Chapter 9

Evaluation

In assessing the Grassroots Mapping project, I wanted to consider not only the technical merits of the tools and their immediate use, but the success of the project as a human endeavor, and its effects on the communities involved. While there are important quantifiable benefits to the balloon- and kite-based techniques for capturing imagery and the web-based tools for processing and publishing that imagery, it is also important to address the degree to which the tools were appropriate for participating communities, and whether they felt that the tools served their needs:

- Did our maps provide better imagery/information to groups in need?
- Were the tools adopted and used? Are they financially and technically within reach of the participant communities?
- Did participants come to believe in the importance of authoring maps and the rhetorical power of mapping?
- Did the mapmaking and the ability to make maps effect change in the participant communities?
- Were the maps used in legal processes? Did they help participants advance an agenda? Did they provide critical information?

In the first two questions, the answer is clearly 'yes' for both the Peru and Gulf of Mexico case studies. Resolution and recency were dramatically better in the maps we produced, and especially in the oil spill mapping project, the tools have been enthusiastically adopted. Also in the oil spill mapping, LABB participants have regularly posted to the LABB blog as well as discussed the project on television and radio, demonstrating a good understanding of the goals of our effort and a strong belief in the maps' intended role and uses.

However, the final two questions remain to be fully answered, largely because the legal, environmental, and social processes upon which they are dependent may span many years, and a comprehensive assessment must address such a longer timeframe. Outreach efforts for the oil spill data to the ecology, environmental law, and cartographic communities have begun, with participants already submitting proposals to relevant conferences and publications to promote the use of our data. It remains to be seen whether the data sees wide adoption in academic and legal use in coming months and years. I plan to remain in contact with all participants across the several case studies discussed here to encourage and monitor whether there were positive outcomes and uses for the data.

9.1 Validity in openly ideological research

Many of my research questions are qualitative in nature, such as 'Did the maps cause participants to re-evaluate their understanding of their environment in political or environmental terms?' or 'Did mapmaking change participants' assumptions about what information they could access or utilize to further their interests?' The answers to these questions are profoundly affected by my advocacy of these tools and techniques in the communities with whom I collaborated — and the degree to which I was able to convince participants to adopt these tools and the beliefs about cartography which they embody. In order to better understand the outcomes of my research, given such an ideological investment by myself and other participants, a degree of reflexivity is required. I therefore look to Patti Lather in her esssay entitled 'Reconceptualizing Validity' where she outlines a framework for assessing validity in the context of openly ideological research. Such an approach is especially appropriate for a discipline which is increasingly understood as a qualitative field; see Section 2.2 for additional discussion on how maps are constructed and the importance of a mixed-methods approach.

Lather advocates a 'vigorously self-aware' regimen of research techniques which she presents in contrast to 'positivist' traditional practices which claim objectivity and neutrality. In the face of similar traditional cartographic claims, it is appropriate and productive to apply several of Lather's proposed evaluative methodologies: construct validity, face validity and catalytic validity.

Construct validity

Construct validity refers to how theory was affected by gathered data and by the human realities of the research site or context. In the case of the Grassroots Mapping case studies, the variety of sites we attempted to map, and the time, cost, materials availability, and mapping goals we established with local partners at each site dictated how we applied these technologies to specific problems. The process of making maps in these places and with these people also brought to light new ways of using and thinking about maps which has gradually changed how I approach mapmaking and present it to others. Most of all, there was a continual re-negotiation of **why** we made maps due to political, social, environmental, and economic context. This led to a shift from technological justifications such as higher resolution, better precision, and the more abstract beliefs in 'open geodata' to more site-specific reasoning, as well as a greater emphasis on non-quantitative results.

In Lima, Peru, we expected our claim that we could produce higher resolution imagery than available in Google Maps to inspire or incentivize participants; however most of the youth we were working with were unfamiliar with Google Maps, and comparisons did not resonate as strongly as we had hoped. However, the ability to see oneself in many of the aerial images resonated strongly with participants of all ages.

The intent of our mapping work became more tactical and aggressive at times — while these tools were originally designed to help communities map themselves, in Rock Creek, West Virginia, we used balloon mapping to gather data about a mining site operated by Massey Energy; a hostile organization. Members of Coal River Mountain Watch considered the land to be 'theirs' in the sense that Massey had gained access to the site through a long history of permit and land ownership manipulations, and the mapmaking was intended to document what the company was doing 'to Appalachia' and the communities surrounding the site.

Another change has been the project's increase in scope, and the application of Grassroots Mapping tools to ever-broader needs, starting with land tenure claims, and growing to include street mapping in Georgia, youth curricula in Boston, Lima, and the West Bank, and environmental monitoring in a wide variety of sites. In the Gulf of Mexico following the 2010 BP oil spill, the realization that our maps were detailed enough to see individual animals and plants became one of the most compelling justifications for the mapmaking, as did the ability to see ourselves in many images, connected to the camera by the 2000-foot tether. These discoveries broadened the scope of the mapmaking and influenced the selection of sites. In general, Grassroots Mapping has been slowly repositioned as a source for both ecologically relevant information at a high frequency of capture, and symbolically relevant imagery of events at a human scale.

In a broader sense, the project has changed most in its refocusing on collaboration and pedagogy. From the start, I have worked with a diverse group of people in prototyping and testing these tools in a variety of settings. As the project has grown, those collaborations, workshops, and the materials we have produced, including videos and illustrated guides, have become the focus of our efforts, perhaps even more than the resulting maps. An appreciation of the process and its ability to inspire and provoke civic engagement has grown to become one of the central tenets of my mapping work, and in my opinion, the key to its successs.

Face validity

The importance of creating a feedback loop where research output is reviewed and interpreted in collaboration with participants cannot be overstated, and this is the focus of 'face validity' as described by Lather. In Grassroots Mapping case studies, I have made every effort to process, analyze, and publish data in a participatory manner — teaching and demonstrating image selection, orthorectification tools, and discussing the pros and cons of output formats such as printed or digital maps. One of the major components of the toolkit I have developed, the Cartagen Knitter, is specifically intended to aid in the production of maps and to be a sustainable and reproducible means of creating maps with aerial imagery. I have been lucky enough to be able to iteratively test Knitter with participants of varying levels of technical literacy, and to make incremental improvements on the tool's interface and abilities.

Figure 9.1: Austin Cowley of OpenMapsCaucasus and a student from Mestia, Georgia use Cartagen Knitter to join images gathered the day before from a balloon.

Ultimately, the use of maps to further the interests of participant communities lays in the hands of those participants, and over a longer timeline of months and years, it remains to be seen whether the maps I have produced with people are, for example, submitted as part of a land claim in Lima, Peru, or used to challenge a mining permit in Rock Creek, West Virginia. However, the interpretation of map data by local participants has been an essential component of the project. In a map of Black Mountain, Virginia, initial images of a reclamation site appeared in vibrant green when compared to previous data from Google Earth. Since the goal of the mapmaking was to highlight the environmental degradation the site had sustained, this was concerning, and indeed, upon first seeing the map many people comment on how beautiful the color is. Members of the Coal River Mountain Watch organization pointed out that despite the color, the main points of interest in the data are the contrast between the naturally forested areas and the sparse vegetation which had been replanted, as well as the tendency of the replantings to follow roadways — the implication being that the mining company has tried to mask the damage by planting where people would see it most.

Figure 9.2: Roadside plantings at a mountaintop removal mining reclamation site on Black Mountain, at the Virginia/Kentucky border.

Face validity can also be assessed when participants present their work to others; in Juan Pablo II, our work culminated in an exhibition of students' maps and drawings to parents and community leaders, who responded with excitement and even surprise. In some cases, specific wording employed by participants has hinted at the degree to which participants took ownership of the process and the resulting maps. Helder Solari, a member of the Escuelab team I worked with in Canta Gallo in Lima, Peru, tellingly referred to the map as 'tuyo', or yours, when he wrote to me asking for a digital copy. (I had left only paper copies with leaders of Canta Gallo.) He did make reference to the fact that our map (as I describe it) is the only one which shows the Canta Gallo community, pointing out that 'in other maps, it simply doesn't exist' [73]

In the largest application of Grassroots Mapping tools in the Gulf of Mexico in 2010, participants blog posts, though from a self-selecting group, demonstrate that many amongst the mapmakers believed strongly in the project's deeper message of cartographic testimony and democratization:

> Even though we cant all be paragliding aerial photographers, wildlife experts or boat captains, we still have a role to play in raising awareness about the effects of this disaster. The best thing that ordinary people can do for the community right now is stay informed, promote action and spread the wordthis is the mission of the Louisiana Bucket Brigade in Grand Isle. — Lauren Craig of LABB, after a balloon mapping trip to Grand Isle [21]

Catalytic Validity

One of the most important outcomes of the Grassroots Mapping project is how it has changed participants' assumptions of what kind of information they are able to collect. This is a key aspect of what Lather refers to as **catalytic validity**, 'the degree to which the research process re-orients, focusses, and energizes participants'. In the case of the 2010 BP oil spill, most organizations I spoke with initially did not understand what I meant by mapping — their response to the spill simply did not take into account the possibility that new aerial data could be captured without a satellite or an aircraft.

Most of the groups I have worked with experience a moment of excited inspiration upon seeing the first images of their own site, fresh off of a balloon flight. Members of Coal River Mountain Watch in West Virginia[1] expressed initial doubts that imagery would be possible due to difficult weather conditions and the challenges in finding an appropriate launch site. However, upon completing a successful flight at the nearby Marsh Fork Elementary School, the excitement was palpable. Our imagery, captured from over 4,000 ft high, proved that monitoring was possible, and the activists began discussing where to acquire the necessary materials. Participants experienced a sudden sense of empowerment, as they recognized their ability to gather direct photographic evidence of the mining companies' destructive effects on the environment.

This moment of inspiration can be frustratingly elusive. In Lima, Peru, mapmaking is performed by civil engineering firms using traditional and expensive surveying techniques. At one point, we were engaged in a mapping exercise with youth from the Canta Gallo community, when leaders of the group came in to the same room to have a meeting with one such firm over the progress of their map! Despite having shown previous maps I had made with other communities, none of the leaders seemed to be interested in applying the techniques towards their apparently immediate needs.

9.2 Comparison with existing techniques

One of the most compelling aspects of the balloon and kite mapping techniques was its low cost; many of the communities I worked with, including those in Canta Gallo, Lima, and Rock Creek, West Virginia, mentioned cost in particular as a motivation to try these tools. For volunteers at the Louisiana Bucket Brigade in New Orleans, it was the low cost of a mapping kit which made it possible to scale up mapping efforts to several teams, with new maps made every few days, all within a budget of only a few thousand dollars. This made kite and balloon imaging techniques feasible at low cost even before the availability of digital cameras and image manipulation tools; today the development of higher-performance kites, lighter cameras, and open source mapping software has made it even more practical. In particular, the absence of engine noise makes both kite and balloon photography more appropriate than imaging from aircraft for sensitive environmental applications such as observing wildlife without disturbing it. [2] In my own work, this was useful while mapping the BP oil spill's effects on birds and other wildlife in the Gulf of Mexico. It has also proven relevant for politically and militarily sensitive areas such as coal mining sites in Appalachia, refugee camps in Palestine.

Compared to the alternatives, of hiring pilots and paying for fuel and aircraft, or purchasing satellite

[1] See Section 10.1.1

imagery, balloon and kite mapping seemed not only inexpensive, but more legible and participatory. The idea that one would have to send a camera into space to photograph things which are right next to oneself seems strange, especially when the area of interest is on the scale of a small community. Imagery taken from only 2-4000 feet preserves a sense of the human scale; mappers can often see themselves or their boat or car in the images, and the occasional photograph shows the balloon or kite string leading down from the camera to the ground. This leaves a powerful impression on mappers, who are literally holding the camera in their hand at thousands of feet in the air... albeit at the end of a string. To them, the millimeter-thick string is both a literal and symbolic link to the camera, a reminder of their control over the image and the authorship they have in the resulting map.

In pragmatic terms, rather than relying on an outside source of expertise, members of participating communities felt that they could perform the image collection themselves, at times of their choosing, and could repeat the imaging at higher intervals than what would be possible with aircraft or satellites. After performing several trips with members of the Louisiana Bucket Brigade and members of Coal River Mountain Watch, participants from those organizations felt comfortable launching their own balloons under observation by myself or Stewart Long, another grassroots cartographer. Several of these participants went on to lead their own trips and bring back their own imagery.

Figure 9.3: Grassroots mappers in a fan-boat at Bay Jimmy, LA on July 22. Photo courtesy Cesar Harada/LABB.

9.3 Quantitative evaluation

9.3.1 Spatial resolution

Resolution can be measured in the spatial, temoral, and spectral dimensions. Spatial resolution refers to the density of information in the x, y, and sometimes z axes in the physical world. Temporal resolution refers to the frequency of image capture, and spectral resolution is the amount of color information preserved in an image[2]. Spatial resolution in aerial imagery is measured in meters or centimeters per pixel; that is, how many meters or centimeters in the real world correspond to the width or height of a single (presumably square) pixel of photographic data. For example, typical res-

[2]More broadly defined, spectral resolution can refer to bands of data outside the range of visual light, as well as the consistency of spectral information due to sun-object-sensor geometry. [75]

olution in Google Maps for urban areas in the United States is 141 cm/pixel, due to their use of the GeoEye satellite of that resolution. This is often referred to simply as 141cm.

On a purely technical basis, there were several key benefits to to the techniques employed by the Grassroots Mapping project. In terms of spatial resolution, the typical balloon or kite map ranges from 2-150 cm in resolution, depending on the camera used, the camera altitude, and the desired output resolution. This bridges an important gap in publicly accessible aerial imagery, as commercial satellites today are limited by US law to 50 cm resolution, and the GeoEye 1 satellite, which offers the best current resolution, offers only 141 cm color imagery. This is especially important in environmental applications; Vierling et al emphasize in their use of balloon imagery that '...there still exists a gap between canopy scale processes and landscape level satellite remote sensing measurement.' [80] The resolution required to identify objects on the ground is typically three to five times smaller than the target objects, so to identify an object 10 cm wide, a resolution of 2-3 cm is required. [1] Jensen and Cowen cite 25 cm as the minimum resolution required to assess attributes such as quality of life indicators and post-emergency imagery. This is well within the typical resolution range for balloon and kite imagery. [35]

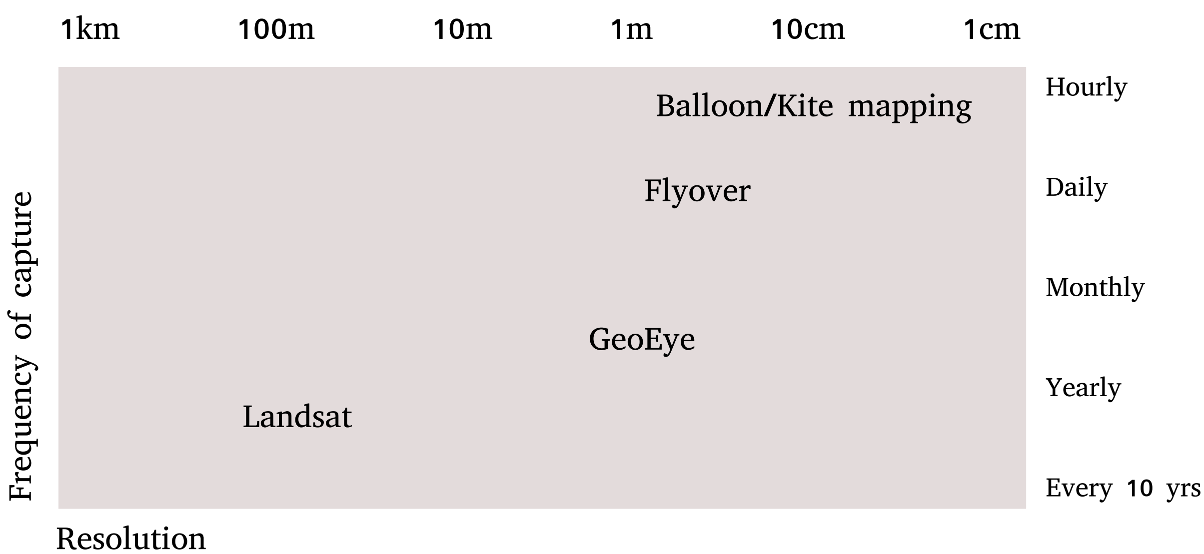

Figure 9.4: Comparison of various imaging techniques and typical resolution/frequency characteristics

Balloon and kite techniques also offer a solution to the lack of control over the timing of imagery capture. Purchasing existing satellite imagery is expensive; in Lima Peru, DigitalGlobe offers imagery from 2008-10 at US$14 per square kilometer, however it is at only 46 cm resolution. Additionally, the imagery may be much as 2 years old and must be bought in large batches. [24] To buy new imagery often requires waiting for a satellite to pass over the target area, or hiring an airplane and pilot, and thus is even more costly, at hundreds of dollars per square kilometer. [53] In the citizen mapping of the BP oil spill in 2010, publicly available daily imagery of the spill was available only from the NASA satellites Terra and Aqua, whose MODIS imaging sensor captured a resolution of only 1 km — though each image could capture the entire oil spill. The images were further obscured by cloud cover (a common challenge with satellite imagery [51]) and glare from the sun, although I emphasize that the MODIS imagery is extremely useful for different reasons than those captured by balloon or kite; volunteers at LABB often used MODIS imagery to identify likely sites to perform kite and balloon mapping. In fact, the two resolutions are almost impossible to reconcile, as all of the citizen maps produced by participants fit within one or two pixels of the MODIS data.

The capture resolution is, of course, a compromise between the desired surface area of coverage and the desired resolution. For example, if a balloon is flown at 1200 meters above the ground, a typical 5 megapixel point-and-shoot camera will capture an area approximately 1000 meters square **per photograph** at a resolution of approximately 40 cm. To double that resolution would require flying the balloon at an altitude of approximately 800 meters, or using a higher resolution camera. In either case, a viable way to increase coverage is to move around with the tether on the ground, either by walking or in a boat or other vehicle. This has the disadvantage of taking a lot of time — in the above example of flying at 1200 meters, to double the map extent would require walking roughly a kilometer in any direction. This is further complicated by obstacles such as closely spaced trees, power lines, etc.

Precision and accuracy in low-altitude aerial imaging

Another important aspect of quantifying spatial resolution is to distinguish the internal precision of an image mosaic and the accuracy of that data compared to the real world. That is, while imagery may be highly spatially consistent in that the location of features relative to one another closely matches reality, the entire image may not be spatially correlated to the real world, and the latitude and longitude positions of those features may vary from their real-world counterparts. This may occur when an image mosaic is assembled from source images with large overlapping areas, and is internally consistent, but cannot be related to the real world due to poor GPS measurements or poor reference map data. Images are typically orthorectified against reference map data of a lower resolution, thus limiting accuracy to the resolution of that source. Further research is required to assess the accuracy and precision of large-scale balloon and kite mapping projects, using a high-resolution differential GPS for reference, following the methodology outlined in Eric Wolf's study of low-altitude balloon mapping. [85]

9.3.2 Temporal resolution

Though **some** satellite imagery is publicly available for virtually every place in the world, and often at useful resolution, even those areas which are mapped at better than 1 meter resolution are often years out of date. There is simply no business case for many satellite imagery providers to capture imagery of many places in the world, and it is impossible to know when the next available dataset will be published, or under what terms. [55] The ability to **repeatedly** image an area at intervals of one's choosing makes balloon and kite mapping techniques useful for time-sensitive purposes such as periodically monitoring the effects of the Gulf oil spill (see Chapter 8) or measuring vegetative regrowth in mountaintop removal mining sites undergoing reclamation (see Section 10.1).

9.3.3 Spectral resolution

Aerial imagery taken from low altitutdes (under 4000 ft) typically has better color saturation compared to imagery captured from space or from higher altitude aircraft platforms. Spectral resolution also refers to consistency, however, and due to sun glare and angle of capture, spectral resolution tends to be quite poor when imagery is captured near solar noon. Balloon and kite imagery does benefit from being captured from below the level of the clouds, which can be important for environmental assessment. Also advantageous is the ability to obtain uncompressed RAW format image data; for example, Crispen Wilson of Conservasi, a member of the Grassroots Mapping mailing list, is attempting spectral analysis of aerial imagery over water. Most easily accessible aerial or satellite imagery is published as PNG or JPEG tiles, and is not useful for such purposes.

Spectral resolution is important for identification of vegetation, and Miyamoto et al have achieved classification of vegetation into 27 different types such as 'moss with alpine plants' and 'moss bogs with pools', using 15 cm imagery. They also assert their belief that balloon aerial photography may be used to allow classification to the genus and species level. [51] Their work has obvious relevance to both the citizen mapping of the BP oil spill (see Chapter 8) and Coal River Mountain Watch's mapping of mountaintop removal mining reclamation sites (see Section 10.1).