walking from room to room in my house (15 ft or so)...My coughing fits continued, every time I coughed I felt like my head was blowing off/ the fits lasted from 5 to 15 minutes...My headache was severe for four days after the exposure, it is receding more on the fifth day (today) after the exposure.

WellWatch Narrative 2:

I went to the X property to meet with the *New York Times* reporter and many of the landowners who have been inundated by the gas wells and the fracking. Across the road were condensate tanks. The well pad and condensate tanks are roughly 350 feet from the X's front door, and we were standing closer than that to the pad by about 30 feet, we were in the front driveway close to the road. ...The smell started immediately when I got out of the car. I tried to cover my face to not inhale the horrible caustic fumes. But it did not work. ...(Intermittent emissions/wavy lines in the air effect were visible, and the black stack emitting the fumes was ticking - due to the heat of the metal stack reacting with the quite cold winter air that day) I came home after an hour or so and was very ill. I had so much pain in my lungs and became very light headed. By the time I went to bed I couldn't breath and the pain became more intense. I was also coughing continuously. ... This morning I was still very weak and having problems breathing. ...I will not be able to go to anymore meetings around the areas of gas company facilities as it is too dangerous for my health and it takes me as my husband says "for an hour or so of visit you are sick for three days after". He tells the truth.

These stories document parallel experiences by two landowners who have developed chemical sensitivity, which they believe is related to air pollution from the heavy gas development in their areas (Colborn *et al.* 2011). Not only do these reports detail their similar symptoms--difficulty breathing, coughing, and headaches, and their slow process of recovery, but also reveal a shared issue: that assisting in media coverage of gas extraction exposes them to further physical harm.

*WellWatch networked narratives to give insights into hidden structural issues and information gaps*

The experience on the ground for those who become advocates on this issue can be one of exhaustion, both from their continued struggle to gain recognition and remediation for their problems and from the experience of performing their story as interview subjects for media outlets. However, this toll for landowners is not reflected in the media coverage itself. This is a structural issue in which media coverage, like academic documentation, tends to export peoples' experience for distant audiences. This process of export rarely attends to the impact that making time for reporters, traveling to hazardous sites and the stress that presenting themselves as "impacted landowners" has on people who are already wrestling with issues such as whether or not they can bathe their children in their well water.

By providing a forum in which landowners can speak about their own experiences, these two landowners are able to reflect and bring to light this shared structural issue. Creating a forum where people can represent themselves is an important part of community based participatory research that breaks down the boundaries between experts and laymen by refusing a structure of "researcher" and "research subjects" (Minkler and Wallerstein 2008). These rich, personal narratives challenge the reductive structures of surveys commonly used to capture and study communities (Brasier *et al.* 2011).

The networked, participatory structure of WellWatch enables situated knowledge, knowledge that is developed and accessible because of one's point of view, to be networked and, through networking, evolve richer analysis of the relationship between those positions (Haraway 1988). Below is a small example of how these rich narratives, when networked, reveal shared structural experiences.

A landowner from Pennsylvania wrote on Feb 20, 2011:

I had to take my daughter to the hospital for nosebleeds that would not stop - they were torrential nosebleeds - the seat belts in the car are wrecked from them... after the nosebleeds she would then be nauseous and have bad headaches... The nosebleeds were very frequent, the

school would call me when they happened at school. I had to send extra shirts for her to change into at school. When we stopped using and bathing in the house water about 2 1/2 months ago the nosebleeds subsided.

This story is echoed in report of a Colorado landowner who lived about half a mile from well pad. She kept an odor log beginning June 2010, documenting a variety of petroleum, diesel, and organic odors:

Feb 9th, 2011 - had first nosebleed (had never had nosebleeds before, maybe once or twice in my life - )

Feb 10th, 2011 - had second nosebleed, it went on for over half an hour, I called the EMT's - they couldn't stop it, and then I was taken to the E R in Rifle. They put a balloon in my nose. That same night I went to the E R in Grand Junction with issues from the balloon in my nose. They wouldn't take the balloon out of my nose because they were afraid the bleeding wouldn't stop if they did.

Feb 14th 2011- I went back to the hospital and they took the balloon out of my nose.

Another homeowner in Colorado also described her son's experience of nosebleeds:

I am uploading more pictures of the welty rashes by son has been experiencing since Company Z started flaring two mammoth towers of flames, that stink to high heaven. His bloody nose bleeds are getting so bad, that we've been using tampons to stop the bleeding.

This family sought the advice of a physician who would eventually treat many people in their area who were experiencing health problems. The physician wrote a letter to the Colorado Oil and Gas Conservation Commission detailing the family's symptoms and describing his efforts to get oil and gas companies operating in the area to release information on chemicals being emitted in the area:

What were their symptoms? One family's oldest son had an unexplained red raised rash like hives after being exposed to the flaming frac'ing gas. He previously had no reported history of similar rashes. The father and younger son developed nose bleeds for no apparent reason, again after the exposure not before. The mother had fatigue and headaches not to the degree pre-exposure. Yes, these symptoms could be related to a long differential diagnosis, but this list of vague symptoms have all been attributed to volatile toxic gases like benzene, toluene, ethylbenzene, and xylene from the gas frac'ing again, starting after exposure. I was taught in medical school - if you hear hoofbeats think of horses not zebras, but this is an exotic extreme, so I thought of the worse case scenario, and thought zebras - before the horse was out of the barn at full gallop. It is always best to be safe than sorry, I told those families to leave to avoid further health damage until I learned what they were exposed to, but I'm still waiting for an answer from Company Z. The other family has a wide range of symptoms: unexplained flu-like symptoms - headaches, body aches, fatigue, dizziness, emotional spells for no apparent reason, gastrointestinal symptoms - nausea, lack of appetite, etc. Again, from an otherwise healthy family that didn't need to see a doctor very often.

The physician shared his letter on WellWatch, thus providing useful information for others experiencing similar symptoms and for other physicians whose patients report similar problems. Recent research documents the difficulty experienced by physicians in accessing and sharing information about chemicals used in fracking and calls for attention to illness narratives in studying connections between illness and natural gas extraction (Frankowski 2008; Hanel 2008; Korfmacher *et al.* 2013; Saberi 2013). Such

narratives are increasingly being identified as vital to healthcare that attends to a patient's lived experience (Campos 2006; Charon 2002, 2006). Personal illness narratives and family histories have been vital to the environmental health and toxics movements, where first-person stories have been influential in both advocacy, policy and in spurring scientific research (Antonetta 2001; Brown 2004, 2007; Steingraber 1998; Walley 2012).

Personal narratives illustrate the many levels that need to be fixed if landowners' experiences are to be addressed (Korfmacher *et al.* 2013; Perry 2012). They show that fracking is not simply the execution of a technical process to break a shale formation, but is the lived experience in which landscapes, bodies, and social and political relations are reconfigured (Cartwright 2013). Some of the most poignant WellWatch stories describe changes in human and animal health coincident with gas extraction (Bamberger and Olwald 2012, 2013). WellWatch, by bringing these stories together, allows us to see patterns across these landowners' health complaints. Of the 42 complaints made about air quality as of May 8th 2011, 29 describe health issues experienced by humans or animals linked to changes in air quality. 27 of those discussed health problems experienced by people. They reported a wide range of symptoms including: nausea, sores, rashes, dizziness, headaches, respiratory problems including asthma attacks, internal bleeding, issues with childbirth such as miscarriages, gastrointestinal issues, lack of appetite, muscle spasms, swelling, and neurological problems such as memory loss. These symptoms align with those reported in academic and community studies (Bamberger and Olwald 2012; Steinzor *et al.* 2013).

Networked grassroots narratives through systems like WellWatch could become vital to the process of environmental health and science research, as capturing the complexity of environmental exposures generates challenges for lab-based methods of knowledge production (Nash 2006; Murphy 2006). Combining such accounts with emerging medical knowledge, such as physicians' reports, provides a promising example of how weight of evidence could be generated through connecting situated knowledges (Haraway 1988). The frustration expressed by this physician at the lack of access to information on chemicals in use and effective regulatory response, is a common emotion experienced by many landowners, who even though they experience illness, do not have epidemiological or similar evidence to incontrovertibly prove the link between their illnesses and gas extraction:

We arrived from MN after our 50th wedding anniversary and there it was the most horrendous thing, the gas rig 700 feet from our home. When we drove up in our yard we noticed a plum of grey smoke hanging in our deck...The smell of benzene and other chemicals were so strong. Little did we know that the fumes had gotten into our home already while we were gone. After being in our home for 15 minutes I passed out and my husband called my son-in-law to come and get me out of there. He took me to their home. While there I could not walk because of the disorientation. I had headaches and dizzy spells.... I kept trying to go home but I would immediately get sick or pass out when I arrived.... I called so many people with the government and gas company for help. The senator's office stated that the landowners had no rights and no laws were in place in Colorado. The federal government was in charge. I thought how can that be and I also did not know of others what kind of tests to perform...The man from Company X stated that they would let me know when the fracing was done and then they would clean our home and vents so I could move back in to our home. **They would not pay for the medicals bills as their attorneys said they could not it would show guilt on their part. I felt like a person on an island, deserted at that, and no one really cared. I had no rights...** The sad part is that it took our lives away and we could not enjoy our lovely home and land anymore. Our dogs would not even go outside....I know all the stories that the gas companies use like it does not cause any problems and **any problems we have it is our burden of proof to prove that the illnesses and air and water problems had nothing to do with the gas companies.** (*emphasis added*)

The lack of responsive and investigative regulatory structures, combined with epidemiological frameworks for studying chemically related diseases, leave landowner's struggling in isolation and waiting for "expert" confirmation of causation for their illnesses (Allen 2003; Steinzor *et al.* 2013). The addition of

corporate processes developed to contain and forestall assignment of responsibility (as described below) enhances this problem, leaving landowners to navigate complex bureaucracies by themselves while also managing their own health issues and their loss of quality of life.

*Through landowners' narratives, the lived burden of structural asymmetries and exclusion become apparent*

WellWatch narratives help to articulate the knowledge gaps about the shale gas industry that exist within fields of academic research and between those impacted by shale gas development. Beyond articulating these gaps, stories in WellWatch begin to fill them by sharing stories of how people have found their way. Many landowners become amateur scientists, organizing and collating their own data about their experiences. However, regulators often dismissed the authority of their data, as these two examples describe.

A cattle farmer from Pennsylvania detailed two and half years of observation of the declining health of his cattle herd on WellWatch (for more on livestock complaints see Bamberger and Oswald 2012):

There was a leak/spill from a pit at the well-pad, and the spilled liquids went onto the field and also ran into the pond where my cows drank. The pit and well-pad are 75 feet from the pasture fence-line and 280 feet from the pond where my cows drink. My cows were bred at the time of the spill, and four months later when the 18 cows gave birth/aborted 10 of the calves were stillborn. This was highly unusual - in 18 years of breeding and raising cattle we had never had anything like this happen, we had close to a 100% live and successful birth rate.

Out of the 10 calves born dead, the first five appeared to look normal although they were dead. The sixth calf had cloudy blue eyes that were very unusual. The 7th calf had the same cloudy blue eyes. The eighth calf had a cleft palate on the right side of it's mouth, it never would have been able to survive/drink with that deformity even if it had been born alive. The ninth and tenth calves had pure white colored eyes. **I contacted everyone I could think of, including the DEP [Department of Environmental Protection]. Although initially they seemed to be sympathetic, they ended by saying it was basically 'farmer's luck...(emphasis added)**

Another landowner from Pennsylvania also reports a lack of responsiveness in describing the results of a fracking fluid spill that contaminated one of his ponds:

All the vegetation in the 2.5 acre pond died. Even the cattails turned yellow and died. While fishing, a friend and his daughter noticed the devastation. I observed that the color of the pond water wasn't right. The pond water turned dark and black. Then the bottom of the stream, that comes from the pond overflow, looked like black velvet. It covered the whole bottom of the stream. I showed this to DEP [Department of Environmental Protection] and Company G personnel. No one had any answers for me.

Regulatory disinterest fosters a general lack of care on the ground by companies for the wellbeing of surface owners and their properties. Many reports on WellWatch described the myriad of large and small impacts from drilling that damaged surface owners' livelihood and sense of agency. Here, a landowner from Colorado described the basic lack of care for a landowner's property and a lack of attention of industry to involving the owner in the process of development:

In Nov of 2000 the landowner was approached by Company D with a form surface use agreement for its access onto his property. Ballard drilled 4 wells on one pad. When Company D came out to survey the property the landowner specified how he wanted the road put in and where the pad should be located. They walked the property together. Company D agreed where the road was to be located. However, when the landowner was at work, Company D came in and located the road on a different line which effectively cut the field in half, making it impossible to irrigate any longer. According to the surface use agreement, Company D representatives were supposed to:

- dig culverts for irrigation after drilling for water run off. **They never did.**
- put temporary fencing around waste pits during drilling and completion and then a permanent fence after the well was complete. **The fence was never put in**
- give verbal notice if they had to do any blasting to landowners and neighbors two days prior to the event. **The warning wasn't given, resulting in the landowner's horse being injured after running through the fence.**
- Test the water after drilling. **Not done.**
- Spray for weeds. **Not done.**
- Paint the tanks, fences, etc. to reduce the visual impact. **Not done.**

Landowner has complained about waste tanks leaking and Company Y has replied that it is just water and it is not a big deal. Landowner has photographs of the leaking tanks verifying it is not just water. Company Y just dumped more gravel on the area where the tanks were leaking.

Landowners express frustration at their perceived loss of control and agency. A homeowner from Pennsylvania detailed the health impacts in her family and her farm animal coincident with the contamination of her water:

At this time, my future is uncertain - re what is going on at our home and the future health of my child...

-I'm not sleeping at night, and when I do sleep I have nightmares.

-I recently had a nightmare of me falling through my water well - the ground where my well was opened up and I fell in and couldn't get out - then I woke up in an anxiety attack.

-The stress of caring for someone dying from cancer for a prolonged time is equal to the stress I am dealing with now re this issue.

In the face of this uncertainty, managing daily life become intensely complex as homeowners struggle to fill basic needs such as clean water supplies and become distrustful of their soil and the health of homegrown vegetables:

I call my house 'death row'. I'm now getting water from other family members and hauling it. I can't keep this up- I go to the laundromat and don't use the house water for anything anymore. Company B recently said they would give me a water buffalo [a free stand container for storing water] and they would bring water for three months then leave us with the equipment, but not bring more water to fill it after 3 to 6 months - but in order for this to happen we have to sign a document stating that they were not the cause of our problems. They said they would do this because they were trying to be 'good neighbors'. Four other house right close by us have the same problems, and also have their wells vented for methane and have buffalos.

This section provides evidence of a second finding of WellWatch's ability to capture social change and help us understand community processes of change, e.g. how the effects of shale gas extraction impacted how landowners interact with one another. We are able to see this process unfolding, and the ethnographic narratives provide context for what is impacting the behavior of individuals, and the results (alienation from peers), that can then lead to bigger, community-level patterns of social change. Landowners described feeling alienated from their homes as they were literally displaced from their physical and social environments:

Landowner had a vegetable garden near the house and had eaten the produce for years, but concerns over increasing health problems prompted him to stop eating the vegetables. Also, he

stopped drinking milk from his goat herd after they began experiencing stillbirths and more health problems within the herd.

Another report reads:

I am afraid to have friends over in fear of making them sick, plus I'm also embarrassed because the water from the toilets and sink stinks...

WellWatch reports show evidence that fleeing homes was not only recommended by doctors, but was often the only viable solution for seriously impacted landowners as these two reports show:

While working as an irrigator near well, I stepped into a toxic cloud that knocked me off my feet and into semi-consciousness. This cloud was created by open topped condensate tanks. Since that moment I was unable to tolerate my property's air inside or outside my house. I had to wear a respirator to exist until I could move from the area. I lived there nine years prior to this incident without problems. My doctor diagnosed me as chemical intolerant due to this extreme exposure. He said I needed to move because I would never be able to regain tolerance.

Yesterday we had those emissions in the air and we would get them at different times. I could not function. I felt like I had was trying to come out of being put to sleep after a surgery....all day long. Today while I have some energy, I am packing our trailer (to leave for good). I wasn't able to do anything yesterday. It affected everyone on the house...in many ways. Dr P is still trying to get the gas company to tell him what the chemicals are that we need to test for. To no surprise, they have not replied. I will let you know how things are as I know them.

Four families from Colorado who used WellWatch had to leave their properties due to health problems. Two families using WellWatch also had to flee their homes in Pennsylvania. WellWatch reports, had the site been sustainable, could have created an important geographically located and publicly accessible archive of their experiences, records of which and their relationship to each other could otherwise have disappeared when the families moved. One family's painful departure from their home and their neighbors' serious health issues (they eventually also left) was also recorded and reported on by the *New York Times* on February 27<sup>th</sup> 2011.<sup>6</sup>

*WellWatch narratives suggest important new avenues for research and advocacy*

In addition to providing data to help answer questions pursued by the researchers, the open-ended approach of WellWatch also pointed to new areas of inquiry. For example, data on WellWatch provided evidence of ties between patterns of inequality and environmental impact, as well as the development and emergence of inequalities because of individual and environmental impact. In this way, WellWatch provides evidence of the emergence of an environmental justice issue (Brulle and Pellow 2006; Bullard 1990; Hofrichter 1993; Martinez-Alier *et al.* 2014). A WellWatch report describes:

The neighbors down the road had high end horses, and there were reported problems with the births - the people moved out. The neighbor across the road gets royalties and moved to Florida. When the fumes were really bad a few years ago you could see a funnel cone shape of fumes from the deck. I am very ill - I have been threatened with eviction if I 'talk and make trouble' I don't know what is going to happen. My former Dr who worked at the Rifle hospital

<sup>6</sup> See video supplement to this *New York Times* story, titled "Natural Gas and Polluted Air": [http://www.nytimes.com/2011/02/27/us/27gas.html?\\_r=1&hp](http://www.nytimes.com/2011/02/27/us/27gas.html?_r=1&hp).

told me there were lots of alarming unaccounted for illness around here - and he advised me 'to get out of Dodge'... he is gone now from the hospital.

From a sociological perspective, the flight of impacted landowners further illuminates the process via which the political ecology of this industry creates environmental injustice (Willow 2014), as those left are individuals without the resources to move or those who have nowhere else to go. As described above, residents with income from royalties and residents with high-income jobs and businesses are able to leave, while renters and those whose lives are built around their surface property have no means of escape:

I had body pains (especially in my back and hands, my kidney area hurt, and I had a lot of difficulty breathing that night. The next morning I felt a bit better. I had told the [state agency official] that I tried to stay away from the ranch as much as possible to avoid breathing the air and the contaminants there from the wells as it made me sick. But, at a certain point I had no choice because this is where I live with my animals on the family ranch - I have nowhere else I/we can go, and I'm way too sick to work.

In the face of these overwhelming issues revealed by WellWatch, other users' narratives helped assist landowners to become citizen scientists, investigating for themselves, as well as putting pressure on agencies and companies to test water, air, soil, grain, injured animals and their own bodies to try and understand their illnesses and ascribe causation.

The usefulness of WellWatch as a tool for popular epidemiology (Martinez-Alier *et al.* 2014) is illustrated in the use of the "notes" feature as a log of symptoms and events as users experienced them (Brown 1997). The need for symptoms logs is important to the study of emerging health issues associated with fracking (Saber 2013; Steinzor 2013).

1/8/2011

-Adult female, no sleep due to horrible pain in top of shoulder that will not leave  
 -8:03 am took picture of smoke coming out of pipe over the well pad by the driveway  
 -8:16 am took another picture of white fumes still coming out of pipe/stack on wellpad by driveway  
 -adult female, experiencing terrible pain in shoulders, chest, breast, and left arm.  
 Got State to do water test on now stinking foul house water today. Headache tonight.

These documents are potentially useful for legal cases as they provide a secondary public record of times and dates of illness experiences. By combining symptom logs with mapping features, WellWatch allowed for symptom and exposure mapping as well as longitudinal diaries of experience. For example, using the geographic location feature, one well in Colorado had twelve complaints associated with it from four different users. Such mapping processes link experiences with physical places that can be further investigated or become focus points for advocacy efforts (Allen 2003; Corburn 2005).

WellWatch reports show that landowners built upon their physical experiences with testing data. Grand Valley Citizen's alliance coordinated with Global Community Monitor to take grab samples in and around the homes of those experiencing the worst health symptoms (GCM 2011). The odor logs forms were shared through WellWatch so other communities might use them. Beyond sampling the air they breathed, landowners also tested their bodies to find the levels of BTEXs [benzene, toluene, ethylbenzene, and xylenes] in their blood:

Landowner had blood test done, and industry related chemicals such as benzene, toluene, xylene and triethylbenzene 125 and 157 were present in his blood.

Landowners reported even testing their grain, trying to locate the cause of livestock deaths:

We also had a rash of animal deaths of many of our animals. Three and a half years ago, about in Nov 2008 we lost 4 horses in one week. The first horse we had had for only two weeks, then one day she was foaming at the mouth and then fell over dead. The vet could not diagnose it. A few days later, another horse was having severe hip problems. The horse was literally dragging it's legs along and the vet diagnosed it with muscular issues. The horses then went down, it's back legs were completely useless. Another horse went down; it was older, and the vet surmised it was old age related. The fourth horse was carrying a foal but wasn't going into labor - we had her induced, but the baby was so herniated it died. The vet could not explain this rash of horse deaths in such a short time period. We had the grain tested and it tested fine.

As Nash describes, the traditional process of exposure studies fails to capture the complexity of lived experience (Nash 2004, 2006). Testing for causation via single exposure routes subdivides and considers in isolation different experiences that are actually composite and interactive. A lack of evidence of significant exposure via one route is often used to dismiss the possibility of harm even when it is readily apparent, such as those described by above (Murphy 2006). The landowner report above continues:

Around that time I was 8 months and 2 weeks pregnant. I went into early labor, had internal bleeding, and I lost the baby.

The focus of regulatory bodies and industry on pinpointing a single cause is illusive, and arguably inappropriate, as it delays attention to remediation or remedy. Given the evidentiary requirements of agencies, tests that were carried out were often insufficient to stimulate regulatory responses and hard to interpret:

We had no baseline water samples done before these wells were drilled and fracked. I called the DEP [Department of Environmental Protection] after our water went bad and I talked to DEP Official X, I feel she did absolutely nothing for us at all... Both the DEP and the company A did water tests. Both entities said that there was obviously a problem with the water, but they didn't know what it was.

Landowners experiencing health problems report feeling dismissed by agencies:

The unnecessary flaring of this well, has caused by son to have huge red and white welts, that itch and burn all over his body, as well as all of us having burning eyes, skin, and throats. Company M just tells everyone to call Employee M, and he in turn tells you to call the COGCC [Colorado Oil and Gas Conservation Commission], and COGCC Employee, thinks it's a joke. He told my neighbor that when people call with complaints about skin issues he thinks, "Waahhh, Waahhh, Waaahhhh, Call 911." Yes, that is what he said. He also said he is to make as many complaints disappear as possible, to keep the budget in good standing. I have called COGCC Employee twice, and followed up with a detailed email, and no reply.

The lack of regulatory support means landowners are frequently put in the position of trying to make sense of their results by themselves:

July 18, 2011 I called Company U for the water test results. He said the water was fine, and the contamination was due to natural occurrences, 'from surface water and too much rain...'. That day I also called the water well company back and they said they did not think that the contamination was naturally occurring. In their opinion the surface water would not have reached 300 ft underground to the depth of our water well. He also said that the water well

people should not have pulled the pump from our water well and put it into the buffalo due to contamination issues....

Since 7/19/2011 I've been on the phone with different entities including Marcellus Outreach trying to get advice and assistance. I spoke to a chemist in late July and I showed him my test results.

One clear finding for academics is that it would be beneficial for landowners if they were able to more easily consult with and find knowledgeable experts to help interpret and contextualize their test results (Allen 2003). Organizations are emerging that network scientists, physicians and engineers to study health energy networks such as Physicians, Scientists, and Engineers for Healthy Energy. It would be excellent to combine such networks with tools like WellWatch.<sup>7</sup>

WellWatch narratives illustrate how landowners wait weeks and months for test results that shed little light on causation and generally result in further testing or fraught battles between companies who seek to blame each other for harms:

In April 2011 Company U came and tested my water well and several neighbor water wells - it seemed to be protocol... After calling the company, I finally got the water report back in July from the April 2011 test.

Another report reads:

Today May 18, 2011 about 3 to 4 years after the date I locked the gate 6 years after the frac liquid spill, at 10 am COGCC Employee of the COGCC Rifle office came out to the property and she stayed for 3 hours, taking soil samples from the location and pictures of the spill location. She said she would get back in touch with me to inform me of the test results within 3 or 4 weeks - which is about how long the tests usually take.

This export of the research process to laboratories, distances landowners from the process of making knowledge about samples, and places them in position of receiving expert knowledge (Brody *et al.* 2007, Minkler 2008). When test results or human experiences illustrate that harms are occurring, stories in WellWatch suggest that companies respond in two ways: debating who is to blame and/or pressuring landowners to sign liability waivers. From a Colorado landowner:

The fumes were really bad a month ago. I called Company S and complained, and one of their employees, the liaison, told me that allot of the fumes around where I lived were coming from Company X's wells.

From a Pennsylvania landowner:

We also have a Company V pipeline running through our driveway. Company N tried to blame Company V for the methane contamination in our water. Company V did a 'sniffer tester' along the pipeline to detect any methane leakage and none was found. Company N then hired a company to do soil spikes around the pipeline to look for methane contamination in the soil. None were found. Then Company N gas company had a camera put down our water well to see if they could locate where the methane was bubbling in from.

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<sup>7</sup> Physicians, Scientists, and Engineers for Healthy Energy: <http://www.psehealthyenergy.org/>

Another worrying observation of company behavior is the offering of remediation or further testing if landowners agree to document that companies are not to blame. From a Pennsylvania landowner:

Company N recently said they would give me a water buffalo and they would bring water for three months then leave us with the equipment, but not bring more water to fill it after 3 to 6 months - but in order for this to happen we have to sign a document stating that they were not the cause of our problems. They said they would do this because they were trying to be 'good neighbors'.

Another landowner in Pennsylvania reported a similar experience:

July 18, 2011 I called Company B for the water test results. He said the water was fine, and the contamination was due to natural occurrences, 'from surface water and too much rain...'. He then said 'I'm being a good neighbor by providing you with water' re the buffalo.

This was also reported in Colorado after a pipeline leak into a local tributary of the Colorado River:

Company X reportedly attempted to get the landowners to sign a document that implied that the landowners domestic well had design issues/ flaws that did not enable Company X to properly sample the well for contamination. The landowners reportedly did not wish to sign the document, and they contacted an attorney. In the interim, no water samples were taken of the landowners domestic well - from the time the pipeline leak was first reported).

Non-disclosure agreements has been identified as a particular issue in studying the health and environmental impacts of fracking (Bamberger and Oswald 2013). Additionally, WellWatch captured experiences of workers who report being fired after exposure to hazards and illness experiences:

Hello: My name is Landowner G, I am married to Landowner H and we live in Garfield County, Colorado. There are over 10,000 active CH<sub>4</sub> (methane) gas wells inside Garfield County, Colorado. I spent one full year working on these CH<sub>4</sub> wells. I was employed by Company S, a Canadian company and I worked on a "swabbing rig". We were not part of the exploration (drilling). We serviced existing and producing natural gas wells. A swabbing rig is a "workover-rig" and our purpose was to remove water from the well that had stopped the flow of natural gas in a producing well. It turns out that the water we were removing was residual "fracing" water and we were never informed of the benzene and other chemicals that exist in this "production water."

In March of 2008, my swabbing rig was working on a well site where the gas company had reused the same "fracing" fluids in an attempt to save money. The problem with that is the reusing of "fracing" fluids causes the manifestation of H<sub>2</sub>S, (Hydrogen Sulfide Gas) which, in doses above 50 ppm for 30 minutes is deadly. My co-worker died and I spent three months in workers-comp recovery. My employer and the billion dollar energy company basically lied and covered-up their gross negligence in ordering my coworker and I to expose ourselves to the deadly H<sub>2</sub>S without proper safety equipment, such as supplied-air-respirators. Federal OSHA fined my employer. I blew the whistle to OSHA and was fired for doing so. My whistleblower case with OSHA is still pending and I have been black-balled from the industry.

The occurrence of similar reports from different areas of the country and landowners with no prior knowledge of each other suggests a deep need for a system that more effectively monitors company and community interactions. WellWatch narratives suggest that one of the structural patterns preventing recursive grassroots engagement in shaping the development of this industry is that landowners, under pressure to

address immediate threats to their health and safety, enter contractual agreements that defray corporate responsibility for those harms. Solving short-term problems through such agreements leave landowners without the means to act collectively to hold companies accountable for systemic practices. Landowners are thus unable to shape the trajectory of gas development beyond their own individual cases.

*WellWatch draws together structurally separated groups*

While this article focuses on the experience of landowners, WellWatch provided a unique space in which gas patch workers, similar landowners, could report their experience as the above report describes. Other WellWatch reports documented the health experience of workers assigned to clean up a waste pit leak in a local gravel pit:

On the night of 2/18/2011 the employee working the disbursement and pump station at the site of the contamination became ill (she was the replacement employee after the other employee got ill with similar symptoms a day or so before). The new employee suffered burning nose and sinuses, swelling in the tongue, burning in the mouth, that then pushes down in their lungs, 'they couldn't barely breathe' - lost voices, unable to speak, similar to laryngitis - also lips went numb. Employee called a friend, was taken to Meeker Hospital, and physicians had no diagnosis.

Dog was vomiting 'his guts out' at the site, and after the humans left the hospital they took the dog to a vet clinic, where the dog was tested and his ph tested at 9 --- the vet was concerned. Today, 2-19-2011, calls went in for more emergency offices to call the numbers were given for the Rifle office of the COGCC which has an emergency #, plus numbers were given for the Colorado Department of Public Health and Environment. These numbers were given through a second party to the afflicted workers. **These numbers were pulled off the MIT Garfield County page, under the Emergency Contact information. These numbers are not in the local phone books to the best of our knowledge.** The doctor at the hospital could not diagnose the illness of the patient brought in. The name of the disbursement used on that site by the Colorado river is "Micro Blast" according to name plates. The employees on the site say when their illness symptom were ongoing the fumes were coming out of a certain location - hole # one. (*emphasis added*)

WellWatch enabled both workers and landowners to begin sharing and networking their experiences. A recent policy statement from the American Association of Public Health highlights the need for attention to worker health issues related to fracking, a tool like WellWatch could assist in that effort (Korfmacher *et al.* 2013).<sup>8</sup> For academics, not only did WellWatch prove a rich medium for documenting grassroots experience which when interrelated suggest shared structural issues, but it also opened new avenues for investigation by revealing the interconnection between disparate places and communities.

## 6. Benefits of WellWatch for individuals and communities

Environmental health and justice scholars stress the need for scientific and social scientific research that incorporates, builds upon and amplifies the expertise of communities, rather than exporting data and modeling communities as "research subjects" (Allen 2003; Brody *et al.* 2007, 2009; Brown 1997, 2007; Corburn 2005; Minkler and Wallerstein 2008). Conceptualized within the health sciences and sociology as Community Based Participatory Research, emerging methods seek to build partnerships between researchers and communities in order to materially address structural inequalities that the research studies (Minkler and Wallerstein 2008). One of the most promising findings of the WellWatch prototype is that the tool was useful not only for academics but also for individual landowners and community organizations.

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<sup>8</sup> <http://www.apha.org/advocacy/policy/policysearch/default.htm?id=1439>.

Indeed the tool was developed not for academics but to create a civic space enabling impacted landowners to network. Investigating how individuals and communities organizations made use of WellWatch sheds light on how a second iteration of the tool could similarly forge links between ethnographically rich research, increasing individual agency and collective advocacy.

WellWatch proved to be a useful tool for its community of users, primarily impacted landowners from Colorado and Pennsylvania where there were active community-advocates working on the ground. It helped landowners manage problems of individual isolation by providing information about other people in similar circumstances, and offering roadmaps for how to resolve problems. It also provided a structure to help manage problems better, gave them data for their own advocacy, and could have profound political and emotional impact on individuals. The tool also worked for existing organizations, and worked to build networks between impacted communities, so people could share best practices. This section reviews the experiences of users of WellWatch in order to understand how it was useful, and to provide a starting point for understanding how future iterations of digital tools can be structured to meet needs of users.

### *Individual benefits*

One community member described the moment she first saw WellWatch as "jawdropping." She recognized the need for this sort of access to information but didn't know that the data existed, let alone that it could be made available this way (Palfrey and Bracy 2011). Users report feeling empowered in a number of ways by learning about other people in similar circumstances. WellWatch assisted users in spotting and recognizing emerging patterns and trends, without the lag time of academic or formal scientific research or state reporting. Users therefore were put into a position to recognize and position themselves in patterns, rather than waiting for an outside authority to deliver the schema of the pattern to the user.

The feature of tagging by company allowed geographically dispersed users to spot and recognize patterns of company behavior and experience with particular company's impacts. Since frac fluids differ by company, geographic neighbors who are dealing with different companies may have less in common than others who are geographically far away but are dealing with same company. A user reported, "It sure is nice to be able to see what people in other places have experienced" (Song 2011). Users could question the approach of companies and also regulators. For example, one inquired whether it made sense for people to have reclaimers on more rural properties:

Landowner was driving near well pad and stopped the vehicle to get out and open a farm gate. Landowner immediately smelled a strong gas (noxious) odor, and heard and noticed that the pressure vent on the top of the condensate tank was releasing gas from the well about 25 yards away. The gas was venting from the pressure vent on top of the condensate tank...The landowner states that if the condensate tank had either a secondary burner or a reclaimer unit, then this gas would not have to be released into the air and breathed...In 2003 the landowner asked Employee from the Company X office why his properties' well, and other nearby wells had no afterburners/secondary burners (or reclaimers). Employee told the landowner that 'he'd look into it...' When the landowner asked some of the subcontractors the same question, he was told that due to the 'sparse population' of the area in which these wells were located, afterburners/secondary burners (or reclaimers) were not necessary. The landowner feels that regardless of the population density, secondary burners or reclaimers are necessary for proper health and environmental reasons. Why should a more rural landowner get weaker regulations for protective infrastructure on the wells at his or her home than a landowner in a more densely populated area? Are their lives and health and well being less important than the health of those in more densely populated areas?

Also, perhaps due in part to the rapid development of the industry, many users were unfamiliar with the regulatory and state structure in place to protect them, their land and resources, and their rights. Users were able to recount to each other their experiences; documenting the logic behind their advocacy, as well as their successes and failures in resolving problems. Here, a user reports his experience of navigating the

regulatory structure by relaying his experience with the DEP. The story can point others towards seeking out the help of the DEP:

When the pond became contaminated I called the DEP. Official A was Official B's replacement while Official B was recovering from a heart attack. I walked around the pond with Official A and told him how disgusted I was about my property being destroyed and not getting any relief. I met with Official A several times on the farm after the pond incident. He told me he couldn't determine where the contamination was coming from. He did tell me that my farm "was a textbook case of what not to do." He said that he had an album full of photos of my farm of which the DEP reviews in their meetings. Official A also said that my name has been brought up numerous times during DEP meetings. He agreed with me that the roads and locations were poorly constructed. Every time it rained locations # 3 and #6 slid down the hill and into the field causing extreme erosion.

The role of local advocates was central in the value of WellWatch for individuals. Through the use of local advocates, who worked with users in inputting their data, participants also expanded their social networks. As users increased their social capital by connecting with others, they reported feeling less socially isolated and also more political empowered. For example, a local advocate reported that a user, in part because of the connection made with her, felt more empowered to pressure the COGCC to address a frack spill that had occurred on his land six years earlier. His increased communication with the COGCC led to three additional visits, and the Colorado Department of Public Health and Environment visiting to test air quality and review the lack of afterburners on well-sites. The local advocate stated:

If we had not done the work on WellWatch I seriously doubt any of this would have happened- the COGCC links/contacts were all a result of the work on ExtrACT. This is just for the ExtrACT team to know - but I wanted you all to know that in a back door way some efforts toward better situations for landowners seem to be happening. He is very happy... He's coming over Sunday to do a report on the last 3 COGCC visits - he's been wanting afterburners on his wells for 3 years.

In addition to networking, WellWatch provided a framework for users to share, organize, and build collective knowledge about companies, industry practice, regulators, and NGOs. This access to information allowed people to feel politically empowered. One user reported, "WellWatch is much easier to navigate than the official state databases, and allows users to compare state-by state trends like never before" (Song 2011).

#### *Community benefits*

In addition to individual uses, WellWatch was also useful as a community resource and for organizations. As a community resource, the site offered a central webspace for the listing of contact information for regulators, politicians, industry, and other contact information useful for individual advocacy. Users could comment on which pathways to problem resolution were effective and which were slow or problematic. This is particularly useful given that the distributed and fast moving nature of the natural gas boom left many landowners without a clear sense of the regulatory structure and process. One user reported about her neighbor:

Landowner did not know he was supposed to complain to the COGCC when something was wrong. He always discussed his problems directly with the gas companies. He did not think it was financially worthwhile to sue companies when they violated the surface use agreement.

Beyond providing a roadmap for advocacy, and reports which can provide data points on how this roadmap functions, users also posted observations on the effectiveness and accountability of regulators and

helpers. This is particularly important because of a lack of regulatory scale for complaints; how regulators are able to respond to small level complaints could have major consequences or landowner. For example, one user posted:

My son's rashes haven't stopped. These photos are from the last three days, they have been frac'ing or flaring every day, since August 9th, 2010. The huge welts on his legs, and body today are really upsetting. Why can't we get any help? The COGCC help person, Employee X, bought an answering machine so he didn't have to hear about minor complaints, like skin rashes and burning skin. He told this to my neighbor, Neighbor Z who also lives on Subdivision Y, (Yes a subdivision), with a rig right behind her house.

Information and listings were paired with reviews, providing qualitative information to other users about the effectiveness of pathways for problem resolution.

In addition to sharing information and developing collective knowledge about regulators, users were also able to develop collective knowledge about specific companies. Users would make observations about company behavior, such as behavior after pipeline spills. This could help others to know what to expect in case of an event such as a spill, or to know how companies were treating other clients. For example, one user provided a list of the types of issues he had encountered with a specific company, including slag, spills, a slow response to liner leaks, and frac fluid spills. Another user reported on how a company had improperly placed a water buffalo after their water had gone bad. Other users made lists of what had been promised by companies compared to what the companies had delivered. Another user reported on how cleanup/remediation efforts prevented further environmental monitoring. This information can function as a community resource of emerging best and worst practices of companies.

This information was valuable not only horizontally, from peer to peer, but also vertically, for landowner to authority/regulator. For example, regulators used the information to develop policy and best practice. An Elbert County, Colorado planner used WellWatch to draft proposed regulations. A local advocate in Colorado reports, "The Elbert County Planner spoke after me (and very well) and said great things about how the WellWatch information and conversations with me and access to 'model regs' from other counties for gas and oil regulations helped him draft their proposed regulations." (WellWatch Coordinator Colorado, personal correspondence, June 8th 2011).

WellWatch also provided resources for community organizations. For example, the wiki format allowed for small organizations to have a website without having to have the knowledge of resources to design and host the site. This allowed them to increase their capacity and reach at little cost. Just as WellWatch facilitated the networking of individuals, it also assisted organizations in learning about each other, which can facilitate coalition building and community organizing. This includes collaboration possibilities for academic researchers and community organizations.

## 7. Discussion and conclusion

WellWatch was both a research tool and intervention. The project built upon ethnographic research, which revealed severe technical and informational asymmetries between individual landowners and the shale gas industry. The project itself attempted to intervene in those asymmetries by offering a new information and technical infrastructure, which allowed lateral sharing of data between landowners, and recorded it through a public archive (Da Costa 2008; Thompson 2004). This is not to say that landowners were not already using digital tools to share information. Social media are providing methods for the development of networked social movements (Juris 2008). Indeed social media and digital media have played key roles in the development of public contestation of the health and safety of hydraulic fracking. The documentary film *Gas Land* hosts a wildly popular Facebook site (Fox 2010). There are web tools being developed specifically to address some of the technical and informational asymmetries between communities and gas extraction companies. Notable non-profit organizations are SkyTruth and FracTracker.<sup>9</sup> The ExtrAct project worked

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<sup>9</sup> <http://www.fractracker.org/2013/05/welimpactsmap/>; <http://www.fractracker.org/>.

with both of these non-profits as they developed their ideas. FracTracker, funded by the Heinz Foundation, develops mapping tools for experts and communities to map data related to hydraulic fracturing. Currently, FracTracker offers individual searchable maps of wells in several states. They have just begun a project to map well water complaints across the county, however, these complaints are not taken as narrative reports and only focus on the issue of water.<sup>10</sup> Additionally, the Community Science Institute has an online database of baseline water tests taken by communities in New York (Pennigroth *et al.* 2013). WellWatch by contrast offered a more open narrative framework that integrated data on a range of issues based on user-generated tags. The relational database structure of semantic media-wiki, utilized by WellWatch, meant the data could be organized based on users' interests. There are websites for gathering community stories but these tend to be strongly politicized--such as the *Gas Land* Facebook page and "List of the Harmed."<sup>11</sup> The stories provided on these sites are not verified by outside sources, neither are they geo-referenced or coherently tagged, making it hard to combine them into substantial weight-of-evidence studies. Additionally, WellWatch offered a unique addition to this field by providing a space for academic and community-based research on the impacts of shale gas extraction.

An oft-repeated industry refrain in the growing popular debate about the health and safety of hydraulic fracturing is that there are no proven cases of water contamination from the process of hydraulic fracturing (Fox 2010). Defining fracking as merely the downhole operation enables this assertion. Landowners' narratives push against this limited perspective as they take into the account the lived experience of the practice, which includes truck traffic, storage of chemicals, and wastewater disposal (Perry 2011, 2012). A medium is needed to reflect and study this industry at this level of lived experience, particularly as landowner stories considered in isolation are often dismissed as anecdotal. Ethnographers and environmental historians have documented the devastating impacts extractive industries can have on surface inhabitants and violent environments they produce over time (Peluso and Watts 2001; Santiago 2006; Sawyer 2004; Tsing 2004; Watts 2008; Zalik 2004, 2009). However, ethnographies take years to write, and their view is frequently limited to that of a single researcher who is able to describe only cultural conditions of a short window of time in a geographically limited area. Ethnographies rapidly become historical documents that circulate well only within academic spaces despite the political importance of their findings. The prototype of WellWatch suggests exciting new possibilities for combining ethnographic study with grassroots experience through a medium that simultaneously supports academic analysis, growth of individual agency and social advocacy (Graeber 2004). Websites like WellWatch could function as digital platforms for building more recursive public relationships to large-scale industries like the Shale Gas industry, and as spaces for para-ethnography by co-producing and disseminating knowledge among impacted communities.

#### *What was learned: advocates*

Of the many lessons learned during the development of this website, one of the most important was the value of engaged advocates from communities who work with their friends and neighbors to gather reports. The work of individuals like Tara helped to manage a trade-off between verification of WellWatch stories and the anonymity of WellWatch users. A challenge of open data frameworks like WellWatch is that its reports are not verified by a third party. The veracity of reports however can be supported with images, videos, links to official reports and news coverage. Additionally, individuals like Tara met and worked with WellWatch participants to upload their stories. However, there is a trade-off between veracity and anonymity of users because recording the time, date and location of events may make vulnerable users identifiable. In the polarized field of gas development, people can be scared to report issues for fear of social retribution, even losing their jobs (Wylie 2011). To ensure vulnerable populations including workers and their relatives were protected, WellWatch made it possible to enter data into the site without providing identifying information. The wiki interface made it possible to communicate with anonymous users through chat and comment features. Additionally, personal contact with coordinators like Tara helped novice users understand how to protect their identities online. A next round of WellWatch development would allow users to select data based on their evidentiary needs. For instance, if a user is interested only in complaints certified by third

<sup>10</sup> <http://www.fractracker.org/projects/usmap/>.

<sup>11</sup> <http://pennsylvaniaallianceforcleanwaterandair.wordpress.com/the-list/>.

party, they could elect only to see those complaints. However, if a user is interested in reports by anonymous users they could select to also see those results. Such a system would allow the downstream user to decide what degree of verification they are seeking, rather than precluding landowners who may fear reprisals from adding their stories by requiring that all users be identifiable.

Local advocates like Tara helped to build network bridges, trust, and literacy between community and academic partners. This is similar to the role community health workers have played in the development of community based participatory research (Minkler and Wallerstein 2008). This suggests that a next generation of WellWatch or similar digital media platform could include roles as local advocates for both anthropologists and active non-academic organizers like Tara. Utilizing a team of social scientists to serve as local advocates provides two main benefits. First, the site of the multi-sited ethnography, whether it is a specific site in a commodity chain or a specific geographic region, can be recursively analyzed by both academics and members of those communities. Second, the production of a recursive site can allow for networking and participation by a broad reach of research subjects. Social scientists, in their role as local advocates, can assist subjects not only with increasing technical literacy, but also by analyzing and feeding back the emerging picture of social structure, which can make help the subject to see the relevance of participation in collective research, and increase their likelihood to add stories and data to an online tool such as WellWatch.

#### *What was learned: sustainability*

A second cautionary note from the prototype of WellWatch is to limit and better moderate the wikimedia data structure. While WellWatch was easy modifiable by wiki-literate participants, it was also very easy to spam. Persistent spam attacks brought the site down on multiple occasions and eventually led the corruption of the database itself. This loss was particularly keen given the personal stories the site held for landowners, making security vital to any successful redesign. A second iteration would have improved spam filtering as well as additional limits on which pages can be edited by whom. One other important issue was that researchers move across institutions but research funding and infrastructure can be tied – the founding professors of the Center for Future Civic Media moved and its name was changed in 2011. Wellwatch was not a standard type of written academic output, which was challenging for the university social scientists involved. The challenges of academic cycles combined with the constraints of the wiki-infrastructure contributed to the termination of the WellWatch Pilot test in the fall of 2012.

Upon reflection, development of this project might be better done in partnership with a non-profit, or be developed as an independent non-profit, to assist with its sustainability. This would have been similar to the traditional process for spinning off a start-up from a design or engineering project but with an emphasis on non-profit rather than for-profit business. The next round of WellWatch development is being pursued in partnership with FracTracker in order to integrate features WellWatch offered into their maps and increase the sustainability of WellWatch 2.0.

#### *Reflections on definition of site, and the potential of multi-sited ethnography*

Strauss, in *Cultures of energy* (2013) stresses the insights gained from tracking the multiple scales, spaces, and speeds operating and constituting fossil fuel based cultures and economies. Vital to the emerging cultural studies of markets, chemicals and consumption around energy are studies of the corporations inter-operating to foster and further the development of this energy and petrochemical infrastructure.

Attempts to study these corporate entities are thwarted by their formlessness. Built around subcontracting and leasing agreements this industry has a temporary relationship to landscapes. The technical infrastructure of the well itself has a complex corporate lineage whose "parentage" defies the biologically encultured kinship models anthropologists have traditionally brought to bear to study cultural persistence (Appel 2011; Barry 2006). The modular markets forms of the industry enables risk management through limiting the diffusion of responsibility and awareness between sections (Appel 2011). Wells might be sold multiple times in their lifetime; development of a single well is a subcontracted, standardized process over which no larger management or monitoring system is constituted.

When responsibility for, and awareness of, harm does spread between modules or across scales the complex structures of ownership, oversight and contractual arrangements creates rich contests over culpability (OSC 2011). Constitutionally this industry is made and has been made hard to study and track (Appel 2011; Barry 2006; Ferguson 2005; Watts 2005; Wylie 2011). The outcome of the total process affects landowners and environments. It is at this scale that connections must be wrought and reflected upon to reconnect this industry to place, and to understand the environments it creates, so as to give it form and to enable more recursive relationships to shaping its perpetuation.

WellWatch is an attempt to facilitate a civil society response to the structural asymmetries between communities and large industries such as oil and natural gas extraction. While the oil and gas industries and their associated technologies, such as hydraulic fracturing, may present problems to these communities, our goal is not to advance a specific normative critique of the industry or the technology. Rather, we are interested in the potential of WellWatch as a tool for impacted communities to highlight and comment on those structural asymmetries, and to develop their own evidence base for normative critique. An advantage to the co-production of the para-ethnographic research sites through the use of the open source web tool framework is that people are able to develop and distribute knowledge to each other in a time cycle that is faster than the production of knowledge by an academic or other outside researcher. This allows for knowledge that is more readily actionable for both advocacy and academics.

WellWatch builds on the lineage of networked social movements, to use digital media as a structure for distributed investigation as well as advocacy (Juris 2008). It successfully captured ethnographic narratives, patterns of social structure, and evidence of emerging social change. Part of the success of the approach was that, while the shale gas industry tries to define fracking in terms of down hole technology, ethnography presses against that understanding, arguing for a multi-fold interpretation of fracking and its lived experiences. A future iteration of WellWatch aims to become a digital para-site enabling lateral interactions between academics and communities, to more rapidly share and analyze emerging experiences. We hypothesize this platform could enable a finer level of analysis of how regulatory and corporate structures impact the lived experience of the shale gas industry. Second, it could provide a closer relationship between academic critique and meaningful improvements in the lives of landowners. Third, it could provide a medium that allows structural problems to be made visible more rapidly, while also building networks that assist in making structural problems actionable. We feel that each of these contributions can allow for a deeper understanding of the structural asymmetries found at the intersection of rapid technological change, neo-liberal capital regimes, and the alteration of communities and ecologies.

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