Designing Map Democracy:
The Creation of the Bad River Watershed Wikimap

Carl Sack
University of Wisconsin-Madison
Faculty Advisor: Dr. Robert E. Roth

Mailing Address:
1021 E Johnson St. Apt. 1
Madison, WI 53703

Phone: (608) 712-8335
E-mail: cmsack@wisc.edu

Designing Map Democracy: The Creation of the Bad River Watershed Wikimap

Abstract

This paper describes the user-centered design and evaluation of an online participatory mapping application, or wikimap, for revealing narratives of place and landscape values in northern Wisconsin's Bad River Watershed. The wikimap represents an emergent use of volunteered geographic information (VGI): collaborative mapping of local knowledge and values to support the goals of a community. Geoweb technologies are broadening Cartography, challenging specialist control over mapmaking by providing tools that allow the general public to participate to a greater degree. Participatory web maps that support VGI may help empower marginalized voices in land use decision-making if built with these users in mind. To explore what tools and interaction strategies should be supported in the wikimap to best fulfill this democratic promise, a user-centered design approach was applied during the development of the wikimap. The process began with a needs assessment consisting of eight interviews with stakeholders from natural resource agencies and nonprofit community groups active in the Bad River Watershed. Participants' answers were analyzed to inform the conceptual design of the wikimap, including the user objectives, information types, and key interactions it should support, as well as ethical considerations and strategies for promoting participation of local residents. Multiple prototypes were developed, with feedback obtained from participants on each. A final stage of user testing currently is in progress. Insights from the development process will be synthesized into recommendations for designing similar applications to meet the needs of community stakeholders dealing with important land-use issues.

Keywords: user-centered design, volunteered geographic information (VGI), Geoweb, landscape values, participatory mapping, wikimap

Introduction: Participatory Mapping and the Geoweb

Rapid technological change is challenging cartographers to think in new ways about how maps are made and used. Like other trades relying on print production, maps are transitioning into a subset of 'new media,' that are published on-demand and online. One of the many profound consequences of this sea change is the move away from one-way knowledge transfer inherent in the representation paradigm and toward maps as social fora for geocollaboration. The emergence of the *Geoweb*, or the growing suite of adaptable and integratable Web 2.0-based mapping technologies and applications, has vastly expanded the ability of Internet users with little formal knowledge of Cartography or GIS to participate in making web maps (Corbett 2012).

Geoweb technologies have been said to entail a 'democratization' of Cartography because they make it easy for non-experts to make maps for widespread consumption, challenging exclusive ownership over mapping by academics and professionals (Crampton 2010). This 'undisciplining' is celebrated by some as a toppling of the colonial power relationships embedded in the history of professional Cartography (Wood 2003a). State- and business-sponsored maps reflect the interests of the institutions that commission them, which over the past century or more often have been capitalist expansion, resource exploitation, and military security (Harley 1989, Wood et al. 1992). Geoweb technologies hold a promise of replacing these heretofore dominant interests with a wide array of lived experiences (Wood 2003b).

Yet, concerns have been raised that new online forms of mapping may replicate these uneven power relationships or create new ones. Access to Internet connectivity is still highly concentrated in North America and Europe. Even within the Global North, this 'digital divide' appears to be growing rather than shrinking across economic status (Sui et al. 2012). In the age of near-constant surveillance, ethical questions remain regarding the open-ended collection of user-contributed geographic information that may be only marginally 'volunteered' (Harvey 2012). Further, the use of computerized information forms may privilege Western epistemologies over traditional knowledge that comes in the form of stories, songs, and spirituality (Elwood 2008).

These issues demand conscientiousness in the use of Geoweb technology if it is to fulfill its democratic promise. One directed use of these tools that may contribute to citizen empowerment is their application to *participatory mapping*. This set of practices emerged in the 1990s, not from the field of Cartography, but from community-centered rural development and resource preservation efforts (Chambers 1994). Participatory mapping seeks to empower local, often Indigenous, communities to assert sovereignty over their territory or resources. The terms 'bioregional mapping,' 'indigenous mapping,' and 'counter-mapping' have been used to describe subsets of these efforts (Aberley 1993, Chapin and Threlkeld 2001). Best practices have been developed that emphasize the emancipatory goals of participatory mapping, as well as the importance of practitioner transparency and community control (Corbett 2009).

Practitioners are just beginning to explore the extent to which Geoweb technologies can serve participatory mapping's democratic and emancipatory goals. Contributing to this emerging research, a participatory web map, or *wikimap*, was created to address a contentious land use issue in the Bad River Watershed of northern Wisconsin, USA.

This 1,061-square-mile rural area adjacent to Lake Superior contains a mix of agriculture, managed forest, wetlands, and wilderness areas. A portion of the watershed recently has been the focus of interest from a mining company proposing to build a surface iron mine up to 22 miles long and 900 feet deep. The proposal has sparked controversy in communities around the watershed, with pro- and anti-mine sides emphasizing different sets of landscape values. Those in favor promote the jobs and economic development that could come from mining, while those opposed focus on ecological, historical, spiritual, and other values that could be harmed by environmental impacts. The mine sits upstream of the Bad River Indian Reservation, the legal jurisdiction area of the Bad River Band of Ojibwe (Anishinaabe/Chippewa) Indigenous people, who have vowed to fight the mine (Bad River Band of Lake Superior Chippewa 2011).

The Bad River Band has sought ways to represent non-economic landscape values throughout the debate on the mine. A *landscape value* is defined as an "operational bridge… needed to connect special place locations (geography of place) with their underlying perceptual rational (psychology of place) for ecological planning and resource management purposes" (Brown 2004, 19). One experimental solution is the Bad River Watershed Wikimap. This online participatory mapping application was created through a user-centered design process in consultation with the Band's Natural Resources Department and other local stakeholder groups.

The rest of this paper describes the process used to create the wikimap and its outcome thus far. The next section introduces the user-centered design structure adhered to in the development of the wikimap. The procedure and results of first two development stages, the needs assessment and conceptual design, are described in detail in the third section. The fourth section explains how prototypes were developed, refined, and user-tested. The conclusion takes stock of the successes and frustrations of the design process and describes work that is ongoing as the project moves forward through implementation.

Background: User-Centered Design

Development of highly usable applications can be aided by *user-centered design* (UCD). This iterative, multi-stage process has been shown to increase the efficiency of use, reduce the need for training and support, and improve adoption of the application (Maguire 2001). UCD relies on early and consistent feedback from the targeted end user community to ensure the ultimate success of the application (Norman 1988). In the case of the Bad River Watershed Wikimap, interested representatives of stakeholder groups in local land use decision-making were considered representative of the probable end users of the application.

The UCD process for this project was modeled after the Robinson et al. (2005) UCD workflow. Development proceeds through a set of six stages that incorporate end-user feedback at each stage (Figure 1). The stages can be loosely divided in half, with the first three focused on the design and initial development of the application, and the last three involving its testing and modification. However, each stage is mutable and iterative, as user feedback in any stage may reveal a need to return to a previous stage for refinement.

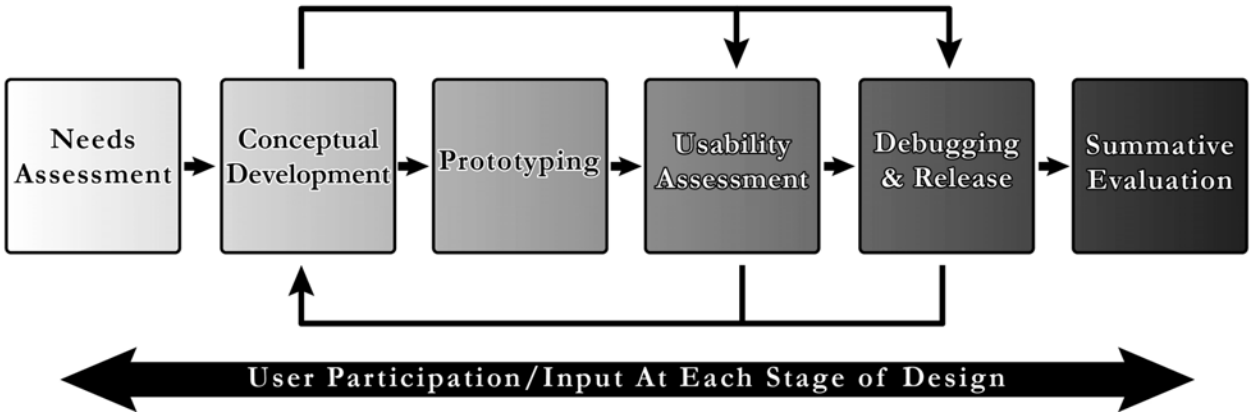

Figure 1: The user-centered design process, adapted from Robinson et al. 2005.

The first stage, a *needs assessment* (referred to as a work domain analysis by Robinson et al.), includes the initial communication with stakeholders about what goals the application should meet, the user objectives it should enable, and tools and design elements it should include. The domain knowledge of stakeholders collected at this stage is used to inform a *conceptual design*, which includes sketches of the application's layout and an outline of its intended features, to be shared with stakeholders for feedback. During the *prototyping* stage, a working model of the application is developed, with a series of feature modifications and regular updates communicated to stakeholders, and stakeholder feedback incorporated into each new prototype.

Once there is a refined and stable prototype, the *usability assessment* stage involves a formative evaluation process that gives a broader set of end users the opportunity to try the prototype application and give constructive feedback. *Debugging and release* is the implementation of a beta version of the application for public use. Ongoing maintenance is required until such time as the application is completely stable and no further feedback is received—in reality, a period that only ends when application maintenance is abandoned. The final stage is a *summative evaluation* of the application, a formal study to determine its ultimate usefulness and usability and inform future application development.

Wikimap Design and Development

Needs Assessment Method

The first stage of the user-centered design process for the Bad River Watershed Wikimap was a formal needs assessment. This involved semi-structured interviews with eight land use, natural resource management, and citizen engagement experts who work in the Bad River Watershed. Fully structured interviews allow answers from all participants to be directly compared to draw conclusions with minimal interviewer bias, but do not allow flexibility to modify questions as new insights are revealed or ask follow-up questions to clarify given answers. Semi-structured interviews start from a set of predetermined questions in a given order, but allow interviewer discretion to probe potentially interesting responses (Robinson 2009). This approach proved particularly useful for the wikimap needs assessment because it allowed for a constructive dialogue with domain experts rather than a rigid question-answer session, enhancing both the

quality of the answers and the buy-in of the stakeholders to the process. While answers to the original questions remained comparable across participants, follow-up questions encouraged the participants to brainstorm extensively and draw new conclusions about the wikimap's possibilities while the interview was taking place.

Table 1: Questions from the needs assessment interview protocol.

Q#	*Question*
	Section 1: Who?
1	What are the key stakeholder groups of which you are aware that influence land use decisions in the watershed?
2a	Do you think the requirement of an Internet will pose a barrier to area residents in contributing to the wikimap? If yes, why?
2b	Are there places in the community where area residents can go to use the Internet, if they do not have personal access? If yes, where are these places? Is there a cost associated to using the Internet?
3	Have you lead or participated in a project that required involvement by area residents?
3a	How were members of the public involved in the project?
3b	What strategies were employed to promote interest/buy-in from the public?
3c	Do you think these strategies would translate to getting people interested in using and contributing to a wikimap?
4	Who should have control over maintaining and moderating the wikimap?
	Section 2: What?
5	What data or information sources should be used to construct a wikimap for the watershed? (Information sources could be specific government agencies, non-government organizations, contributions from the general public, or others.)
6	What types of knowledge should people be able to contribute to the wikimap? (Types of knowledge could be, for example, knowledge of vegetation/wildlife, historical knowledge, scientific observations, recreational information, narrative experiences, etc.)
7	Should limits be placed on the kind of information people can contribute to the wikimap? If yes, what kind of limits? How should those limits be enforced?
	Section 3: Why?
8	What do you see as the advantages (if any) of having a wikimap of the Bad River Watershed available?
9	What are the disadvantages (if any) of having such a wikimap available?
10	To your knowledge, have there been any past mapping projects involving public input in the Bad River Watershed? If so, please describe their purpose, procedures used, and any impact they had on the community.
	Section 4: How?
11	In what ways should users of the wikimap be able to work with it? In other words, what should they be able to *do* on the website? Please be specific.
12	Think about pair of wikimap examples that I forwarded in my recruitment email (Wikimapia and the UW Arboretum map), or another online map with which you are more familiar:
12a	What does each do that you particularly like?
12b	What could each do better?
12c	What do you wish you could do with it that you currently cannot?
	Section 5: Landscape Values
13	The following is a list of possible landscape values. For each landscape value, if you think there are places in the watershed that represent that value, please write down on this sheet of paper a place that represents that value. You may use the atlas and gazetteer provided for inspiration if needed.
13a	Economic: the place provides opportunities for jobs and/or income
13b	Scientific: the place provides opportunities for scientific study
13c	Recreation: the place provides opportunities for fun and/or relaxation
13d	Aesthetic: the place provides pleasant or beautiful scenery
13e	Wildlife: the place provides habitat for animals, including game
13f	Biotic diversity: the place provides for a variety of plants, animals, and other organisms
13g	Historic: the place has natural and human history embedded in it
13h	Spiritual: the place is sacred or provides a place of religious worship
13i	Intrinsic: the place has value simply because it exists
13j	Subsistence: the place provides food and materials necessary to sustain people's lives
13k	Cultural: the place is important to particular wisdom, traditions, and ways of life
13l	Therapeutic: the place makes people feel better, physically or mentally
13m	Wilderness: the place is wild
13n	Ecosystem services: the place produces, preserves, cleans, and/or renews air, soil, and water
13o	Are there values missing from this list?
	Section 6: Conclusion
14	Are there any additional aspects of participatory mapping or the Bad River Watershed wikimap that we have not covered and you would like to discuss?
15	Are there any potential ethical issues, problems, or conflicts regarding this project that we have not discussed?

16	After having this discussion, what do you see as your role or potential role in the Bad River Watershed Online Participatory Mapping Project?
17	Would you be willing to continue to be consulted via e-mail on the development of wikimap prototypes?

Interview questions were ordered in five sections according to the fundamental aspect of the wikimap they explored, plus an open-ended sixth section requesting any final comments (Table 1). The first section focused on characterizing stakeholders and potential users. The second section discussed what information the wikimap would contain, including what data services it should draw from as well as what guidelines and limits should be placed on user contributions. The third section asked participants about the advantages and drawbacks of developing the wikimap in an attempt to gauge the level of community support for this type of project. The fourth section compared Geoweb technology to other computerized and non-digital forms of participatory mapping. The fifth section tested the usefulness of a typology of landscape values by asking participants to name a place within the watershed linked to the value for each landscape value in the typology.

All eight of the interviews were conducted in Ashland, WI, the largest population center near the Bad River Watershed, over a four-day period in April, 2012. Seven of the interviews were in person, and one took place over the telephone. All of the interview sessions lasted between 45 and 70 minutes and were audio-recorded for later transcription and analysis. For each question, participant answers were coded by extensiveness, with the number listed of participants who gave that answer or a synonymous one. Participant responses that clearly expressed key ideas or themes also were reported as direct quotations (Figure 2). This semi-structured approach allowed the capture of a broad range of opinions and ideas from participants, while revealing the key themes within each set of responses.

1. The wikimap will rely on users having access to the Internet.
    a. Do you think the requirement of an Internet will pose a barrier to local people in contributing to the wikimap? If yes, why?

- Access and motivation varies depending on age and background 3
- No 3
- Much of the population is older 3
- No for agency/organization workers, varies for others 2
- Yes 2
- Population is very rural 1
- People are becoming more computer-savvy 1
- Hard to get high-speed Internet in rural areas 1
- Training will increase access/use 1

Key quotes:
"Even if everybody has access to the Internet, people have different capacities to engage in that media."

"It's kind of an interesting facet of people up in this area, that the technology is something they really like having in the region, and having more access, more availability to it, maybe on a city-wide basis, would be something that people would really like, as opposed to having to go and park in front of a library or something to get that Internet access."

"I think obviously Internet is still a growing and very much going to be more important in the future, as it is everywhere else. I just think in this area of the state it's a little, I don't know if behind is the right term, it's just not quite as important here as it is in some other more populated areas of the state."

"We did a survey related to our comprehensive plan... back in 2003 and 4. We asked respondents whether or not they had access to the Internet, which I'm sure most do now, but back then 70% did, 30% did not. I would guess now it's more like 80% do and 20% do not… In town here, we have pretty good Internet access, but out in the rural areas, it's mostly dial-up."

Figure 2: Example of question analysis.

Needs Assessment Results

Several key themes were drawn from the results that were used to inform the conceptual design of the wikimap. A clear digital divide emerged due to much of the watershed's population being older and rural (Figure 2). Strong community engagement and the use of paper maps as a supplement were seen by some participants as ways to counteract this divide. Participants wanted a broad range of information types and sources included in the base map, particularly including waterways, aerial imagery, and information from county government land information websites.

There generally were two types of user-contributed information discussed, with some participants focusing on the addition of scientific and locational data to the map, and others highlighting stories and values related to places. The most contentious topic was whether and how user contributions should be limited, with some participants stressing openness and others concerned about keeping contributions accurate, respectful, and on-topic, and controlling sensitive information such as locations of endangered species and Native American sacred sites. Despite these potential hazards, all participants thought there would be an overall advantage to having a wikimap of the watershed.

The fifth interview segment, which pertained to landscape values that exist within the Bad River Watershed, was different from the other sections in that it was designed to test whether the concept of landscape values as defined in the Introduction could be integrated with the wikimap. A typology of fifteen landscape values for the Bad River Watershed was constructed for the needs assessment interviews (Table 1, Section 5), modeled on similar typologies tested through map-based surveys regarding land use conducted in several areas of Alaska, Canada, and Australia (Brown 2004, Brown 2006, Beverly et al. 2008).

Including a way to map landscape values was considered integral to the goals of the wikimap. Participants identified at least two locations matching each value in the proposed typology, indicating that all of the value types could be of use in the wikimap. Two participants each mentioned a value that was not included: Geologic and Art, respectively. Each of these was only mentioned once and could potentially be considered a subset of other values in the typology. An "other value" type was included in the final typology to allow users to customize the values they submit for display.

Conceptual Design and Prototyping

Using the results of the needs assessment, a conceptual design document was developed that listed the website objectives, interface components, and Geoweb technologies to be used (Table 2). A static visual mock-up of a potential interface design was also created (Figure 3). The conceptual design and mock-up were sent to interview participants via e-mail for voluntary feedback. Four of the participants gave useful comments and suggestions.

The conceptual design proposed a focus on ease of use, with interaction through both highly visible controls and direct mouse manipulation. Users would be able to click on a feature to retrieve information on that feature, displayed in an information panel to one side of the map. A layers checklist would allow users to toggle between different information sets. Drawing tools would allow users to add new features, and feature content would be added through separate pop-up windows, one for new features and one for comments on existing features. Moderation was proposed to take place through a flagging mechanism that would allow users to alert a moderator of inappropriate content. As an added response to concerns about sensitive features being exposed, users would be able to randomly position point feature within 500 meters of the feature's actual position. A stack of Geoweb technologies for the application development environment was also proposed. Some unknown components were identified but left blank for the time being.

Table 2: Conceptual design of the wikimap.

Objectives	
Provide a map with information relevant to the Bad River Watershed derived from specialist sources and crowdsourced from residents and users of the watershed.	
Present personal narratives added to the map by users, consisting of text, photos, audio files, and/or video.	
Present scientific information relevant to the Bad River Watershed to policymakers and the public, derived from public agencies, non-government organizations, and volunteers.	
Present the living history of the Bad River Watershed, collected from and/or added to the map by long-time residents of the area.	
Provide a forum for identifying landscape values connected to places in the Bad River Watershed and making those values visible to policymakers and the public.	
Non-Map Components	
Web page containing the map	
Account login page/window	
Account registration page/window	
Disclaimer/informed consent page/window	
Brief video tutorial on how to use the map	
Basic written tutorial on how to use the map	
Map Interface Components	
Map Interface Tools	Zoom slider, Zoom buttons, Pan buttons, Rotate buttons/widget, Measure (line, area), Draw point, Draw line, Draw polygon
Direct Map Manipulation	Click-drag, Shift-box zoom (optional), Mouse wheel zoom, Click select
Dark overlay outside Bad River Watershed boundary	
Scale bar	
Mouse location lat/long	
Layer Control/Legend (minimizable)	
Layers—on at start	Stories, Information, Observations, Water bodies, Watershed boundaries, Roads Settlements, Basemap (imagery)
Layers—off at start	Land cover, Waterway designations, Political boundaries (county, township/municipality, reservation), Basemap (terrain)
Layers—other possibilities (off at start)	Land ownership type, Soils, Mineral deposits, Bedrock geology (not mentioned by participants)
Info Panel Content	
Information about selected feature	Landscape values, Text and/or data table, Photos, Audio, Video, Links, “Flag” button/link (alerts moderators of possible violation), “Add Comment” button/link (comments submitted to moderators before posting), Comments
When no features active	Guidelines, tips, contact links, general metadata
“Add Information” Window	
Pops up automatically when user completes adding point/line/polygon (if pop-up blocked, use info panel)	
Would you like to generalize this location?” 3-way selection (if the feature is a point)	If “I don’t know” is clicked, a separate window pops up defining generalization and its purpose (obscure the precise location of the feature)
	If “Yes” is clicked, the feature borders will be expanded into a feather-edged circle with a 500-meter radius and the feature recentered randomly within 500 meters of the original feature
	If “No” is left selected, the feature will be displayed as-is.
Layer checklist	“This feature description is a: Story About a Place / Feature Description / Scientific Observation”
Title field	
Text field	
“Add photo” link	When clicked, adds a URL and an “upload” button; can click multiple times to add up to X photos smaller than 2 MB
“Add audio” link	When clicked, brings up an Open File window for upload; uploaded file will be played using an embedded application.
“Add video” link	When clicked, adds a URL field; video must be stored externally on YouTube or similar service and will be embedded in info panel.
“Add landscape values” link	When clicked, adds landscape values checklist, with “definition” link next to each (mouse hover or click pops up separate window with definition), and an “add your own landscape value” field
“Add links” link	When clicked, adds a field to enter comma- or line-separated URLs to be converted to hyperlinks
“Receive e-mail updates about this post?” checkbox	
“Submit” and “Cancel” buttons	
“Add Comment” Window	
Pops up when “add comment” link in info panel is clicked	
Text field	
“Add links” link	
“Add landscape values” link	
“Receive e-mail updates about this post?” checkbox	
“Submit” button (sends to moderators for posting; once posted, alerts post subscribers via e-mail)	
“Cancel” button	
“Flag Post” Window	

"Add a message to the moderators?" text field	
"Submit" and "Cancel" buttons	
Back-end Technology	
Language	JavaScript/AJAX
Libraries	jQuery, jQuery UI, Google Maps API, Google Maps API Drawing Library
Web Service(s)	Google Maps, ArcGIS Web Feature Service hosted by X, possibly state-hosted WFS
Database	Microsoft SQL with ArcSDE, hosted by X
Servers	ArcGIS Server, hosted by X
Interaction logging software	?
Other needs	?

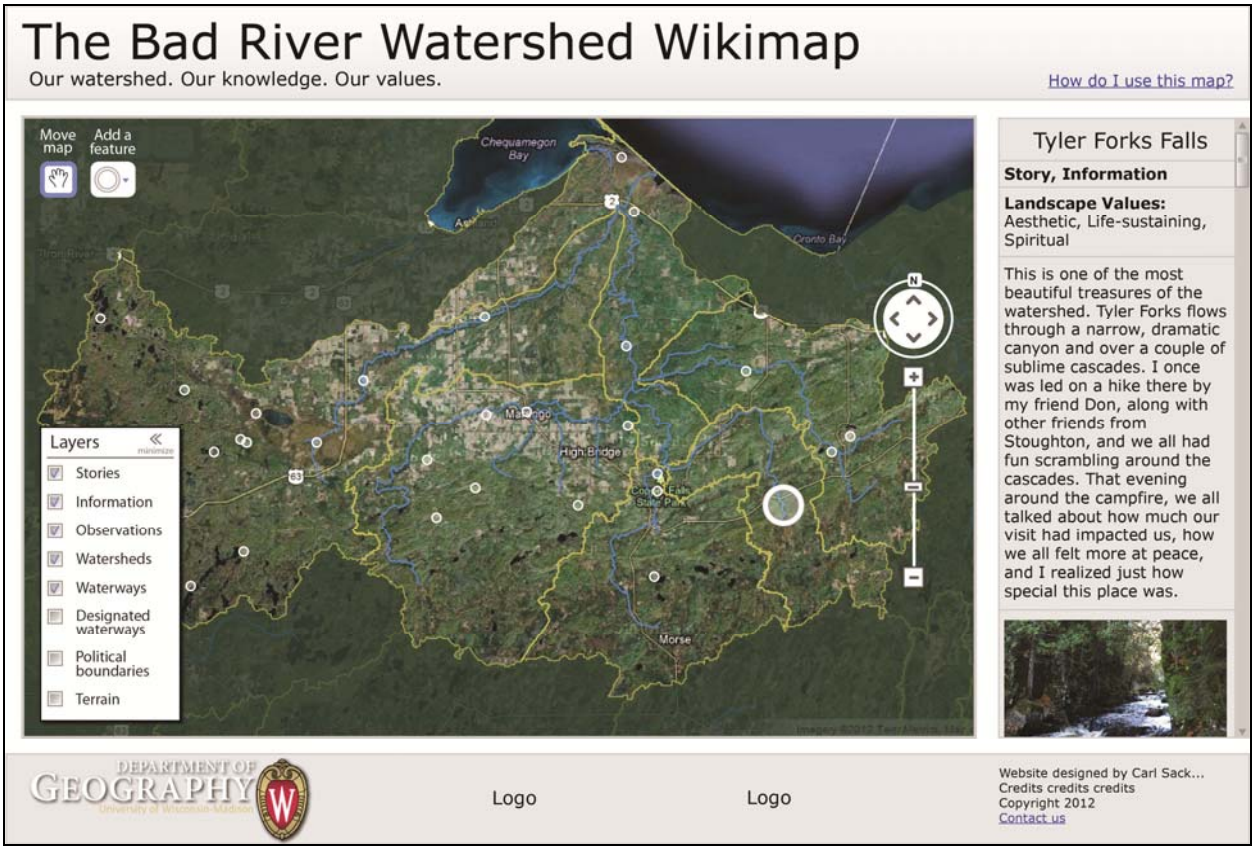

Figure 3: An initial static interface mock-up.

Following the conceptual design was a lengthy process of application development that extended over the summer and into the fall. After an initial prototype was built using the Google Maps API JavaScript code library (Figure 4), Google Maps was abandoned in favor of the open-source Leaflet code library, which included most of the necessary interface components and allowed greater flexibility for layering raster tile services and vector data (Figure 5). The decision was made to use other open-source Geoweb technologies, instead of proprietary tools identified in the conceptual design, due to cost and long-term maintenance considerations. A PostgreSQL/PostGIS database was created to hold vector features and user-contributed information on the server. Geoserver was selected to serve the information to users' browsers through OGC-standard Web Feature Services. PHP scripts were written to handle information

transfer from users to the database, with security measures added to the script to reduce the danger of the system being hacked.

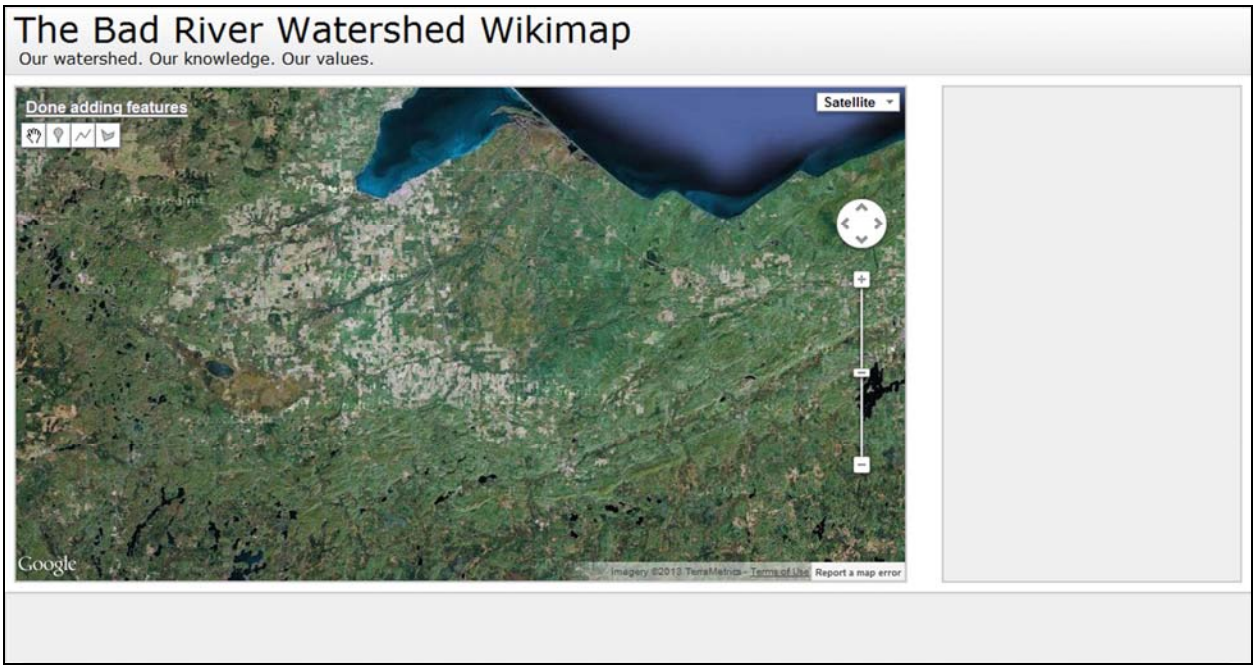

Figure 4: The initial wikimap interface prototype using the Google Maps API.

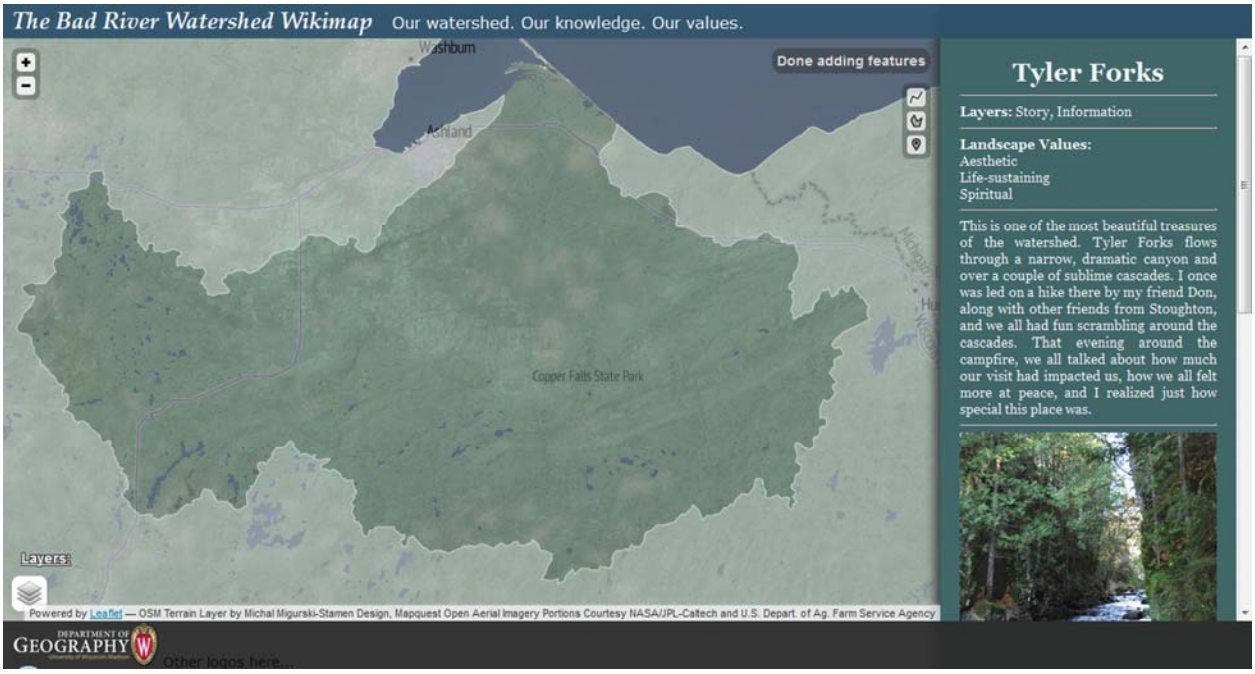

Figure 5: The second prototype, using the Leaflet code library, but with no Web Feature Services running yet.

Two instances of partially-working prototypes and a tutorial video were sent to needs assessment participants for feedback. Much less feedback was received on the prototypes than on the conceptual design, with only two to three participants responding to each and giving little in the way of detailed suggestions. Most of what was received was positive, although one participant could not get some tools to work on his machine. The reason for this did not become evident until the usability assessment workshops, which revealed a browser compatibility issue as the likely culprit.

Wikimap Testing and Implementation

Usability Assessment Workshops

Four public workshops were scheduled when the first fully-functioning prototype was reached. The workshops were held in November, 2012, at four locations in and around the Bad River Watershed. The goals of the workshops were twofold: to spur public buy-in and adoption of the wikimap, and to gain open-ended feedback from in-person user testing beyond what could be gleaned from remote users. As suggested by some stakeholders in the needs assessment interviews, the workshops included a printed map that participants could annotate as a way of getting comfortable with telling stories of place before adding to the online version. The workshop sessions involved some initial direction followed by unstructured application use, which held the advantage of easy setup and flexibility to fit different levels of participation at each workshop (Sweeney et al. 1993). Specific feedback regarding the application was recorded as notes, without identifying the user giving the feedback.

The results of the workshops were mixed. Despite attempts at advanced publicity in local media and through print materials, the turnout was lower than expected. Only three of the four workshops were attended. However, by simply using the system, the eight participants that did attend helped to expose several code glitches. The user testing also revealed that the application was not compatible with older versions of Internet Explorer due to the browser's lack of support for vector graphics used by Leaflet, a problem that would not likely have been discovered through remote user feedback alone. As an added benefit, some participants added large amounts of information to the map during the workshops, in essence seeding it with examples for other users.

Debugging and Release

After extensive modification, the beta version of the wikimap was deployed in January, 2013 (Figure 6). The fully-featured application included the ability to see the features and retrieve the information contributed by workshop participants. Additional functions were added to the side panel, including a search function not included in the conceptual design, and a filter function that added efficiency to viewing the crowdsourced information. The drawing tools, pop-up submission forms, flagging mechanism, and layers panel were retained as in the final prototype, while a distance-measure tool and a tool to add features by geographic coordinates were added. Bugs in the upload interface that caused it not to store files correctly were eliminated. Because a workaround for the browser compatibility issue proved very difficult to implement, a pop-up

alert was added to warn users of older Internet Explorer versions that the wikimap would not be supported in their browser and suggest alternative browsers (Firefox and Chrome).

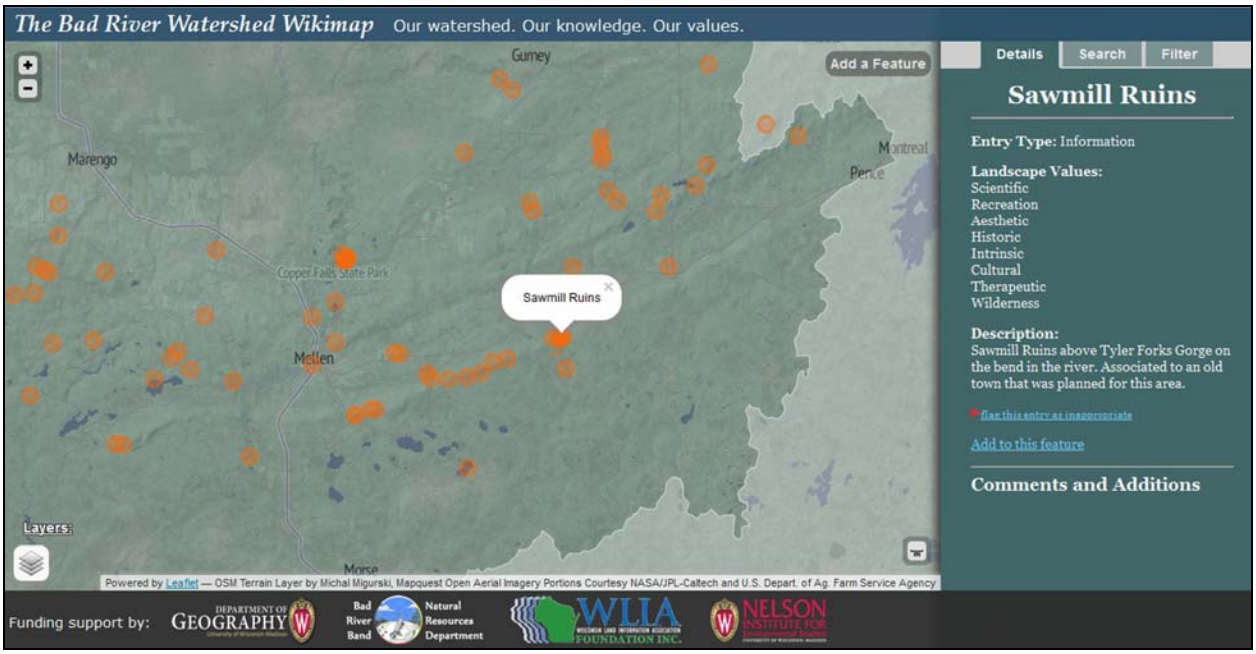

Figure 6: The beta-version Bad River Watershed Wikimap. Orange symbols are user-contributed locations.

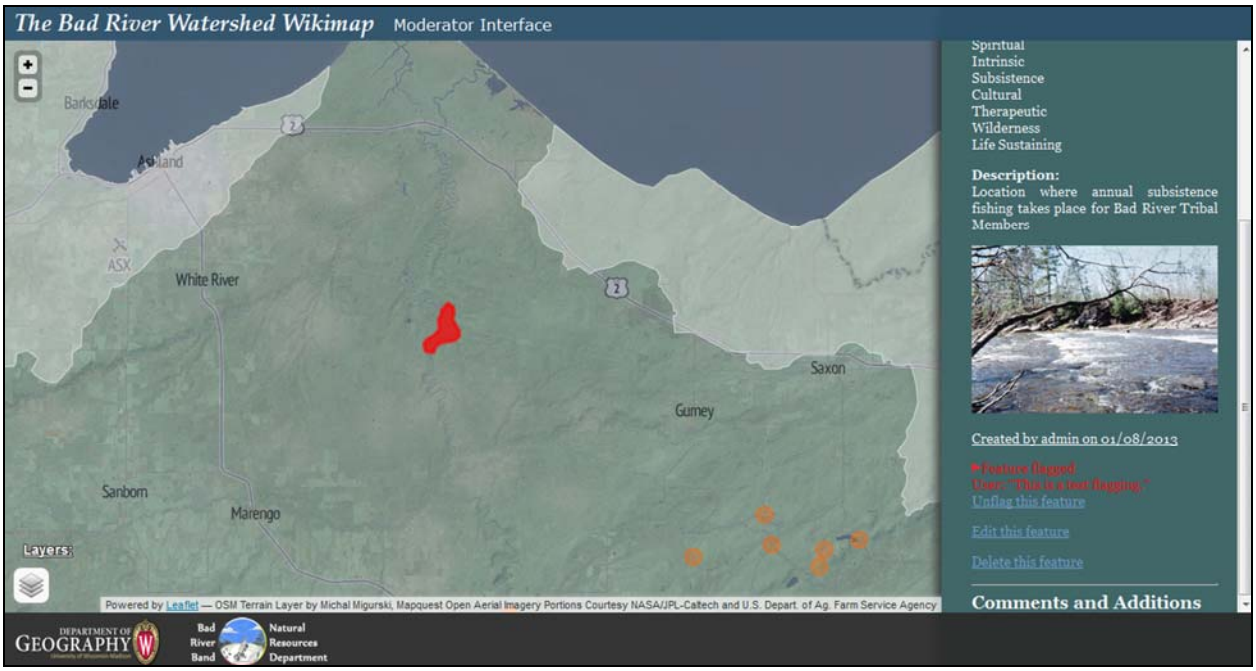

Figure 7: The moderator interface allows privileged users to approve, modify, and delete user-contributed information. Features with information flagged by users are shown in red, and new features awaiting approval are orange.

Because of the low workshop turnout, further recruitment was done through passing out information at two major public events in the Ashland area, which resulted in a number of new wikimap users. To address the initial concerns about information appropriateness and privacy first raised during the needs assessment, a separate application was designed to facilitate moderation of the wikimap content by privileged users (Figure 7). All new content appears on the moderator interface for approval. When a user flags an entry as inappropriate on the wikimap, that feature appears on the moderator interface in red to bring it to immediate attention for modification or deletion.

Future Work and Conclusion

The final user-centered design stage, summative usability testing, is ongoing. Summative testing evaluates how the application is used and whether it supports the user objectives that are of interest (Sweeney et al. 1993). Logging was built into the JavaScript code that records the frequency and timestamp of every interaction that each user does with the map (e.g. pan, zoom, identify, etc.) and places the information in a database table. The logs will be analyzed and data visualizations applied to determine common use patterns and interaction strategies (Edsall 2003).

The Bad River Watershed Wikimap was created to fill the important and timely need of presenting non-economic landscape values within the watershed held by local residents. Geoweb technology was used to facilitate self-directed user contribution of geographic information, partly fulfilling the democratizing promise of this technology. To ensure that it met local needs and increase adoption, the wikimap was developed through a process that would took the needs of users into account at every stage.

The initial needs assessment was successful at eliciting key themes regarding the goals of such an application, what functions it should include, and important ethical considerations. Feedback on the conceptual design and prototypes was much more limited, possibly due to the remote and unstructured nature of e-mail as a communication device. Personal phone calls set up in advance may have netted more valuable feedback. The messages received were prescriptive enough to guide the application development, but major problems went undetected until the usability assessment workshops.

Although public workshops appeared to be necessary to both promote and test the initial release of the wikimap, these workshops did not garner the hoped-for interest. Despite assistance from the needs assessment participants, media advisories, and print materials mailed in advance to local community organizations, turnout was low. This may have been a function of inadequate lead time, but may also point to a need for further groundwork and relationship-building with local organizations prior to the user recruitment phase.

The wikimap has slowly but steadily gained adoption by an increasing number of users. At the time of this writing (early March, 2013), there are 33 registered users and 108 user-contributed features. The user-centered design approach insured that it would be a useful and usable tool for people with little formal knowledge of mapping techniques. Summative assessment using the interaction logs should reveal what uses the map serves. It is hoped that the insights gained

through this design process and the final analysis will be informative for the future development of similar online participatory mapping applications.

References

Aberley, D. (Ed.). 1993. *Boundaries of Home: Mapping for Local Empowerment.* The New Catalyst Bioregional Series. Philadelphia: New Society Publishers.

Bad River Band of Lake Superior Chippewa. 2011. *Position Statement on Proposed GTac Iron Mine and Proposed Iron Mining Legislation in Wisconsin*. Odanah, WI: Bad River Band of Lake Superior Chippewa.

Beverly, J.L., K. Uto, J. Wilkes, P. Bothwell. 2008. "Assessing Spatial Attributes of Forest Landscape Values: An Internet-Based Participatory Mapping Approach." *Canadian Journal of Forest Research* 38: 289–303.

Boulos, M.N.K., B. Resch, D.N. Crowley, J.G. Breslin, G. Sohn, R. Burtner, W.A. Pike, E. Jezierski, K.-Y. Chuang. 2011. "Crowdsourcing, Citizen Sensing and Sensor Web Technologies for Public and Environmental Health Surveillance and Crisis Management: Trends, OGC Standards and Application Examples." *International Journal of Health Geographics* 10: 1-67.

Brown, G. 2004. "Mapping Spatial Attributes in Survey Research for Natural Resource Management: Methods and Applications." *Society & Natural Resources* 18: 17–39.

Brown, G. 2006. "Mapping Landscape Values and Development Preferences: a Method for Tourism and Residential Development Planning." *International Journal of Tourism Research* 8: 101–113.

Chambers, R. 1994. "The Origins and Practice of Participatory Rural Appraisal." *World Development* 22: 953–969.

Chapin, M. and B. Threlkeld. 2001. *Indigenous landscapes: A Study in Ethnocartography*. Arlington, VA: Center for the Support of Native Lands.

Corbett, J. 2009. *Good Practices in Participatory Mapping: A Review Prepared for the International Fund for Agricultural Development (IFAD).* Rome: International Fund for Agricultural Development.

Corbett, J. 2012. "'I Don't Come from Anywhere': Exploring the Role of the Geoweb and Volunteered Geographic Information in Rediscovering a Sense of Place in a Dispersed Aboriginal Community." *Crowdsourcing Geographic Knowledge: Volunteered Geographic Information (VGI) in Theory and Practice*, edited by Sui, D.Z., S. Elwood, and M. F. Goodchild, 223-241. New York: Springer.

Crampton, J. 2010. *Mapping: A Critical Introduction to Cartography and GIS.* Chichester, UK:

Wiley-Blackwell.

Edsall, Robert M. 2003. “Design and Usability of an Enhanced Geographic Information System for Exploration of Multivariate Health Statistics.” *The Professional Geographer* 55: 146-160.

Elwood, S. 2008. “Volunteered Geographic Information: Future Research Directions Motivated by Critical, Participatory, and Feminist GIS.” *GeoJournal* 72: 173–183.

Goodchild, M.F. 2007. “Citizens as Sensors: The World of Volunteered Geography.” *GeoJournal* 69: 211–221.

Harley, J.B. 1989. “Deconstructing the Map.” *Cartographica: The International Journal for Geographic Information and Geovisualization* 26: 1–20.

Harvey, F. 2012. “To Volunteer or to Contribute Locational Information? Towards Truth in Labeling for Crowdsourced Geographic Information.” *Crowdsourcing Geographic Knowledge: Volunteered Geographic Information (VGI) in Theory and Practice*, edited by Sui, D.Z., S. Elwood, and M. F. Goodchild, 31-42. New York: Springer.

Maguire, M. 2001. “Methods to Support Human-Centred Design.” *International Journal of Human-Computer Studies* 55: 587–634.

Norman, D.A. 1988. *The Design of Everyday Things.* New York: Basic Books.

Robinson, A.C. 2009. “Needs Assessment for the Design of Information Synthesis Visual Analytics Tools.” *IEEE 13th International Conference on Information Visualization*, 353–360.

Robinson, A.C., J. Chen, E.J. Lengerich, H.G. Meyer, A.M. MacEachren. 2005. “Combining Usability Techniques to Design Geovisualization Tools for Epidemiology.” *Cartography and Geographic Information Science* 32, 243–255.

Sui, D. Z., S. Elwood, and M. F. Goodchild. 2013. “Volunteered Geographic Information, the Exaflood, and the Growing Digital Divide.” *Crowdsourcing Geographic Knowledge: Volunteered Geographic Information (VGI) in Theory and Practice*, edited by Sui, D.Z., S. Elwood, and M. F. Goodchild, 1–12. New York: Springer.

Sweeney, M., M. Maguire, and B. Shackel. 1993. “Evaluating User-Computer Interaction: A Framework.” *International Journal of Man-Machine Studies* 38: 689-711.

Wood, D., 2003. “Cartography is Dead (Thank God!).” *Cartographic Perspectives* 45: 4–7.

Wood, M., 2003. “Some Personal Reflections on Change: The Past and Future of Cartography.” *The Cartographic Journal* 40: 111–115.

Wood, D. and J. Fels. 1992. *The Power of Maps*. New York: Guilford Press.