To the Graduate Council:

I am submitting herewith a thesis written by Sara H. McNamee entitled "Geospatial Data Accessibility in a Web 2.0 Environment." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Information Sciences.

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Geospatial Data Accessibility in Web 2.0 Environments

A Thesis Presented for the
Master of Science
Degree
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Sara Helen McNamee
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ABSTRACT

Geographically referenced data is becoming a robust source of information because the use of place-based relevance searching is being employed as a popular form of information access and dispersal. To address this trend, the researcher conducted a study on the usability of the USA National Phenology Network (http://www.usanpn.org/), engaging 6 volunteer participants structured usability test of the USANPN mapping application. The participants were asked to complete two tasks, and data was collected both during (in the form of a think aloud exercise) and after the test (in the form of an exit interview). From the data collected, the researcher aimed to identify common and serious usability issues using both quantitative usability metrics and the qualitative think aloud and interview data. This study was primarily directed at assessing the usability of a geospatial Web 2.0 application and identifying common user problems. The researcher concluded that the search functionality and general navigation options were the most pressing usability issues associated with using the USA National Phenology Website to contribute geospatial data.

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CHAPTER I
INTRODUCTION AND GENERAL INFORMATION

Introduction

Geographically referenced data is becoming a robust source of information because the use of place-based relevance searching is being employed as a popular form of information access and dispersal. The growing importance of geographic reference enhancing data is increasing the use of place-based relevance searching. To address this growing trend, many social media tools now offer geospatial applications that users may access and, more importantly, to which they may add content. However, without any guidelines or standards in place for contributing to these Web 2.0 applications, a copious amount of heterogeneous, and sometimes unreliable, content is being added. There is a need to make these applications more authoritative, and therefore more valuable to the general user, therefore the researcher conducted a study examining the usability of a mapping application in which users create and contribute useful information related to locations on Earth. This research designed a usability study to examine individuals utilizing a map application to complete common tasks, and focused on identifying recommendations that make geospatial information more accessible to the general public.

The use of Geographic Information Systems (GIS) data in the Web 2.0 environment is expanding at an exponential rate (Jones et al. 2009), with little structure or standardization applied to the content (Elwood 2009). What does exist is found in the form of multiple standards or lack of consistently applied standards (de facto standards). This lack of established guidelines leads to search and retrieval issues for the casual Web 2.0 participant (Hudson-Smith et al. 2010). There is a growing body of research reflecting the complex and multivariable nature of geospatial data (Lu et al. 2010, Granell et al. 2010), but little has been investigated with regards to finding a remedy or guide that would prove useful in adding diverse content to web-based repositories of GIS data. However, tools like Google Earth are providing the platform for GIS information and scientific datasets to merge in online applications (Oberlies et al. 2009). Usability of such

applications has not been studied comprehensively (Elwood 2009, Crampton 2009), and an investigation of the most common usability issues present in geospatial web 2.0 programs would greatly further the development of a set of 'standards' to aid users in the creation of accurate contributions to these social applications. Identification of the most common usability issues in a geospatial Web 2.0 application could lead to modifications in this application, with the resulting Web 2.0 GIS data being more reliable, authoritative, and accessible.

It is commonly acknowledged amongst researchers and experts that Geographic Information Systems programs and software are inherently difficult to use (Luna et al. 2010, Eicher et al. 2010, Lu et al. 2010). Because of this, many usability studies have been performed with professional geospatial experts as participants in the attempt to make these programs more accessible to the geospatial specialists (Eicher et al. 2010, Luna et al. 2010). The barriers of computer technologies, poorly designed user interfaces, and an extremely steep learning curve for many of the programs has led to the creation of tutorials and learning tools to aid geospatial professionals in utilizing the complex GIS software (Eicher et al. 2010). The inherently complex nature of GIS data requires even those with specialized knowledge to obtain instruction for using the complicated traditional software. However, the majority of the usability studies have been directed at geospatial researchers and scientists, most of who already possess a deep understanding of the theory behind the science. Hence, the potential for the casual Web 2.0 participant to utilize the simplified geospatial applications currently available is reduced due to unfamiliarity with the complex nature of GIS information.

Web 2.0 is the term used to refer to web applications that facilitate collaboration and information sharing among users. These sites allow individuals to actively contribute content and interact in a social media environment. Tim O'Reilly posited that Web 2.0 can be viewed as a "network as platform," implying that the decentralized user base creates the application (O'Reilly 2005). Previous studies have been conducted on the use of Web 2.0 geospatial applications, and many issues have been enumerated (Elwood 2009, Crampton 2009, Goodchild 2007). Much of GIS user contributions are qualitative in nature (they are not clear-cut numerical additions), so the user is free to define what

will be added to the application. Hence, the addition of the contextual element creates inconsistencies and vague descriptions of user-added content. For example, an individual may submit photos of a stream that is described as “near” their home. However, what is “near” to one person may not be “near” to another. Resolving these types of disparities in the digital recording of personal and subjective geospatial data is becoming a pertinent issue as the popularity of public participation in the creation and dispersion of information increases, especially for use in geographic reference and community planning (Goodchild 2007, Bugs et al. 2010).

The researcher conducted a study on the usability of the USA National Phenology Network[1], engaging volunteer participants in a structured think aloud exercise. Data was collected on the overall usability of the application. From the data collected, the researcher aimed to identify common and serious usability issues. This study was primarily directed at assessing the usability of a geospatial Web 2.0 application and identifying common user problems. If distinct and common usability issues can be established by a population of casual Web 2.0 participants, subsequent modifications to the application can be suggested to make the application more effective.

CHAPTER II
LITERATURE REVIEW

As the technological sector continues to innovate at an exponential rate, research into various new applications for technology is on the rise. With the explosion of Web 2.0 applications, where users can contribute and edit content, the ability to combine geospatial technology and user-created content is being discovered. A few applications, including GoogleMapIt, WikiMapia, OpenStreetMaps, and PublicEarth, have been established and are in developing stages of use. The level of user interaction varies by application, but preliminary investigations and research indicate a trend toward increased user participation in generating and editing digital maps (Hudson-Smith et al, 2010, Crampton 2009). The study proposed may be one of the first in the field of geospatial Web 2.0 user behavior. For the purposes of this study it was necessary to define this user, as previous work in the field of geospatial application usability has not addressed this. The casual geospatial Web 2.0 participants is an individual who has used and made contributions to general Web 2.0 applications, and who is familiar with geospatial Web 2.0 applications. This user does not need experience in contributing content to the geospatial Web 2.0 application, but will have made contributions to general Web 2.0 applications.

The literature review examines the various disciplines that contribute to knowledge required for this study and others conducted on the emergence of geospatial Web 2.0 applications. The history and guidelines of usability research is discussed, as well as the think aloud method, the technique employed in the study. Additionally, the applications used by geoscientists and usability research conducted on GIS systems is examined. The emergence of the new Web 2.0 applications and the research conducted on them are discussed, and a brief introduction to the application used in this study is included.

Usability Research

The usability of systems has been studied since the technologies were first made available. The history of the field of usability stretches back about three decades, with experts debating which measures to use and how to conduct these studies. Usability was first coined as 'ergonomics' (Shackel 1959), then called 'ease-of-use' (Miller 1971, Bennet 1972), and was finally termed 'usability' (Bennet 1979, Shackel 1981). Usability became very popular during the 1980s, reflecting the shift in focus from the structure of the technologies to the user's needs in utilizing the technology (Shneiderman et al. 2010). This research originally focused on what was termed 'user-friendliness,' but is now commonly known as computer-human interaction (CHI), user-centered design (UCD), and the most popular, human-computer interaction (HCI) (Nielsen 1993). The key question found in HCI research is how to work with and improve the usability of systems (Hornbaek 2006), giving rise to many forms of defining usability. One definition, posed by Shackel (1991), states that usability is "...the capability to be used by humans easily and effectively." Nielsen elaborates, first establishing that 'usefulness' is inspecting whether a system "...can be used to achieve some desired goal" (Neilsen 1993), before defining usability as "...how well users can use a systems functionality" (Nielsen 1993). Additionally, Shneiderman states that usability studies are "…designed to find flaws in user interfaces" (Shneiderman et al. 2010). Usability studies attempt to examine all the aspects of a system that any given user may interact with. Nielsen defines for the researcher five aspects of usability to standardize research: (1) learnability, (2) efficiency, (3) memorability, (4) errors, (5) satisfaction (Nielsen 1993).

In determining the level of usability for a given system, a number of usability metrics are employed during testing and evaluation. One of the foremost educators in the field of usability, Alan Dix, suggests several, including (1) the time taken to complete a task, (2) the time a user spends correcting errors, (3) the number of times a specific interface misleads a user, (4) the number of regressive behaviors a user makes in a session, or (5) the number of times a user expresses satisfaction or frustration with the interface (Dix). Some of these measurements, including time to complete tasks and number of regressive behaviors were used in the discussed study. In using these

measurements, usability testing can aid in facilitating data entry to an application, the primary focus of this research study. Proper evaluation of usability testing metric results can (1) improve consistency of user transactions, (2) minimize input actions by the user, (3) minimize the memory load, (4) improve the flexibility for user control (Shneiderman et al. 2010).

Three types of user evaluation methods, or usability methods, have been developed and are commonly used to achieve this information. They are (1) cognitive walkthroughs, (2) heuristic evaluation, and (3) think aloud (Jacobson et al. 2001). The cognitive walkthrough is a step-by-step procedure that looks at each sequence in a given task within a system, and was first utilized in 1990 (Lewis et al. 1990). This method requires the researcher to first identify the user of the system, choose specific tasks that will be evaluated, and then construct task sequences for the participants to complete (Jacobson et al. 2001). The heuristic evaluation method was also introduced in 1990 (Nielsen 1990), proposing to evaluate a system against certain characteristics, which Nielsen termed 'heuristics.' This method usually engages HCI-trained evaluators, or experts, to look at the interface and compare the various characteristics with the listed heuristics (Jacobson et al. 2001). The third method, and the one of the methods used in this study, is the think-aloud method. Considered to be the most important usability evaluation method (Nielsen 1993), it is also the method that commonly yields the most information (Jaspers 2009). This method will be further discussed in a later section later in the chapter in a section labeled "Think Aloud".

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Applications for Geoscientists

There has been a significant amount of research conducted on technical applications of Geographic Information Systems (GIS) technology for scientists and researchers, investigating applications created solely for geospatial data (Lu et al. 2010). The bulk of the literature to date has focused on advances and potential for collaborative geospatial applications for scientists and researchers. Though this does not directly apply to the more basic Web 2.0 applications, it provides a strong foundation for the

architecture and interoperability of the user-created content maps that are becoming very popular. Starting early in the 21st century the popularity of web-based mapping tools and Internet GIS started to rise (Schultz et al. 2008). Additionally, the potential to link visual, geospatial images with scientifically gathered information is recognized as a more robust method of providing science data. As Oberlies et al. 2009 state, "...comparing the geographic distribution of scientific data is a growing area of interest that is applicable to many fields." The importance of spatial knowledge can be seen across a wide range of scientific disciplines, but up until now, has been undervalued, and hence underutilized (Schultz et al. 2008). This, however, is changing as many scientific researchers are embracing the use of maps in displaying their data in the hopes of reaching a wider audience. The ability to visualize these complex datasets in a more "vibrant and informative" manner than the traditional written descriptions has allowed cross-disciplinary understanding and collaboration (Oberlies et al. 2009). Geographically referencing scientific datasets allows for the analysis of the collected data in new ways, easily identifying sampling gaps or trends of clustering and distribution inherent in the collected data.

Historically this was not a common practice in the earth sciences, because using traditional GIS tools with large scientific datasets was very difficult due to the learning curve associated with GIS software. Researchers collected vast amounts of ecological and biological data at specific locations, associated with a given latitude and longitude, yet were unable to combine these types of information to provide a more comprehensive and accessible result (Oberlies et al. 2009). With the advent of the use of the Keyhole Markup Language (KML), outreach to the general population became a reality, as KML allowed for the visual representation of scientific phenomenon and scientific results to an audience outside of the academic and research spheres. Such examples of this include the visual representations of glacial movement and retreat, or the KML files created by the USGS used by citizens and scientists alike on a daily basis to monitor real-time water and earthquake data (Ballagh et al. 2010).

As defined by the Open Geospatial Consortium, "KML is an XML language focused on geographic visualization, including annotation of maps and images.

Geographic visualization includes not only the presentation of graphical data on the globe, but al the control of the user's navigation in the sense of where to go...” (Wilson 2008). KML is an open standards eXtensible Markup Language (XML) grammar and file format that allows for the storage and modeling of geographic features like points, lines, and images, and is complementary to many other OCG standards like Geographic Markup Language (GML), Web Service Feature (WSF), and Web Map Service (WMS) (Oberlies et al. 2009). Google purchased Keyhole in 2004, and through this merger also acquired KML. Because KML is an open standards language, it allows for the creation of GoogleEarth and Google Map “mashups”, using both Google Earth and other applications simultaneously to create unique and distinctive maps (Schultz et al. 2008). Google Earth provides the satellite imagery of the globe as well as the user interface, and then allows KML files to be incorporated into these existing images to create new maps (Oberlies et al. 2010). In 2007 Google released the KML rights to the OGC, allowing the OCG to manage the language on behalf of the community, and KML has been adopted by the Open Geospatial Consortium, Inc. as the OpenGIS KML Encoding Standard (OGC KML), with the most recent version being OGC KML 2.2, approved in November 2008 by the OCG KML 2.2 Standards Working Group (Wilson 2008).

Further research was conducted (Granell et al. 2010) on the potential for a web-based geospatial platform, accessible to geoscientists and geographers. The Open Geospatial Consortium (OCG) proposes specific interface descriptions to standardize data formats, semantics, and spatial relationships in dealing with geospatial data to streamline both data collection and discovery. Granell et al. concludes with the need for data to be properly described upon collection, with homogenous and clear search methods made available.

Like the professional application of web platforms, this is also a pressing issue in developing Web 2.0 geospatial applications, as the complexity and disparity of the data requires a standardized method of input and map creation. With 500 million downloads of Google Earth, this is an extremely pertinent area of study as casual users become aware of the possibilities provided by the mapping application and underlying KML

functionalities (Ballagh et al. 2010). Furthermore, because the causal Web 2.0 participant lacks formal training in the geosciences, the data contributed can be even more disparate.

Usability in Geographic Information Systems

Due to the complex nature of GIS data, usability issues are commonly cited by research as this technology becomes more popular with professionals in the geosciences (Jones et al. 2009, Eicher et al. 2010, Luna et al. 2010). GIS software requires "high levels of interaction and user control" (Jones et al. 2009), leading to the need for user training. It has been asserted that many of the newest and most innovative GIS tools are not easy to utilize, and as a consequence, the number of individuals in the geosciences using these tools is well below expected (Jones et al. 2009). GIS data is inherently complicated, so combining this with the accelerated use of new technologies expands the possibilities for the user to interact with the map. Geospatial data is generally defined by two different characteristics: both a position (position on the earth), and attributes (or descriptive characteristics), adding complexity to both the addition and subsequent retrieval of the information (Schmigiuel 2005).

Research has shown that even individuals with a solid geospatial background find difficulties in gaining useful information from the systems (Eicher et al. 2010). One solution proposed by Jones et al. (2009) has been to return to a simple design for traditional GIS software. Others (Eicher et al. 2010, Luna et al. 2010), upon conducting usability studies on the traditional GIS software, have suggested the creation of learning tools and guides to aid professional users in maximizing their use of these systems. This research lays a foundation for further investigation into the usability of geospatial applications, and is especially helpful in illuminating the need for studies with applications aimed at the casual Web 2.0 participant, as the complex building blocks of GIS software are translated into the popular media forum. Jones et al. (2009) asserts, "... for non-expert users, time is lost when choosing color palettes, classifying ranges, moving around the maps and trying to interpret complex statistics rather than gaining knowledge and insight from the data." Schmigiuel 2005 furthers this idea, asserting that the usability of these publicly accessible application should reflect the variety of different

users, with individuals utilizing the application in a number of different ways and for very different tasks.

Catherine Plaisant conducted usability testing and a case study using the U.S. Census Bureau's DataMap, retrieving informative results (Plaisant 2004). Emphasizing the need to use real datasets and simulate real tasks in conducting a relevant experiment, she conducted a case study of the new interactive map application used to display census data. She argues that these usability reports for geospatial applications will help the early adopters see the potential of the new tools as well as provide feedback for initial improvements in the system (Plaisant 2004). After finding that many users found the initial interface to be 'complicated' to navigate as well as issues with using the zoom functions of the map application, she suggested simplifying the interface and providing a help section for new users (Plaisant 2004). However, she also enumerated the limitations of a controlled usability test. The most serious of these is the fact that the user only gets to perform given tasks, without having the time to navigate the full application or receive training and experience with the tool (Plaisant 2004).

Applications for Web 2.0

The study of the use of Web 2.0 geographic applications is only just beginning. To date, most literature on this subject has been focused primarily on evaluating the new Web 2.0 platforms (Wikimapia, OSM, MapTube, etc.), with little or no research into the usability of each service. Hudson-Smith et al. (2009) focus on explaining the use of Web 2.0 applications in sharing geocoded data, asserting that the phenomenon observed among users can be called "mapping for the masses." They define crowdsourcing as a "…term used for methods of data creation, when large groups of users who are not organized centrally generate content that is shared" (Hudson-Smith et al. 2010), leading in this context to volunteered geographic information. The potential for crowdsourcing is enormous—though one individual's information may be incorrect, the law of large numbers asserts that many people's information aggregated together will produce accurate, expert data. Hudson-Smith and collaborators (2009) explain, without

conducting any experiments, many Web 2.0 applications including Google Maps and OpenStreetMaps, which are two of the most interactive services currently in use.

Another summarization and call for further investigation comes from Elwood (2009), where she also explains the newest geospatial applications for Web 2.0 and illustrates both the potential and current issues that are present with the services (Elwood, 2009). She and other researchers (Hudson-Smith et al. 2010, Crampton 2009) highlight the problem of widely varying semantics that will be inherent with user-generated content. How can data with heterogeneous metadata be integrated into one system to make the system more usable? Elwood suggests that natural language terms be used in this context, but a method for creating and implementing such a system has not yet been explored.

The vast applicability of geospatial Web 2.0 programs has been recognized (Elwood 2009), but issues regarding successful map creation and subsequent retrieval have yet to be addressed. The problem lies predominantly with the fact that geospatial data can be extremely complex and difficult to capture and represent (Jones et al. 2009, Schmigiuel 2005). As Hudson-Smith et al. state, "Mapping, notwithstanding its immediately usable form, is considerably more technical in content than might appear at first sight, and thus rules are required to any user to create content that is then added to the map" (Hudson-Smith et al. 2010). Hence, the usability of map-making Web 2.0 applications needs to studied, and the dearth of investigation into this area provides ample room for research and improvement. The advantages to these applications are abundant, with crowdsourced data and user participation allowing for an incredible amount of information to flow. However, to make this data increasingly accessible and usable, the need for modifications to the existing applications is apparent.

Much of the groundwork has been laid for future studies involving Web 2.0 applications. Current evaluation practices for information visualization applications include controlled experiments that look at the design elements, usability studies, and case studies (Plaisant 2004). For web applications, it has been asserted "…clarity and usabiliy are features generally demanded by the users" (Schmigiuel 2005). Additionally,

the ISO 25010 Quality Model lists six characteristics of good software, all of which are extremely pertinent in evaluating a geospatial Web 2.0 application: functionality, reliability, usability, efficiency, maintenance, and portability (ISO/IEC 25010:2011). The usability characteristic is extremely important, relating to the understanding, learning, and operating capabilities in using an application, with many benchmarks to measure it's efficacy (Schimiguel 2005). Using this foundation for research, the future of the investigation and improvement of Web 2.0 geospatial applications is promising.

Think Aloud

The think aloud method was chosen for this usability study based on a number of different factors. The Think Aloud method, or TA, is considered the most authoritative and exhaustive of the three most commonly used methods (Neilsen 1993), and is a 'user-based' method of evaluation (Jaspers 2009). While the cognitive walkthrough and heuristic evaluation are both 'expert-based' in that they traditionally recruit human-computer interaction specialists to evaluate the systems, "...these methods however do not give any clear indication why a certain interface aspect poses a problem to a user..." (Jaspers 2009). Additionally it has been argued that "the informal method atmosphere of a TA is pleasant and often leads to many spontaneous suggestions for improvements" (Shneiderman et al. 2010). The think aloud method employs non-expert users in evaluating the system, giving greater insight into the underlying problems with the usability of a system (Jaspers 2009). This method of evaluation became popular in the 1980's, and illustrated the shift in focus from technological complexity to the users' needs when interacting with the system (Shneiderman et al. 2010). First used in systems development, the think aloud method has become the most popular way to study usability, as it can be utilized in all stages of a system's development and life cycle due to it's flexible structure (Dumas et al. 1993).

The core of the think aloud method is the construction of a study utilizing a small number of users or participants using a system while "simultaneously and continuously thinking out loud" (Hwang et al. 2009). This, in essence, means having the participant say any and all thoughts and feelings they have while interacting with the system or

application. Designed to find flaws in user interfaces, this method is ideal due to the need for fewer participants while still gathering a rich data set (Shneiderman et al. 2010). While the participant is vocalizing their thoughts, an evaluator will concurrently observe and record the participant's statements (Jacobson et al. 2001). The study is composed of two general stages: (1) performing the study while collecting the think aloud statements in a systematic manner, and (2) subsequently analyzing these statements to construct a list or model of the cognitive processes occurring while a user accomplishes as task in the system (Jaspers 2009). There are two general methods of conducting the usability study: the researcher can either employ the Concurrent Think Aloud (CTA) method, having the participant verbalize thoughts while completing the task, or the Retrospective Think Aloud (RTA) method, where the participant will reflect on the task after completion, or a combination of the two (Shneiderman et al. 2010). The researcher(s) will familiarize themselves with the system to be evaluated, analyzing both the use environment and the system, and identify common tasks that a user will accomplish in the system. During testing, the evaluator will give the participant specific tasks to complete, and also give the participant instructions on how to 'think aloud' (Jacobson et al. 2001). Upon task completion, an exit interview is usually conducted to gain additional insights regarding the user's experience, followed by the compilation and evaluation of a list (complete, nonduplicate) of problems uncovered during the study (Jacobson et al. 2001). The think aloud method is extremely informative due to the participant's ability to verbalize their thoughts as they are completing the task--as Jaspers (2009) asserts, "...the information that is actively being processed." It has been argued that verbalizing may distort the participant's performance on assigned tasks due to cognitive disturbance. However, it is less than is commonly found in retrospective interviews, making the think aloud method highly effective in gaining uncensored, robust participant data (Jaspers 2009).

Geospatial Application

The USA National Phenology Network (USA NPN) is the organization and website that will be evaluated for this research. According to the website, the "…USA National Phenology Network brings together citizen scientists, government agencies, non-profit groups, educators and students of all ages to monitor the impacts of climate

change on plants and animals in the US" (USA National Phenology Network 2010). Planning and implementation of the USA NPN started in 2004 by Dr. Julio Bentancourt and Mark D. Schwartz with the idea of harnessing the general public and the internet to collect and share far more data than could be collected by individual researchers (USA National 2010). The United States Geological Survey (USGS) and the University of Arizona subsequently reached an agreement to establish the USA NPN Coordinating Office in Tucson, AZ, with the website (www.usanpn.org/) going live in June of 2008. USA NPN activities are organized by staff at the Coordinating Office, governed by a twelve-member board of directors. Funding and support come from the USGS, the National Science foundation, NASA, Oak Ridge National Laboratories, as well as many others. The USA NPN is divided up into four major working groups, emphasizing the four focuses of the organization: Citizen Science and Education, Land Surface Phenology and Remote Sensing, Cyberinfrastructure, and Species and Protocalls (USA National 2010).

Phenology is defined as the "…recurring plant and animal life cycle stages, such as leafing and flowering, maturation of agricultural plants, emerging of insects, and migration of birds…" (USA National Phenology Network 2010). These cycles are extremely important with regard to their relationship to the weather and climate, and many agencies and the White House as a key indicator of climate change describe phenology. The USA NPN was established to track these cycles and changes with the goal of answering questions such as: (1) How is the timing of events in plant and animal life cycles responding to climate change, and (2) how are these responses affecting people and ecosystems? (USA National Phenology Network 2010). By allowing individuals to contribute personal observations to a personal account established on the site, the USA NPN hopes answer these questions and contribute meaningful data to six key areas, including scientific research, human health, agriculture, natural resources, tourism, and education (USA National Phenology Network 2010).

Figure 1. USA NPN Mapping Interface

CHAPTER III
MATERIALS AND METHODS

Research Questions

This study addresses the following research questions:

(1) What usability issues arose when the casual user contributed content to the USA National Phenology Network?

(2) What can be learned about the skills and competencies that will define Web 2.0 map literacy?

Research Design

To address these questions, a mixed methodology of both qualitative and quantitative techniques was used to gather a wide variety of potential information from participants so that a baseline is established for subsequent research within the discipline. The researcher conducted a within-subject usability test, requiring the participants to complete the same tasks using the same website (Shneiderman et al. 2010). This allowed for a comparison of results from participants completing the same assigned tasks. The study also used the think aloud method (Jacobson et al. 2001, Shneiderman et al. 2010) of usability testing to collect data. This requires the participants to verbalize all thoughts and emotions as they complete the tasks. Though some work has been done in researching access and retrieval features in these applications, the process of contributing content has been left unexamined. This study was be one of the first in examining user contributions to this geospatial Web 2.0 application, and was therefore exploratory in nature.

The participants were instructed to complete two assigned tasks using the USA National Phenology Network: (1) the addition of a specific geographic location, or 'site', to the application when provided with an address, and (2) the contribution of an

additional site given only a general location. The researcher observed the exercises while audio recording all of the individual participants' remarks and statements while using the application. The software used to complete the tasks included the functionality to record both the on-screen actions of the participant as well as any verbal remarks. Following the think aloud exercises, each participant was involved in an exit interview including questions designed to elicit cognitive and affective responses to the tasks. With this data, the researcher transcribed the comments from the participants and aggregated these responses. A bottom up coding scheme was created (Jaspers 2009) and utilized to identify common usability issues and concerns among casual Web 2.0 participants. Additionally, various usability metrics were measured during the participants' interaction with the USA NPN and subsequently evaluated. The researcher then used this data to discuss the most significant usability problems amongst the sample and suggest future research in this area of study to improve the usability of such applications.

Population and Sample

This research study focused on the non-professional casual Web 2.0 user participant, and/or individuals without formal training with Geographic Information Systems (GIS) but who have experience with geospatial applications and services. The individuals did not need to have experience in contributing content, but were required to have browsed, searched and subsequently accessed GIS information with a geospatial Web 2.0 application. The participants' experience with the technology was established by the use of a screener and the results of the participants' completed Task 1, which was designed to establish a baseline of the participant's technological knowledge. The researcher conducted a think aloud usability study utilizing a sample of the casual Web 2.0 participant community. The participant pool consisted of adults between the ages of 18-30, who are college students with a knowledge of and experience using Web 2.0 applications, as well as an expressed interest in geotagging. Again, this was established by the use of a pre-study screener, or questionnaire, designed to gather background information on the volunteer participants. The university population was targeting for this study as a convenience sample, as the majority of available undergraduate students at

the University of Tennessee are in this age range. Due to the ubiquitous use of Web 2.0 applications among 18-30 year-olds, the researcher only used the screener and Task 1 to establish the participant's familiarity with web-based applications. The target sample size for this study was 6-8 individuals, which is consistent with the research to date (Nielsen 1993, Jacobson et al. 2001, CHI 2006). A preliminary pilot test of the software was conducted with one individual. Six individuals were subsequently recruited for the study. Due to the robust amount of data collected during think aloud experiments, a small sample size is sufficient to retrieve meaningful results.

To obtain a sample of acceptable participants, the researcher used selected undergraduate classes in the College of Communication at the University of Tennessee, Knoxville. The researcher obtained the permission of the instructor of the undergraduate courses to offer the opportunity to participate in a voluntary research study. A drawing for a gift card as an incentive to draw volunteers was provided, as this was anticipated to increase the number of students willing to participate. A short electronic screener was given to each volunteer (in the form of a web address they could voluntarily visit to complete the questionnaire). The screener was composed of a series of minor demographic questions, as well as questions used to ascertain the participant's competence and experience with Web 2.0 applications and basic geospatial knowledge. The participants were also asked questions regarding the volunteer's use of Web 2.0 applications and other computer and Internet usage to provide the researcher with the necessary information to select participants. These initial questions were completed without the provision of any of the volunteer's personal information. If the initial screener indicated that the individual qualified for the study, the individual was then asked if they would like to participate in the study. If so, the individual was asked a key question to verify interest in participating, and contact information was solicited. The contact information was not attached to the data collected from the screener.

The research study was conducted on the University of Tennessee, Knoxville campus in the Communications Building, in the UT ORNL-CCI Usability Lab, using the Morae usability software. All study participants completed the assigned tasks during one session. The researcher developed and issued the instructions for completing the tasks,

and observed and recorded each individual user's experience in using the application. Each session lasted approximately 30 minutes.

At the completion of the study, the researcher randomly selected the name of one of the participants in a drawing for a Visa gift card. The winning participant was contacted, and the gift card was provided to the individual.

Instrumentation

The researcher used 4 instruments to both quantitatively and qualitatively collect data: (1) Screener, (2) The results and evaluation of the transcribed task think aloud data, (3) The evaluation of the results of the measured select usability metrics, and (4) Retrospective exit interview. Before beginning the online activity, the participants were asked to complete a questionnaire with several questions that established a user profile, as well as identifying the individual's prior experience or knowledge of geospatial applications. Questions related to a person's educational background, comfort with the application, amount of time spent using general Web 2.0 applications, and inquiries about the perceived level of competence with map services like MapQuest and Google Maps. The researcher then employed both Concurrent Think Aloud (verbalizing thoughts and emotions as they interact with the website) and a retrospective exit interview with each participant (Shneiderman et al. 2010), recording each participant's responses in a digital audio file. The use of audio recordings allows the researcher to refer to this data after the conclusion of the usability test to gain greater information and understanding for subsequent data analysis.

The participants completed the assigned tasks using the USA National Phenology Network, a geospatial Web 2.0 application, with instructions to simply talk out loud about what they are thinking while completing the tasks. The entire exercise was observed and audio recorded by the researcher, and the analysis of proper completion was assigned by the researcher as either completed/not completed. This data can be found in the appendix. Finally, a retrospective exit interview was performed with each participant, where a mix of both open-ended and closed-ended questions was asked about the activity.

These questions were related to the user's affective state following the assignment and relevance judgments on the Web 2.0 service's search/contribution features and current help section (if utilized during the task completion). With this data, the researcher transcribed the comments from the participants and aggregated these responses into a digital text file. Additionally, various usability metrics were gathered during the participants' interaction with the USA NPN, and subsequently evaluated. A Pilot test was completed prior to formal data collection to evaluate the viability and usefulness of both the questionnaire and exit interview questions, as well as establish a practical time limit for task completion.

The researcher evaluated the results from the usability measurements in order to assess such factors as: (1) the time to learn the system, (2) the rate of errors by users, and (3) the subjective satisfaction of users (Shneiderman et al. 2010). The usability metrics selected for measurement include: (1) the time spent to complete each task, (2) time spent in correcting errors, (3) the percentages of favorable and unfavorable comments elicited from the participants (Dix). The results of the measurements from each participant was recorded and analyzed to evaluate the learnability and overall usability of the USA NPN for a casual user.

Tasks

Participants were given two basic tasks to complete using the National Phenology Network; (1) the addition of a geographic location to the application given a specific address, (2) the addition of a site to the USA NPN given only a general location. A test account was created with the USA NPN prior to test commencement. Task 1 consisted of the individual participant being instructed to add a site to their 'Nature's Notebook' on NPN. The specific address of the site to be added was given, and they were instructed to find the site using the search functions and the map provided. Once the site is located, the participant was instructed to note the coordinates of the location, and to record their answer on a form provided by the researcher and return to the researcher during the exit interview. Additional information about the site was supplied and participants were given

the opportunity to add optional additional data to the site. The first task was designed to be fairly simple, and took on average 4 minutes. The results of this task were assigned a pass/fail score based on whether the coordinates found were correct or incorrect, and were utilized predominantly to identify to establish whether the participant can use the geospatial application effectively or not. Task 1 was designed to identify the participant's individual skill sets and information-seeking behaviors, providing contextual information that would aid the researcher in evaluating each participant's results for the second task. In addition to establishing a baseline for each participant, the think aloud data and usability metric measurements were evaluated.

The second task was designed to be more complex, requiring the participant to add a site to their 'Nature's Notebook' given only a general location and not an exact location. Again, the participants were instructed to find the site using the search and map functions available to them. They were also instructed to add any additional information they would like about the site in the optional areas below the map. The researcher observed the participant as they interacted with the map interface, recording the participant's actions based on selected usability metrics. Once the general location was displayed in the map view, the participant was instructed to mark the location and note the resulting coordinates, recording them on the form provided. Because a specific address and site description was not provided, the participant was given 15 minutes to complete this task. The results were evaluated and assigned a score of pass/fail based on an established range of acceptable coordinates. This qualitative data was considered along with the Task 2 think aloud transcriptions and usability metric measurements in evaluating and assessing the USA NPN interface.

Procedure

The researcher solicited volunteers from an undergraduate class in the College of Communications at the University of Tennessee, Knoxville. The researcher sent an invitation email to those willing to participate, providing a link to a secure online questionnaire. The potential participants were administered the screener via the link, and

those that qualified were asked to participate in the study. The data from the online screener was captured in an online spreadsheet application, password protected and accessible only by the principal researcher. Upon screener completion and voluntary acceptance to participate in the study, the researcher contacted the individuals via email with further information about the study, attaching a copy of the informed consent form. The researcher requested the participant read the document fully before agreeing to participate, and upon meeting requested the participant sign the informed consent form and provides it to the researcher. The researcher anticipated a large enough pool of volunteers to be able to obtain enough qualifying students for the study. A pilot test was run with one individual, and the general experiment of 6 participants followed with the small modifications elicited from the test run.

The principal researcher developed and issued the instructions for completing the tasks, observing and recording each individual user's experience in using the application. Each task session lasted approximately 10 minutes. Upon completion (or at the expiration of time) of the tasks assigned, the researcher conducted an interview (and audio recording) each participant before releasing the individual. The researcher asked questions pertaining to both assigned tasks. These questions followed two lines of inquiry: (1) Questions formulated to ascertain the participants feelings of success or failure with the assigned tasks and which strategies they found most effective, and (2) questions regarding the utilization and subsequent perceived usefulness of the help sections of the National Phenology Network. The recorded sessions with each participant were then be fully transcribed into a digital text document in preparation for coding and analysis. The transcribed sessions from each individual participant were evaluated by the researcher with the goal of establishing a bottom-up coding scheme (Jaspers 2009): all unique affective words were identified and extracted, then these sub-processes were be grouped into categories, further refined until 5-6 coding themes were identified. Additionally, the number of times the participant expresses satisfaction and/or dissatisfaction with the interface were recorded and used in subsequent evaluation.

Data Management

The exit interview, in conjunction with data extrapolated from the completed tasks, were compiled and evaluated by the researcher with the goal of assessing the general usability of the USA NPN. The research study was conducted on the University of Tennessee, Knoxville campus in the Communications Building, in the UT ORNL-CCI Usability Lab, using the Morae usability software. Morae allowed the researcher to conduct the test, observe the participant, record audio, and subsequently store and analyze this data. The data was saved to the local server, and the files were password encrypted. Once a secondary copy of the participant data was created, the data on the local server was destroyed. A secondary copy of the data was stored on a Western Digital external hard drive and stored in a locked and secure location in the School of Information Sciences offices of the Communications Building. Access to the data was only provided to the principal investigator.

The volunteers' screener data was contributed anonymously and stored in a secure database. Those screeners that are found to be ineligible for the study were only used for statistical analysis, and no identifying information was kept from each contribution. Only upon approval of the second component to the screener would the volunteer be notified of qualification for the study, and asked to participate. If participation is accepted, the volunteer's name and contact information was obtained and stored in a secondary, secure database for use solely by the principle researcher. No other individuals have access to this data, and it was only used to contact and establish study sessions for each participant. This information was not associated or linked to the participant's study results. All participants' completed audio recordings of tasks and exit interviews were stored on a secure server, and kept completely confidential. Access was only granted to the principle researcher. The recorded data was transcribed into a digital text file and separated from any of an individual's identifying information, and the audio recordings were destroyed. Sole access to the data was granted to the principal researcher. Backup copies of the study data were stored on an external hard drive in a locked, secure location accessible by only by the principal researcher.

Limitations

The researcher recognizes that by using usability testing as a data-gathering method, populations of people were left out. Using the think aloud method, the researcher solicited casual users and not experts, which effectively "...emphasize[d] first time usage" (Shneiderman et al. 2010). However, one of the primary goals of the study was to observe how a user who is not familiar with the system interacts with the interface. Additionally, the study was structured for a specific population, the casual Web 2.0 participant, and so by limiting the type of user participating in the study will not harm the validity of the results.

Additionally, it must be recognized that a thorough investigation of all features found on the USA NPN website was not conducted in one session with the participants. Hence, data collected provided coverage of specific features of the application, and not usability data for the entire website. However, the goals of the study were not to provide a comprehensive usability assessment for the USA NPN, but rather to investigate some of the usability features associated with the geospatial functions found on the site. Furthermore, it is recognized that applications perform differently for different tasks (i.e. looking for a specific location vs. browsing a general area) (Plaisant 2004), and the researcher addressed this by using the same USA NPN mapping application for two different tasks.

The researcher also recognized that the study used a convenience sample of potential users, soliciting the readily available undergraduate students from the College of Communications at the University of Tennessee, Knoxville. Though a random cross-section of potential users may not be achieved, it is recognized that the communications classes offered in the undergraduate program often include students from a variety of majors, and therefore a variety of experiential backgrounds. By using these classes the researcher aimed to obtain volunteers who properly exemplified the definition of a casual Web 2.0 participant.

Lastly, the technology was considered as a potential limitation to the study. Due to the unreliable nature of Internet connectivity and human error, the researcher

acknowledged that not all of the participants' completed tasks might be usable for analysis. The pilot test was conducted to attempt to fix any problems or unforeseen issues.

CHAPTER IV
RESULTS AND DISCUSSION

Chapter 4 includes the results and analysis of both the screener data and the research tasks accomplished by the qualifying participants during the usability testing in the laboratory.

Screener Results

The screener was completed by twenty-six undergraduate students from a college of communication at a large publicly funded university in the southern United States. Of the 24 qualifying respondents, 42% were male and 58% were female. Almost all of these individuals (85%) were between the ages of 18 and 24, with only 17% aged 25-30. Table 1 illustrates the participants' responses to the amount of time spent online completing common tasks. Some tasks were commonly engaged – for example all participants responded that they used the internet to check email daily. Other tasks showed greater variation -- 92% of the respondents said they used the Internet for social networking daily. One individual responded that she used social networking applications once a week and one responded that he never used social networking sites. It should be noted that an ambiguous response was detected since in a subsequent question where all the respondents stated that they regularly used social media, so it may be inferred that the individual mistakenly answered one of the two questions. Since it is impossible to determine which is the correct answer, the respondent with the ambiguous responses has not been included in final analysis. It is interesting to note that the undergraduate students spent more time online using social media applications than they did online for schoolwork: 75% of the respondents stated they used the internet for schoolwork daily, and 25% used the internet for schoolwork weekly. This could suggest that greater emphasis and importance is placed on social media than the traditional online scholarly resources, and indicates the need for further research to explore the potential for further incorporating Web 2.0 and scholarship. The majority of the respondents indicated that

they spent time online gaming or shopping every few weeks (23% and 42% respectively). Reading the news online is a daily activity for about 60% of the participants.

Table 1. Time Spent Online

Internet Use	Daily	Weekly	Every Few Weeks	Once a Month	Never
Email	100%	0%	0%	0%	0%
Schoolwork	77%	23%	0%	0%	0%
Social Networking	92%	4%	0%	0%	4%
Gaming	15%	19%	23%	23%	19%
Shopping	12%	19%	42%	23%	19%
News	58%	31%	4%	4%	0%

As stated earlier, all of the respondents indicated regular usage of social media applications, and all respondents also stated they have contributed content to these Web 2.0 applications. Respondents use three popular social media applications-- almost all (96%) of the participants said they were users of Facebook. 90% of respondents use YouTube and half use Twitter. A few indicated that they used flickr (1/10), two said they used MySpace, and one indicated her use of del.icio.us. The time spent using these common social media applications was normally distributed, with half indicating spending 1-3 hours on social media sites daily, a quarter spending less than an hour and a quarter spending more than 3 hours daily. The potential for enhanced scholarly communication via social media and Web 2.0 applications is further illustrated with these figures, as three quarters of the target age demographic spends greater than an hour online daily engaged with these applications. This suggests that tailoring the existing citizen science websites to be more appealing and user-friendly, like the popular social media sites listed above, could potentially increase their usage.

All of the participants responded that they had also used an online map application. An online map application is an online service that integrates geographic and geotagged information into an open interface that allows a casual user to contribute and retrieve geospatial data. MapQuest was the most popular one listed, with 77% of respondents indicating their use of this site. Google Maps was used by about half (54%),

and GoogleEarth was used by 38%. There were a couple other map applications mentioned: One individual said she used Bing Maps, and one listed the Expedia mapping application as one she commonly used. Almost all of the participants (9 out of 10) stated they commonly used these popular mapping applications for looking up directions to a location. Finding addresses was also a popular use of these applications, with 38% saying they used the maps for this, while 20% stated they used the street view features available on many of these applications.

Table 2. Social Media Usage

Facebook	**Twitter**	**YouTube**	**MySpace**	**Flickr**	**del.icio.us**	**digg**
96%	54%	88%	8%	12%	4%	8%

Table 3. Hours Per Day Spent Using Social Media

0-1	25%
1-3	50%
3+	25%

It is important to note, however, that though most respondents have used a mapping application, 90% of the individuals have never contributed content to a mapping application. This is a marked difference in the number who contribute to other social media applications. The trend of contributing instead of solely retrieving information from popular social media sites is becoming the more prevalent manner for interacting with an online application, and the response of the participants highlights the potential to increase contributions to geospatial applications. All 26 respondents contribute to the popular social media applications, while only three have contributed to a Web 2.0

mapping application. The discrepancy in the number of individuals using the maps to get information and the number of individuals who actively contribute information indicates the potential for extreme growth in the community of geospatial Web 2.0 users, and I suggest modification of these mapping applications might increase the interest and subsequent use of such websites and applications. This study's results from the usability tests and analysis of the participants' interactions and responses to the USA NPN website will support making suggestions to improve one of these mapping applications.

Table 4. Map Application Use

Online Maps Used	% of Use		Used For	% of Use
Google Maps	54%		Directions	88%
MapQuest	77%		Addresses	38%
Google Earth	38%		Street Views	19%
Bing	4%			
Expedia	4%			

Task Results and Analysis

The participants were asked to complete two tasks using the website for the USA National Phenology Network (http://www.usanpn.org/). Task 1 asked the participants to add a trail to their Nature's Notebook account, recording the resultant geographic location. They were provided with the name of the trail and the city and state in which the trail was located. Task 2 also required the participants to locate and add a site to their personal account. The site was a familiar location on their college campus, and they were provided with the city, state, and location name. No street address was provided, and they were again instructed to record the resulting latitude and longitude of the location.

To analyze and evaluate the qualitative task information the researcher first transcribed the audio and screencapture recordings for each participant. Each action or comment was noted, and by using the Grounded Theory Method (Glaser & Strauss 1967) the researcher was able to create categories of actions to evaluate the USA NPN geospatial interface. This method was used to establish the four categories discussed below. To accomplish this, the Grounded Theory Method dictates that a researcher will first start with the raw transcription, make general observations about the information, and then begin to look for patterns in which to further develop theories (Babbie 2004). The researcher was able to specify similar concepts, and from these define distinct categories in which to divide up the participants' actions. A form of bottom-up open coding was utilized, where the categorization of the data is based on the content of the data, and not preformed hypotheses or theories.

A number of themes, or categories of behavior, emerged during Tasks 1 and 2 completions. The participants were able to demonstrate their general knowledge and experience with basic internet functionality and navigation as well as a certain level of comfort using an online interactive mapping interface. However, there were some conditions that caused many of the participants to exhibit confusion, or frustration, or to make errors. Most had a greater degree of difficulty with Task 1 due to unfamiliarity with both the web interface and the location of the site. Also, the USA NPN's terminology, or heading vocabulary (i.e. page names and menu items), caused confusion among most of the participants. Marker movement and manipulation in the Google Maps API, the mapping interface employed by the USA NPN website in the Nature's Notebook, was also a commonly cited issue that caused hesitation and backtracking. Finally, local navigation from one website page to another was observed to be difficult and confusing for many of the participants. The discussion of the results for the two tasks is divided into four sections to expose these issues in greater depth and with illustrative examples. These sections allow the experiences and results extrapolated from the two tasks to be better organized. The sections are: the established experience level of the participants, what was found to be positive or negative in utilizing the map API, the

search functionality of the “Add a Site” page, and general navigation issues encountered in moving through the site.

Table 5. Usability Metrics and Categories of Analysis

Experience Level of Participants	**Positive/Negative Aspects of map API**	**Search Functionality**	**General Navigation Issues**
Behaviors showing basic internet knowledge	Behaviors showing basic user map skills [zoom/grab functions]	Behaviors showing basic search experience	Header/Label vocabulary and terminology
Behaviors showing basic navigational knowledge	Behaviors showing map navigation issues	Situations that show search functionality issues [vocabulary]	Moving between pages in “Nature’s Notebook”
	Map situations that elicit confusion/uncertainty/frustration	Utilization vs. Rejection of search options	

Experience Level of Participants

All of the participants exhibited behaviors that demonstrated a general knowledge of and proficiency with Internet functionality and navigation. Both tasks require the participants to open a new Internet Explorer browser and enter a website address into the address bar. None of the participants displayed any hesitation or confusion with these actions, with the majority copying and pasting the URL given [http://www.usanpn.org/] from the instructions pop-up directly into the address bar. This demonstrated a fair amount of experience in computer use, with some of the participants using the control functions on the keyboard to accomplish the task. Furthermore, website navigational skills were found to be acceptable as determined by the participants observed comfort using the USA NPN homepage, with all of the participants demonstrating proficiency in moving from one page to the next in a web browser. All were able to locate icons on a webpage, recognizing which images were ‘clickable’. Many also used both the universal navigation bar and the local navigation bars to move from page to page during both Task 1 and Task 2. When instructed to “add a site” to his or her personal account, the participants immediately searched the local navigation menu of their Nature’s Notebook page in search of the correct link. This suggests that all participants have had experience

with navigating using a menu. The participants also understood where to look for the latitudinal and longitudinal results of each task, navigating to the area of the page below the map. The participants recognized that what is displayed in the browser window is not all of the content on a page, prompting them to use the scroll bar, another common navigational tool. Furthermore, it can be noted that even when a participant made an error, such as incorrectly entering information into a search box, the participant was able to backtrack to correct the error by using the common navigational tools found on the USA NPN interface.

The participants also displayed a level of proficiency in manipulating the Google Map API found on the USA NPN interface. Common actions employed when using a digital map application were used by all of the participants, including the zoom function and map manipulation via the grab function. Those participants that opted to search for the location in Task 1 using only the map interface all used the zoom function (zoom bar found on the left-hand side of the map) to achieve a more magnified projection, by zooming in, of the general region in which the site was located. Those that chose to use the search boxes for Task 1 also used the zoom function on the resulting map. This was done in an attempt to ascertain the resultant location either by zooming out to get an understanding of the surrounding area or to zoom in to further refine the location result. However, both situations illustrate the participants' understanding and knowledge of the zoom function found in many popular online mapping applications and establish a baseline proficiency that the researcher used in evaluating issues encountered with the USA NPN map API.

The grab functionality was also utilized by all of the study participants. With no instructions or prompting, all but one participant adjusted the map view by 'grabbing' the map image via mouse click and holding and dragging the image in the map window to view another area. Many executed this action multiple times during each task, using their knowledge of map functionality to achieve their intentions. This was especially apparent in the completion of Task 2, where the participants' search results gave a location near downtown Knoxville, and each (if they elected to do so) had to move the field of view east to locate Circle Park and place the marker. As noted, Circle Park is a familiar

location on the campus of the University of Tennessee Knoxville that the participants could easily identify on a geopolitical map. Participant 1 did not use the grab function available, but instead manipulated the map and the resulting field of view by using the four arrow keys available in the top left corner of the map. However, this accomplished the same objective, moving the viewable map area to the participant's desired location. Again, the pervasive use of the grab function by the study participants demonstrates basic digital map literacy and a geospatial knowledge that was used when assessing the common issues met during the task completion.

Positive/Negative Aspects of Map API

Establishing a baseline experience level with online mapping applications allowed for the inspection and evaluation of user navigation issues that arose while utilizing the map API. Though there were not a large number of issues associated with navigating and manipulating the map, those that did occur were either by those participants who chose to solely use the map to search the locations or by participants that completely failed to consult the map to verify location accuracy. One participant elected to forgo the search boxes available above the map API, instead attempting to locate the Task 1 site by manual map manipulation. Though able to execute basic tasks using the map (such as zoom and grab), this participant expressed confusion and uncertainty about how to use the map a number of times. Knowing that this participant needed to find a location in Georgia, she moved the field of view so that it was located over the east coast of the United States, zooming in on the southeast. At this point she voiced her confusion, stating, "…I'm on Florida…I don't know." The participant continued to exhibit confusion over how to manually find the location, zooming in and out and adjusting the view multiple times in manipulating her map view over Georgia. Finally, the participant expressed her frustration with using the manual search option to find the Task 1 location, and backtracked in an attempt to find the site via the search boxes located above the map API. Though not insignificant, this confusion and frustration may also be due to the participant's unfamiliarity with the Task 1 location. While the participant was able to

demonstrate proficiency with using the map, the participant wasn't aware of where the Tsalaki Trail was located in Georgia, and so was unable to focus her efforts on a specific region.

The other map navigation issues arose with participants who incorrectly labeled sites due to a disregard for the map results. While most participants searched for the locations with the search box options and then verified correctness by consulting the map, two participants erred by not viewing the map following search box entry. Instead, both scrolled right past the map to the resulting latitude and longitude without consulting the map for more than a glance, and subsequently recording the numbers. Both instances occurred during Task 1 completion, however. When the participants were familiar with the location sought, as was the case with Circle Park in Task 2, both that neglected to inspect the map in Task 1 consulted the resulting map in Task 2 to verify location accuracy.

A discussion of the relation between Tasks 1 and 2, the success and failure rates of these, as well as the time taken to complete the tasks, is pertinent when examining the usability of the USA NPN map application. Four of the six participants recorded the incorrect coordinates for Task 1. All four individuals entered the geographic location that initially was displayed after searching "Cleveland, TN." Two retrieved the coordinates for the center of downtown Cleveland, TN, and two retrieved the results for the intersection of two roads in the Cleveland, TN area (New Bethel Church Road and 441 Club Road). It is interesting to note that all four of these participants entered the same data into the search fields, yet the location results were different. This is an issue with the map interface that may be investigated later. However, all four of these participants took the location results initially displayed and recorded them as their correct answer. This may suggest something about the map literacy level of the participants, with the individuals incorrectly assuming that the map interface will immediately provide the correct location. Failing to consult and verify the accuracy of the resulting location implies the participants did not feel the need to assess the validity of their results. Though some completed the task in a relatively short time period (in comparison to the other participants), one of the failure cases spent the longest on this task, about 5.5

minutes, so this doesn't necessarily imply that the incorrect locations were failures because of a lack of task commitment.

However, the two that did complete Task 1 with correct coordinates did take a significantly longer amount of time in completing the task, with one taking over 3 minutes and another taking over 5 minutes (as seen in Table 6). Though they were able to complete the task correctly, this indicates issues with the usability of the map application. The application was designed for a user to complete a search such as this in a significantly shorter amount of time, and the fact that those that are able to correctly find a location took substantial amounts of time is worth noting.

The times taken to complete the tasks in relation to resulting coordinate accuracy merits discussion. As illustrated in Tables 6 and 7, three who did not answer Task 1 correctly answered Task 2 correctly, and in much shorter times. One cut the completion time by 2 minutes, taking 3.75 minutes on the first task and only 1.22 minutes on the second. This is an improvement of over 200%, a very significant amount of time. This may suggest the learnability of the map application is quite reasonable, allowing participants greater ease of use and better knowledge of the application after only one use. Also, the participant that was able to complete both Tasks 1 and two with the correct coordinates improved her time from over 5 minutes for Task 1 to slightly over 1 minute for Task 2. Though this may be partly due to a greater familiarity with the location required for Task 2, the learnability of the map application is likely to have influenced this dramatic difference in time taken to complete the tasks.

Table 6. Completion Times on Task 1 and Task 2

Participant	Task 2 Completion Time	Correct/Incorrect
P1	1.82	Incorrect
P2	1.33	Incorrect
P3	3.13	Correct
P4	1.18	Correct
P5	1.48	Correct
P6	1.22	Correct

Table 7. Errors on Tasks 1 and 2

Participant	Task 1	Task 2
P1	Incorrect	Incorrect
P2	Correct	Incorrect
P3	Incorrect	Correct
P4	Correct	Correct
P5	Incorrect	Correct
P6	Incorrect	Correct
No. Correct/Incorrect	2 Correct/4 Incorrect	4 Correct/2 Incorrect

Search Functionality

The majority of the usability issues uncovered during the completion of Tasks 1 and 2 were found to be associated with the search options available to the participants. Confusion arose when attempting to decipher the type of data and information that was to be entered into the search boxes. All participants demonstrated a basic familiarity with using geospatial search boxes to look for a location, most confidently entering the city and state into the correct boxes when searching for both the Tsalaki Trail and Circle Park. However, error arose when the participants attempted to enter information into the "Site Name" and "Address" boxes available in the search section of the page. None attempted to enter "Tsalaki Trail" into the "Address" field, assuming this was for the traditional and common street address only. However, the real confusion centered on using the "Site Name" box. Some participants did not immediately understand that this was a field in which a user-generated label was required. Many hovered with their mouse over the box

for several seconds, illustrating a hesitation and confusion with the purpose of the field. One participant remarked, "…I don't know what to enter for this. Just make up a name?" Three did not initially insert anything into the field, scrolling down further to investigate the other search options before backtracking to the "Site Name" field to enter a form of "Tsalaki Trail." One participant confused the "Site Name" box with the "Address Box", inserting "trail" into the "Address" and subsequently backtracking later to correct the error after consulting the map. Another participant completely misunderstood the purpose of the "Site Name" box, entering "office" (which was a suggested site name in the website instructions) into the field. Again, however, she recognized her error after further experience with the map, and backtracked to rectify her mistake. Though all were able to correct the errors eventually, frustration was exhibited at the vagueness of the vocabulary used, and many wasted time in backtracking to fix the discovered mistake. This was reinforced in the exit interviews with the participants, and was a factor in their overall impression of the usefulness of the site.

The "City" box was neglected by some of the participants as well. Though clearly given in the task instructions, some participants elected to use only the "Site Name" box and the "State" box to initially search for the assigned location. One participant entered "Tsalaki Trail" into the "Site Name" box and then "Georgia" into the "State" box in Task 1, then scrolled down to view the resulting map. Only after realizing this was not enough detail to provide a relevant region on the map view, he returned to further refine the search by adding a city to the correct search box. This may have created an error due to his assumption that the "Site Name" box information was used in the map search algorithm, with the resultant map reflecting the data he entered. However, as this box only provides a user-generated name or tag to the associated site, it has no influence over what the map API will display. By separating this field from the other search options may reduce user confusion about the "Site Name" association with the "Address", "City" and "State" search boxes. Clearly identifying the "Site Name" box as a user-generated naming option, either with a mouse hover explanation or a "What is this?" click for help link, may reduce time taken to search for a site by lessening confusion over its relationship to the other search boxes.

General Navigation Issues

An interesting and unexpected result of the study was revealing user confusion and resultant difficulty in navigating the website due to the vocabulary employed in the website menus and icons. In first navigating the USA NPN homepage the participants were asked to enter personal site via the "Nature's Notebook" icon at the top right of the page. Though all were able to accomplish this with little difficulty, many commented on the naming choice. One participant remarked "…Uhhhh, ok…Nature's Notebook…not quite sure what that is, but okay." There was no indication of the purpose of the icon and page link, but the participants were able to navigate to the page because the task instructions explicitly directed them to the icon. However, if asked to simply 'navigate to your personal account,' it is likely that many wouldn't have identified the "Nature's Notebook" icon as the correct link to click. More clearly identifying the purpose of the "Nature's Notebook" with a small description (available on hover), or by completely changing the name of this feature to more clearly reflect its purpose would reduce confusion while navigating the website.

Major navigation issues resulted when the participants were required to use the left-hand local navigation menu in their "Nature's Notebook" to add sites to their account. The label "Add a Site" stood out as particularly confusing to most participants, with many hesitating before clicking on the menu item. One participant read the instructions for Task 1 and then proceeded to hover her mouse over the "Add a Site" text before asking the facilitator "…am I adding a new site?" Another participant did the same thing, hovering over the "Add a Site" menu item before asking the researcher "…go to add a new site?" The task instructions provided used the USA NPN vocabulary, asking the participant to "add a site to their Nature's Notebook." However, the terminology still confused many participants, not clearly conveying what the menu item was used to accomplish. This implies that a first time user of the site who does not have instructions available to them may have even greater difficulty in navigating to the correct page in which they would be able to contribute data.

Label vocabulary also was a source of confusion and error when attempting to navigate from the first task to the second task. The participants were required to navigate

away from the newly created site back to their personal account page ("Nature's Notebook Home") before navigating to a new page in which they can add another site. All but one of the participants executed the same sequence of tasks in an attempt to add an additional site. The participants recorded the latitude and longitude for Task 1, and then selected the "Add a New Site" option on the left-hand navigation menu. No action would result, leading to hesitation and confusion for the participants, with many scrolling the page to verify that no action had taken place. After the initial confusion, the participants all selected "Nature's Notebook Home" from the menu, returning to the original personal account page. Once here they realized a small icon was located under the "My Sites" box that also offered the opportunity to "Add a New Site." Only when they clicked on this button were they directed to the map interface once again. This appeared to be an error in the architecture of the website, and did indeed cause confusion for all the participants. The left-hand menu is the intuitive location for local navigation options for the user, with the participants assuming this menu would provide the link to accomplish their task. When it did not achieve the desired outcome the participants exhibited confusion and hesitated to act further, resulting in wasted task time. One participant remarked after the failed attempt at selecting "Add a New Site" from the left-menu, "…So add a new site. Is that what it's wanting me to do?" When the desired and expected result was not initially achieved, the participant questioned her actions. Utilizing common organizational and navigational features of similar websites would prove beneficial, allowing the user to reduce mental load by referring to previous experiences.

Exit Interview Results

The researcher conducted exit interviews with the volunteer participants immediately after completion of the two tasks. They were asked questions regarding their experiences using the USA NPN site to complete Tasks 1 and 2 as well as questions to ascertain their affective cognitive responses to the experiences. The exit interview demonstrated an even distribution among the participants regarding their perceptions of task difficulty. Additionally, it is interesting to note that few commonalities emerged in the interviews regarding features the individuals liked. The participants also revealed usability problems, with most easily identifying and discussing their experiences. The success rates of participant task completion are illustrated in Figures 2 and 3, found on the following page.

When asked about their overall experience using the USA NPN, two participants responded that they had had a positive experience completing the two tasks. One participant remarked that she "…found it pretty easy to use, nothing too difficult." Three participants stated they had a neutral impression of the site after completion, with two of these asserting that they had negative feelings about the site as well. Most of the comments related to usability issues they encountered during task completion. This may be ascribed to an unfamiliarity with the website, although distinct and common usability issues were evident during task completion, and talked about by the participants during the exit interviews. These will be discussed in greater detail as perceived by the volunteers, illuminating not only the "what", but the "why."

The major complaints about the website were centered on the search options available to the participants when trying to look up a location. One participant remarked "…The lack of a clear address search box made it really hard to search without using the map." The terminology utilized as labels for the search options was a ubiquitous problem for the participants as already noted in the Task Analysis section. One remarked she found that "…doing the naming was a little difficult. I have to figure out which field was used for what." And indeed, the suggestion of improving the search functionality when looking up a specific location in the Nature's Notebook was commonly cited by the

participants when they were asked to name a single improvement to the USA NPN website. These suggestions were from participants who responded with a negative overall impression of the site, and corresponded directly with the major usability issues uncovered during task analysis. The “Site Name” field was confused for the traditional “Address” field, causing some of the participants to incorrectly enter location data into the “Site Name” field. One remarked, “…the search boxes were not clear, and the ability to use the box to enter an address was not clear…”.

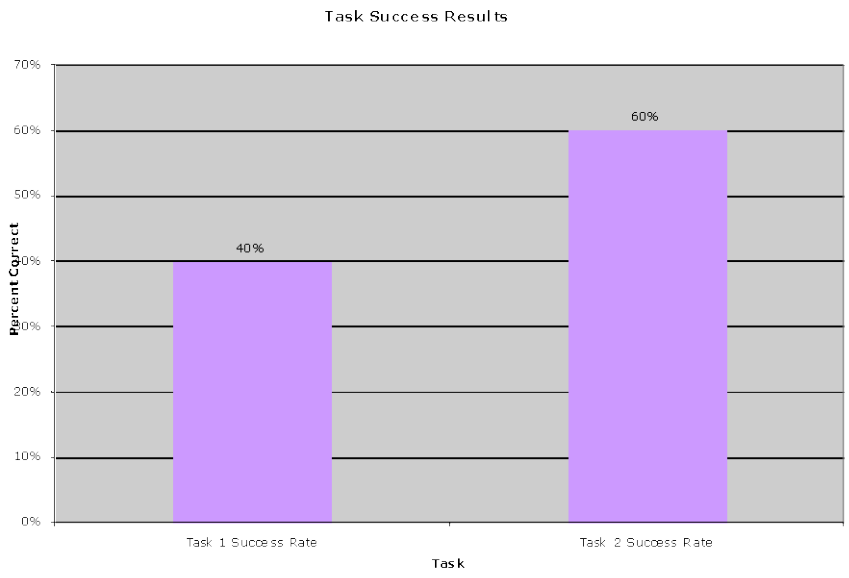

Figure 2. Task Success

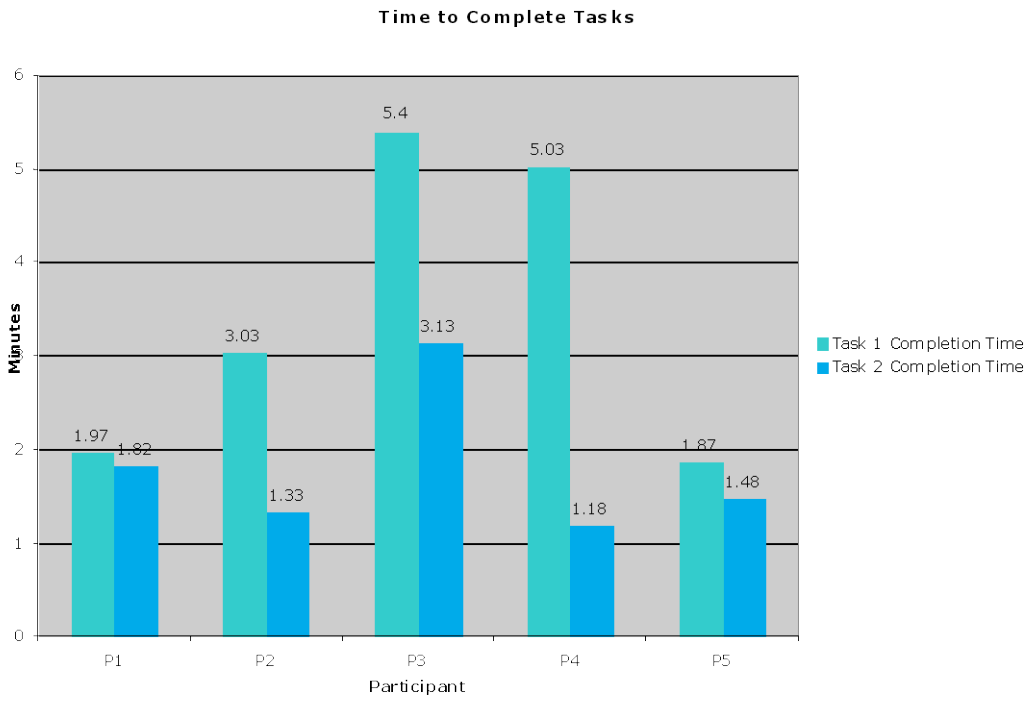

Figure 3. Time to Complete Tasks

Some found that the lack of familiarity with the location of the first site made using the search options more difficult (see Figure 4). Another participant stated she "…had no idea where Cleveland, GA was, and using the map and search was not easy to find it." Another suggestion for improvement was to imbed an address-locating application, where an individual could take a place name (such as a trail name or store name) and search the exact address. One even referenced the Google Maps interface, stating that she "…would make it like the Google Maps search screen." Though not necessarily the only factor, the inability to easily search a location led to an overall negative opinion of the USA NPN.

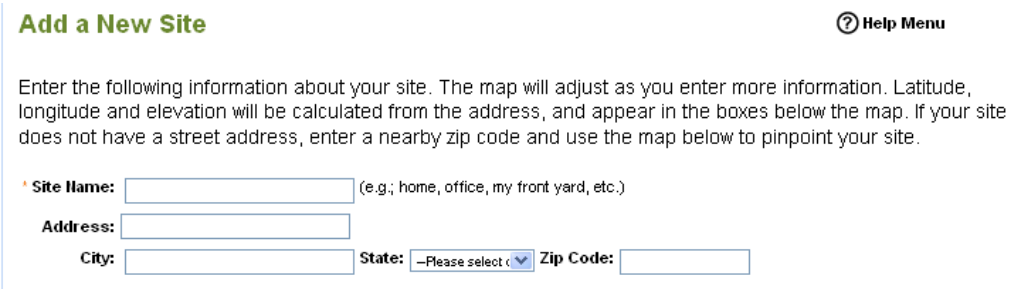

Figure 4. Search Options

One very interesting finding, however, was uncovered when looking up a location familiar to the participants. This occurred in Task 2, with the participants expressing much less frustration in utilizing the search options. The same participant stated "…I was definitely more familiar with the area I was looking for, but I don't think I could have done it if I didn't know exactly where Circle Park was." This may also be ascribed to a greater familiarity with how the website functions. Indeed, when asked how they felt about Task 2 compared to Task 1, all of the participants responded they found Task 2 to be easier. It should be noted that this is the opposite result of the researcher's prediction. The participants expressed greater confidence with the completion of task two, and felt "…way more confident adding a site after only one try." This was an unexpected result,

as Task 2 did not contain a specific address. Many expressed the presence of a learning curve associated with correctly using the "Nature's Notebook," but all seemed to exhibit greater confidence on the second attempt at adding a location. One participant remarked Task 2 was "…super easy. I knew what to do at that point." Task 1 appeared to be a learning experience or trial attempt for the majority of the users, and all demonstrated less hesitation and greater confidence while completing Task 2. Another participant stated "…after I 'cracked the code,' I felt pretty good about my experience." However, he did mention he felt the site had a steep learning curve when referencing the search options and functionality, and would benefit from modifications to make contributing user data easier. Others expressed the difficulty in learning to use the application, but demonstrated increased self-assurance after the first task. The confidence among participants can be ascribed to a greater familiarity with the website, but may also be due to the greater familiarity with the location in Task 2, which is a geographic site that most visit on a daily basis (as discussed in the Task Analysis section). One participant recognized this, saying "…I am very familiar with Knoxville, so it wasn't hard at all to use the map." Further investigation with first-time users adding only unfamiliar locations would give more complete results regarding the usability and learning curve associated with the "Add a Site" feature of the USA NPN.

The presence of the map interface mitigated some of the search issues. When asked about their favorite features of the site, over half the participants responded that the mapping programmable application interface (map API) was a good resource when looking up an unfamiliar location. One participant responded "…I liked that you could just move the map around instead of looking up an address if you needed to." The topographic layer was also appreciated, especially in the context of finding a location in a rural area without a straightforward address. Using satellite map images indicates an understanding of the primary user of the site, appealing to individuals who wish to add locations outside town and city limits in wilderness areas. Many found the map option very familiar, with one participant remarking "…the map on the 'Add a Site' page was nice, as I was pretty familiar with using a map like that." The sample population from which the participants were selected all responded to the questionnaire as having a

general familiarity and previous experience with mapping applications, and though some of the participants exhibited difficulty in using the map API as the primary search option, all demonstrated a general level of comfort and basic knowledge of how to use the application. The general ubiquity of the Google Maps API (which is employed on the USA NPN) contributes to the usability of the application, as many individuals are familiar with the functionality of such an application. This was clearly evident during task completion, with all participants demonstrating basic online map skills and knowledge. The ability to use the map to search became and important option when some found difficulty employing the search boxes to locate the site.

The focus and organization of the homepage was another feature that participants asserted they would change about the website. Only one participant expressed a positive first impression of the website, with the others remaining either neutral or having a negative feeling toward the homepage. Most liked the idea behind the website (the ability to contribute meaningful scientific information), but felt the homepage did not emphasize contribution at all. One participant noted that if "…the primary aspect of the site is getting people to contribute, that should be totally obvious when someone first goes to the page. Secondary information should be on another page." Many were confused about the purpose of the website, wondering if the site was merely an informative page or one in which you were "…supposed to add sites you enjoy?" Furthermore, all the participants exhibited difficulty in navigating the website. This was illustrated during both task analysis and exit interviews, with participants citing the navigation menus and vocabulary employed as confusing and hard to use. One participant remarked that the most difficult part of the first task was "…getting to the actual screen where you add the information. I feel like there were too many steps to get there, and I didn't really know how to get there or what to do."

Even though all participants exhibited actions during task completion indicating basic web skills (such as locating an icon), many remarked that having the "Nature's Notebook" icon at the top of the screen without an explanation of purpose was confusing. One participant remarked that he did not have much difficulty in using the actual site, but noted that without the explicit directions provided to him he "…wouldn't have known

that to add content I had to click on the button [Nature's Notebook icon] at the top of the screen." Creating a more explicit or recognizable option directing new users to add content is a solution to this navigation issue. Terminology in the navigation menus was cited multiple times, the most prominent being the "Add a Site" header. The participants found this wording confusing, expressing that this was not the most intuitive or effective phrase available to indicate the contribution page. One participant remarked she "…thought the terminology was kind of strange, and I didn't know if this was the right thing to click on…maybe they should have used wording that better corresponds with the site." Again this is reinforced by the task analysis, where many participants hesitated or remained stagnant for a significant amount of time before selecting the "Add a Site" option. This is a significant issue, as users who find an interface difficult to navigate are less likely to use the site or return to the site in the future.

Figure 5. Nature's Notebook Icon on Homepage

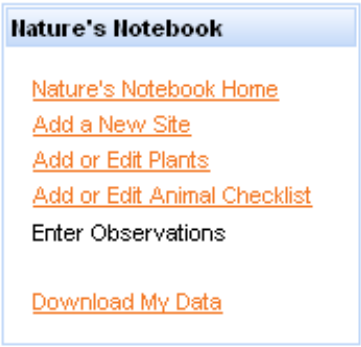

Figure 6. Nature's Notebook Navigation Menu

It must be noted, however, that participants appreciated some aspects of the navigation. Some cited the ability to either browse the informative pages or go directly to

their personal account as clear options from the homepage. This is likely due to the organization of similar task options on the USA NPN homepage, with the general information links grouped together in the center of the page. Personalized, or sign-in options could be found along the top universal navigation bar, and like the information pages, were grouped together to alleviate user confusion. Additionally, participants referred to the use of universal navigation menus as a helpful feature. One participant stated that she "…liked that the Nature's Notebook was right up at the top of the page, and stayed at the top across the pages. Also, the side menu when you got into the Nature's Notebook stayed there as well, which was nice." Uniformity and recognizable options contributed to task completion among participants and subsequent feelings of success following the assigned exercises. However, it should be noted that the task instructions gave explicit directions for where to locate the "Nature's Notebook" icon on the USA NPN homepage. The participants were not tested on their ability to navigate the site as a whole, and this could benefit from further investigation.

Almost all of the participants asserted that they either felt the same or more confident about using the site when they completed the two tasks. The only participant to express negative feelings about the USA NPN following task completion stated she "…didn't think the site was very inviting at all…learning how to add specific locations was pretty hard." However, all the other volunteer participants expressed overall positive opinions regarding the USA NPN interface. One stated "…I thought the site was pleasing-looking…I thought the homepage was pretty." The homepage and subsequent pages did not appear to affect the participants one way or the other, with most expressing neither a negative nor a positive reaction to the appearance and overall design on the website. This may be attributed to a lack of observation or attention to detail on the part of the individual participants. One participant claimed she "…felt pretty neutral about the site as a whole." Another spoke of how she felt the website was very similar to many other websites, indicating the design of the USA NPN site had a familiar layout which may have led to ease of initial use for some of the participants. Recognizing commonalities with well-known websites will often increase an individual's confidence in utilizing a new site, as they assume that many of the features (such as the presence or

navigation bars in normal locations on the page) of the new site will operate in a similar fashion to the previously encountered website. Furthermore, most expressed a greater confidence following task 2 completion, asserting they now felt they could add sites faster and with little difficulty.

Yet, the site did not appear to make a substantial impression on the participants. One stated, "…I felt the same as when I started. The website served it's purpose." It appears there was not anything unique or substantial on the USA NPN site that grabbed the participants' attention. Many were surer of their abilities to contribute data to the site, but all stated they would not expect to use the site again in their daily lives. Most cited a lack of interest in the subject and purpose of the website, a valid reason, but this highlights an area of possible improvement. By emphasizing how phenology can be useful and accessible to a wider range of people might generate greater enthusiasm in the citizen scientist community. One participant remarked he would likely use the site if "…there was more emphasis on the community aspects of the site, and [it] was modeled a little more like other social websites." Making the website more appealing to the audience of social media and Web 2.0 users may increase the popularity and interest in participating in data contributions sought by the USA NPN.

CHAPTER V
CONCLUSIONS AND RECOMMENDATIONS

Discussion

The research was originally begun to examine the efficacy of the USA NPN mapping application in allowing the casual Web 2.0 user to contribute meaningful data in a 'citizen science' setting. Though many interesting findings related to the use of geospatial applications by the non-technical user were discovered, the study also illuminated some unexpected usability issues with the website as a whole. The researcher found that most participants experienced little trouble in using the actual map API to locate the sites, but instead encountered difficulty in deciding whether to use the search box options or the actual map in finding the task locations. Additionally, the vocabulary employed on the website caused confusion for the participants. Some of the terminology was field-specific, but some headers and language seemed unintuitive for the task. Many remarked that the labels didn't properly explain or describe their purpose, which led to greater confusion during task completion. In this section the results of the study will be broken down into three sections: (1) the lessons learned from the research and what these findings may mean for the overall website design, (2) what the findings mean in the context of the geospatial and social media communities, (3) and suggestions for future research.

Lessons Learned and Suggestions for Improvement

Overall, the USA NPN mapping application proved to be fairly easy to use for the participants. Due to the ubiquity and growing popularity of Web 2.0 maps and applications (i.e. MapQuest, Google Maps, Open Street Maps, etc.), many individuals have a basic geographic/cartographic knowledge and literacy when using digital maps. Hence, the participants did not have much difficulty in using the actual map. All the participants exhibited basic map skills, such as the ability to zoom in and out on the map or manipulate the field of view. The greatest area of difficulty with the map API came from the search functionality provided by the application. Some participants were

confused by the search box choices, which resulted in the decision to search the location of Task 1 using the map only. Though the correct location could indeed be found this way, the method proved unsuccessful for both participants and resulted in their use of the search boxes to rectify their error.

A major discovery involved the confusion about the search box options, revealing this issue was due to the vocabulary chosen for some of the field names. Though most individuals are familiar with the common search options, including 'Address', 'City', and 'State', adding the "Site Name" field title directly above these boxes led to participant confusion over the purpose of each box. "Site Name" and "Address" seemed to be confused regularly, with one participant remarking "…the ability to use the box to enter an address was not clear, and I missed it at first" during the exit interview in reference to the vocabulary. By either changing the field name to something more intuitive to the casual user or by separating and delineating this field, user confusion will likely be diminished. Clearly indicating that the "Site Name" box is to be filled with a user-created label will clarify that the box is not intended to contain data that will influence the resulting map location.

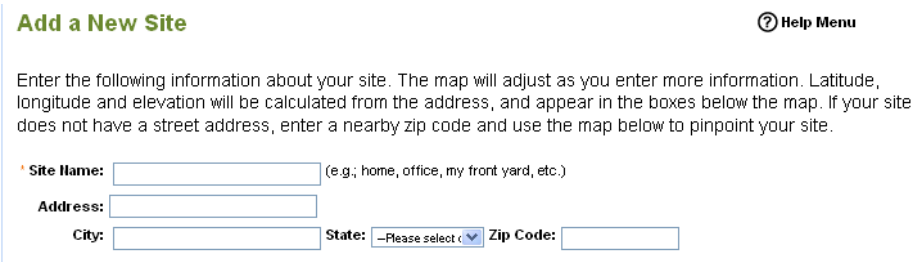

Figure 7. Nature's Notebook Search Options

The other major usability issue uncovered during the study related to the search function issue, but on a broad, site-wide scale. The resulting errors and usability problems all centered on the website 'jargon,' or labeling vocabulary. Some of these labels seemed directed to a more specialized audience, and some did not clearly indicate their purpose or what result the user would achieve by clicking on them. The "Nature's Notebook" icon and the "Add a Site" label in the local navigation menu were two

illustrative instances of confusing vocabulary selections. One of the participants suggested that "…I thought I was going to find a location, and they should have used wording that better corresponds to this" in reference to the "Add a Site" menu option. Though there appeared to be a consistent use of terminology across the pages on the USA NPN website, considering the scope of the audience in determining the vocabulary utilized for important navigational links. If the USA NPN is interested in increasing interest among citizen scientists and not necessarily individuals specialized in a scientific field it might be prudent to define more specifically the user groups. Tailoring the labeling to multiple groups by making the terminology as clear and basic as possible may be one way to reduce confusion and errors. Alternately, the specific user groups may be defined, and the website may be restructured to cater to these particular groups. If the main user groups are found to be citizen scientists and researchers in the fields associated with phenology, it may prove effective to section the website so that one group is exposed to language and vocabulary more tailored to their experience level while the other will navigate to a page better suited to their needs.

An additional theme emerged during the exit interviews that were not necessarily evident during task completion. Though the participants were able to complete the tasks as requested, many found they still did not understand the purpose of the site once they had finished the two tasks. This may be due to the structuring of the tasks, not allowing the participant time to browse the other pages of the site. However, many commented that they did not feel that the homepage "properly" emphasized user contributions. This related to many other comments about the future use of the site. When asked if the participants would use the site in their real life, all answered they would not. However, all participants hedged this statement with the caveat that they would consider using the USA NPN if they had an "interest in observing nature." Clearly indicating on the homepage of the site the ability and benefits of contributing user data could increase public interest and participation in the program. One participant directly articulated this during the exit interview, stating "…if the main goal of the site is to gather information from the users, they should focus the content here [on the homepage] on what they are most trying to do, which is get contributions." Furthermore, the USA NPN could

increase participation among the study participant demographic, the casual Web 2.0 user, by emphasizing the social media aspects involved in contributing data. Many of the participants indicated they enjoyed spending time outdoors, and so by creating a larger atmosphere of 'community' in contributing data to USA NPN, greater interest in the environmental aspects could increase. When asked about his general feelings toward online mapping applications in general, one participant remarked "…I think these maps increase the awareness of the area around you, and help develop a greater sense of community." By leveraging the popular social media trends of crowdsourcing and connection through online contribution, the USA NPN could garner a new group of users with significant data to supply.

Comparison with Earlier Studies

This study corresponds very closely with previous research conducted in the fields of usability, geospatial applications, and the Web 2.0 environment. However, the research done here was able to combine these three disciplines, contextualizing their use in a novel way. The importance of online geospatial tools has been enumerated by many in the last decade, as applications and software like Google Earth and Mapquest provide a new platform for GIS information and datasets to be utilized in online functions (Oberlies et al 2009). In conjunction with this, the interest and popularity of public participation in contributing geographic information is on the rise, as noted by many researchers (Goodchild 2007, Bugs et al. 2010). To leverage these two trends and produce easily accessible applications for the casual Web 2.0 participant, usability testing needs to occur to maximize the potential for crowdsourced geospatial and scientific information collection and dissemination.

There have been preliminary investigations and research into the trend of user participation in generating or editing digital maps (Hudson-Smith et al. 2010, Crampton 2009), with this study further contributing to the knowledge of how individuals interact with these mapping applications. This research uncovered that many casual Web 2.0 users are familiar with popular mapping applications, and have a basic skill/knowledge base from which they may use information to effectively use and interact with a new map

API such as the USA NPN. This study highlights the need for a simple and easily usable interface in which to house the Web 2.0 geospatial application, as previous research has clearly indicated the complexities inherent in using geospatial data (Eicher et al. 2010). By streamlining and simplifying the USA NPN homepage and personal account portal ("Nature's Notebook"), individuals will have a reduction in mental workload when attempting to contribute environmental and geographic information to the application.

Case studies and usability tests previously conducted on various online geospatial applications have produced findings that are in accordance with the results of this study. As enumerated by many researchers in the field of general usability, there are metrics that can test the efficacy of a given system. Proper evaluation of usability testing metric results can (1) improve consistency of user transactions, (2) minimize input actions by the user, (3) minimize the memory load, and (4) improve the flexibility for user control (Shneiderman et al. 2010). Research has been conducted on some of the popular applications, with one researcher reaching the conclusion "... for non-expert users, time is lost when choosing color palettes, classifying ranges, moving around the maps and trying to interpret complex statistics rather than gaining knowledge and insight from the data" (Jones et al. 2009). Another study conducted on the US Census Bureau DataMap led the researcher to assert that simplifying the interface and providing a help section to new users (Plaisant 2004). This is concurrent with the results of this study, with the participants finding the interface difficult to navigate as well as confusion over search functionality.

Future Research

This study has illuminated many potential future research opportunities for the USA NPN website as well as general geospatial online mapping applications. A comprehensive usability test of the entire USA National Phenology site would further reveal and refine some of the most critical usability issues associated with navigating and utilizing the website. This study only examined the use of the geospatial application by a very specific demographic of college Web 2.0 users. Conducting studies of different user groups would gather knowledge of how different demographics interact and use the site. Additionally, further usability testing of the Nature's Notebook, or personal account

would be beneficial. This research conducted here illuminated the difference in confidence and success between the two tasks, which could be a result of the participants' familiarity with one of the locations. By conducting a study where familiarity with the locations was the only independent variable (instead of have multiple variables, such a knowledge of the discipline or experience level with the application), further information about how the user interacts with the site will be gained. Lastly, a navigation stress test could aid the site designers in setting up the website architecture to make it more easily navigable for the user.

The study results are also extensible to the online geospatial community as a whole. The question of what constitutes general online map literacy is an important one is developing future geospatial applications. Further research aimed at establishing a solid and discrete definition of this map literacy will aid developers in tailoring the interface of the online map application to best serve the user.

Conclusion

It must be recognized that the study was not a comprehensive investigation of all the features of the USA NPN website. The results describe specific aspects of the application and not a full usability evaluation of the site. Additionally, the study used a convenience sample of potential users, volunteer undergraduate students from the College of Communication at the University of Tennessee, Knoxville. Using this demographic, sample populations were inherently left out. However, by utilizing this demographic the research garnered a representative sample of casual Web 2.0 participants who were able to simulate the first time user in which the researcher aimed to investigate.

The study was constructed to investigate what usability issues arose when the casual user contributed content to the USA National Phenology Network. Navigation and website vocabulary were identified as issues. Furthermore, the search options available to the participants for contributing geospatial data were found to be confusing and difficult to utilize. This study contributes to the growing body of knowledge about the usability of Web 2.0 geospatial applications, furthering the objective of creating

systems in which usability is a primary goal in aiding users in contributing diverse and cross-disciplinary geospatial data to an online community. Issues identified in the course of the research are significant in the creation of a more efficient interface in which casual Web 2.0 participants can contribute and subsequently access accurate geospatial information. The use of place-based relevance searching in is increasing in popularity, and though this research focuses on a single mapping application of the USA National Phenology Network, the data collected here is extensible to other similar online geospatial resources.

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APPENDIX

Instruments

Screener

I. Demographic information

1. Gender
    a. Male
    b. Female
2. Age:
3. College
    a. Agriculture
    b. Architecture
    c. Arts & Sciences
    d. Communication and Information
    e. Education
    f. Engineering
    g. Nursing
4. Current year of study/academic standing
    a. Freshman
    b. Sophomore
    c. Junior
    d. Senior
5. Academic Status
    a. Full-Time Student
    b. Part-Time Student
    c. Other If Other, please specify:

II. Experience

1. How often do you use the internet for the following activities? (use Likert Scale for each)
    a. Email
    b. Schoolwork/Research
    c. Social Networking (Facebook, Twitter, etc.)
    d. Gaming
    e. Shopping
    f. News

2. Have you used any social media/Web 2.0 applications (these would include websites like Facebook.com, MySpace.com, Twitter, etc)?

a. Yes

b. No [If no, terminate questioning]

3. Which social media/Web 2.0 applications do you regularly use (at least once a week)? Please check all that apply.

___Facebook

___Twitter

___MySpace

___YouTube

___del.icio.us

___digg

___flickr

4. How many hours, per day, do you estimate you use social media/Web 2.0 applications?

a. 0-1

b. 1-3

c. 3+

5. Have you ever contributed content (ex. photos, comment, blog posts) to a social media/Web 2.0 application?

a. Yes

b. No [If no, terminate questioning]

III. Geographic Experience

1. Have you ever used an online map application (MapQuest, GoogleEarth, etc)?

a. Yes

b. No [If no, terminate questioning]

2. Which one(s) have you used?

3. What was the main purpose in using the application(s) (ex. looking up an address, getting directions to a location, viewing satellite photos of a place)?

4. Have you ever contributed content (ex. photos, tags, comments) to an online mapping application?

a. Yes

b. No

5. Have you ever used/visited the National Phenology Network's website?

a. Yes [If yes, terminate questioning]

b. No

“Thank you for answering these questions. You have been selected to participate in a research study involving the USA National Phenology Network website. The study is estimated to last 50 minutes, and would involve the completion of tasks using the USA National Phenology Network. Would you like to participate?”

a. Yes--> Name:

Contact Phone:

Email:

b. No--> Thank you for your time.

Informed Consent Form

INTRODUCTION

Thank you for your interest in participating in this research study. The purpose of this study is to see how easy or difficult it is for an individual to contribute content to an unfamiliar website. If you consent to participate you will use the website for the USA National Phenology Network to complete two tasks. The goal is to identify issues with the usefulness of the website in the hopes of modifying and improving the website for future use.

INFORMATION ABOUT PARTICIPANTS' INVOLVEMENT IN THE STUDY

First, you will receive (via email) a short questionnaire that will be used to gain some background information for the researcher to obtain an understanding of your individual level of experience with both the internet and geographic tools. If you are selected, you will then be invited to an individual study session. This study will be performed in the CCI-ORNL User Experience Lab in the Communications Building and the University of Tennessee, Knoxville. You will be asked to complete two tasks using the website for the USA National Phenology Network, and to give your thoughts and opinions about the website as you use it. You will complete these tasks using a desktop computer with software that will audio record your voice as you move through the tasks. After both tasks have been completed, you will be asked (individually) questions by the principal investigator about your experiences in completing the two tasks. This interview will also be audio recorded. Any and all information gathered during the session will be kept strictly confidential, and will only be reviewed by the principle researcher. Additionally, any identifying information that would link you to the data collected during the study would be separated from the results.

The entire session will take no more than one hour, and will be conducted in a single session.

RISKS

The nature of the proposed research does not pose significant risks to volunteer participants. There is no physical, mental, or emotional danger involved in using the USA National Phenology network in completing the proposed tasks. The only potential risk in participating in the study would involve your privacy. However, the researcher will perform the study with the utmost care, and has listed all measures taken to maintain confidentiality in the section below. You may choose to end the session at any time without any penalties, and all information collected to that point will be destroyed.

BENEFITS

Risks for participation in the study are minimal, and the benefits of the study is an increase in knowledge in the field of Web 2.0 geospatial application usability. With the data collected from the proposed study, the researcher aims to identify the most common usability issues found with the geospatial Web 2.0 application.

CONFIDENTIALITY

Data will be stored securely and will be made available only to persons conducting the study (the principle investigator) unless participants specifically give permission in writing to do otherwise. No reference will be made in oral or written reports which could link participants to the study. Your name and contact information will be stored in a secondary, secure database for use solely by the principal researcher. No other individual will have access to this data, and it will only be used to contact and establish study sessions for each participant and for the drawing. This information will not be associated or linked to your study results. Any audio recordings will be stored on a secure computer, and be kept completely confidential. Access will only be granted to the principal researcher. The recorded data will be transcribed into a digital text file and separated from any of your identifying information, and the audio recordings will be destroyed. Backup copies of the study data will be stored on an external hard drive in a locked, secure location accessible by only by the principle researcher.

CONTACT INFORMATION

If you have questions at any time about the study or the procedures, (or you experience adverse effects as a result of participating in this study,) you may contact the researcher, Sara McNamee, at 865-318-0742, or by email at smcnamee@utk.edu. If you have questions about your rights as a participant, contact the Office of Research Compliance Officer at (865) 974-3466.

PARTICIPATION

Your participation in this study is voluntary; you may decline to participate without penalty. If you decide to participate, you may withdraw from the study at anytime without penalty. If you withdraw from the study before data collection is completed your data will be returned to you or destroyed.

CONSENT

I have read the above information. I have received a copy of this form. I am at least 18 years of age, and I agree to participate in this study.

Participant's signature _____ Date _____

Investigator's signature _____ Date _____

Think Aloud Instructions

Hi, my name is Sara, and I'm going to be walking you through this session. You probably already know, but let me explain to you why we've asked you to come here today: We're testing the National Phenology Network website [www.usanpn.org] to see what it is like for actual people to use it. I want to make clear right away that we're testing the site, not you. You can't do anything wrong here. We want to hear exactly what you think, so please don't worry that you're going to hurt anyone's feelings. We want to improve the website, so we need to know honestly what you think.

As we go along, I'm going to ask you to think out loud, to tell me what's going through your mind. This will help us. If you have questions, just ask. I may not be able to answer them all right away, since we're interested in what people do when they don't have someone sitting next to them, but I will try to answer your questions you still have when we're done. I want to record today's session, so that I can analyze the data in depth at a later stage. The tapes will not be used for any other purposes, and will be destroyed after use. Please read and sign the consent form, which gives me the permission to tape record this session. [Administer consent form].

So, as you work through the tasks given today, I want you to verbalize any and all thoughts you have as you use the website. Just say everything that goes through your mind as you complete the tasks. I am not as interested in the completion of the task as I am about how you are thinking about the task. I may prompt you from time to time to ask what you are thinking. Do you have any questions before we begin?

Tasks Script

At this stage we will start the recorder by pressing the red “record” button at the top right of your screen. I will be asking you to complete a few tasks today. Though you may not be familiar with this kind of website, I want you to pretend that you have an interest in contributing environmental observations to the USA NPN so that others can view and use your data. I'm going to give you locations, or 'sites,' that you will then add to the USA NPN. In essence, we will pretend that you went to a certain location, observed some natural phenomena, and are now going to put this information up on the website for others to find and use. I will give you some instructions on how to navigate the website, and then provide you with a scenario that you will then use to add information.

For this first task, I want you to add a site to your personal 'Natures Notebook.' I will give you the printed description of the location for later reference, but also explain the location as we move along. Today I want you to pretend that you frequently visit the Smithgall Woods Conservation Area in Cleveland, Georgia. While here, you like to walk along the Tsalaki Trail, taking in the scenery and observing the local wildlife. Because this is a preserve, it has little development, and is predominantly wooded, with pine trees most common. The trail itself is an unpaved road, and it about 2 miles from the river where trout and bass are very populous. You usually stay within a one mile radius of your car, getting plenty of bird sightings in this area. Also, the terrain is relatively flat along the trail. From this description, please add the the Tsalaki Trail to your 'Nature's Notebook' as a site. Also, please record the coordinates and elevation that will appear below the map of the location on the instructional sheet provided to you. You will have 10 minutes to complete this task. If you finish before, we will move forward. [Give the participant the instructions. Allow them to complete the task.]

Thank you. We’ll now move on to Task 2.

For the second Task you will again be adding a site to your 'Nature's Notebook.' Now you are a student at the University of Tennessee, Knoxville, and have many of your classes here in the College of Communications building. In between classes, you like to sit outside in Circle Park and do your homework. While out here, you often make notes of the birds you see. For this task, as there is no specific address for the park, I would like you to use the map to locate the site, and place the red marker in the center of Circle Park. Like the previous task, you may also enter any additional information about the surrounding areas that you would like below the map. Again, please note the resulting coordinates that appear after you have placed the marker and saved the

location as a 'site,' and record them on the instructional sheet provided. You will have 15 minutes to complete this task. If you finish before, we will move forward. Remember, please speak out your thoughts as you complete this task. [Give the participants the printed instructions. Allow them to complete the task]

Thank you. That completes the tasks. I have a questionnaire that I'd like you to complete. Again, the information you provide is for my use only, and will be kept completely confidential.

[Administer the exit interview, and allow the subject to complete it.]

Once, again, I would like to thank you for participating. Do you have any other comments or questions at this time?

[Give the participant my contact information, with instructions to contact me with any further needs or questions].

Task Instructions

TASK 1:

You frequently visit the Smithgall Woods Conservation Area in Cleveland, Georgia. While here, you like to walk along the Tsalaki Trail, taking in the scenery and observing wildlife in the area. Because this is a preserve, it has little development, and is predominantly wooded, with pine trees most common. The trail itself is an unpaved road, and it about 2 miles from the river where trout and bass are very populous. You usually stay within a one mile radius of your car, getting plenty of bird sightings in this area. Also, the terrain is relatively flat along the trail. Because it is a natural preserve, there are no any domesticated animals.

Please use the options and map in your 'Nature's Notebook' to add the Tsalaki Trail site to your account. You may also add any additional information about to your 'site' at this time. Record the coordinates of this 'site' below.

Lat:_____ Lon:_____

TASK 2:

You are a student at the University of Tennessee, Knoxville. You have many classes in the College of Communications Building, and enjoy spending time between classes sitting in Circle Park. Please use the options and map provided in your 'Nature's Notebook' to add this location to your account. You may also add any information about the location to your 'site'. Record the coordinates provided by USA NPN for the 'site' below.

Lat:_____ Lon:_____

Exit Interview Questionnaire

1) Tell me about your experience with using the National Phenology Network.

2) How easy was the National Phenology Network to use to complete task one?

3) Did you find any aspect of the National Phenology Network difficult to use in completing task one?

4) How easy was the National Phenology Network to use in completing task two?

5) Did you use the help section in completing task two?

a. (If yes), What aspects of the help section were useful?

b. (If yes), What aspects of the help section would you change/add more instructional content to?

6) What would you change about the National Phenology Network to make it more user-friendly?

7) What did you find to be the most useful feature of the National Phenology Network?

8) Would you use the National Phenology Network again in your daily life?

Feelings

1) What was your initial feeling when you started using the National Phenology Network?
2) How did you feel after you finished using the National Phenology Network?
3) What did you like about the National Phenology Network?
4) What didn't you like about the National Phenology Network?
5) What are your general feelings toward interactive map applications like the National Phenology Network or Google Maps?

Exit Interview Questionnaire Coding Scheme

1) Positive/Neutral/Negative

2) Easy/Neutral/Difficult

3) Naming/Search Navigation Vocabulary

4) Easy/Neutral/Difficult

5) Yes/No

6) Nothing Focus/Concept Search

7) Menus/Navigation Map API

8) Yes/No

Feelings

1) Positive/Neutral/Negative

2) Confident/The same/Less Confident

3) Navigation Focus/Concept Map API

4) Nothing Search Navigation Vocabulary

5) Positive/Neutral/Negative

Definitions

Web 2.0: The term used to refer to web [internet-based] applications that facilitate collaboration and information-sharing amongst users. These sites allow individuals to actively contribute content and interact in a social media environment. Web 2.0 has been commonly referred to as a "network as platform" (O'Reilly 2005).

User-Generated Content: Any kind of publicly available online media produced by end-users. Can be considered the cornerstone and building block of Web 2.0.

End User: For this study, the end user is considered the person using the geospatial application. This individual has has no contact with the application's development, only interacting with the application as a 'patron'.

Casual Web 2.0 Participant: An individual engaged with one or more Web 2.0 applications, either searching for information or contributing information.

User Contribution: User-submitted material to a Web 2.0 application. For the purposes of this study, a contribution is considered a complete piece of content that conveys information (e.g. comment, user tag, social bookmark, etc.).

Citizen Science: In this study, the term used to refer to scientific projects where volunteers outside the scientific discipline (geography) contribute information, observations, and measurements (Goodchild 2007).

Crowdsourcing: The idea that highly relevant and accurate information can be obtained from contributions by a large sample of individuals. This invokes the theory of large numbers by asserting that many individuals' contributions aggregated together will produce accurate or expert data (Hudson-Smith et al. 2010)

Volunteered Geographic Information (VGI): A subset of user-generated content and closely related to citizen science, this is a participatory approach to GIS that enables users to utilize web-based tools to create and disseminate geographic data provided by untrained individuals (Goodchild 2007).

Geographic Information Systems (GIS): An information system that integrates, stores, analyzes, shares, and displays geographic information. Common geographic information systems include digital cartographic applications and remote sensing programs.

Keyhole Markup Language (KML): According to the Open Geospatial Consortium, "Keyhole Markup Language Encoding Standard is an XML language focused on geographic visualization...[and] is complementary to most of the key existing OCG standards including GML (Geography Markup Language), WFS (Web Feature Service) and WMS (Web Map Service)" (Wilson 2008).

Geospatial Application: To be considered an online service supported by a database that integrates cartographic information and geotagged data, characterized by an open, collaborative interface that permits non-professional user (casual participant) contributions.

Google Maps: A web map serving application created by Google that provides many map services, such as the Google Map website [http://maps.google.com] and maps for other sites that utilize Google Maps API. As one of the creators, Lars Rasmussen, states, "Google Maps is a way of organizing the worlds information geographically" ("ABC-Fora").

Google Maps API: A free Application Programming Interface (API) provided by Google for any website to use to embed Google Maps into an application to layer data on top of the map. This allows developers to integrate maps into their website ("Google Maps API Family").

Mashup: A mixture of content or elements. In this study, a mashup is considered a compilation of geospatial digital data combined to create a unique map. "Internet applications that combine the content from more than one source, one of which is usually a Web-based mapping application" (Schultz et al. 2008).

Geotag: Like tags found in numerous Web 2.0 applications like Wikipedia, a geotag is "a standardized code that can be inserted into information in order to note its appropriate geographic location" (Goodchild 2007).

Geocoding: The process of obtaining coordinates in a GIS system and matching these to a registered street address.

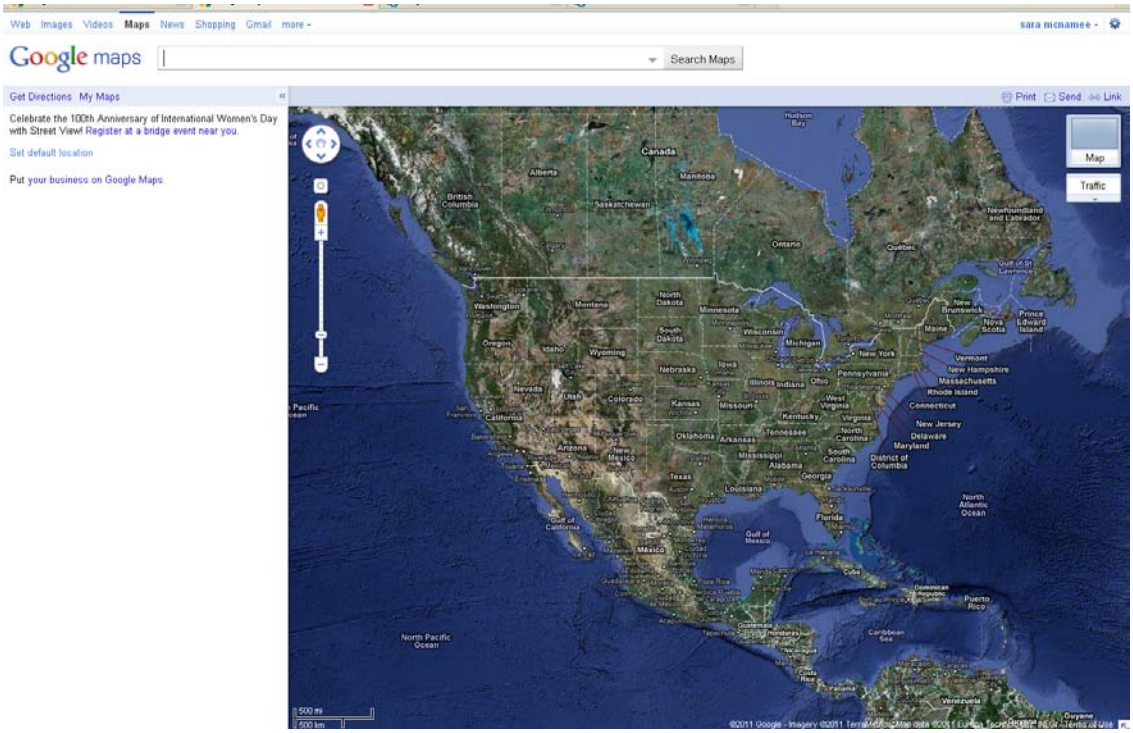
Place-Based Relevance Search: A search conducted for an information artifact with a defined geographic parameter. These are commonly aided by the presence of geotags within the objects metadata. (Ex. the search for a community center within a particular town, or, more traditionally, searching for the history of a piece of artwork while on display in Rome).

Phenology: "Refers to the recurring plant and animal life cycle stages, such as leafing and flowering, maturation of agricultural plants, emerging of insects, and migration of birds" (USA

National 2010). Phenology is very important with regard to their (life cycles) relationship to the weather and climate.

Application Interfaces

USA National Phenology Network Homepage



Google Maps Interface

VITA

Sara H. McNamee was born in Jacksonville, FL on October 18, 1985. Sara graduated from Trinity Preparatory School in Winter Park, FL in 2004. In 2008 Sara graduated cum laude from the University of Florida in Gainesville, FL, with a Bachelor of Arts in the Geological Sciences. In 2009 Sara entered the Graduate School at the University of Tennessee to pursue a Masters of Science in Information Sciences.