Mapmaking for Change: Online Participatory Mapping Tools for Revealing Landscape Values in the Bad River Watershed

By Carl M. Sack

A thesis submitted in partial fulfillment of the requirements for the degree of

Master of Science,
Cartography and Geographic Information Systems

at the

University of Wisconsin-Madison

May, 2013

Acknowledgements & Dedication

This master's thesis would not have been possible without the help and support of a number of people, to whom I am grateful. First among these is Dr. Robert Roth, who bravely took on an eager but unknown student while on new footing himself. His strong guidance, enthusiastic encouragement, and unflinching support helped shepherd a challenging project largely of my own design to fruition. I am also very thankful to Cyrus Hester, of the Bad River Band of Lake Superior Chippewa Natural Resources Department, whose faith in me extended so far as to build crucial support for the project in the Bad River Watershed and beyond, and even to use his influence to direct tribal funding my way. Financial support was also generously provided by the Wisconsin Land Information Association, the Association of American Geographers Cartography Specialty Group, the UW Geography Department Trewartha Fund, the Nelson Institute for Environmental Studies Center for Culture, History, and Environment, and the SciFund Challenge. Thanks to Tanya Buckingham for allowing me to usurp a desk in the UW Cartography Lab, to Rich Donohue for working his expert magic whenever I got into a programming hangup, and to my other Cart Lab colleagues, who provided a light-hearted yet stimulating atmosphere in which to work. Finally, thank you to Melissa and Xander for the warm fire, free bed and good eats whenever I came calling, and to all of my other dear friends up north for saving a place for me in their hearts.

This thesis is dedicated to the people of Bad River, whose struggle for the water gives us all a reason for hope.

Abstract

The research reported here contributes to an emerging understanding of crowdsourced information and collaboration in the Geoweb. Its focus is Online Participatory Mapping (OPM), or the public, collaborative synthesis and presentation of Crowdsourced Geographic Information to support the goals of a community. This research draws from the fields of GIScience and participatory development practice to examine how new Geoweb technologies might empower communities to promote their own values and agendas when faced with contentious land use issues. It tests whether crowdsourced web maps can replace or complement specialist-generated geographic information with local knowledge and landscape values.

A case study was conducted around the deployment of a wikimap, or OPM application, for the Bad River Watershed of Northern Wisconsin, the site of a contentious proposal for an open-pit iron mine. The wikimap was developed through a user-centered approach, relying on feedback solicited from stakeholders and targeted users to inform the application design. Interviews with local stakeholders were conducted and analyzed to produce a conceptual design and multiple prototypes of the wikimap. Public workshops were held to assess the usability of the wikimap and to promote buy-in. System interaction logging revealed that most users focused on map reading and information seeking, with only a small minority of users chosing to contribute information. A follow-up survey found that user-contributed information increased users' understanding of features in the watershed, but to date has had little impact on public discourse.

The case study resulted in a functional wikimap adopted by a modest number of Bad River Watershed area residents. The research results indicate the need for robust community partnerships throughout the OPM process, further inquiry into the motivation of wikimap users, and design strategies to increase the breadth of user contributions and the social impact of future wikimaps.

Table of Contents

Acknowledgements & Dedication……………………………………………………………i

Abstract………………………………………………………………………………… ii

Chapter 1: Landscape Values and Mining in the Bad River Watershed………………….1

1.1 Introduction…………………………………………………………………………… 1

1.2 Contentious Natural Resource Development Case Study: The Penokee Mine Proposal…. 2

1.3 Problem Statement and Research Goals……………………………………………… 4

1.4 Thesis Structure……………………………………………………………………….. 6

Chapter 2: Literature Review…………………………………………………………... 7

2.1 Defining Online Participatory Mapping……………………………………………... 7

2.2 Themes from Cartographer and GIS…………………………………………………... 8

2.2.1 Geographic Information…………………………………………………………....8

2.2.2 Interaction……………………………………………………………………....... 10

2.2.3 Cartographic Empowerment……………………………………………………… 13

2.3 Themes from Participatory Development Practice……………………………………14

2.3.1 Goals and Objectives…………………………………………………………….......14

2.3.2 People and Ethics………………………………………………………………….... 15

2.3.3. Landscape Values……………………………………………………………….… 16

2.4 User-Centered Application Design, Development, and Evaluation.……………….. 18

Chapter 3: Wikimap Needs Assessment………………………………………………… 20

3.1 Needs Assessment Method………………………………………………………….20

3.2 Needs Assessment Results……………………………………………………………...24

3.2.1 People and Ethics……………………………………………………..………..25

3.2.2 Geographic Information………………………………………………...………...27

3.2.3 Goals and Objectives………………………………………………...…………28

3.2.4 Cartographic Empowerment………………...…………………………...……… 29

3.2.5 Interaction.…………………………………………………………...……... 30

3.2.6 Landscape Values……………………………………..……………………. 31

3.2.7 Conclusion…………………………………………………………...……… 32

Chapter 4: Development and Formative Assessment……………………………......33

4.1 Conceptual Design……………………………………………………...……...33

4.2 Prototyping………………………………………………………..…………….. 38

4.3 Formative Assessment Method..41

4.4 Formative Assessment Results………………...………...……………………...……….. 42

4.5 Debugging and Release…………………………………………………..…………… 45

Chapter 5: Summative Evaluation……………………………......……………………47

5.1 Interaction Analysis Method….……………………………………………...……...47

5.2 Interaction Analysis Results……………………………..…………………………. 51

5.2.1 Overall Interaction Analysis…………………………......…………………….51

5.2.2 Pairwise Analysis………………...………………...........………………...……… 53

5.2.3 Use Session Analysis………………………………………………..…………. 54

5.2.4 Interaction Analysis Results Summary……………………………………..….. 58

5.3 User Survey Method….………………………………………..…………………...58

5.4 User Survey Results……………………………………………………………... 60

Chapter 6: Conclusion………………………….…………………………………….…..... 64

6.1 Wikimap Design and Development Process: Discussion and Recommendations............ 64

6.1.1 Stage 1: Needs Assessment..64

6.1.2 Stages 2-5: Conceptual Design, Prototyping, Formative Assessment, and Release.......66

6.1.3 Stage 6: Summative Evaluation..68

6.2 Wikimap Utility: Discussion and Recommendations………………………..………...69

6.2.1 Fulfillment of Research Goals…....................……………………………………....... 69

6.2.2 Usage of the Wikimap……………………………………………………………..70

6.2.7 Landscape Values and Public Discourse………………………………………………72

6.3 Final Words…………………………………………………………………….....74

References…………………………...…………………………………………………… 76

Maps and Figures

1.1 Map: Location of the Bad River Watershed.. 3

2.1 The Cartography Cube…………………………………………………………………11

2.2 The User-Centered Design process…………………………………………………… 19

3.1 Needs Assessment……………………………………………………………………….. 20

3.2 Map: Landscape values in the Bad River Watershed……………………………………. 32

4.1 Conceptual Design……………………………………………………………………..33

4.2 Static mockup…………………………………………………………………………. 37

4.3 Prototyping……………………………………………………………………………. 38

4.4 Initial wikimap interface prototype…………………………………………………… 39

4.5 Second wikimap interface prototype…………………………………………………..40

4.6 Formative Assessment…..……………………………………………………………..41

4.7 Debugging and Release……………………………………………………………….. 45

5.1 Summative Evaluation…………………………………………………………………47

5.2 Pairwise Sankey diagram..............…………………………………………………….... 53

5.3 Sankey diagram of wikimap use sessions: interactions 0-9…………………………..…. 55

5.4 Sankey diagram of wikimap use sessions: interactions 9-18………………….………... 55

5.5 Method for categorizing sessions by wikimap use patterns……………………………... 56

Tables

2.1 Cartographic interaction operators implemented in the Bad River Watershed Wikimap...13

2.2 Landscape values included in the Bad River Watershed Wikimap……………………… 17

3.1 Questions from the needs assessment interview protocol……………………………..… 22

4.1 Conceptual design document…………………………………………………………..34

5.1 User interactions recorded by system logging……………………………………………49

5.2 Frequency of recorded interactions…………………………………………………… 52

5.3 Frequency of interaction operators……………………………………………………52

5.4 Interaction pairs accounting for >1% of all pairs……………………………………... 54

5.5 Wikimap use patterns and their constituent interactions……………………………..... 55

5.6 Frequency of each overall use pattern or combination……………………………........57

5.7 User survey questions from online questionnaire……………………………………...... 59

5.8 Age distribution of survey respondents……………………………………………….. 61

5.9 Location of survey respondents……………………………………………………..61

Chapter 1: Landscape Values and Mining in the Bad River Watershed

<u>Values Added</u>

What do you value the most?

A trout stream?
A job with a $60,000 salary?
A new car?
A stretch of continuous forest?
The Penokee Hills landscape?
Community infrastructure improvements?
Opportunities for your children?

Almost all natural resource conflicts revolve around important values. If you asked Wisconsinites whether they think a strong economy, vibrant culture, and healthy environment are important parts of "the good life," most would say yes. Conflicts arise when values are pitted against each other. "Jobs vs. environment" is a typical phrase.

Must we favor one value, or can we make choices that promote all important values? What value choices will determine the future of the Penokees?

—from *Penokee: Explore the Iron Hills* collaborative art exhibit (Szot et al. 2012).

<u>1.1 Introduction</u>

Policy decisions on contentious natural resource management issues are informed largely by competing sets of ***landscape values***, defined as concepts, objects, or activities involving land use that an individual prefers for a place (Beverly et al. 2008). One problem that arises in many natural resource management conflicts is the lack of means for representing landscape values held by area residents. Maps and GIS data embody the values of their creators (Corbett 2009). Many available cartographic representations are produced by business- and government-employed professionals, and thus express the values of capital and/or the state, and not the needs and wishes of area residents who are impacted by contentious land use practices (Harley 1989).

Traditionally, Cartography has been performed by specialists and professionals, and thus replicates landscape values that are culturally dominant whether or not they are those held by local communities (Wood 2003a). However, emergent and quickly-evolving forms of web-based mapping are changing this relationship, empowering non-specialist map users to make maps that support their own goals and values through the use of interactive maps on the Internet (Wood 2003b). The recent emergence of the ***Geoweb***, or the growing suite of mapping technologies and applications linked over the Internet, has vastly expanded the ability of Internet users with little formal knowledge of Cartography or GIS to participate in making web maps (Corbett 2013). These technologies can be harnessed to serve the needs of communities impacted by contentious land use problems through ***Online Participatory Mapping (OPM),*** or the public, collaborative synthesis and presentation of Crowdsourced Geographic Information to support the goals of a community. For brevity, an application that leverages OPM is referred to here as a ***wikimap***.

1.2 Contentious Natural Resource Development Case Study: The Penokee Mine Proposal

A major motivating factor for this research is a proposal to develop an open-pit iron ore mine within the Bad River Watershed, a 1,061-square-mile rural area of northern Wisconsin containing a mix of agricultural, forestry, and ecological land uses (Figure 1.1). The watershed boundary is used to delineate this area by local groups, in recognition of the interretlationships of ecosystems and human communities that are connected by contiguous waterways, defining it as a *bioregion* (see Section 2.3.1). The Penokee Mine proposal, described below, is a contemporary land use issue in the Bad River Watershed that has sparked

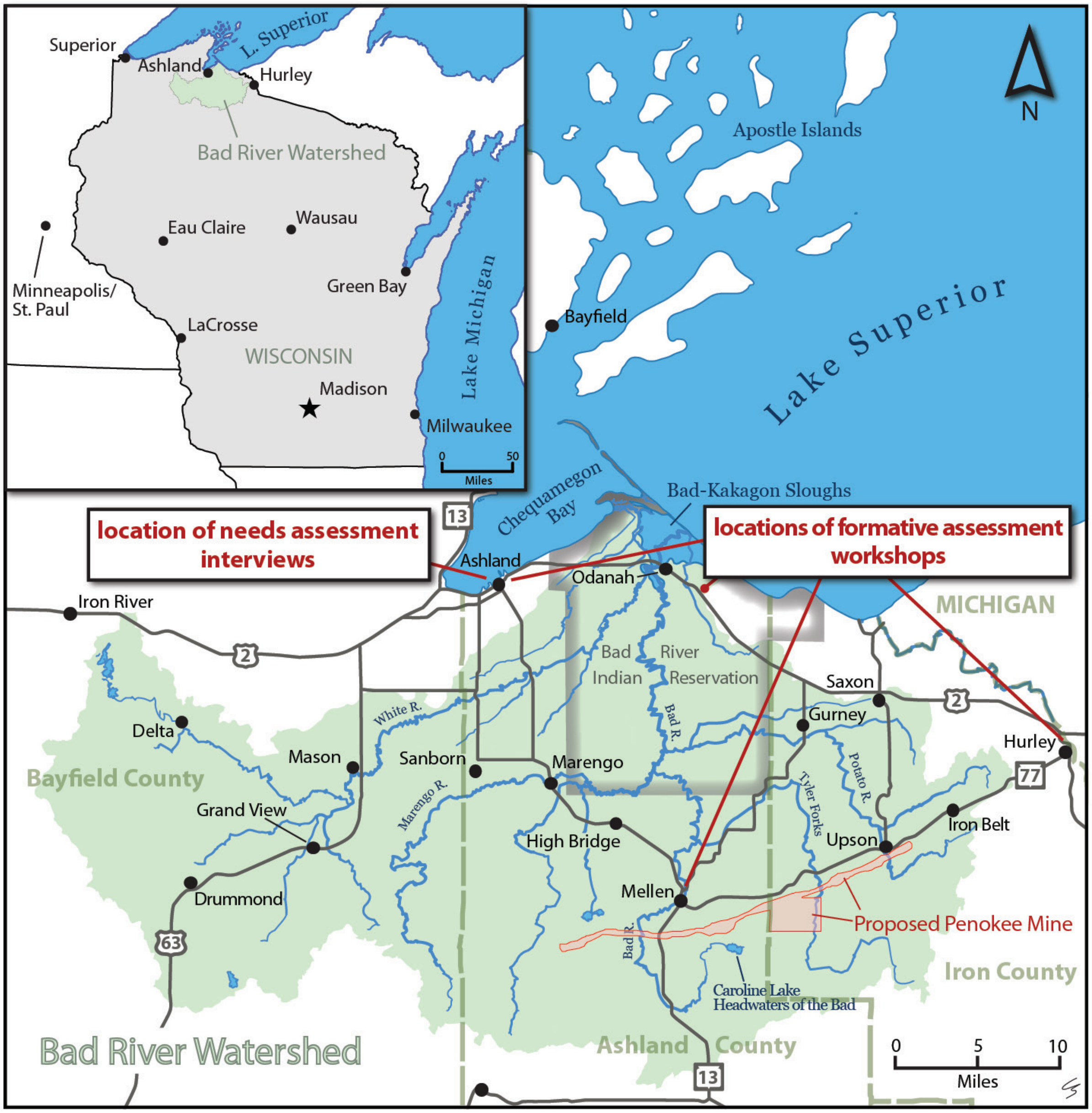

Figure 1.1: Location of the Bad River Watershed.

statewide interest and debate (Gedicks 2011). This dynamic issue provided the backdrop for a case study to examine how Online Participatory Mapping can elicit local knowledge to reveal landscape values and empower communities to influence important land use decisions.

Northern Wisconsin has a long mining history. In the Penokee-Gogebic Range area of northern Wisconsin and the western Upper Peninsula of Michigan, subsurface iron mining took place from 1884 until 1965, mostly in the eastern half of the range (Alanen 1997). These mines lost economic viability once their easy-to-reach deposits were mined out. In late 2010, a mining company announced plans to build an open-pit taconite mine in the western Penokee-Gogebic Range, a much larger-scale operation than any previous mines. The proposal sparked statewide controversy, which grew when mining supporters proposed revisions to state mining laws. The new legislation failed in 2012, but passed in March, 2013 (Associated Press 2013).

Debate over the mine proposal is ongoing at the time of this writing. Impending legal challenges to the new legislation are part of the larger struggle over legislative priorities between promoting economic resource development and protecting environmental quality (Gedicks 2011). The struggle reflects a long-standing conflict between landscape values that view the land as useful for extractable resources and those that see it as useful for purposes that may be negatively impacted by resource extraction. Officially, the State of Wisconsin balances opposing landscape values by considering mining an acceptable land use, while attempting to minimize its deleterious environmental impacts (Evans 2011). The goal of this case study was to inform such important policy debates by empowering Bad River Watershed residents to map their landscape values and share this information with the rest of the public-at-large.

1.3 Problem Statement and Research Goals

The fundamental research problem this thesis addresses is how residents of a watershed can be empowered to cartographically represent their local knowledge and landscape values to the end of influencing land use policy decisions. Three goals were developed to respond to this problem:

1) Design and implement a wikimap that successfully supports synthesis and presentation of local knowledge and landscape values;

2) Analyze the usage of the wikimap, in order to draw conclusions that can inform the development of future wikimaps;

3) Evaluate the influence of the case study wikimap on public discourse regarding land use issues within the Bad River Watershed.

This research contributes to the field of Cartography by testing claims that emerging Geoweb technologies can empower Indigenous and other marginalized communities to map what is of value to them, thus 'democratizing' map mapking as discussed in Section 1.1 (Elwood 2008, Crampton 2010). The development process, which relied on a User-Centered Design model, provided insights into the utility of Geoweb technology for Participatory Mapping. These insights can inform a set of practices to ensure robust community participation and sound ethics in future OPM projects. User interaction analysis provided a direct look into how users interact with an online map that enables two-way communication and information sharing. Conclusions drawn from this analysis can inform the design of future wikimap applications. Finally, a survey was conducted to determine whether public discourse was impacted in favor of local landscape values. Such impacts could indicate that the map was empowering at some level, but they were not conclusively detected by the survey. The conclusions drawn from this research are discussed further in Chapter 6.

1.4 Thesis Structure

This thesis is divided into six chapters. Chapter 1 provides an introduction to the concept of landscape values and discusses how Geoweb technologies might be used to empower the local values of a community through Online Participatory Mapping. Chapter 2 provides background from literature on the theory that informs Online Participatory Mapping, including the components of a wikimap, Participatory Mapping best practices, and the User-Centered Design process applied during the development of the wikimap. Chapter 3 describes the initial needs assessment study that informed the design of the Bad River Watershed Wikimap. Chapter 4 explains initial development of the wikimap, including the method and results of a formative assessment used to test the initial application. Chapter 5 describes the method and results of a summative assessment of the wikimap conducted through logging of user interactions with the application. Chapter 6 synthesizes the overall insights from the project into a set of conclusions about the utility of the wikimap and how the development process might be applied to similar Online Participatory Mapping projects.

Chapter 2: Literature Review

2.1 Defining Online Participatory Mapping

Online Participatory Mapping (OPM), defined in the Introduction, is a relatively new phenomenon that is part of the growing field of Geoweb technologies. The Geoweb, or Geospatial Web, refers to the standards, technologies, and services that together make up an interconnected network for generating, analyzing, and sharing geographic information (Abernathy, 2011). Through the Geoweb, OPM incorporates two different sets of methodologies: one that is based on Cartography and Geographic Information Science (GIS), and another linked to participatory development, particularly in rural or impoverished areas.

While the two influences are rooted in different origins, they have converged over the past two decades around similar sets of emancipatory goals and digital methods. Each contributed fundamental themes to an OPM framework informing design and development of the Bad River Watershed Wikimap. Cartography and GIS contributed three of these themes, described in Section 2.2: ***geographic information***, or the different forms of knowledge that are represented and disseminated in the web map (DiBiase et al. 2006); ***cartographic interaction***, or dialogue between humans and a map facilitated by computers and the Internet (Roth 2011b); and ***cartographic empowerment***, or the challenge posed by Geoweb technology to embedded power relationships within specialist-produced maps (Crampton 2010). Participatory development practice added three additional themes, described in Section 2.3: OPM ***goals and objectives***, or what practitioners hope to accomplish from its implementation; ***ethics***, or measures taken to ensure that the practice of OPM is empowering, rather than disempowering, for its participants; and ***landscape values***, or meaningful human connections to places included in the map (Brown 2004).

The practical application of OPM requires a development process that fits with these theoretical elements. In the field of Human-Computer Interaction, ***User-Centered Design*** (UCD) is described as an approach that is driven by the needs of system users, incorporating their feedback at each stage of application development (Maguire 2001). This process was applied during wikimap development, and is detailed in Section 2.4.

2.2 Themes from Cartography and GIS

2.2.1 Geographic Information

A major driver behind the design choices for any map is the nature of the geographic information that the map intends to convey (MacEachren 1995). Online Participatory Mapping attempts to expand the limits of information representation beyond those imposed by computer-based Geographic Information Systems (GIS) in order to contribute to the social production of geographic knowledge. According to the Geographic Information Science and Technology Body of Knowledge,

> “Geographic information is observed, comprehended, organized, and used in human processes, with both personal and social influences. Therefore, models of geographic information should be grounded on a sound understanding of human perception, cognition, memory, and behavior, as well as human institutions.”

Perceptions of place and spatiality are derived from a mix of physical, cultural, and political influences, and may be difficult to represent adequately within a traditional computer-based information model (DiBiase et al. 2006: 60).

The information represented in a computer-based GIS is typically limited to the domains of location, time, and object/attribute and almost always quantitative (Peuquet 1994). These limits were critiqued during debate over the influence of GIS on society as representing certain knowledge forms—primarily scientific and institution-driven ones—while leaving out others such as stories, songs, images, and mental sketch maps (Harris and Weiner 1998, Kwan 2002). The only visual forms typically allowed in a GIS are points, lines, polygons, and pixels, which may change position over time. ***Public Participation GIS*** (PPGIS) is one attempt to democratize GIS by training local community members to add their knowledge to a GIS database (e.g., Al-Kodmany, 2001). But PPGIS often lacks democratic control over the parameters of information that is collected and does not incorporate qualitative information (Wood 2010).

The hegemony of these institutional geographic information types has recently been challenged by ***Crowdsourced Geographic Information*** (CGI; initially labeled Volunteered Geographic Information or VGI), defined as geographic information resulting from "the widespread engagement of large numbers of private citizens, often with little in the way of formal qualifications" (Goodchild 2007). CGI may be ***contributed***, i.e., collected from computer system users by default, often without their full knowledge and agreement, or ***volunteered***, i.e., freely given by users, who control the collection process (Harvey 2012). Online Participatory Mapping is based on volunteered geographic information, since the information collection must be part of a collaborative process among users that supports the goals of a community (see Section 1.1). This information comes in many forms, including some that may not have a place within institutional GIS. OPM includes qualitative information types such as text, graphics, audio, and video, in addition to traditional map symbols.

Practitioners do not yet agree on what to call applications that utilize CGI/VGI. Some refer to them generically as 'VGI applications' or group them within the broader categories of web mapping, ubiquitous cartography, or neogeography (Tulloch 2008, Elwood 2008, Goodchild 2008). The term 'wikimap' is a logical contraction of the phrase "Wikipedia of the Earth," used as a descriptor by Boulos et al. (2011: 1).

2.2.2 Interaction

Evaluating how users interact with a wikimap requires understanding the process of human-computer interaction in a cartographic context. A key starting point for assessing map use is MacEachren's (1994) Cartography Cube (Figure 2.1). The Cartography Cube is a framework that identifies four stages of map use: ***exploration*** (examining available information to develop research questions), ***analysis*** (testing a research question), ***synthesis*** (compiling the results to generate knowledge), and ***presentation*** (efficiently communicating this knowledge). These activities are characterized along three axes. One axis describes the setting of the user: the first two stages are considered private activities, since they are typically done by a single map user on one computer, while the last two are considered public activities, as they entail collection and dissemination of research results. Another axis describes the user's task: exploration and confirmation are conducted to reveal unknowns about the mapped information, while synthesis and presentation solidify and disseminate knowns. The third axis describes the user's level of interaction with the map, from highly interactive exploration to low-interaction presentation.

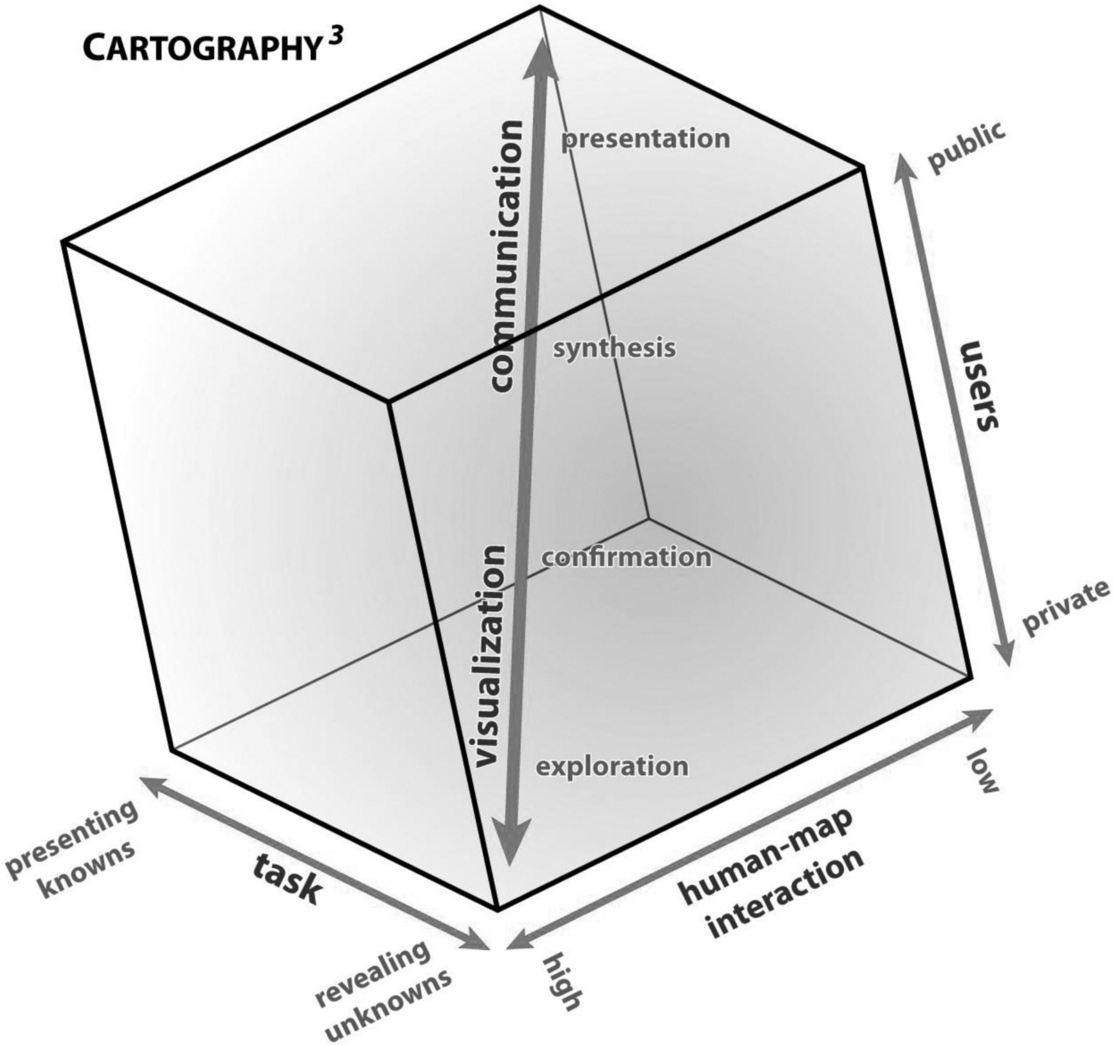

Figure 2.1: The Cartography Cube developed by MacEachren (1994), from Roth (2013).

The Cartography Cube has primarily been used to situate ***Geovisualization***, or the development of highly interactive maps to uncover new insight in large datasets, in the exploration stage (MacEachren and Monmonier 1992). The utility of OPM lies primarily in the presentation stage, as it allows a broad set of users to disseminate local knowledge through the map. It also may support synthesis, as it allows users to view Crowdsourced Geographic Information and communicate with the authors of that information through the map, a process of social knowledge creation.

This collaboration between multiple users across cyberspace can be considered a form of ***Geocollaboration***, or multi-party map use. MacEachren (2005) uses a framework of *same-place vs. different-place* and *same-time vs. different-time* axes to categorize multi-user interfaces. Wikimaps facilitate different-place/different-time collaboration efficiently, in contrast to other forms of mapmaking that are non-collaborative, same-place/same-time collaborations (such as other forms of Participatory Mapping, described in Section 2.2), same-place/different-time collaborations (such as Public Participation GIS, described in Section 2.2), or different-place/same-time collaborations (such as exploratory Geovisualization tools used by researchers). Much of the utility of a wikimap lies in its ability to be accessed and modified at the user's convenience, requiring only a personal computing device with an internet connection and browser.

The collaborative mapping environment facilitates a social conversation mediated by a digital map. The conversation involves dialogue between the people on each end of the map, through their computing devices and the map itself, a process described as ***cartographic interaction***. Roth (2012) presents a cartographic interaction framework that focuses on three sets of primitives: ***objectives***, or tasks a user wishes to complete with the interaction; ***operators***, or specific interactions that allow a user to perform tasks on the map; and ***operands***, or the mapped object on which the task is performed.

While objectives and operands lead to important overall design considerations, interaction operators are the specific interface functions that allow users to manipulate the wikimap. Evaluating the usage patterns of operators can provide insight into the interaction strategies employed by wikimap users, to the end of generating guidelines for wikimap design. The Roth (2011b) operator taxonomy, reduced to include operators most relevant to the synthesis and presentation stages of map use, was applied to interpret user interactions with the wikimap observed through system logging (see Chapter 5). Table 2.1 lists and defines the operators that were recorded through system logging.

Table 2.1: Cartographic interaction operators implemented in the Bad River Watershed Wikimap.

Operator	Definition
import	load information onto the map
save	store changes to the map display or underlying information
edit	manipulate geographic information represented on the map
annotate	add graphical markings and textual notes to the map display
overlay	adjust feature types included in map display
pan	change the center of the map display
zoom	change the scale of the map display
filter	indicate map features that meet a set of user-defined conditions
search	indicate the location of a particular map feature
retrieve	request specific details about map features
calculate	derive new information about map features of interest

2.2.3 Cartographic Empowerment

The proliferation of highly interactive Geoweb technologies, combined with increasing access to them by non-specialist map users, have narrowed the gap between professional mapmaking and amateur map use (Wood 2003b, Crampton 2010). In the 1990s, critical cartographers such as Harley (1989) and Wood (1992) pushed the recognition of embedded power relationships within seemingly 'objective' maps made by professionals, such as state road maps. They argue that government- and business-sponsored maps reflect the interests of the professionals who create them through the features that are chosen for inclusion or exclusion.

Online Participatory Mapping has the potential to ‘democratize’ Cartography by replacing economically-driven specialist viewpoints with a wide array of life experiences through information volunteered by non-specialist users (Rød et al. 2001). A wikimap has the advantage of at least partially removing the need for specialist facilitation and allowing alternative knowledge forms such as stories and songs to be represented through text, graphic, and audiovisual information formats. These benefits make it increasingly possible to connect Geoweb technologies with the practice of Participatory Mapping, of which OPM is a subset.

2.3 Themes from Participatory Development Practice

2.3.1 Goals and Objectives

Interactive, web-based maps represent one side of a wide spectrum of cartographic technologies that have been used in the context of ***Participatory Mapping***, with the other end represented by maps drawn on the ground using natural materials (NOAA 2009). Participatory Mapping starts from the premise that mapmaking is a universal ability among humans (Aberley 1993). It seeks to empower indigenous, rural, and oppressed peoples to make and use maps to defend their territories and resources against exploitation by outsiders (Chambers 1994, Chapin and Threlkeld 2001). Hence, Indigenous Mapping and Counter-Mapping are somewhat narrower synonyms for Participatory Mapping. Also closely related is Bioregional Mapping, community-based mapmaking motivated by the desire to right environmental wrongs in a specific local territory or bioregion. Under this approach, the Bad River Watershed is an example of a ***bioregion***, or “distinct physical territor[y] defined by continuities of land and life” (Aberley, 1993: 3).

Beyond the overarching goals of community empowerment and environmental sustainability, each participatory mapping project has a different set of narrower objectives that the participating communities hope to accomplish through the project. For example, a land use planning project in Mae Hong Son province, Thailand aimed to improve the sustainability of land use while intensifying agricultural production on suitable land, while a project conducted by the Philippine Association for Intercultural Development attempted to delineate ancestral territories to support Indigenous communities' land claims (Corbett 2009). Participatory mapping objectives typically fit into six categories: gaining recognition of land rights, territory demarcation, gathering and guarding traditional knowledge, managing land and resources, education and awareness-raising, and conflict resolution (Poole 1995). The Bad River Watershed Wikimap serves a primarily educational and awareness-raising purpose.

2.3.2 People and Ethics

Community-level decision-making, inclusiveness, transparency, and respect for the intellectual property rights of local communities are core principles of the various forms of Participatory Mapping (Di Gessa et al. 2008, NOAA 2009, Corbett 2009). Practitioners have acknowledged that these concepts are not always implemented in practice (Chapin and Threlkeld 2001). In particular, the case of the México Indígena project has raised controversial questions about the definition of free, prior, and informed consent and the expropriation of indigenous knowledge for neocolonial purposes. This Participatory Mapping project, conducted in Oaxaca, Mexico by University of Kansas researchers, was condemned by two of the participating Oaxacan communities as an act of "geo-piracy." Participants said that they were not informed in advance that funding was provided by the U.S. Army's Foreign

Military Studies Office, under the auspices of an American Geographical Society program of reconnaissance-driven mapping called the Bowman Expeditions (Bryan 2010). Ongoing U.S. Military interest in Participatory Mapping, which may apply local knowledge to uses other than those intended by participating communities and possibly detrimental to those communities, has highlighted the need for full transparency and local control when collaborating with indigenous communities on mapping projects (Grossman et al. 2010).

Regardless of practitioner intentions, unequal access to technology can pose a separate ethical issue, as it can exacerbate existing inequalities between rich and poor, young and old, and developed and underdeveloped areas (Crampton 2010). While they provide benefits over paper or sketch maps, computer-based maps may be more difficult to understand and use, and some users may require training and equipment to be provided, which may be expensive (Corbett 2009). Online participatory mapping in particular necessitates careful consideration of the needs of different sets of community members to ensure equal levels of access and participation across ages, genders, socioeconomic strata, and neighborhoods.

2.3.3 Landscape Values

Ensuring that OPM captures and communicates the values of a local community requires a means of identifying those values. Rolston and Coufal (1991) proposed using the concept of landscape values (defined in Section 1.1) to guide land use policy decisions, as values provide an "operational bridge" between places and how they are perceived in the context of planning and management (Brown 2004). Sets of landscape values were subsequently tested and deemed successful by several practitioners (Beverly et al. 2008, Brown 2004, Brown 2006, Brown and Reed 2000). The basic typology proposed by Brown (2004) defines

14 values. It has been modified with each use to fit the social and ecological particularities of each area and situation to which it is applied (e.g., Brown 2006, Beverly et al 2008). Most of the landscape values included in the original Brown typology were included in the Bad River Watershed Wikimap, with one value added (*wildlife*), one renamed (*learning (knowledge)* changed to *scientific*), and one removed (*future*) (Table 2.2). These values can be broadly grouped into three categories: *ecological values* (*biological diversity, wildlife, wilderness,* and *life sustaining*), *sociocultural values* (*aesthetic, therapeutic, recreation, historic, scientific, cultural, spiritual,* and *intrinsic*), and *economic values* (*subsistence* and *economic*) (de Groot et al. 2002).

Table 2.2: Landscape values included in the Bad River Watershed Wikimap.

Category	Value	Definition
ecological	biological diversity	the place provides for a variety of plants, animals, and other organisms
	wildlife	the place provides habitat for animals, including game
	wilderness	the place is wild
	life sustaining	the place produces, preserves, cleans, and/or renews air, soil, and water
sociocultural	aesthetic	the place provides pleasant or beautiful scenery
	therapeutic	the place makes people feel better, physically or mentally
	recreation	the place provides opportunities for fun and/or relaxation
	historic	the place has natural and human history embedded in it
	scientific	the place provides opportunities for scientific study
	cultural	the place is important to particular wisdom, traditions, and ways of life
	spiritual	the place is sacred or provides a place of religious worship
	intrinsic	the place has value simply because it exists
economic	subsistence	the place provides food and materials necessary to sustain people's lives
	economic	the place provides opportunities for jobs and/or income

Landscape values are particularly pertinent to the Bad River Watershed in light of the mining debate discussed in Section 1.2. Mining supporters prioritize economic values tied to certain types of land use, emphasizing the jobs that would be created as a result of mining (Ward et al. 2011). In contrast, the Bad River Band of Lake Superior Chippewa (2011) and their allies prioritize ecological and sociocultural values. Business and government mapmakers generally view the landscape as a collection of natural resources and prioritize possible commercial or industrial landscape uses. The wikimap seeks to balance resource use debates by providing ways to cartographically represent the non-economic landscape values of local communities on a more equal footing to economic ones, and privilege the values of local contributors over those of outside specialists and developers.

2.4 User-Centered Application Design, Development, and Evaluation

Building a highly usable website is critical for generating use of a web-based application by non-experts. Further, the ethical principles of Participatory Mapping discussed in Section 2.3.2 demand a transparent and community-driven design and development process. ***User-Centered Design*** (UCD) is an iterative, multi-stage process that involves user input into the design at each stage. UCD relies on early and consistent feedback from the targeted end user community to ensure the ultimate success of the application (Norman 1988). It increases the efficiency of use, reduces the need for training and support, and improves adoption of computer applications (Maguire 2001).

The User-Centered Design process for the Bad River Watershed Wikimap was modeled on a six-stage process recommended by Robinson et al. (2005) for development of epidemiological geovisualization tools, with slight modifications based on the needs and development environment of the Bad River Watershed Wikimap (Figure 2.2). The six stages were: a ***needs assessment***, to determine requirements and guidelines for the application; a ***conceptual design***, to create a working document from the needs assessment findings; ***proto-typing***, to develop partially-working instances of the application that can garner iterative user feedback; a ***formative assessment***, to test for problems and bugs with the alpha version of the complete application; ***debugging and release*** of the application; and a ***summative evaluation*** to determine the usefulness and usability of the final application and draw lessons for future development.

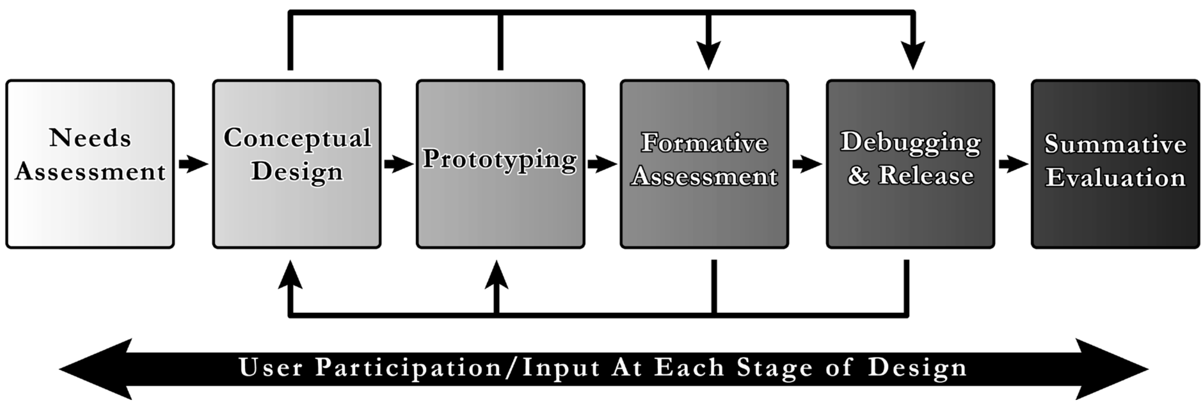

Figure 2.2: Diagram of the six-stage UCD process, modified from Robinson et al. (2005).

The description of the UCD process for the Bad River Watershed Wikimap is reported in the subsequent three chapters. The methods and results of the initial needs assessment are detailed in Chapter 3. Chapter 4 discusses the design, development, formative assessment, and debugging and release of the wikimap. Chapter 5 details the methods and results of the summative evaluation.

Chapter 3. Wikimap Needs Assessment

3.1 Needs Assessment Method

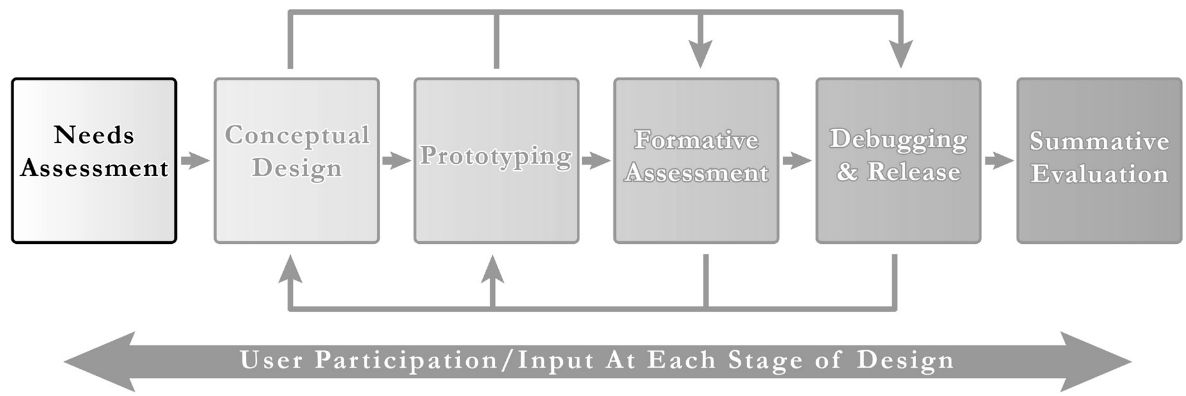

Figure 3.1: The Needs Assessment was the first stage of the UCD process for the wikimap.

Initiating the User-Centered Design process, the first stage of development for the Bad River Watershed Wikimap was a formal needs assessment, a procedure designed to elicit ideas from domain experts to guide application development (Figure 3.1; Robinson 2009). The needs assessment consisted of semi-structured interviews with land use, natural resource management, and citizen engagement experts who work in the Bad River Watershed. Participants were identified through Internet searches for local organizations and government agencies. A letter of invitation was sent to the main contact person or leader of each institution. Eight people (n=8) responded to the invitations and participated in the interviews.

The interview protocol was designed to explore participant ideas about the project while maintaining some comparability across participant answers. Fully structured interviews minimize interviewer bias, but do not allow flexibility to modify questions as new insights are revealed or ask follow-up questions to clarify given answers. Unstructured interviews maximize exploration of participant ideas, but do not allow responses from different participants to be directly compared. Semi-structured interviews start from a specified set of preordered questions, but afford the interviewer discretion to probe potentially interesting responses (DiCicco-Bloom and Crabtree 2006). This approach created a constructive dialogue with the 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.

Interview questions were ordered in six sections, each of which related to one of the key themes discussed in Chapter 2 (Table 3.1). The first section focused on characterizing potential users and explored ethical questions of access and information control (see Section 2.3.2). The second section discussed the information that the wikimap should contain, including which data services it should draw from and the guidelines and limits that should be placed on user contributions (see Section 2.2.1). The third section asked participants about the advantages and drawbacks of developing the wikimap, in an attempt to determine what wikimap objectives have the most community support (see Section 2.3.1). The fourth section compared Geoweb technology to other computerized and non-digital forms of Participatory Mapping and asked which forms would be most empowering to the community (see Section 2.2.3). The fifth section asked participants about tools and interactions that they would find useful to include in the wikimap (see Section 2.2.2). The sixth section tested the usefulness of the Brown (2004) typology of landscape values (see Section 2.3.3) by asking participants to name a place within the watershed for each landscape value that they thought contained that value. Following the six sections of questions, participants were allowed to discuss any additional topics not addressed in the interview protocol.

Seven of the eight interviews were conducted in person in Ashland, WI, the largest population center near the Bad River Watershed (see Figure 1.1), over a four-day period in April, 2012. One interview was conducted over the telephone during that period. 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 according to unique responses, and the extensiveness of each response was tallied to show the number of participants that gave each unique response. 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.

Table 3.1: Questions from the needs assessment interview protocol.

Q#	*Question*
Section 1: People and Ethics	
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: Geographic Information	
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: Goals and Objectives	
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: Cartographic Empowerment	
11	What do you think would be advantages and disadvantages of using the following three types of Participatory Mapping to show landscape values in the Bad River Watershed?
11a	Physical maps made by the community (i.e., ground or sketch maps, not using a computer)
11b	Maps that are digital, but not online (i.e., GIS software)
11c	Maps that are digital and online (i.e., a wikimap)
12	Which of the above seem like appropriate ways to display local knowledge and landscape values in the Bad River Watershed? Which do you think is most appropriate and why?
Section 5: Interactions	
13	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.
14	Think about the 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:
14a	What does each do that you particularly like?
14b	What could each do better?
14c	What do you wish you could do with it that you currently cannot?
Section 6: Landscape Values	
15	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.
15a	Economic: the place provides opportunities for jobs and/or income
15b	Scientific: the place provides opportunities for scientific study

15c	Recreation: the place provides opportunities for fun and/or relaxation
15d	Aesthetic: the place provides pleasant or beautiful scenery
15e	Wildlife: the place provides habitat for animals, including game
15f	Biotic diversity: the place provides for a variety of plants, animals, and other organisms
15g	Historic: the place has natural and human history embedded in it
15h	Spiritual: the place is sacred or provides a place of religious worship
15i	Intrinsic: the place has value simply because it exists
15j	Subsistence: the place provides food and materials necessary to sustain people's lives
15k	Cultural: the place is important to particular wisdom, traditions, and ways of life
15l	Therapeutic: the place makes people feel better, physically or mentally
15m	Wilderness: the place is wild
15n	Ecosystem services: the place produces, preserves, cleans, and/or renews air, soil, and water
15o	Are there values missing from this list?
Section 7: Conclusion	
16	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?
17	Are there any potential ethical issues, problems, or conflicts regarding this project that we have not discussed?
18	After having this discussion, what do you see as your role or potential role in the Bad River Watershed Online Participatory Mapping Project?
19	Would you be willing to continue to be consulted via e-mail on the development of wikimap prototypes?

3.2 Needs Assessment Results

Several key themes were drawn from the results that were used to inform the conceptual design of the wikimap. The results from each section of questions are discussed below, with the extensiveness of each response shown in parentheses. Participant responses that clearly expressed key ideas or themes are reported as direct quotations.

3.2.1 People and Ethics

The first set of questions focused on who would use and who would control the wikimap. To characterize groups with a potential interest in the outcomes of the wikimap, participants were asked to identify stakeholders in land use and natural resource management in the Bad River Watershed. All participants (n=8) mentioned local (county, municipal, and/or town) governments as stakeholders in land use decision-making in the Bad River Watershed. The Bad River Band of Ojibwe was frequently mentioned as having significant influence over land use throughout the watershed, on and off the reservation (n=5). The Bad River Watershed Association was discussed as playing a major role in watershed monitoring and public outreach (n=5). Northland College also was mentioned frequently (n=4). Participants also mentioned stakeholders aligned with economic activities that occur in the watershed, particularly farming (n=5), logging (n=5), and tourism (n=3). One participant characterized the general nature of the residents thus: "[I]t's largely a very rural watershed, so people that live there have a very strong connection to the land and to the water." Another mentioned that, "Just about everybody in the watershed is a nature appreciator."

Next, participants were asked about the potential ethical hazard of unequal access to the wikimap and how this divide should be addressed. There were differences of opinion over whether lack of Internet access would pose a barrier to wikimap use for some people. Several participants were concerned that a good portion of the watershed's population is older (n=3) and rural (n=1), thus less likely to have access, but some also stated that more young and tech-savvy people were moving into the area and access to technology was continuing to improve. One participant cited a 2004 survey conducted by the Bad River Watershed Association that found 70% of watershed residents had Internet access at the time. Libraries were identified by most participants as places people could go to access the Internet (n=5), although only one of those mentioned (Mellen library, n=1) is actually within the watershed boundary. Coffee shops (n=3) and schools (n=1) were places identified as having wireless access for those with a laptop computer or mobile device. One participant argued, "the technology is something [residents] really like having in the region," while another pointed out that, "even if everybody has access to the Internet, people have different capacities to engage in that media."

While participants had differences in opinion about the accessibility of a wikimap, there seemed to be consensus that a local organization should control and maintain the wikimap. Many described what they saw as important characteristics of such an organization, which included stability (n=2), strong ties to the community (n=3), and the capacity to provide upkeep (n=4). The majority felt that the Bad River Watershed Association would be a strong candidate (n=5), with others also mentioning Northland College (n=2), the Bad River Tribe (n=2), and UW Extension (n=2). One participant argued that the organization in charge should be as non-political as possible: "anybody that's actually making decisions about land use planning will certainly benefit from it, but just from the legitimacy of the tool, I would avoid having them have direct control over it."

All participants had experience engaging the public in projects, and several offered useful advice on how to promote the wikimap. Organizing events (n=4), press releases (n=3), and recruiting key stakeholders to reach out to the public (n=3) were the most-mentioned means of promoting buy-in. These insights led to the design and promotion of public workshops for formative assessment, discussed in Chapter 4.

3.2.2 Geographic Information

The second set of questions discussed the types of geographic information that the wikimap should contain. A broad range of information types and sources was identified for inclusion in the basemap, with waterways (n=4), aerial imagery (n=3), and information from county SDI (spatial data infrastructure) websites (n=3) the most extensive answers. One participant thought of connecting the map to outside information sources; for instance, "the county local land records information [could] have a connection… you could connect out to the NRCS and look at the soils information for building on the property and septic suitabilities."

There seemed to be two schools of thought on what types of knowledge the public should be able to contribute, with some participants focusing on the addition of scientific and locational data to the map, and others highlighting narrative stories and values related to places. For example, one participant envisioned "connecting people to their natural environment through this map system, where they just share stories and show how strongly they connect to these features, and maybe have a little sharing of those values as a pop-up on the map." Stories of place (n=4) and historical knowledge (n=4) were discussed the most.

Whether and how these contributions should be limited was the most contentious question in the interview protocol. The majority thought that the map should be moderated and should have limits placed on what could be posted (n=5). Several participants were concerned about keeping contributions respectful, free of violent language or obscenities (n=3). Some mentioned controlling sensitive information such as locations of sensitive ecosystems (n=1) and sacred sites (n=1). A few thought that there should not be limits (n=2) or that limits should be as minimal as possible (n=2). This could be a difficult question for Tribal members, according to one participant, because "culturally it's often taboo to share [sacred places] until someone has earned that information… but at the same time, you have other members of the community that will want to at least have some level of acknowledgement that there is a traditional cultural aspect of that property that needs to be protected." How to balance open access with maintaining reliability and credibility was a recurring question throughout the interviews, without any definitive answer.

3.2.3 Goals and Objectives

The third set of questions asked about the potential objectives of the wikimap. All participants (n=8) thought there would be some kind of advantage to having a wikimap of the watershed. Several participants mentioned uses related to promoting dialogue and communication around land use and natural resource issues, including communication between the public and land use planners (n=2), fostering respectful dialogue (n=1), and showing values that could be lost due to development (n=1). With issues such as mining, thought one participant, "having tools and data for people to come around about and discuss, have these dialogues in a respectful manner, can help people realize that there are multiple opinions and multiple value systems about a resource." Others were excited about displaying living history (n=3), or "what [residents'] stories are about living in the Bad River Watershed." A few thought that it could serve as a centralized information source or spatial bulletin board (n=2). On the other hand, there were concerns about disagreement (n=1) and controversy (n=1) resulting from the wikimap, and its users not being representative of the watershed's population (n=2) due to lack of access and technical skills.

Several past mapping projects in the watershed were identified, the most noted being a project to map all culverts in the watershed conducted by Northland College and the Bad River Watershed Association (n=4). The project was conducted to identify culverts that needed replacement to reduce erosion and restore stream habitat for migratory fish species (Northland College 2012). None of the identified mapping projects had a focus on mapping landscape values.

3.2.4 Cartographic Empowerment

The fourth set of questions asked about different mapping technologies and whether the wikimap would be the right choice. Paper maps were identified by some as the most familiar (n=3) and garnering the most buy-in (n=3), with the added advantage of bringing people together for face-to-face dialogue (n=3), and also the easiest to carry into the field (n=2) or hang on a wall (n=2). GIS systems and online maps were seen by some as an improvement for spatial analysis (n=1) and layering information (n=2), while a wikimap specifically was said to allow public access at any time (n=3) and direct public input to the map (n=1). These aspects were seen as empowering, “not just a mapmaker making decisions on what’s important to map and to display, but it’s the residents of a community that are deciding what’s important to map.” But the digital technologies also were seen by some as having a technical skills barrier that could limit buy-in and bias the map toward younger and more professional segments of the population (n=2). Some thought that the most empowering application of Participatory Mapping would be through multiple methods (n=2), integrating the use of printed maps in public workshops to add non-specialist information to the wikimap. With this approach, “you can build momentum through direct engagement, face-to-face conversation, and then… maintain that momentum through digital or easier-to-access stuff," in the words of one participant. These insights led to the use of a paper map in the formative assessment workshops discussed in Chapter 4.

3.2.5 Interaction

How users should interact with the wikimap itself was the fifth topic discussed. Every participant had a different vision. Multiple participants mentioned importing information in some form (n=3) and retrieving information added by others (n=5). Many answers specified an information format to import or edit (such as text, pushpins, lines, audio, and photos), indicating a lack of distinction between the interaction operator (what the user *does*) and operand (what the user *does it to*) in participants' minds; the same operator with two different operands were seen as separate interactions. The *import* operator was mentioned once (n=1) with each of five different operands: point features, line features, audio, photos, and missing features. Importing stories was mentioned twice (n=2). The *annotate* operator was mentioned twice: once as adding comments, and once as adding ratings to existing features. The *overlay* operator was mentioned once. *Search* was mentioned twice (n=2): once for information, and once for map features. *Retrieving* information about a feature by clicking it (n=3) and by brushing (n=1) were both mentioned. Some users had very specific map use objectives in mind, such as *calculating* the time a canoe trip would take and *retrieving* water quality data.

Although the ability to *zoom* to different scales was not mentioned as a way for users to interact with the wikimap, this was the most mentioned operator (n=5) when participants were asked to think about features of other online maps that they liked. Participants also appreciated the ability to *overlay* or toggle different layers of information (n=3). A few mentioned having a very simple (n=1), user-friendly (n=2) interface as important to gaining buy-in from less tech-savvy members of the public: "If something's going to be used by people who don't use computers very often, it's got to be super simple and… there can't be any small text."

3.2.6 Landscape Values

To investigate whether landscape values could be integrated with the map, the sixth section presented participants with the typology of fifteen different landscape values presented in Section 2.3.3. Participants were asked to name specific places in the watershed matching each value. At least two places were identified for every value in the list, indicating that all of the listed values could be of use. A number of participants identified general place categories (e.g., "rivers") as holding value. Some also mentioned places that were not within the boundaries of the watershed, possibly because those boundaries are not well known even by those who work on watershed issues. The Bad-Kakagon Slough stood out, being mentioned by a majority of participants and assigned to eleven of the fifteen values altogether (Figure 3.2) . Two participants each mentioned one value that was not categorized: *geologic or mineral*, and *art*.

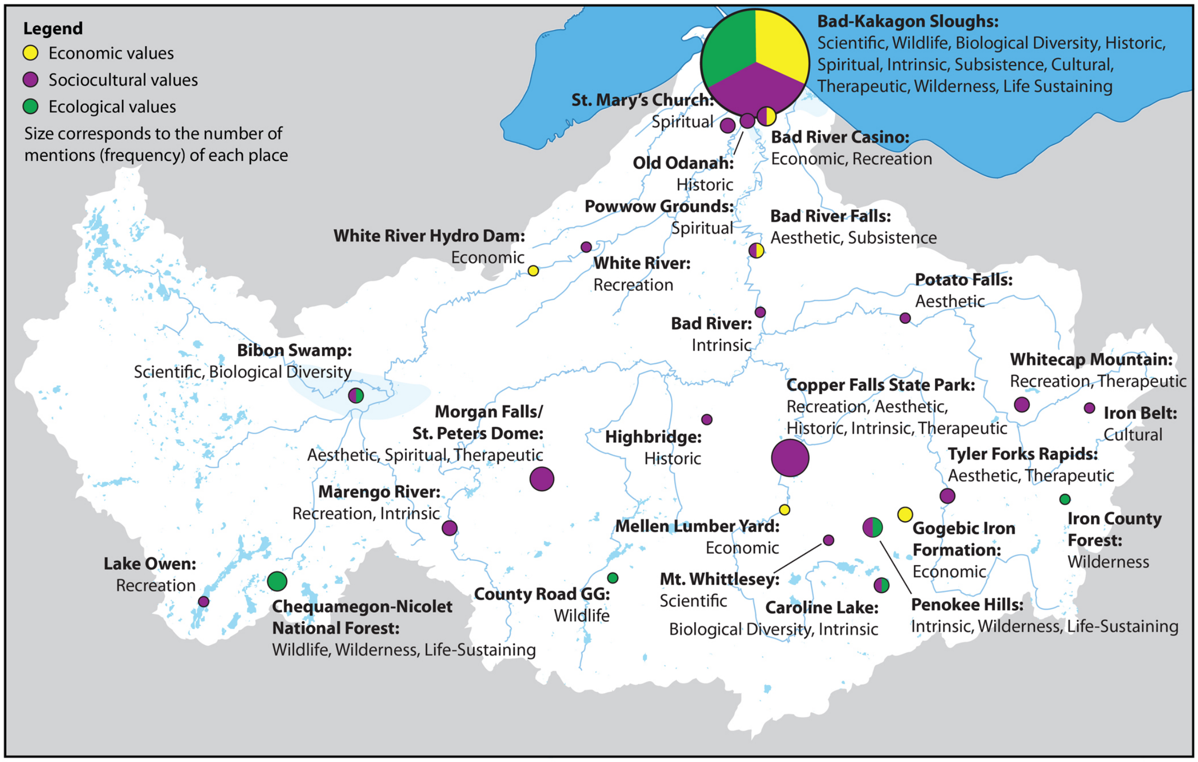

Figure 3.2: Map of landscape values in the Bad River Watershed that were identified by needs assessment participants.

3.2.7 Conclusion

In the last section of the interview, participants were allowed to offer open-ended thoughts and opinions about the project. Most participants returned to and extended themes touched on previously. One participant brought up the use of a wikimap to "make people feel part of a community" based on the geographic boundary of the Bad River Watershed. Another participant promoted extending the wikimap as a mobile web application for use in the field. A few asked about the next steps (n=2) and the tentative timeline of the project (n=1). Some also mentioned a need to be as open as possible with users about the purpose of the wikimap so as not to lead to false expectations (n=2), such as those experienced by the Oaxacan communities discussed in Section 2.3.2.

Chapter 4. Development and Formative Assessment

4.1 Conceptual Design

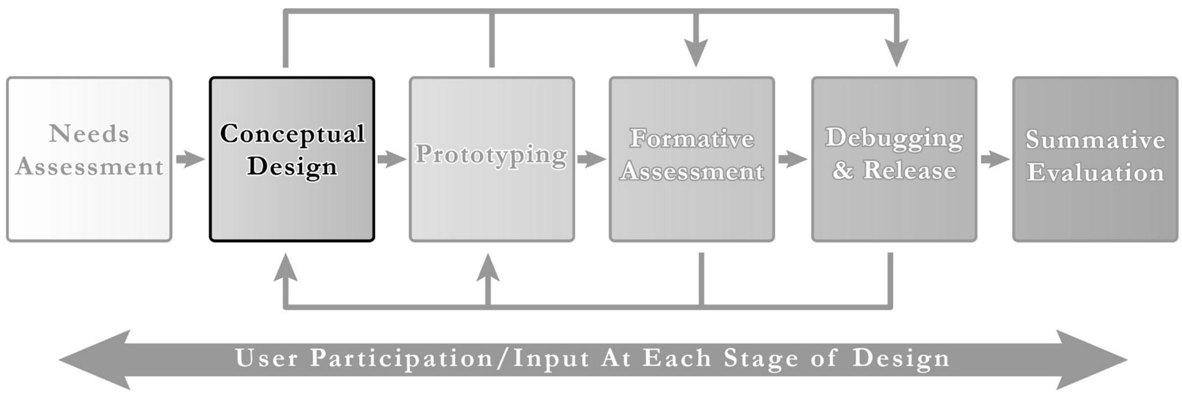

Figure 4.1: The Conceptual Design was the second stage of the UCD process for the wikimap.

Using the results of the needs assessment discussed in Chapter 3, a conceptual design document was developed that listed the website objectives, interface components, and Geoweb technologies to be included in the Bad River Watershed Wikimap (Figure 4.1; Table 4.1). The five objectives included in the document were to provide both crowdsourced and specialist-derived information relevant to the Bad River Watershed, to present personal narratives through a variety of information formats (text, photos, audio, and video), to present scientific information relevant to the watershed, to present the living history of the watershed as provided by watershed residents, and to make landscape values in the watershed visible to the public and policymakers.

The interface specifications of the conceptual design were geared toward ease of use, with highly visible controls and direct mouse manipulation of the map. They included the ability of users to click on a feature to retrieve information about that feature, displayed in an information panel to one side of the map. A layers checklist allowed users to toggle between different information sets. Drawing tools were provided to allow users to add new features, and separate pop-up windows facilitated the addition of feature information, with one window format for new features and another for comments on existing features. For moderation purposes, a flagging mechanism was proposed to allow users to alert a moderator of inappropriate content. As an added response to concerns about exposure of sensitive features, a checkbox in the input window for point features allowed users to randomly position a feature within 500 meters (later expanded to 850 meters) of the feature's actual position (see Section 3.2.2).

A stack of Geoweb technologies for the application development environment also was proposed. Some unknown components were identified but left blank for the time being. While many of the listed components were ultimately included in the wikimap, some were modified from the original concept, and the Geoweb technologies used changed significantly during the development process (see Section 4.2).

Table 4.1: Conceptual design of the wikimap, showing the components originally intended to be included in the wikimap, including those that were unknown at the time of its creation.

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 (stories) 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.

<table>
<tr><th colspan="2">Non-Map Components</th></tr>
<tr><td colspan="2">Web page containing the map</td></tr>
<tr><td colspan="2">Account login page/window</td></tr>
<tr><td colspan="2">Account registration page/window</td></tr>
<tr><td colspan="2">Disclaimer/informed consent page/window</td></tr>
<tr><td colspan="2">Brief video tutorial on how to use the map</td></tr>
<tr><td colspan="2">Basic written tutorial on how to use the map</td></tr>
<tr><td colspan="2">Map Interface Components</td></tr>
<tr><td>Map Interface Tools</td><td>Zoom slider, Zoom buttons, Pan buttons, Rotate buttons/widget, Measure (line, area), Draw point, Draw line, Draw polygon</td></tr>
<tr><td>Direct Map Manipulation</td><td>Click-drag, Shift-box zoom (optional), Mouse wheel zoom, Click select</td></tr>
<tr><td colspan="2">Dark overlay outside Bad River Watershed boundary</td></tr>
<tr><td colspan="2">Scale bar</td></tr>
<tr><td colspan="2">Lat/long display based on mouse location</td></tr>
<tr><th colspan="2">Layer Control/Legend (minimizable)</th></tr>
<tr><td>Layers—on at start</td><td>Stories, Information, Observations, Water bodies, Watershed boundaries, Roads, Settlements, Basemap (imagery)</td></tr>
<tr><td>Layers—off at start</td><td>Land cover, Waterway designations, Political boundaries (county, township/municipality, reservation), Basemap (terrain)</td></tr>
<tr><td>Layers—other possibilities (off at start)</td><td>Land ownership type, Soils, Mineral deposits, Bedrock geology (not mentioned by participants)</td></tr>
<tr><th colspan="2">Info Panel Content</th></tr>
<tr><td>Information about selected feature</td><td>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</td></tr>
<tr><td>When no features active</td><td>Guidelines, tips, contact links, general metadata</td></tr>
<tr><th colspan="2">“Add Information” Window</th></tr>
<tr><td colspan="2">Pops up automatically when user completes adding point/line/polygon (if pop-up blocked, use info panel)</td></tr>
<tr><td rowspan="3">Would you like to generalize this location?” 3-way selection (if the feature is a point)</td><td>If “I don’t know” is clicked, a separate window pops up defining generalization and its purpose (obscure the precise location of the feature)</td></tr>
<tr><td>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</td></tr>
<tr><td>If “No” is left selected, the feature will be displayed as-is.</td></tr>
</table>

Layer check-list	“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	?

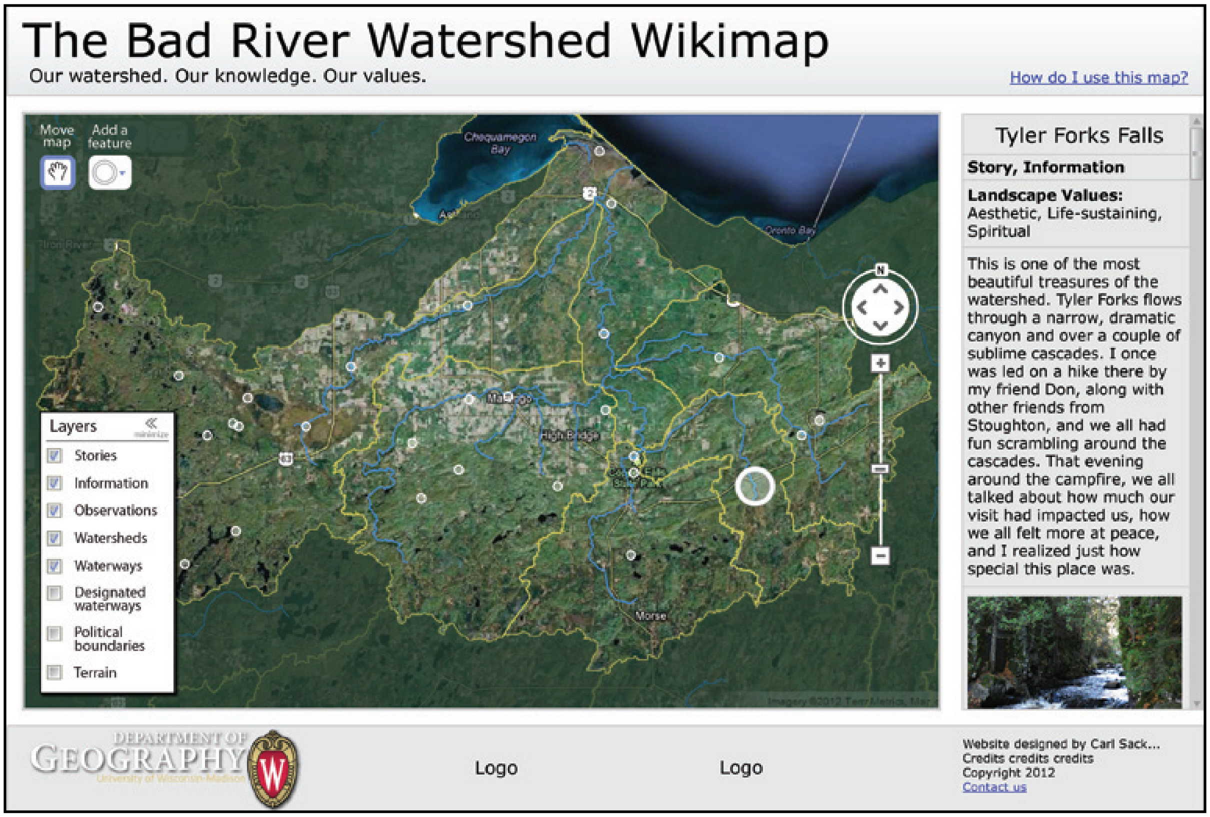

Figure 4.2: An initial static interface mock-up.

The requirements document (Table 4.1) and a static visual mock-up (Figure 4.2) were sent to interview participants via e-mail to solicit open-ended, unstructured feedback on the conceptual design. Responses were received from four of the participants (n=4). Components that were well-received included the variety of feature types, the inclusion of a tutorial, an "inviting" layout, space for stories and observations, the ability to add audio and video, and the ability to receive updates about additions to user-contributed features. One participant asked, "Will there be certain elements of the map that are not wiki-able (e.g., political boundaries)? Will this be fully self-managed for content, or will there be some higher power watching over it?" Another gave an accounting of the features they liked and asked, "Is there a way for users to comment on submissions? Should there be a way to identify who made the post if they want to be contacted? Would there be icons to indicate what the post was, say a cross for a cemetery or a fruit for free apple tree pickings?"

A response was sent to each participant answering their questions where possible and specifying how their ideas would be addressed during the prototyping stage. This discussion prompted detailed attention to the development of a moderation strategy for user-contributed information and the interface design components for adding comments about user-contributed features.

4.2 Prototyping

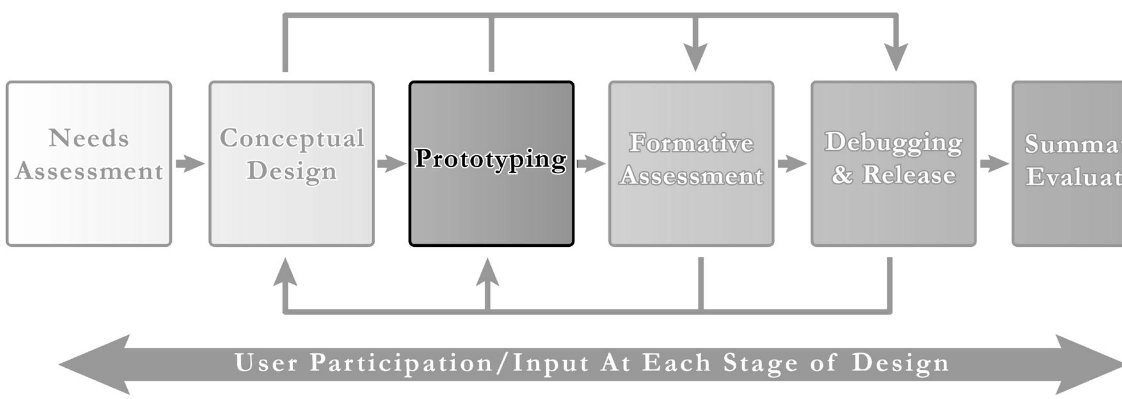

Figure 4.3: Prototyping was the third stage of the UCD process.

The conceptual design was followed by a lengthy process of developing application prototypes that extended throughout the summer and into the fall of 2012 (Figure 4.3). After an initial prototype was built using the Google Maps API JavaScript code library (Figure 4.4), 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 4.5). This decision prompted a switch to open-source server and database software as well. 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.

While the needs assessment participants were not technology experts and did not suggest specific software to use, open-source Geoweb technologies provided greater flexibility to build the tools that were specified during the needs assessment, reduced the short-term cost of development and long-term cost of maintenance, and fit with the overarching principles of open collaboration and democratic control. This decision ensured that if a community group ultimately took on maintenance of the wikimap, they would not be required to bear the cost of purchasing and updating commercial software. Participants were informed of the software change and asked for feedback on the modified look and feel of the interface.

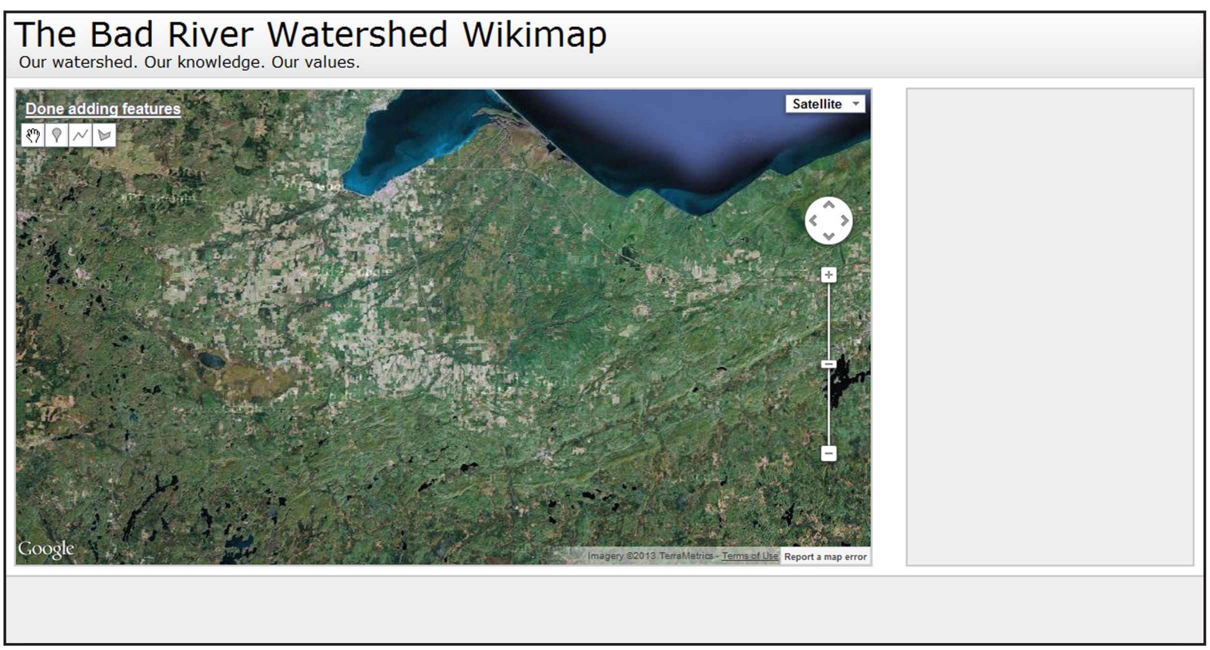

Figure 4.4: The initial wikimap interface prototype using the Google Maps API.

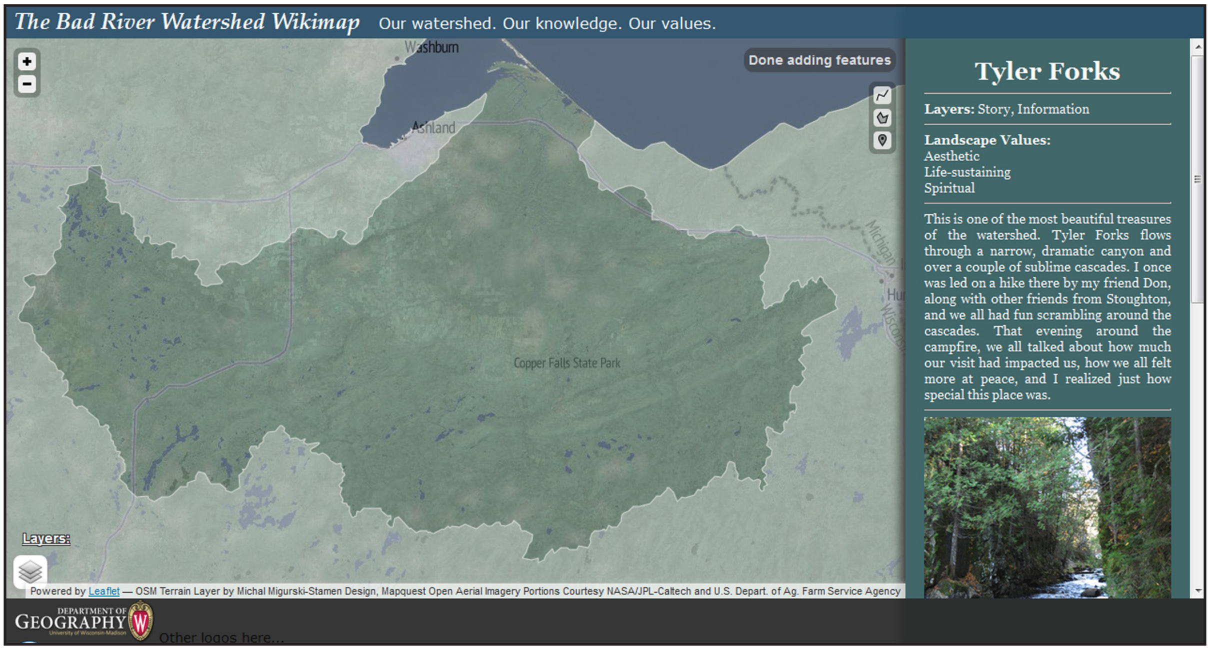

Figure 4.5: The second prototype, using the Leaflet code library, without working web feature services.

In all, two partially-working prototypes and a tutorial video were sent to needs assessment participants with specific questions to prompt feedback. Much less feedback was received on the prototypes than on the conceptual design. This may have been partially due to participants being unable to contribute or see user-contributed information until shortly prior to the formative assessment because of technical difficulties with server setup. Only the wikimap interface could be manipulated in the prototypes. The first prototype received one response, which was that the participant could not see the drawing tools. A browser compatibility problem was later revealed as the likely issue. The second prototype garnered two participant responses, both positive and lacking in detail. One participant aided the project by working out logistical details for the formative assessment workshops, which provided much more useful feedback on the application.

4.3 Formative Assessment Method

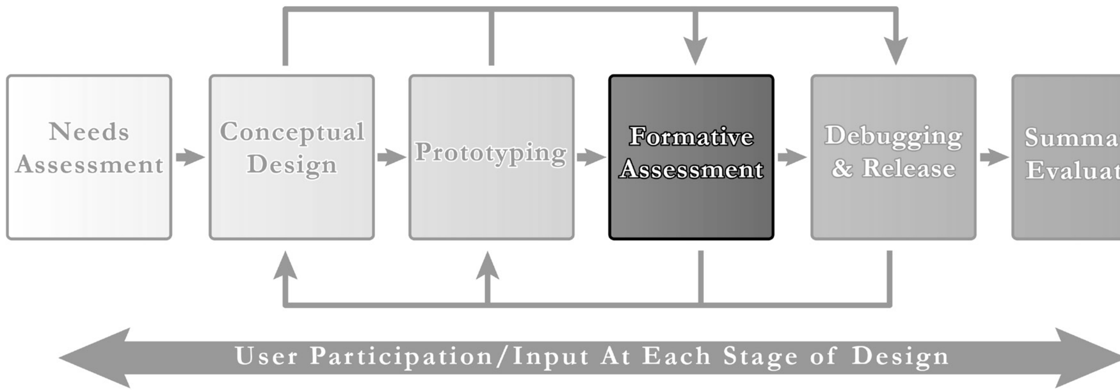

Figure 4.6: Formative Assessment was the fourth stage of the UCD process.

Following a six-month period of prototype development, a formative assessment—the fourth step of the UCD process—was conducted (Figure 4.6). This procedure had two goals: to test the initial version of the full application for technical issues, and to promote buy-in among local residents in and around the Bad River Watershed. Based on the suggestions of needs assessment participants, the assessment took the form of public workshops at various locations around the watershed. Four workshops were held in November, 2012. The locations were a technical college in Ashland, a public computer lab on the Bad River Indian Reservation, and high schools in Mellen and Hurley.

A workshop plan was developed, outlining the procedure for each workshop. This plan detailed a strategy for promotion, which included sending press releases to local media outlets, sending letters to town boards within the watershed, and placing posters at coffee shops, libraries, grocery stores, schools, town halls, and a temporary art show focused on landscape values in the watershed. The workshop objectives listed in the plan were to have each participant share at least one story relating to a place in the watershed that is important to them, elicit the landscape values implicit in these stories, and teach participants how to use the Bad River Watershed Wikimap to display these stories and values.

The workshop plan detailed a two-part procedure, which was informed by the needs assessment responses discussed in Section 3.2.4. In the first part, a large-format paper map—a 3-foot by 4-foot printed composite of 1:100,000-scale USGS topographic maps of the watershed—was used. Participants were asked to think of an experience they had in the watershed that would make a good story, and write or draw that experience on a piece of lined loose-leaf paper. Then, they were asked to place a round, colored sticker on the paper map in the location where they had that experience, and label that place with the landscape value(s) from the typology in Table 2.2 that they thought it contained. This was followed by a period of participants sharing their stories and values with the group.

The second part of the workshop involved initial direction from the facilitator regarding the use of the wikimap, followed by unstructured wikimap use under facilitator observation. This process held the advantage of easy setup and flexibility to fit different levels of participation at each workshop (Sweeney et al. 1993). Participants were asked to access the Bad River Watershed Wikimap from a computer terminal, then follow verbal instructions on how to place the locations they identified previously on the wikimap. The workshop facilitator took notes on any problems with the software that participants experienced. Each workshop lasted approximately an hour.

4.4 Formative Assessment Results

The results of the workshops were mixed. The promotion strategy detailed in the workshop plan was carried out, and additional outreach was conducted via e-mail to needs assessment participants and other contacts living in the area. However, these efforts failed to translate into robust participation in the workshops. Only three of the four workshops were attended—those in Ashland, Mellen, and the Bad River Reservation. Due to low attendance at each, the workshop procedure was only partially completed. The workshops were successful in identifying technical issues with the wikimap and seeding the map with a significant set of user-contributed features. Each of the three attended workshops is described in detail below.

The Ashland workshop was held on a Saturday. Despite the weekend time and Ashland being the largest population center in the region, only one person attended the workshop. That participant only was interested in using and experimenting with the wikimap, and did not complete the first part of the workshop procedure after it was explained. However, they used the wikimap prototype enthusiastically, placing dozens of features on the map.

The workshop in Mellen was held late on the following Monday afternoon. Two participants attended this workshop. They also were not interested in completing the paper map portion of the workshop procedure. After being instructed in the use of the wikimap, each placed a few features on the map. They did not experience any technical problems using the interface, but gave feedback on what base layers could be added to the map, including a suggestion to add property boundaries and public lands.

The third workshop, on the Bad River Indian Reservation, was the most well-attended with five participants, including one who had participated in the needs assessment. However, a major technical issue prevented the wikimap from being accessed at terminals in the computer lab. The only Internet browser installed on these computers was Microsoft Internet Explorer, and the website had a programming bug that prevented the data from being loaded on Internet Explorer. Workshop attendees participated in the paper map portion of the workshop, but only added some stickers to the map without the accompanying written or drawn entries. In the second half of the workshop, participants took turns using the wikimap on the laptop brought by the facilitator, which had a compatible browser installed. Only one added new features to the map, but the others were able to explore the application and give feedback.

There are no clear answers as to why the workshops did not generate the hoped-for attendance and buy-in. One speculation is that rural communities such as those around the Bad River Watershed rely in large part on word-of-mouth and face-to-face personal relationships to build discussion and enthusiasm about events. Since the workshops were set up remotely, this type of promotion relied on assistance from local contacts without a large stake in the project. Additionally, there was little budget for commercial advertising of the workshops, and fliers were only able to be posted in public a few days prior to the workshop dates. Some residents may have been unable or reluctant to participate due to time constraints or lack of incentive. At the time of the workshops, the mining proposal that had initially helped to spark interest in the project (discussed in Section 1.2) was on hold, and there was a lull in public discussion of the mine, which may have also contributed to a general lack of interest.

What the workshops did provide was user-contributed information to 'seed' the map with over 100 features, and valuable technical feedback. Multiple bugs were identified, including the browser compatibility issue and an error with the file upload interface, both of which were later rectified. Suggestions for what information and features to include were taken under consideration; some were implemented, while others were not due to ethical considerations or time constraints. Those implemented included: adding features by latitude/longitude coordinates, adding a dialog to submit a reason when a feature is flagged as inappropriate, an alert was added to caution users that submissions would appear on the Internet immediately, and a feature was added to allow users to reset their username and password.

4.5 Debugging and Release

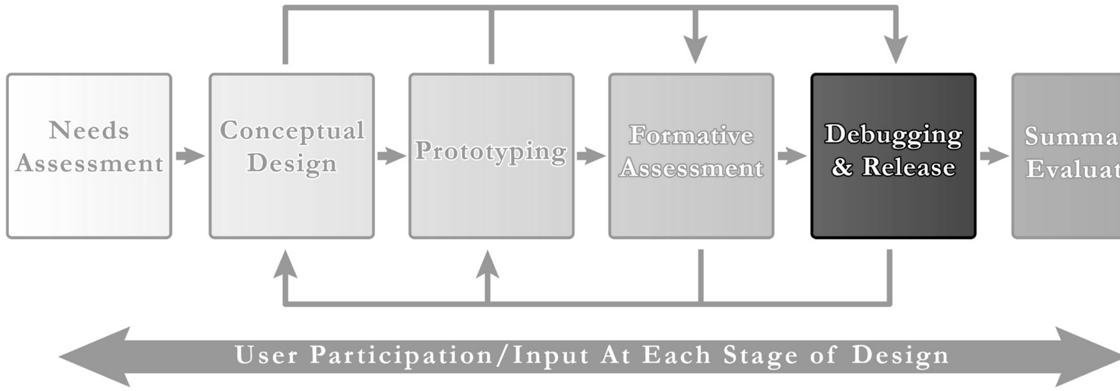

Figure 4.7: Debugging & Release was the fifth stage of the UCD process.

After a debugging period of approximately two weeks to address the problems identified by the workshops, the wikimap was released for public use. Additional debugging took place on an ongoing basis. The Internet Explorer compatibility issue in particular took several weeks to overcome. Before it was repaired, wikimap users were alerted to the issue and asked to access the website using a browser other than Internet Explorer.

Due to the low turnout at the workshops, other opportunities were sought to present the wikimap to the public at pre-scheduled public events. Promotion took place at two such events. The first event was a public hearing on the reintroduced legislation related to the proposed Penokee Mine (see Section 1.2), held in Ashland by local elected officials. The hearing was attended by 265 local residents (With and Kemble 2013). The wikimap was displayed on a laptop computer on a table at the entrance to the event for attendees to use, along with business cards listing the website address. The second event was the Book Across the Bay Expo, a collection of table displays set up by local businesses and organizations at the registration station for an annual cross-country ski race that drew 3,500 participants. The wikimap and associated business cards were displayed next to a copy of the large-format paper map used for the workshops. Together, the events accounted for approximately 12 hours of contact time with the public, exposed over 300 area residents to the Bad River Watershed Wikimap, and resulted in a number of new user registrations. Additionally, the wikimap was presented at professional conferences remote from the Bad River Watershed, generating some additional users without direct connections to the watershed.

The release period for the wikimap began on November 20, 2012. From that date until mid-April, 2013, user participation rates were monitored, and user interactions were logged in the database on the server. These logs were leveraged for a summative evaluation of the application, described in Chapter 5.

Chapter 5. Summative Evaluation

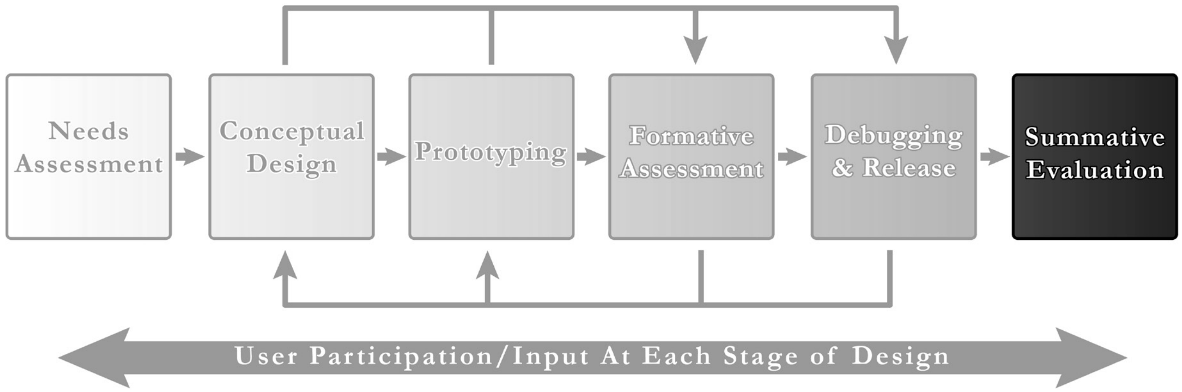

Figure 5.1: Summative Evaluation was the final stage of the UCD process.

A two-part summative evaluation was conducted as the final stage of the wikimap development process to analyze wikimap use patterns and the impact of the wikimap on public discourse regarding land use (Figure 5.1). The first part of the evaluation was an analysis of user interaction logs produced by the wikimap, and the second part was a survey sent to wikimap users that asked about their use of the wikimap and its broader social impacts. The interaction analysis is described in Sections 5.1 and 5.2, while the survey is described in Sections 5.3 and 5.4.

5.1 Interaction Analysis Method

Systematic interaction coding was a useful method for extracting information about application use that revealed insights into the usability of the wikimap and informed design recommendations for future wikimaps (Robinson 2008). During application development, JavaScript code was written to record each user interaction, using the interaction operators listed in Table 2.1. User interactions were recorded in a database as a string of ***interaction***

codes for subsequent analysis. Because many of the interaction operators could be evoked using different interface tools in the wikimap, a unique interaction code was given to each implementation of an operator (Table 5.1). Each row in the database table corresponded to a ***use session*** that began when a user logged in to the wikimap, and ended when the user closed the browser window or refreshed the web page. When the user performed an interaction, the associated interaction code and its ***timestamp*** (the exact time when the interaction was performed) were added to the table row. Initially, each log was recorded only after the use session ended; the code was subsequently updated to record interactions in real time, as they were performed by the user. The resulting string of recorded interaction codes allowed each use session to be tracked, the frequency of each interaction to be calculated, and patterns of use to be distinguished.

Analysis of the interaction logs relied on information visualizations and descriptive statistics. The visualizations were used to aggregate and interpret the frequency of interactions performed by all users, and to gain initial insight into distinct ***use patterns***, or interaction sequences that appear to indicate a particular type of wikimap use, present within individual use sessions. Descriptive statistics were applied to determine the relative frequency of different interactions, interaction sequences, and use patterns. For each type of analysis, the sample consisted of a set of use sessions recorded in the interaction logs, with each use session considered an individual in the sample set.

Interaction log data was first visualized using Sankey-style flow diagrams, constructed using the Sankey.js plug-in for the D3 (Data-Driven Documents) JavaScript code library (Bostock et al. 2011). A ***Sankey diagram*** displays the volume of energy or product flows between nodes of metabolism (Schmidt 2008). In each diagram, ***nodes***, shown as colored boxes,

Table 5.1: User interactions recorded by system logging

Interaction Code	Operator	Definition
upload	import	load information onto the map
submit	save	store changes to the map or underlying information
cancel	-	abandon potential changes to the map before saving
editentry	edit	change the information related to a feature on the map
editgeom	edit	manipulate features on the map
drawpoint	edit	add a point feature to the map
drawline	edit	add a line feature to the map
drawpoly	edit	add a polygon feature to the map
generalize	edit	intentionally obscure the location of a point feature when it is added to the map
flag	annotate	indicate a problem with the feature to the moderators
layeron	overlay	add a basemap layer
layeroff	overlay	remove a basemap layer
pan	pan	move the map
zoom	zoom	change the scale of the map
filterbytype	filter	change the set of features on the map by selecting features of one or more information type(s)
filterbylandval	filter	change the set of features on the map by selecting features with one or more landscape value(s)
searchfor	search	enter text to indicate a particular feature of interest
retrievetag	retrieve	request the name of a feature of interest
retrieveinfo	retrieve	request information about a feature of interest
calculate	calculate	measure distance between two points on the map

represent interactions performed at a given sequence position, with each node scaled vertically according to the frequency of that interaction. Nodes are aligned along vertical axes, with each axis representing a position in the overall interaction sequence. The connections between nodes, or ***links***, are scaled in thickness according to the frequency of the sequence of interactions that the link connects. The node bordering the left side of a link is referred to that link's ***source*** interaction, and the node on the right side is the ***target*** interaction.

Two different kinds of Sankey diagrams were generated to interpret the interaction logs. A *pairwise* diagram was created to represent the frequency of each unique sequence of two interactions performed by users across all use sessions with two or more interactions (Figure 5.2). This diagram visualized the overall use of each interaction and the relative frequency of each order in which interactions were performed. A sample of 93 use sessions (n=93), which included 3,490 recorded interactions, was used for this diagram.

Additionally, two *use session diagrams* were generated to visualize an aggregation of longer use sessions, showing interactions performed at each position in the overall interaction sequence. One diagram was constructed to show the first nine interactions, and another to show interactions 9 through 18. Including interaction 9 in both diagrams allowed the links between interactions 9 and 10 to be visible. The first use session diagram (Figure 5.3) included use sessions with at least nine interactions; it displays 59 use sessions (n=59) and 531 total interactions. The second use session diagram (Figure 5.4) included only those sessions with 18 or more interactions; it displays 42 sessions (n=42) and 420 total interactions. A drop-down menu was used to select individual use sessions for highlighting in each diagram. Visual comparison of use sessions revealed distinct use patterns among different sessions.

Following visual inspection of the Sankey diagrams, descriptive statistics were performed for the overall set of all interactions, the pairwise analysis, and the use session analysis. The overall interaction analysis counted the frequency and extensiveness of each interaction and interaction operator performed across all use sessions with at least one interaction, a sample size of 101 sessions (n=101) including 3,498 interactions. The interaction pairs analysis counted the overall frequency of each unique sequence of two interactions performed by users (i.e., each link in Figure 5.2), to compare the overall use of each interaction sequence.

The use session analysis determined the use patterns exhibited by each session, and counted the frequency of each unique combination of use patterns to reveal the preferred uses of the wikimap.

5.2 Interaction Analysis Results

In the following descriptive statistics, percentages are rounded to two significant figures.

5.2.1 Overall Interactions Analysis

Table 5.2 shows the frequency of each interaction across all use sessions. The most used interaction was *pan*, accounting for 29% of all interactions, followed closely by *zoom* (24%) and *retrievetag* (23%). The interaction *retrieveinfo* accounded for 12% of interactions, while all others accounted for less than 3%. The top four interactions all involve direct manipulation of the map interface, while the other interactions acted upon other elements of the wikimap, such as the layers panel, filter and search functions, and drawing tools. This appears to indicate that direct manipulation was a more popular way to interact with the map than separate interface tools. This may be partly due to user motivations, and partly due to the small cognitive and/or time investment they require compared to tool-based interactions. For instance, *submit* takes longer than other interactions due to the need to first fill in a form with contributed information about a feature, and it may simply take longer for a user to notice the interface tools that provide drawing, overlay, and filter functions. Panning, zooming, and retrieving via direct map manipulation are intuitive interactions now common to most web maps.

Table 5.2: Frequency of recorded interactions.

Interaction Code	Operator	Count	% Of Total	Histogram
pan	pan	1016	29.0%	
zoom	zoom	850	24.3%	
retrievetag	retrieve	816	23.3%	
retrieveinfo	retrieve	432	12.3%	
layeroff	overlay	100	2.9%	
submit	save	93	2.7%	
layeron	overlay	80	2.3%	
drawpoint	edit	68	1.9%	
filterbylandval	filter	29	0.8%	
cancel	-	9	0.3%	
drawpoly	edit	2	0.1%	
filterbytype	filter	2	0.1%	
drawline	edit	1	0.0%	
upload	import	0	0.0%	
generalize	edit	0	0.0%	
flag	annotate	0	0.0%	
searchfor	search	0	0.0%	
calculate	calculate	0	0.0%	
Total	All	3498	100.0%	

Table 5.3: Frequency of interaction operators.

Interaction Operator	Count	% Of Total	Histogram
retrieve	1248	36%	
pan	1016	29%	
zoom	850	24%	
overlay	180	5.1%	
save	93	2.7%	
edit	71	2.0%	
filter	31	0.9%	
other (cancel)	9	0.3%	
import	0	0.0%	
annotate	0	0.0%	
search	0	0.0%	
calculate	0	0.0%	
Total	3498	100.0%	

When interaction operators alone are considered, retrieve is shown to be the most popular operator, accounting for 36% of all interactions (Table 5.3). Retrieve, pan, and zoom dominate the spectrum of operators, together accounting for 89% of all interactions. Only a 2% minority of interactions included additions or edits to the user-contributed information on the map.

5.2.2 Pairwise Analysis

The pairwise visualization displays every sequence of two interactions applied to the wikimap by users (Figure 5.2). Table 5.4 shows the frequency of interaction pairs that each account for greater than 1% of all pairs. In total, there were 90 unique source-target pairs recorded at least once, of which 72 had a frequency of less than 1% of all pairs. The most frequent pairs were *pan→pan* (15% of all pairs), *zoom→zoom* (12%), and *retrievetag→retrievetag* (11%), with these three repetitions altogether accounting for 38% of all pairs. The pairs *zoom→pan* (7.6%),

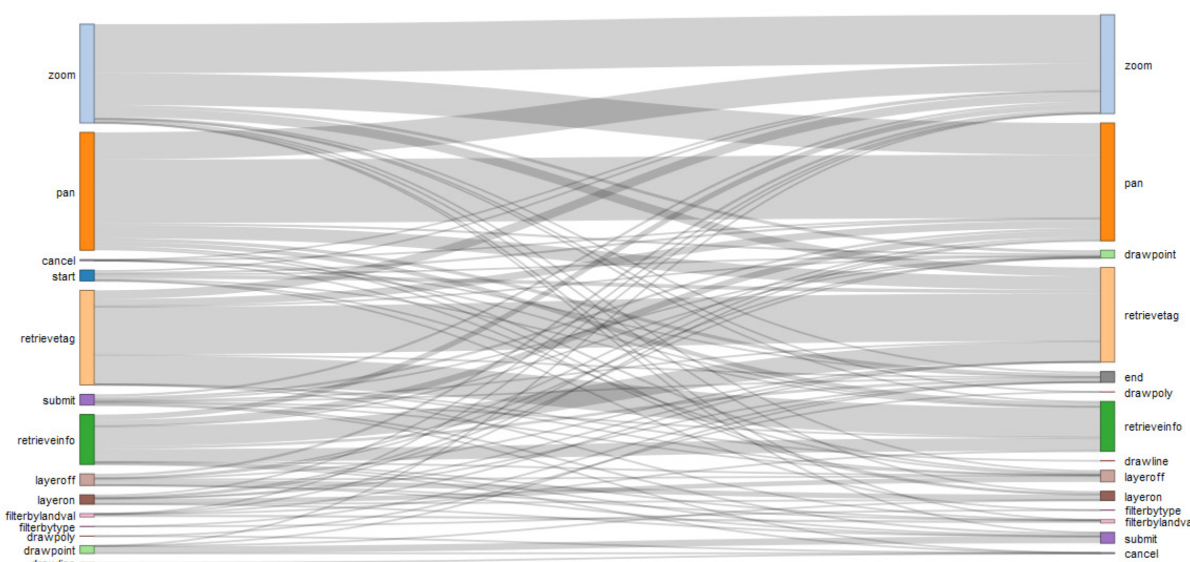

Figure 5.2: Pairwise Sankey diagram showing frequency of interactions and interaction pairs.

Table 5.4: Interaction pairs accounting for >1% of all pairs.

Source	Target	Frequency	% Of Total	Cum. %	Histogram
pan	pan	545	15%	15%	
zoom	zoom	421	12%	27%	
retrievetag	retrievetag	409	11%	38%	
zoom	pan	273	7.6%	46%	
retrievetag	retrieveinfo	250	7.0%	53%	
pan	zoom	233	6.5%	59%	
retrieveinfo	retrievetag	171	4.8%	64%	
pan	retrievetag	113	3.2%	67%	
retrieveinfo	retrieveinfo	111	3.1%	71%	
zoom	retrievetag	77	2.2%	73%	
retrievetag	zoom	75	2.1%	75%	
retrievetag	pan	63	1.8%	77%	
drawpoint	submit	58	1.6%	78%	
retrieveinfo	pan	54	1.5%	80%	
retrieveinfo	zoom	46	1.3%	81%	
layeroff	layeron	44	1.2%	82%	
layeron	layeroff	41	1.1%	83%	
pan	retrieveinfo	39	1.1%	84%	

retrievetag→retrieveinfo (7.0%), and *pan→zoom* (6.5%) were the most frequent pairings of two different interactions. This pattern appears to indicate that users tended to repeat one interaction consistently, changing interactions less frequently. Only interaction pairs that involved the pan, zoom, and retrieve operators accounted for greater than 1.6% of pairs each, suggesting that most use sessions primarily involved viewing, rather than contributing to, the wikimap. The only contributing pair accounting for greater than 1% of all pairs was *drawpoint→submit* (1.6%).

5.2.3 Use Sessions Analysis

The use session visualizations (Figures 5.3 and 5.4) revealed more detailed patterns of wikimap use. Figure 5.3 displays the first nine interactions performed during sessions that contained nine or more interactions total, while Figure 5.4 displays the ninth through eighteenth interactions performed during sessions that contained eighteen or more interactions. Each diagram could be dynamically altered to highlight a particular use session by selecting that session from a dropdown menu.

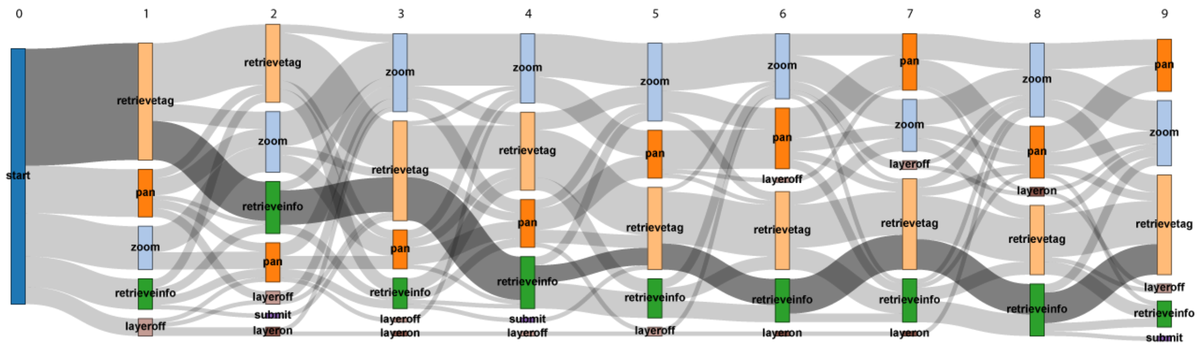

Figure 5.3: Sankey diagram showing the first nine interactions performed during 59 wikimap use sessions. The highlighted session represents a typical information seeking use pattern.

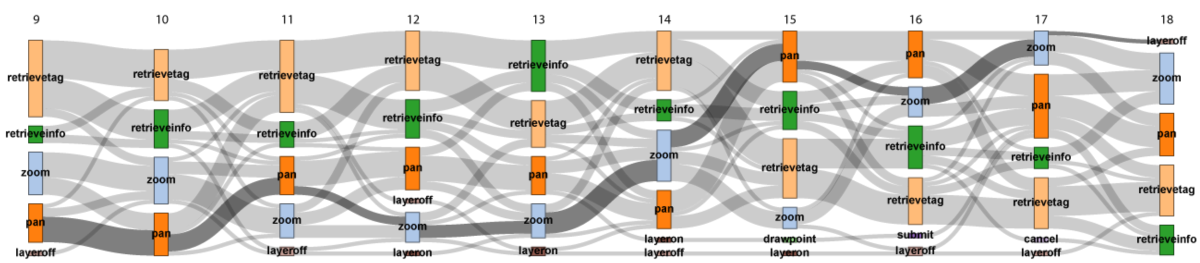

Figure 5.4: Sankey diagram showing interactions at sequence positions 9 through 18 in 42 use sessions. The highlighted session represents a typical map reading use pattern.

Table 5.5: Wikimap use patterns and their constituent interactions.

Use Pattern	Interactions
map reading	pan, zoom, layeroff, layeron, calculate
information seeking	retreivetag, retreiveinfo, filterbylandval, filterbytype, searchfor
contributing	drawpoint, drawline, drawpoly, submit, cancel, upload, generalize, flag

The diagrams revealed three basic wikimap use patterns (see Section 5.1; Table 5.5). Some use sessions primarily or exclusively involved interactions with the basemap (*zoom, pan, layeron, layeroff*), subsequently referred to as a ***map reading*** use pattern. Other sessions primarily or exclusively involved interactions with the user-contributed information on the map (*retrievetag, retrieveinfo*), subsequently referred to as an ***information seeking*** use pattern. A small minority of sessions involved contributing information to the map (*drawpoint, submit, cancel*), subsequently referred to as a ***contributing*** use pattern. Some sessions combined two or all three use patterns, usually by performing the different patterns in sequence, rather than mixing their constituent interactions at random. Because the session diagrams display a subsample of all sessions analyzed (n=59 and n=42 respectively), and a subsample of interactions within those sessions, most of the nominally-performed interactions (*upload, drawline, drawpoly, filterbytype, filterbylandval*) were not displayed.

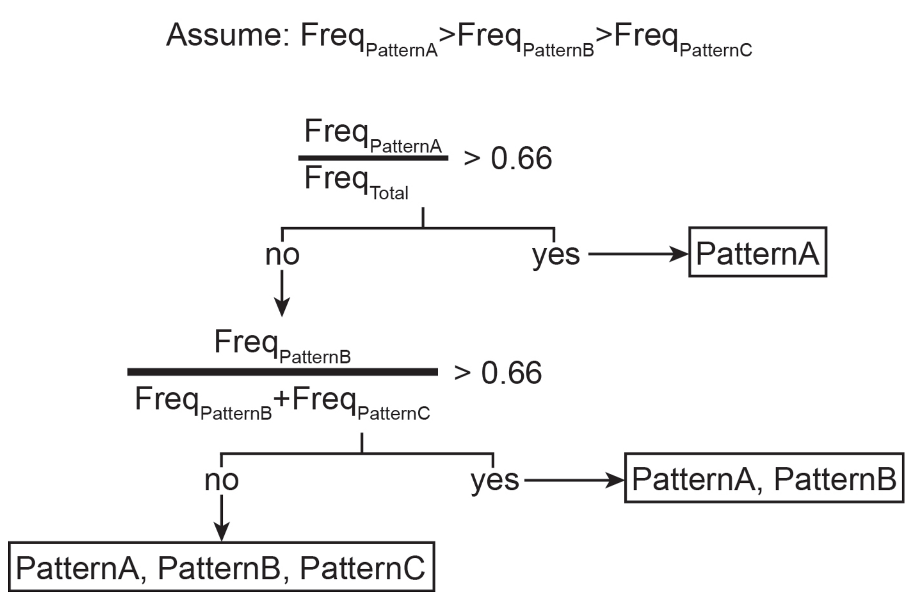

Figure 5.5: Method for categorizing sessions according to wikimap use patterns.

To further delineate the frequency of each use pattern, analysis was performed on the full sample (n=93 sessions) to categorize each use session according to use pattern. A use session was defined as having a given use pattern when greater than 66% of all interactions constituting the session were interactions associated with that use pattern. For sessions in which no use pattern accounted for more than 66% of interactions, if the second-most-performed use pattern accounted for greater than 66% of the non-primary interactions, the session was categorized as a combination of the two most common use patterns; otherwise the session was considered to exhibit all three patterns (Figure 5.5).

The frequency of each use pattern category is shown in Table 5.6. These results corroborate the visual patterns shown by the Sankey diagrams. The majority of sessions focused primarily or exclusively on either *information seeking* or *map reading*, with some sessions exhibiting both patterns relatively evenly, and only 6 sessions out of 93 primarily focused on *contributing* to the map. Other combinations of use patterns that included contributing were incidental, accounting for 7% of all sessions.

Table 5.6: Frequency of each overall use pattern or combination.

Use Pattern	Count	% of Total	Histogram
Information Seeking	32	34%	
Map Reading	31	33%	
Map Reading, Information Seeking	17	18%	
Contributing	6	6%	
Map Reading, Information Seeking, Contributing	3	3%	
Information Seeking, Contributing	3	3%	
Map Reading, Contributing	1	1%	
Total	93	100%	

5.2.4 Interaction Analysis Results Summary

Overall, analysis of user interaction logs shows that users preferred using the wikimap to view basemaps of the Bad River Watershed and/or view information placed on the map by other users. Only a small minority of use sessions involved contributing new information to the map. This does not necessarily indicate that interactions allowing users to contribute information are not useful to the map's purpose, but does show that those willing and able to contribute form a small subset of wikimap users, and thus the information on the map may not reflect a set of values and experiences that is as diverse as intended. The population of contributors might be increased by changes to the interface design, which are further discussed in Section 6.2.2. The exit survey described in Sections 5.3 and 5.4 was created in an attempt to further illuminate the motivations of map users.

5.3 User Survey Method

A major goal of the Bad River Watershed Wikimap was to influence public discourse regarding land use issues within the Bad River Watershed by eliciting and promoting local landscape values (see Section 1.3). To investigate the extent to which the map accomplished this goal, wikimap users were surveyed regarding their experiences using the wikimap and how they felt it impacted their perceptions of landscape values in the watershed. An online questionnaire was selected as the most appropriate survey method given the need to reach participants in a limited amount of time without requiring their physical presence (Roth 2011a).

The questionnaire contained demographic questions regarding the user's age, gender, ethnicity, and location in relationship to the Bad River Watershed. Multiple-choice questions

Table 5.7: User survey questions from online questionnaire.

Question	Answer options		
What is your age range?	Under 18	34-41	58-65
	18-25	42-49	66-73
	26-33	50-57	74 or older
What is your gender?	Male		
	Female		
	Other		
What is your race/ethnicity? (Open-ended)			
Do you live in or near the Bad River Watershed?	Yes, in the watershed, full time		
	Yes, in the watershed, part time or seasonally		
	Yes, close to but outside the watershed, full time		
	Yes, close to but outside the watershed, part time/seasonally		
	No, but I visit regularly		
	No, but I have been to the watershed		
	No, I have never been to the Bad River Watershed		
How did you find out about the Bad River Watershed Wikimap? (Open-ended)			
How many times have you used the Bad River Watershed Wikimap?	Once		
	2-5 times		
	6-10 times		
	More than 10 times		
When you used the wikimap, what did you use it for? Check all that apply.	Just logged in		
	Explored the map itself		
	Looked at features added to the map by other users		
	Added comments or information to features placed on the map by others		
	Added features to the map		
	Other: (space for text)		
Did you encounter any problems or difficulties using the wikimap? Please describe them below. (Open-ended)			
What did you particularly like, and what did you particularly dislike, about the wikimap? Please include suggestions for improvements. (Open-ended)			
Did using the wikimap change what you know or how you think about places in the Bad River Watershed? If so, how? (Open-ended)			
To your knowledge, was the wikimap used in any public forum or venue? If so, how? (Open-ended)			
Did you learn about any landscape values in the watershed that you didn't think about previously? If so, which ones? (Open-ended)			

asked how many times the user had used the wikimap and how they used it, based on the three use patterns identified in Section 5.2.3. The remaining questions were open-ended. Two of these questions asked users about their user experience with the application, while three questions asked about the impact of the wikimap on them and their community. An e-mail message asking registered wikimap users to participate in the survey and including a link to questionnaire was sent to all registered wikimap users three times in April, 2013.

5.4 User Survey Results

Ten Bad River Watershed Wikimap users responded to the survey (n=10) out of 54 users e-mailed, a response rate of 19%. Respondents were evenly split between male and female. Three opted to provide their ethnicity: one Anishinaabe (Ojibwe), and two Caucasian. The age ranges of those who responded were surprisingly diverse and evenly distributed, with one or two respondents from each eight-year range except under 18 and 74+ (Table 5.8). This may indicate that the digital divide between age groups in and around the Bad River Watershed discussed by participants in the needs assessment study is less of a concern than suggested (see Section 3.2.1), although it is difficult to draw reliable conclusions about the age distribution of wikimap users from a sample of ten. However, only two of the survey respondents lived within the watershed full-time (these were within the 42-49 and 50-57 age ranges, respectively). Three (n=3) lived close to, but outside of the watershed, while 50% of respondents (n=5) lived far away from the watershed, but had been to the watershed (n=4) or visited regularly (n=1) (Table 5.9). This seems to support the concern of some needs assessment participants that the wikimap might appeal more to those who live outside of the Bad River Watershed watershed than actual watershed residents.

Table 5.8: Age distribution of survey respondents.

Age	Count	% Of Total	Histogram
Under 18	0	0%	
18-25	1	10%	
26-33	2	20%	
34-41	1	10%	
42-49	2	20%	
50-57	1	10%	
58-65	2	20%	
66-73	1	10%	
74 or older	0	0%	
Total	10	100%	

Table 5.9: Location of survey respondents.

Location of respondents	Count	% Of Total	Histogram
Live in the watershed, full time	2	20%	
Live in the watershed, part time or seasonally	0	0%	
Live close to, but outside the watershed, full time	3	30%	
Live close to, but outside the watershed, part time/seasonally	0	0%	
Do not live near the watershed, but visit regularly	1	10%	
Do not live near the watershed, but have been to the watershed	4	40%	
Have never been to the Bad River Watershed	0	0%	
Total	10	100%	

The geographic distribution of wikimap users also may explain the disproportionate use of the wikimap for map reading and information seeking tasks and relatively small amount of contributing. The survey results showed similar use patterns to the interaction log analysis, with two respondents (n=2) either volunteering new features or adding new information to existing features. One of these contributors was a watershed resident, while the other lived outside of, but close to the watershed. Every respondent (n=10) said that they explored the map itself, while six (n=6) looked at user-contributed features on the map.

Respondents had heard about the wikimap through a variety of channels. Two (n=2) were exposed to it through promotion at a public event (see Section 4.5), two (n=2) through the Internet, two (n=2) through presentations given by the researcher, and four (n=4) through word-of-mouth from other people. Most respondents were interested enough to return to the wikimap at least once after their initial use, but not to use it regularly. Seven respondents (n=7) use the wikimap between two and five times, while two (n=2) used it once and one respondent used it more than ten times.

Most respondents indicated that they had success using the wikimap, although two encountered what appeared to have been client-side browser issues: one respondent said the application was “not working right now,” although it appeared to the researcher to be functioning normally, while another said that the application froze after a prolonged pause in its use. One respondent commented that the measurement feature would not work. Another requested the ability to draw larger polygons. The initial incompatibility with Internet Explorer was mentioned as a minor issue by one respondent. Three respondents commented that they experienced no problems.

When specifying the wikimap features that they appreciated, several respondents highlighted using the zoom, pan, and retrieve operators to view features and information on the map. One liked the ability to overlay/toggle basemap layers. One of the respondents indicated that they had participated in a formative assessment workshop, “liked getting the training,” and wanted the map to be “popularized.” One respondent specifically appreciated the variety of feature types that resulted from the crowdsourcing of mapped information. Another made two requests: the ability to log in with an Open ID or Google ID, and a publicly available Web Map Service containing the contributed features.

The final three questions of the survey were open-ended and asked about the personal and broader social impacts of the wikimap. Six respondents (n=6) felt that the wikimap changed what they knew or how they thought about places in the Bad River Watershed, compared to one respondent (n=1) who did not (three respondents chose not to answer this question). Of those who felt impacted, one respondent said that it gave them new places to visit, while five felt they had gained a better understanding, familiarity, or sense of place related to the watershed area. However, respondents did not indicate much broader social impact from the wikimap to date. None were aware of it being used in a public venue other than its promotion at events by the researcher. Only one respondent indicated having an increased understanding of landscape values present in the Bad River Watershed.

Chapter 6. Conclusion

6.1 Wikimap Design and Development Process: Discussion and Recommendations

Overall, the User-Centered Design process leveraged to create the Bad River Watershed Wikimap was a success. The process began with a needs assessment study with Bad River Watershed land use experts. From the results of the needs assessment, a conceptual design was created, and prototypes were developed, with iterative feedback from study participants at each stage. The application was tested formatively through public workshops designed with the help of study participants, which resulted in important improvements and seeded the map with Crowdsourced Geographic Information. The end result was a dynamic wikimap application with more than 50 active users as of this writing, most of whom used the map at least twice. The development of the Bad River Watershed Wikimap can serve as a model for future applications of Online Participatory Mapping. Key lessons that were learned at each project stage are summarized in the following sections, along with recommendations for improvements in future OPM implementations.

6.1.1 Stage 1: Needs Assessment

The needs assessment (Stage 1) was effective, eliciting both a useful structure outlining how the project should proceed and enthusiastic support from stakeholders connected to community groups with a broad local impact. However, not all of the assertions of the participants were shown to be correct. Notably, participants were concerned about an age-driven digital divide that ultimately did not appear to impact access to the wikimap. Although several participants suggested that carefully-planned and promoted public workshops would likely attract interest and enthusiasm in the project, such workshops were not as effective at garnering buy-in as promotion at large public events and by word-of-mouth. On the other hand, the interface suggestions given by needs assessment participants did result in development of a usable and useful application, as indicated by the considerable length of many use sessions and the positive user survey responses. The opinion of some participants that sharing stories and information on the map would increase users' understanding of the watershed appears to be supported by the user survey results.

A needs assessment is a necessary initial component of any OPM project, critical for making contact with local stakeholders who may have a direct interest in such a project. Stakeholders should be recruited who have widespread connections in the community and the capacity to provide assistance and promote buy-in. Local communities, especially in areas as geographically large at the Bad River Watershed, typically contain a diversity of viewpoints and sometimes conflicting interests, e.g., those of loggers, tourism business owners, and biologists. Care should be taken to ensure that stakeholders represent the spread of interests present within the community to the greatest extent possible.

The Bad River Watershed needs assessment accomplished this indirectly by seeking participants in agencies and organizations that work with these diverse potential wikimap users. Including community members who were representative of different viewpoints, but were not agency or non-profit professionals, may have provided a more complete characterization of potential wikimap users and more thorough conceptualization of the wikimap's utility. One of the needs assessment participants acted as a champion of the Bad River Watershed; more such champions would have significantly increased participation in the formative assessment and adoption of the wikimap. Future projects should intentionally seek out individual leaders and 'gatekeepers' within the community who can effectively promote community buy-in to both the process and the final wikimap.

6.1.2 Stages 2-5: Conceptual Design, Prototyping, Formative Assessment, and Release

The conceptual design that resulted from the needs assessment provided a list of features that were almost all ultimately implemented. However, the feedback from participants on the conceptual design document (Stage 2) and each successive prototype (Stage 3) was lighter than expected. Part of this was due to unexpected difficulty in setting up a server that could host user-contributed information, which significantly delayed implementation of this component of the wikimap. Without this primary feature, participants could do little more than ask questions and comment on the prototype interface. Information contribution was enabled shortly prior to the formative assessment workshops, but the tight timeline for the project did not allow the workshops to be pushed back to allow additional time for participant feedback. Additionally, using e-mail as a communication medium allowed for a very fast response time, but meant that responding to each prototype was optional and may not have been a priority for participants. Some stakeholders who were motivated by the mining issue to participate may have lost motivation when that political issue became dormant during prototype development.

Stakeholder feedback on prototypes is important for the development of a wikimap that meets the needs of the community. During the prototype stage, adequate time should be set aside for coding the application, with flexibility to increase the amount of time if needed, so that participants are able to experience and give feedback on all of the wikimap's functionality prior to its initial release. Conducting follow-up phone calls or in-person focus groups with participants as prototypes are released may generate more substantial feedback and retain participants' attention to the project to a greater extent than e-mail communication alone. A larger pool of participants would also maintain a more adequate supply of feedback even if some participants lose motivation to continue their involvement with the project. Increasing the number of researchers to at least two, with one researcher responsible for coding and another responsible for direct contact with local stakeholders, also may improve communication while avoiding researcher exhaustion.

The formative assessment workshops (Stage 4) accomplished their primary goal, the identification and resolution of problems with the application. Further, some additional features suggested by workshop participants were implemented, such as extra affordances alerting the user that their submitted information would be visible to the public, and a tool to add point features by latitude/longitude coordinates. Some members of the public who were first exposed to the wikimap through the workshops became supporters who later helped recruit wikimap users. As a result of the formative assessment, the first version of the wikimap released for public use was stable and relatively bug-free (Stage 5).

While successful, the workshops suffered from low attendance due to lack of awareness in the community. The workshop with the greatest attendance was promoted and assisted by one of the needs assessment participants, demonstrating the importance of community stakeholder support. This workshop also took place on the Bad River Indian Reservation, where opposition to the mining proposal is strongest, possibly generating more interest in the project than elsewhere. Due to an unforeseen bug that prevented the wikimap from displaying properly on Internet Explorer, the only internet browser loaded onto the available computers at this workshop, a backup computer had to be used by participants. While some workshop attendees became promoters of the wikimap, more members of the public ultimately were recruited by presentation at unrelated public events.

The formative assessment turned out to be an important piece of the development process leading to a successful final wikimap. Similar or better turnout and results might have been achieved with a non-public workshop to which hand-selected stakeholders were invited, and/or public workshops held in conjunction with larger, separately-planned public events. If OPM researchers decide to include independent public workshops in future projects, it will be important to directly partner with a community-based organization that can promote and/or conduct each workshop, generating more buy-in from the public. Logistically, when utilizing an unknown venue, it is important to bring along trusted devices as a fallback in the event of a technological glitch, and in general be prepared for the unexpected to occur.

6.1.3 Stage 6: Summative Evaluation

After the public release, system logging successfully captured the use patterns of wikimap users to a fine degree of resolution, facilitating reliable conclusions about the utility of the wikimap (Stage 6). A novel way of visualizing user interactions and use sessions based on Sankey flow diagrams was implemented, which revealed three use patterns employed during use of the wikimap. These use patterns indicate that wikimap design should anticipate use primarily for map reading and information seeking, and increase affordances for contributing information beyond what was provided in this case study application (See Section 6.2.2). Similar use pattern tracking should be implemented in future wikimaps to allow for examination of how they are being used.

Finally, the summative user survey corroborated the results of the interaction analysis and generated feedback on the utility of the wikimap for impacting public discourse about land use in the Bad River Watershed. It received an acceptable response rate of 19%. The survey found that few problems were encountered during respondents' wikimap use, and the majority of respondents were positively impacted by their use of the wikimap, though little impact on public discourse was noted. The user survey suffered the drawback of any survey, in that the results were biased toward the experiences of people who voluntarily returned the survey, which in this case may have been the more active and interested users of the wikimap. Nonetheless, it was a useful tool for gaining direct and open-ended feedback from the end user community.

Given more time for follow-up, a stronger survey recruitment effort and/or face-to-face dialogue with wikimap users could reveal further insights into the use and impact of the wikimap. Several unanswered questions remain regarding what motivated wikimap users, and what would further motivate them to make more extensive use of the wikimap. Future OPM projects should seek to better understand user motivations, ideally through additional social science methods such as interviews and focus groups.

6.2 Wikimap Utility: Discussion and Recommendations

6.2.1 Fulfillment of Research Goals

The first research goal of the Bad River Online Participatory Mapping Project was to design and implement a wikimap that successfully supports synthesis and presentation of local knowledge and landscape values. The end result of the UCD process was a working wikimap for the Bad River Watershed with a robust set of user-contributed information. Thus, the project could be considered a success in regards to this research goal.

The second project research goal was to analyze the usage of the wikimap, in order to draw conclusions that can inform the development of future wikimaps. The analysis that was conducted proved highly useful in drawing conclusions about how users interacted with the wikimap. The conclusions drawn point to the need for further inquiry into ways to promote more user contribution, so as to enhance the wikimap's facilitation of two-way community dialogue.

The third project research goal was to evaluate the influence of the case study wikimap on public discourse regarding land use issues within the Bad River Watershed. The user survey results indicate that, at least as of yet, the wikimap has not had a discernible impact on public discourse. With time and greater use, it has the potential to garner greater buy-in from the community, and will perhaps eventually be used as a tool for defending local values in regards to land use in a public venue. Transferring control over the project to an organization based in the community may facilitate more community use, especially if the organization enthusiastically promotes and uses the wikimap.

The Bad River Watershed Wikimap can serve as a template for future wikimaps, applicable to any geographic area. While it is possible to use in tandem with other forms of participatory mapping, the web-based nature of the wikimap enables it to include participants who would not otherwise have the time or transportation needed to take part in face-to-face participatory mapping exercises. Some alterations to the wikimap interface and interaction components based on information and user feedback gained during the summative evaluation (see Chapter 6) may increase its use and its effectiveness for displaying local information and landscape values. These recommended changes are discussed in the following sections.

6.2.2 Usage of the Wikimap

The primary purpose of the wikimap was to empower users to share information and landscape values pertaining to places in the Bad River Watershed. While adding features and information was possible for any registered wikimap user, surprisingly few users took advantage of this opportunity. Without a greater balance of information contribution to information retrieval, the conversation between wikimap users remains largely a monologue.

While users' motivations were not well revealed by the summative evaluation, it is possible that users found the idea of being able to contribute to the map unfamiliar, felt they had nothing to contribute, or were simply uninterested in contributing information and values to the map. The level of information contribution might be increased given the right promotion strategy. This strategy should be given significant thought in the design of future OPM projects. It should include more direct contact and promotion within the community, as well as improvements to the wikimap interface design.

The interface tools for contributing to the Bad River Watershed Wikimap are small, positioned off-center, and contained in an initially collapsed menu, which could be inconspicuous to some users. The visual footprint of these tools should be increased in size, and the tools should be visible as soon as the map is loaded. Since a major goal of the wikimap is to gain a diverse range of user contributions, users could be prompted to contribute upon login, shifting CGI collection from an 'opt-in' to an 'opt-out' strategy. This prompt should be accompanied by a simple, straightforward tutorial or other affordances aimed at making it as easy as possible for users to contribute. Contributions can be further promoted by connecting the wikimap to social media websites such as Facebook and Foursquare, such that information contributed to the wikimap would be seen by others who have a relationship to the poster on those sites. Utilizing some motivational elements of computer gaming, such as providing points or tokens on a user's account for each contribution made by the user, as well as allowing users to 'promote' features or posts that they like, could further stimulate contribution.

While few users contributed to the map, 58% of users sought out information on the map that was contributed by other users, making information seeking the most exhibited use pattern. Survey respondents also commented on the value of being able to read the information that others had posted. Thus, crowdsourced information appears to serve an important purpose for most wikimap users, even if they themselves do not contribute, allowing users to be more fully informed about places in the Bad River Watershed. This utility can also be promoted by connecting the wikimap to other social media, perhaps following the suggestion of one user survey respondent to allow users to log in through a Google, OpenID, Facebook, or other general-purpose online account. Designing the wikimap to be usable on mobile devices would allow users to take it into the field with them, increasing its direct applicability to map reading and information seeking tasks in the watershed.

6.2.3 Landscape Values and Public Discourse

The user survey responses indicate that simply knowing about additional features in the Bad River Watershed and some of the history behind those features may increase a sense of place among watershed residents and motivate the preservation of those places that are considered special by a portion of the community. The information added to date also appears to be ethically sound, devoid of sensitive locations or negative opinions. Of the 54 wikimap users with registered accounts at the time of the survey, none objected to any of the information placed on the map, although there was ample opportunity both through the wikimap interface and through the survey. The fact that so many features could be added to the wikimap by users in such a short timespan indicates the uniqueness of the watershed and the presence of broad place-based local knowledge within at least some of its inhabitants.

While the number of contributed features was high, the number of contributing users was below the minimum necessary for an unbiased analysis of locational patterns of different landscape values in the Bad River Watershed. A point pattern analysis similar to the one presented in Beverly et al. (2008) would support the empirical use of landscape values to inform land use and natural resources management decision-making. Although well over 100 features with identified landscape values were placed on the map, most of those features were contributed by a very small number of users, whose values may not reflect the full range of values held by various components of the community at large. The fact that the large majority of survey respondents lived outside of the watershed is also problematic for accomplishing this purpose. These outcomes suggests that design changes are needed before the wikimap can be considered an appropriate medium for collecting a representative set of landscape values for the Bad River Watershed.

On the Bad River Watershed Wikimap interface, there is not an easy way to distinguish the relative importance of different landscape values to a feature for which they are identified. The landscape values map in Figure 3.2 suggests that some places hold a greater overall importance than others, and some landscape values are more important than others that may yet be present in a given feature. An interface method should be devised that allows users to rate the importance of the landscape values identified for each existing feature, and in turn display these rankings to users. Adding additional landscape values should be simplified and the ability to do so made very obvious. Finally, some users may be deterred from contributing to the wikimap by the prominence of logos of sponsoring organizations in the visual hierarchy. The visibility of these could be reduced, perhaps by placing them within a collapsible interface module or separate acknowledgements window.

6.3 Final Words

The Bad River Watershed Wikimap was conceived as a tool for publicizing the values of a community that faces a potential mining project with far-reaching implications for environmental change in the watershed. The tension of economic development versus cultural and ecological protection remains a crucial point of debate for people living in and around the Bad River Watershed. Although online participatory mapping did not influence this discussion in the four months since the final wikimap's release, it did spark the interest and imagination of at least some residents in and around the watershed, and provided a medium for these individuals to share information about places in the watershed that was of interest to others. Moreover, the year-and-a-half-long experience of developing the map was a tremendously valuable learning process that produced new friendships and collaborations as well as new technical skills. It is hoped that the experience described in this thesis will be instructive to others seeking to use Geoweb technology for emancipatory goals.

> "It is important to repeat over and over that there is no 'good' mapping or 'bad' mapping. Leave the need for perfection to the scientists; what you are being encouraged to do is honestly describe what you already know about where you live in a manner that adds momentum to positive forces of change… [E]very region has the potential to be represented by as many unique interpretations as it has citizens. Reinhabitants will not only learn to put maps on paper, maps will also be sung, chanted, stitched and woven, told in stories, and danced across fire-lit skies."
>
> —Doug Aberley (1993)

References

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

Abernathy, D., 2011. Teaching the Geoweb: Interdisciplinary Undergraduate Research in Wireless Sensor Networks, Web Mapping, and Geospatial Data Management. Journal of Geography 110, 27-35.

Alanen, A., 1997. Homes on the Range: Settling the Penokee-Gogebic Iron Ore District of Northern Wisconsin and Michigan, in: Ostragen, R.C., Vale, T.R. (Eds.), Wisconsin Land and Life. University of Wisconsin Press, Madison, WI.

Al-Kodmany, K., 2001. Bridging the gap between technical and local knowledge: Tools for promoting community-based planning and design. Journal of Architectural and Planning Research 18, 110–130.

Associated Press, 2013. Scott Walker signs mining bill into law; opponents prepare for legal battle. Wisconsin State Journal, March 12.

Beverly, J.L., Uto, K., Wilkes, J., Bothwell, P., 2008. Assessing spatial attributes of forest landscape values: an Internet-based Participatory Mapping approach. Canadian Journal of Forest Research 38, 289–303.

Bostock, M., Ogievetsky, V., Heer, J., 2011. D3: Data-Driven Documents. IEEE Transactions in Visualization and Computer Graphics.

Boulos, M.N.K., Resch, B., Crowley, D.N., Breslin, J.G., Sohn, G., Burtner, R., Pike, W.A., Jezierski, E., Chuang, K.-Y., 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, 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.

Brown, G., Reed, P., 2000. Validation of a Forest Values Typology for Use in National Forest Planning. Forest Science 46, 240–247.

Bryan, J. 2010. Force multipliers: Geography, militarism, and the Bowman Expeditions. Political Geography 29, 414-416.

Cameron, J., 2005. Focussing on the Focus Group, in: Hay, I. (Ed.), Qualitative Research Methods in Human Geography, 2nd ed. Melbourne: Oxford University Press.

Chapin, M., Lamb, Z., Threlkeld, B., 2005. Mapping indigenous lands. Annual Review of Anthropology 34, 619–638.

Chapin, M., Threlkeld, B., 2001. Indigenous landscapes: A study in ethnocartography. Center for the Support of Native Lands, Arlington, VA.

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

Chambers, R., 2006. Participatory Mapping and Geographic Information Systems: Whose Map? Who is Empowered and Who Disempowered? Who Gains and Who Loses? Electronic Journal of Information Systems in Developing Countries 25, 1–11.

Chippewa, B.R.B. of L.S. (Ed.), 2011. Position statement on proposed GTac iron mine and proposed iron mining legislation in Wisconsin.

Corbett, J., 2009. Good practices in Participatory Mapping: A review prepared for the International Fund for Agricultural Development (IFAD). International Fund for Agricultural Development, Rome, Italy.

Corbett, J., 2010. The IFAD adaptive approach to Participatory Mapping: Design and delivery of Participatory Mapping projects. International Fund for Agricultural Development, Rome, Italy.

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

de Groot, R.S., Wilson, M.A., Boumans, R.M.., 2002. A typology for the classification, description and valuation of ecosystem functions, goods and services. Ecological Economics 41, 393–408.

DiBiase, D., 1990. Visualization in the Earth Sciences. Earth and Mineral Sciences 59.

DiBiase, D., DeMers, M., Johnson, A., Kemp, K., Luck, A.T., Plewe, B., Wentz, E., 2006. Geographic Information Science & Technology Body of Knowledge. University Consortium for Geographic Information Science, Alexandria, VA.

DiCicco-Bloom, B., Crabtree, B.F., 2006. The qualitative research interview. Medical Education 40, 314–321.

Di Gessa, S., Poole, P., Bending, T., 2008. Participatory Mapping as a tool for empowerment: Experiences and lessons learned from the ILC network (No. 5), Knowledge for Change. International Land Coalition, Rome, Italy.

Dunn, K., 2005. Interviewing, in: Qualitative Research Methods in Human Geography. Oxford University Press, USA, pp. 79–105.

Elwood, S., 2008. Volunteered geographic information: future research directions motivated by critical, participatory, and feminist GIS. GeoJournal 72, 173–183.

Elwood, S., Leitner, H., 1998. GIS and Community-based Planning: Exploring the Diversity of Neighborhood Perspectives and Needs. Cartography and Geographic Information Science 25, 77–88.

Evans, T., 2011. Iron Mining in the Gogebic Again? An Overview of Wisconsin's Regulatory Process and the Public's Access to Decision Making. Madison, WI: University of Wisconsin Extension. January.

Gedicks, A., 2011. Resisting Resource Colonialism in the Lake Superior Region. Z Magazine 24, 32-35.

Goodchild, M.F., 2007. Citizens as sensors: the world of volunteered geography. GeoJournal 69, 211–221.

Goodchild, M.F., 2008. Commentary: whither VGI? GeoJournal 72, 239–244.

Grossman, Z., et al. 2010. AAG Indigenous Peoples Specialty Group's Declaration of Key Questions About Research Ethics With Indigenous Communities. Indigenous People's Specialty Group of the Association of American Geographers.

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

Harris, T., Weiner, D., 1998. Empowerment, Marginalization, and "Community-integrated" GIS. Cartography and Geographic Information Systems 25, 67–76.

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

Haug, D., MacEachren, A.M., Hardisty, F., 2001. The Challenge of Analyzing Geovisualization Tool Use: Taking a Visual Approach. 20th International Cartographic Conference, Beijing.

Iron Mining in the Lake Superior Basin: Project Report 11-1, 2011. Great Lakes Indian Fish and Wildlife Commission Environmental Section, Odanah, WI.

Kwan, M-P., 2002. Is GIS for Women? Reflections on the critical discourse in the 1990s. Gender, Place & Culture 9, 271-279.

MacEachren, A.M., 1994. Visualization in modern cartography: Setting the Agenda, in: MacEachren, A.M., Taylor, D.R.F. (Eds.), Visualization in Modern Cartography. Pergamon, Oxford, England, pp. 1–12.

MacEachren, A.M., 1995. How Maps Work. The Guilford Press, New York.

MacEachren, A.M., 2005. Moving Geovisualization toward Support for Group Work, in: Dykes, J., MacEachren, A.M., Kraak, M.-J. (Eds.), Exploring Geovisualization. Pergamon.

MacEachren, A.M., Kraak, M.-J., 1997. Exploratory Cartographic Visualization: Advancing the Agenda. Computers and Geosciences 23, 335–343.

MacEachren, A.M., Monmonier, M., 1992. Geographic Visualization: Introduction. Cartography and Geographic Information Science 19, 197–200.

Maguire, M., 2001. Methods to support human-centred design. International Journal of Human-Computer Studies 55, 587–634.

Morgan, D.L., Scannell, A.U., 1998. Planning Focus Groups, Focus Group Kit. SAGE Publications, Thousand Oaks, CA.

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

Northland College, 2012. GLRI funded projects helped prevent wash outs from spring flooding. Current News, http://www.northland.edu/news-current-news.htm?id=258. Accessed April 19, 2013.

Pequet, D.J., 1994. It's About Time: A Conceptual Framework for the Representation of Temporal Dynamics in Geographic Information Systems. Annals of the Association of American Geographers 84, 441-461.

Poole, P., 1995. Indigenous Peoples, Mapping & Biodiversity Conservation: An Analysis of Current Activities and Opportunities for Applying Geomatics Technologies, Biodiversity Support Program Peoples and Forest Program Discussion Paper Series. Biodiversity Support Program.

Robinson, A.C., 2009. Needs Assessment for the Design of Information Synthesis Visual Analytics Tools. IEEE, pp. 353–360.

Robinson, A.C., 2008. Collaborative Synthesis of Visual Analytic Results. IEEE Symposium on Visual Analytics Science and Technology 2008, pp. 67-74.

Robinson, A.C., Chen, J., Lengerich, E.J., Meyer, H.G., MacEachren, A.M., 2005. Combining usability techniques to design geovisualization tools for epidemiology. Cartography and Geographic Information Science 32, 243–255.

Rød, J.K., Ormeling, F., van Elzakker, C., 2001. An agenda for democratising cartographic visualisation. Norwegian Journal of Geography 55, 38–41.

Rolston III, H., Coufal, J., 1991. A Forest Ethic and Multivalue Forest Management. Journal of Forestry 89, 35–40.

Roth, R.E., 2009. A Qualitative Approach to Understanding the Role of Geographic Information Uncertainty During Decision Making. Cartographic and Geographic Information Science 36, 315-330.

Roth, R.E., 2011a. A Comparison of Methods for Evaluating Cartographic Interfaces. Proceedings of the 25th International Cartographic Conference.

Roth, R.E., 2011b. Interacting With Maps: The Science and Practice of Cartographic Interaction (Dissertation).

Roth, R.E., 2013. Interactive Maps: What We Know and What We Need to Know. The Journal of Spatial Information Science 6.

Roth, R.E., Harrower, M., 2008. Addressing Map Interface Usability: Learning From the Lakeshore Nature Preserve Interactive Map. Cartographic Perspectives 60, 46-66.

Schmidt, M., 2008. The Sankey Diagram in Energy and Material Flow Management. Journal of Industrial Ecology 12, 82–94.

Sieber, R., 2006. Public Participation Geographic Information Systems: A Literature Review and Framework. Annals of the Association of American Geographers 96, 491–507.

Stakeholder engagement strategies for Participatory Mapping, 2009. Social Science Tools for Coastal Programs. NOAA Coastal Services Center, Charleston, SC.

Suchan, T.A., and C.A. Brewer, 2000. Qualitative Methods for Research on Mapmaking and Map Use 52, 145–154.

Szot, A., A. Noyes, A. Singsaas, A. Metcalfe, A. Stone Dahl, A. Meza, D. Randolph, D. Daulton, F.A. Montano, F.J. Hutton, J. Richter, J.M. Slack, J. Bates, M. Burns, P. Sandin, P. Rasmussen, P. Kucera, P. Adams, S. Balbin, and T. Daulton, 2012. Penokee: Explore the Iron Hills. http://penokeearts.wordpress.com

Tuan, Y.-F., 1979. Space and place: the perspective of experience. Edward Arnold, London.

Tulloch, D.L., 2008. Is VGI participation? From vernal pools to video games. GeoJournal 72, 161–171.

Ward, David J. et al., 2011. The Economic Impact of the Gogebic Taconite Mine. Madison, WI: NorthStar Economics, Inc., http://gogebictaconite.com/News/GTAC%20Impact%20FINAL.pdf

Wallace, T.R., 2010. The University of Wisconsin-Madison Arboretum Map. Cartographic Perspectives 66, 31–40.

Wood, D., 1992. The power of maps. Guilford Press, New York.

Wood, D., 2003a. Cartography is Dead (Thank God!). Cartographic Perspectives 45, 4–7.

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

Wood, D., 2010. Rethinking the Power of Maps. The Guilford Press, New York.

Wisconsin Historical Society, 2011. Term: badger (origin of name). Dictionary of Wisconsin History, http://www.wisconsinhistory.org/dictionary/index.asp?action=view&term_id=9113&term_type_id=3&term_type_text=things&letter=B

With, B., Kemble, R., 2013. Ashland Listening Session Sends Strong Message: “There Will Be No Mine”. Wisconsin Citizens Media Cooperative. http://wcmcoop.com/2013/02/12/ashland-listening-session-sends-strong-message-there-will-be-no-mine/