ABSTRACT

SUPAK, STACY K. Advances in Customized Open Source Web Mapping: A Geographic Information System (GIS) Application for Tourism Planning and Marketing. (Under the direction of Dr. Hugh Devine and Dr. Gene Brothers.)

Global trends in Internet use, along with technologies for creating and sharing geographic information have led to the rapid development of web-based mapping and web-based Geographic Information Systems (GIS). These developments occur as both generic mapping and discipline specific applications and are created with both proprietary and open source software. For discipline specific applications, the ability to create and share geographic information requires both a thorough understanding of the discipline and a detailed knowledge of the skills and tools necessary for delivering the appropriate mapping content. This research focuses on the development of a web mapping system for tourism planning and marketing. To establish context for the tourism web mapping system, a study involving geology tourism operations at 39 North Carolina (NC) State Parks was conducted and the results are published as a book chapter “Geotourism potential in North Carolina: perspectives from interpretation at state parks” in Geotourism: The Tourism of Geology and Landscape. Next the investigation focused on the web mapping system software required to implement a tourism specific planning and marketing application. This was accomplished by working with two NC state government agencies to deploy an open source, transferable, web mapping environment. These successful applications are described in the Transactions in GIS article “Who’s Watching Your Food? A Flexible Framework for Public Health Monitoring.” The first application supports the NC Department of Health and Human Services’s goal to visualize and query all state-regulated food service facilities as well as provide analysis tools crucial for contamination tracking and food recalls. The second application developed for NC Division of Forest Resources allows landowners to identify the forested areas they wish to inventory or manage by drawing and editing polygon features to represent forest stands. Each of these applications exemplifies user driven customization, that when emulated in the tourism industry would benefit both professionals and
researchers. Combining these efforts (i.e., the tourism operation study and the web mapping applications) led to the development of a comprehensive web mapping system designed specifically for tourism planning and marketing.

A common need of tourism professionals and researchers is to evaluate site-specific tourism demand by mapping customers who may be geographically disperse. Typically, a GIS provides the best options for performing these tasks. Unfortunately, traditional desktop GIS can be complex and expensive. Using web-based open source GIS software that is customized for tourism objectives can save users time and money, increase accuracy and efficiency in planning and help improve resource management. The open source web mapping application (MapMyClients) developed in this study addresses these needs. MapMyClients gives users the ability to easily determine and visualize the spatial distribution of U.S. client origins and visitation patterns, and it provides other relevant tourism specific and general demographic information. This customized, easy-to-use, open source application reduces user expense and allows for broad accessibility via web delivery. The findings of this research improve the empirical understanding of open source web mapping as a medium to achieve discipline-specific goals and provide an immediate tool for the tourism industry.
Advances in Customized Open Source Web Mapping: A Geographic Information System (GIS) Application for Tourism Planning and Marketing

by
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A dissertation submitted to the Graduate Faculty of North Carolina State University in partial fulfillment of the requirements for the Degree of Doctor of Philosophy

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DEDICATION

To my loving husband Del for his patience and understanding, my nurturing mother who always believed in me and my pragmatic father who gave me science.
BIOGRAPHY

Stacy K. Supak is a Geographer at the US Geological Survey. Stacy received a Bachelor’s of Science degree in Environmental Civil Engineering from Columbia University and a Master’s of Science degree in Geophysics from University of California at Santa Barbara. She earned her Ph.D. from the College of Natural Resources at North Carolina State University as a Hofmann Research Fellow. She also received a full doctoral minor in Geographic Information Systems. While at NCSU, Stacy has pursued interests in geology tourism, tourism analytics, recreation demand and web mapping. She has maintained a four year teaching relationship with NCSU’s Masters of Science in Analytics program where she has both developed and delivered Geospatial Data Analytics curriculum. She was also a consultant for the tourism analytics company TRX Inc., where she developed a multi-step clustering solution for recommending alternative hotels for their clients. Currently, her focus at the USGS involves preparing LiDAR terrains for hydrologic modeling, managing their spatial data library and developing hurricane related flood inundation movies. Stacy’s previous research has been published in *Earth and Planetary Science Letters, Geochem. Geophys. Geosyst.*, and *Transactions in GIS*. 
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INTRODUCTION

Global trends in Internet use, along with technologies for creating and sharing geographic information have led to the rapid development of web-based mapping (Haklay, Singleton, & Parker, 2008). This development occurs as both generic mapping and discipline specific applications that are created with either proprietary, open source or a combination of both proprietary and open source software. For discipline specific applications, the ability to create and share geographic information requires both a thorough understanding of the discipline and a detailed knowledge of the skills and tools necessary for delivering the appropriate mapping content. This section introduces the tourism specific and open source web mapping experiences that laid the foundation for the development of MapMyClients, an open source web mapping system designed for tourism planning and marketing. The two resulting publications from these efforts are included as the following sections. The two sections directly following those publications first present the additional motivations, theoretical contributions and community response to MapMyClients followed by a manuscript detailing the creation and usage of the MapMyClients system. Lastly, expanded map application details, challenges encountered and the future of MapMyClients are discussed.

To establish context for the tourism web mapping system, I conducted a study involving geology tourism operations in North Carolina (NC) State Parks. The book chapter entitled “Geotourism potential in North Carolina: perspectives from interpretation at state parks” in Geotourism: The Tourism of Geology and Landscape details the qualitative and quantitative results of that study (Supak, Leung, & Stewart, 2010). Spatially significant geology tourism data for 22 geologic features as well as the presence and type of interpretation for those features was cataloged for 39 park units across the state. Overall, these results illustrate the wide range of geotourism opportunities in NC, which can be leveraged to foster environmental knowledge through greater
public engagement. Although these data have not yet been incorporated into a web-mapping
application, they have the potential to be web delivered as a suite of layers not dissimilar to the
geology layers available in the national atlas (http://www.nationalatlas.gov/mapmaker) (“National
Atlas Map Maker,” 2013). Map layers communicating park features with corresponding
interpretations would provide a detailed picture of tourism opportunities within the state that could assist planning efforts for those interested in visiting the state parks system.

To gain familiarity with the web mapping system software required to implement a tourism specific planning and marketing application, I worked with two NC state government agencies to deploy an open source, transferable, web-mapping environment (or flexible framework). These successful applications are described in the Transactions in GIS article “Who’s Watching Your Food? A Flexible Framework for Public Health Monitoring (Supak et al., 2012).” The first application builds on an extensive body of public health literature detailing web-mapping applications designed for specific user groups, datasets and analysis objectives. It specifically supports the NC Department of Health and Human Services’s goal to visualize and query all state-regulated food service facilities as well as provide analysis tools crucial for contamination tracking and food recalls. This application named Best Environmental Health Technology System Map (BETSMap) illustrates how public safety can be enhanced through web-mapping technology. After I presented the BETSMap application at the 2011 FOSS4G conference, a short article from an online magazine that promotes spatial design for a sustainable tomorrow relayed its utility (Ball, 2011). The second application developed for the NC Division of Forest Resources (ForestMap) allows landowners to identify the forested areas they wish to inventory or manage by drawing and editing polygon features to represent forest stands. These applications built from the open source flexible framework can save users time and money, increase accuracy and efficiency in planning and help improve resource management through the dissemination of spatial information to diverse user groups, who may have no prior experience with
GIS. The idea of a flexible framework to support diverse web mapping objectives is far from novel; the team at OpenGeo has pioneered this effort by creating a powerful web mapping software suite that is in itself a flexible framework ("OpenGeo Suite," 2011). Still, despite the ubiquitous nature of web mapping applications, most of those described in the literature are designed for a singular purpose. This effort reverses that trend by deploying a framework that is easily moved and customized to meet specific mapping objectives that serve selected audiences.

In addition to supporting contamination tracking and food recall, a tool such as BETSMap could benefit the tourism industry. For example, the hotel industry is taking various initiatives to promote food safety by adopting the internationally recognized ISO 22000/ food safety management standards or implementing total quality management approaches (Wang, Hung, & Li, 2011). Outside the hotels, cooked street food can play a significant role in visitor attraction because it offers both inexpensive food and insights into the society and heritage of the destination (Henderson, Yun, Poon, & Biwei, 2012). Environmental hazards recognized and tracked on the micro level could help tourist understand the risks associated with travel to a particular region at a particular time. The detailed mapping technology provided by a system such as BETSMap can help a potential tourist make more targeted travel decisions by allowing them to answer the question “Will a current food contamination outbreak affect my travel to region A or is it only a concern for region B which is 200 miles away?” The ability to answer this question could mean the difference between the abandonment of travel plans and travel completion.

These combined efforts (i.e., the tourism operation study and the web mapping applications) led to the development of a comprehensive web mapping system designed specifically for tourism planning and marketing. A common need of tourism professionals and researchers is to define market areas and profile customers who may be geographically disperse. Unfortunately, many tourism professionals and researchers can’t perform these spatial analytic tasks because traditional desktop
GIS can be expensive and complex. Yet, the current body of tourism literature does not document the development of any customized web-based GIS applications to address this issue. This dearth of development in web-based GIS is surprising because the utility of a GIS tool to evaluate site-specific tourism demand is well recognized (Miller, 2008). There exists a clear need for prudent market area definition and customer profiling to support the tourism marketing goals of competing for new customers, retaining current customers and striving to balance supply and demand. In these cases, the tourism industry and research community needs an alternative marketing decision support tool that will permit them to use their own consumer related data to capitalize on the value of spatial analytics. This tool should be customized and easy to use, employ open source software to reduce expense and allow for broad accessibility via web delivery. The MapMyClients application described in the manuscript for the *Journal of Travel & Tourism Marketing* entitled “An Open Source Web Mapping System for Tourism Planning and Marketing” addresses this gap. Specifically, MapMyClients gives users the ability to easily determine and visualize the spatial distribution of client origins and visitation patterns, and it provides other relevant tourism specific and general demographic information. With web-based GIS planning and marketing support, tourism professionals and the researchers who assist them can facilitate effective marketing strategies to create, capture, communicate and deliver value to customers.
REFERENCES


13 Geotourism potential in North Carolina: perspectives from interpretation at state parks

Stacy Supak and Yu-Fai Leung, North Carolina State University and Kevin Stewart, University of North Carolina at Chapel Hill

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Introduction
Established in 1789 as the 12th state, North Carolina lies in the eastern seaboard of the United States of America between the Appalachian mountain range and the Atlantic Ocean. It is ranked 28th with respect to its size (139,389 square kilometers) and is the 10th most populated state with 9.1 million residents as of 2007 (US Census Bureau, 2008). The state was known for its farming/tobacco, textile and furniture industries, but substantial transformation has taken place over the past few decades and now the service industry, led by tourism, is the major part of the state’s economy (Gade, 2008).

North Carolina has a unique and rich natural heritage which includes geological, landscape and biological resources that span three physiographic regions: the Appalachian Mountains, the Piedmont Plateau and the Coastal Plain (Horton et al., 1991; Stewart and Roberson, 2007). This natural heritage forms an integral part of the network of attractions enticing local, out-of-state and international tourists, who spent over $17 billion in the state and generated almost 200,000 jobs in 2007 (TIA, 2008). Indeed, North Carolina’s tourism promotional material (e.g., travel guides, brochures, websites) routinely highlight physical landscapes such as the Great Smoky Mountains, peaks like Pilot Mountain and geomorphic features such as waterfalls. Many of these geological features and attractions can be found in North Carolina’s state park (NCSP) system, which received over 12.8 million visitors in 2007–2008 (Leung et al., 2009), with an estimated annual economic impact of $289 million to local economies (NCDPR, 2009). Landform-dependent recreation opportunities draw tourists to the state as well, with skiers enjoying the mountains and kitesurfers flocking to sandy beaches at the Outer Banks. In addition, mineral hunting has become a popular tourist activity with several independent contractors offering mine tours, cave tours and gemstone mining.

The geodiversity of North Carolina supports not only aesthetic and economic values, it also offers tremendous potential for research, education and recreation (Gray, 2004). The state capital city of Raleigh hosts the Museum of Natural Science, while the Museum of North Carolina Minerals is located along the Blue Ridge Parkway. Bulletins published by the North Carolina Geological Survey (NCGS) describe the geology at Eno River State Park, Gorges State Park, the Blue Ridge Parkway and the state park system as a whole (Carpenter, 1989; Carter et al., 2001; Wooten et al., 2003; Bradley, 2007).
Although the Roadside Geology Series has decidedly overlooked the southeast with the exception of Florida, other guides are being published to fill the need. Recently, the first geology guide book for North and South Carolina was published with the state-park visiting public as the target audience (Stewart and Roberson, 2007).

In pursuit of an eco-friendly path to development, North Carolina is embracing sustainable forms of tourism, in which geotourism, or tourism based on geoheritage and its conservation (Dowling and Newsome, 2006) seems to have a significant role to play. Similar to ecotourism, geotourism has the potential to support sustainable economic development while cultivating public support for geoheritage conservation (Burek and Prosser, 2008). However, these goals can be attainable only if geotourism opportunities are communicated to nature-seeking as well as causal tourists. Hence, interpretation is the key to connecting sustainable tourism with geoheritage conservation (Hose, 1996, 2006).

While there is a wealth of information about the resource base (geoheritage) and park facilities (infrastructure) that are important for geotourism development, we know far less about interpretation services that facilitate geotourism experiences. Two published studies seem to be particularly relevant to our discussion. Hose (1996) reports results from visitor studies on three geoheritage sites in the UK, which suggest a need for more interpretation and using appropriate vocabulary in interpretive materials. In China, Wei and Wang (2007) evaluated the effectiveness of interpretive materials and programs in Yuntaishan World Geopark using a visitor survey. The respondents were found to have a strong preference for interactive interpretation through interpreters or multimedia, and they were more interested in the scientific explanation on Yuntaishan's landform than in the fairy tales related to the site. These two studies point to the need for more evaluation of interpretive programs and materials in support of geotourism.

The purpose of this chapter was to take a first look at the current status and potential of geotourism in North Carolina from an interpretive perspective using state parks as an example. We were interested in the extent to which North Carolina's geoheritage is communicated to state park visitors and in what ways. We begin with a concise review of geoheritage in North Carolina. The rest of the chapter focuses on the results of a recent survey of state park managers on geoheritage resources and their interpretation. Implications to management and research are discussed in light of survey results.

**Geoheritage in North Carolina**

The varied landscapes in North Carolina are controlled for the most part by the underlying geology (Figure 13.1). The Blue Ridge Mountains make up the westernmost part of the state and include over 40 peaks that reach 1800 m in elevation. East of the Blue Ridge, the Piedmont is characterized by rolling hills and subdued topography, although there are several locations in the Piedmont with high elevations (over 900 m). The Coastal Plain makes up the eastern half of the state and has low elevation (about 120 m down to sea level) and low topographic relief. The Atlantic Ocean coast of North Carolina is marked by a chain of narrow barrier islands.

The rocks that make up the Blue Ridge mountains are metamorphic rocks that were created during a series of plate tectonic collisions beginning about 1 billion years ago with the assembly of the ancient supercontinent of Rodinia during an event known as the Grenville orogeny. Billion-year-old metamorphic rocks are ubiquitous in the western part of the Blue Ridge (Hatcher, 1989; Horton et al., 1991).
Rodinia began to rift apart beginning about 700 million years ago, and as the crust stretched, it broke along a series of faults. Crustal blocks slipped down along these faults creating basins that received thousands of meters of sediment. These rift-basin sedimentary rocks, now metamorphosed, are well-exposed in the Great Smoky Mountains and on Grandfather Mountain and the surrounding area. Igneous rocks, such as granite and basalt, were also created during this rifting and can be found scattered through the western Blue Ridge. The rifting eventually led to the complete breakup of Rodinia and the creation of an ancient ocean, known as Iapetus (Hatcher, 1989).

The eastern Blue Ridge also contains metamorphic rocks, but these are younger than those in the western Blue Ridge. Iapetus began to close beginning about 500 million years ago, and a continental fragment, now exposed in the western Piedmont, collided with North America about 460 million years ago (Hatcher, 1989). This event is known as the Taconic orogeny, and the eastern Blue Ridge is mostly made of metamorphosed sediments that were originally deposited on the Iapetus Ocean floor and were then scraped off as the continental fragment collided. The highest point in eastern North America, Mount Mitchell, is made of these metamorphosed ocean floor sediments. As the Taconic collision progressed, rocks of the North American continental margin were overridden and deeply buried. Some of the rocks melted and the rising bodies of magma intruded the metamorphosed sediments. These igneous rocks are now exposed in the eastern Blue Ridge at Whiteside Mountain (Miller et al., 2006).

The Iapetus Ocean continued to close, and parts of the edge of the ancient continent of Gondwana, the continental land mass that consisted of South America and Africa, broke away and eventually collided with North America. These exotic fragments of crust are known as peri-Gondwana terranes and make up the bedrock geology that underlies the eastern half of the Piedmont. These rocks are mostly metamorphosed volcanic rocks and sediments that formed when these terranes were still attached to Gondwana, between about 550 and 650 million years ago. The collision between the peri-Gondwanan terranes and North America is possibly associated with the Acadian orogeny, which is a well-documented orogeny in the northern Appalachians, but its existence in the southern Appalachians is not well-established (Trupe et al., 2003).

Final closure of Iapetus occurred about 330 million years ago when Gondwana collided with North America creating the supercontinent of Pangea. This major continent—continent collision is known as the Alleghanian orogeny and created a Himalayan-scale mountain range in the southern Appalachians. The effects of this collision are well-preserved in the Blue Ridge and in parts of the Piedmont. Major Alleghanian faults separate kilometer-scale sheets of metamorphic rock that were thrust over one another. A spectacular example of one of these thrust faults is exposed at Linville Falls along the Blue Ridge Parkway (Trupe et al., 2004). As happened during the Taconic orogeny, thickening of the crust during the Alleghanian orogeny caused localized melting in deeply buried rocks. These rising bodies of magma crystallized and are now preserved throughout the Piedmont and Blue Ridge, including Stone Mountain State Park (Miller et al., 2006).

North Carolina was tectonically quiet for about 100 million years following the Alleghanian orogeny. Pangea began to rift apart beginning about 220 million years ago during the Triassic period and a series of fault-bounded rift basins formed. Eventually, Africa separated from North America and the Atlantic Ocean was born. Since about 200 million years ago, there has been no active plate boundary in North Carolina. The high mountains have been eroding, and the sediments from this erosion have been deposited on the Coastal Plain and along the Atlantic continental shelf.
The Coastal Plain is underlain by sedimentary rocks that range in age from the Late Cretaceous period (~100 million years old) up to modern sediments that are being deposited along the Atlantic Ocean coast. The low topographic relief of the Coastal Plain is due to the presence of thick, easily erodible sediments that have been deposited on top of the metamorphic rocks of the Piedmont. The barrier islands that line the coast are Pleistocene features that have been actively moving at least since 18,000 years ago and continue to move today, primarily as a result of storms and sea-level rise.

Not only has this series of geological events created the landforms and landscapes which we see today, they have also shaped the ecosystems and play an important role in the development of urban and rural communities in the state. Some of the best examples of natural history and the interplay between nature and culture can be found in North Carolina’s parks, natural areas and historic sites, of which the state park system is a major component.

![Map of North Carolina](image)

**Figure 13.1:** Physiographic regions and state parks in North Carolina.

### Geotourism: a survey of state park managers

#### Purpose and methods

In order to gauge the extent to which geotourism in North Carolina is facilitated through interpretation of the state’s geoculture to park visitors, we conducted a survey to examine state park managers’ perceptions of the occurrence of geological features and the interpretation of those features. The entire NCSP System consists of 66 different units, covering about 83,000 hectares of lands and waters (Leung *et al.*, 2009). This online survey included managers of 39 North Carolina state parks, state recreation areas and state natural areas (state park units hereafter) which are accessible to the public.

In February 2009, the NCSP system’s Lead Interpretation and Education Specialist sent an e-mail request on our behalf to park superintendents urging them to take the ‘Geotourism at North Carolina State Parks’ online survey. The survey instrument consisted of 10 questions and addressed the following items:
The park’s major interpretive themes:

- Identification of geologic features and existing interpretation related to a set of 22 basic geologic features listed in the survey. These included 10 landscape elements related to rock outcrops and large boulders and 12 general features such as hills and valleys, erosional features, sand dunes and estuaries. Survey participants also were given an opportunity to identify and comment on features not listed.
- Missed educational opportunity in the indoor or outdoor displays.
- Perceptions of the level of geotourism interest among the visiting public.

The survey was available online for three months and phone calls were conducted with non-respondents. At the end of the survey period, managers from all 39 target state park units had responded.

Survey results

Of the 39 North Carolina state park units participating in the survey, 15 superintendents responded themselves, while 24 passed the request along to a park ranger who completed the survey. The respondents were asked to rate their own geology knowledge and 21 percent reported moderate geology experience, 69 percent reported limited geology experience and 10 percent reported no geology experience. No respondent self-reported to have extensive geology experience or to be a geology expert.

Despite the low level of self-identified geologic knowledge, the respondents believed that the park system as a whole provides a variety of interpretation of geologic features across the state. Of the 289 total identified features at North Carolina state park units, 46 or 16 percent of the features were declared to have no interpretation. Interpretive talks were identified by the respondents as the most common form of interpretation, connecting to 181 or 63 percent of the identified features. Other forms of interpretation selected included exhibits (25 percent), outdoor signs (12 percent), indoor signs (2 percent) and websites (2 percent). Of the total identified features, 40 or 14 percent were identified as having other forms of interpretation and some respondents described additional publications, external websites or educational programs in which state park units are used for activity-based field trips. Morrow Mountain State Park, for example, conducts on-site geology based program entitled ‘Old as the Hills.’ Pilot Mountain State Park in the Piedmont conducts a hands-on simulation of the process of creating sedimentary and metamorphic rocks and another discussing water quality and how the surrounding terrain affects water quality.

Of the 22 features presented to the survey respondents, creeks, streams or rivers had the highest occurrence, with 82 percent of the parks responding positively with interpretation such as talks, exhibits and outdoor signs offered to visitors. The least commonly reported feature in the state park system was earthquakes, with only two parks identifying and interpreting this occurrence. Only 62 percent of the total parks have exposed rock and park managers believe that 28 percent of the total parks have igneous rocks, 36 percent have metamorphic rock and 38 percent have sedimentary rock. Of the geologic features listed in the survey, respondents said they did not know if their park contained rocks that had been dated, unconformities or fossils more than the other features. The features that are most prevalent, with the least amount of interpretation, are hills and valleys. From this study we also have learned that creeks, rivers and streams along with water-related erosional features are the most interpreted features in the NCSP system.

Each park unit within the NCSP system has its own unique physical features, biota, biology, ecology and cultural history. When a state park is established, a set of interpre-
tive themes are developed as well. These themes provide the foundation from which programs, exhibits and educational publications are promoted. The major interpretive themes for NCSPs vary widely and encompass, geology, ecology, wildlife, water related issues, plant life and culture as reported by the respondents. Each respondent was asked to identify the major interpretive themes of their park and geology or geological features were reported as being a major interpretive theme at 46 percent of the parks.

When respondents were asked for their perceptions of missed educational opportunities in the indoor or outdoor displays, several responses were geologically based. These opportunities included increasing general knowledge of geologic history, coastline erosion processes, lake processes and employing basic learning aids for geology or offering fossil displays. Park specific suggestions included desires to add interpretation of the local mountain formations (Morrow Mountain State Park) and to have “a knowledgeable geologist to periodically offer geology walks and talks in the park” (Gorges State Park). Missed educational opportunities in some cases were related to perceptions of the public’s aptitude and the need to simplify the information presented, so that the ‘majority of people can quickly read, understand and remember.’ Another respondent claimed that ‘visitors don’t actually take the time to read the indoor or outdoor displays.’

Without directly surveying tourists at state parks, it is hard to gauge geotourism interest from the visitor’s perspective. Park managers were asked for their perceptions of the level of geotourism interest among the visiting public. Only 5 percent believed the public to be very interested, 44 percent somewhat interested and 51 percent not interested. Almost one third of the respondents were uncertain about the geotourism interest of their visitors.

Some examples: the good, the bad and the possible

North Carolina state park units are dispersed across the state and although they are not a random sample of the statewide geology, many were chosen to showcase a portion of the state’s natural beauty (Carpenter, 1989). Prior to this study, there was very little known about the geoheritage interpretation in the state park system. We have examined what a geotourist can expect in terms of geology and interpretation. A large disconnect that falls out of this survey is that geology or geological features were reported as being a major interpretive theme at 46 percent of park units, yet the level of geologic knowledge of park superintendents and rangers is self-reportedly low. In many cases the rangers have a strong educational background in natural resources management, with strong foundations in wildlife management and ecology. This disconnect in part is being bridged by the NCGS’s willingness to assist state park staff with educational content and activities.

Although geoheritage interpretation is prevalent throughout the NCSP system, one place where geotourism can be better promoted is Stone Mountain State Park, which only offers one paragraph on the general park display interpreting the park’s namesake. It reads:

One of the park’s most spectacular features is Stone Mountain, a 600-foot granite dome. This magnificent feature is part of a 25-square-mile pluton, an igneous rock formed beneath the earth’s surface by molten lava. Over time, wind, water and other forces gradually eroded the softer layers of rock atop the granite block and exposed the outcrop we see today. Wet weather springs continually carve troughs in the granite as water runs down the mountain’s sloping face.
Interestingly, several state parks have taken a more active approach to offering geohertiage interpretive materials and programs which correspond to their respective geologic interpretive themes (Figures 13.2 and 13.3).

Figure 13.2: Geohertiage and its visual interpretation in four North Carolina state park units (also refer to Figure 13.3 for interpretive themes, identified features and interpretations).
Mount Jefferson State Natural Area

Geologic Interpretive Themes: “Mount Jefferson appears to be an inselberg, an isolated mountain surrounded by mountain ranges. The outcrops provide an excellent opportunity for interpretive study of the formation and subsequent erosion of the southern Appalachian Mountains.”

Survey results:
- Talks and/or outdoor signs cover topics such as the network of waterways, water and wind erosional features, weathered rocks, monadnocks, cliffs, signs of faulting, interesting minerals, metamorphic rocks and geologically dated rocks.
- There is additional interpretation for the rock cycle, the mountain vista, frost wedging, lichens and air quality.

Eno River State Park

Geologic interpretive theme: “The metavolcanic rock lying under the water’s surface and scattered about the valley tells the story of the Eno River’s formation. Lying within the Carolina Terrane, the park contains many interesting geologic features that have enhanced the interpretive opportunities offered. Current programming focuses on the basics of geology, identification of rocks and minerals, and the park’s geologic history. Oconeechee Mountain State Natural Area includes the highest point in Orange County at 807 feet and numerous rock outcrops demonstrating evidence of ancient volcanic activity. The recent publication by the North Carolina Geologic Survey, A Geologic Adventure Along the Eno River, interprets the many geologic features found along the park’s trails and is an invaluable resource for park staff and the public.”

Survey results:
- Talks and/or outdoor signs cover topics such as the topography, the network of waterways, water and wind erosional features, monadnocks, cliffs, dykes/sills, interesting minerals, signs of faulting and igneous, sedimentary and metamorphic rocks.

Carolina Beach State Park

Although the interpretive themes for this park are plant related, several geological features were identified through this survey. Additionally, the park’s indoor displays highlight the important role of geology in creating distinct habitats within the park.

Survey results:
- Talks and/or exhibits cover topics such as the network of waterways, sand dunes, estuaries, weathered rocks, sedimentary rocks and sink holes.

Cliffs of Neuse State Park

Geologic interpretive themes: “The main feature of the park is the multi-layered cliffs along the banks of the Neuse River. The steep, colorful cliffs are not only an important scenic resource; they are also a valuable educational resource that provides visitors with a view back through time. Most of the exposed cliff layers belong to the Black Creek Formation, which was deposited during the late Cretaceous period more than 66 million years ago. The cliffs present a challenge to park interpreters because they are fragile and difficult to view from overlooks in the park. Therefore, exhibits and creative programming techniques must be used to make the cliffs and their geologic history come alive for park visitors. Activities help students learn how geologists and paleontologists use observations of landforms and fossils to create a picture of the...”
local geography, climate and life forms of the Cretaceous period. The park museum provides models and dioramas that further illustrate this geologic age. Other park programs and museum exhibits demonstrate the geologic processes that formed the cliffs and continue to shape them today."

Survey results:
- Talks and/or exhibits cover topics such as the topography, the network of waterways, water erosional features, weathered rocks, fossils, interesting minerals, sedimentary rocks, cliffs and unconformities.

Figure 13.3: Interpretive themes and survey results for four selected North Carolina state park units.

Implications: a call for geotourism as an educational tool

This survey is reflective of managers' perceptions and may not be a comprehensive look at the geology statewide. Additionally, state parks may not be a complete sampling of statewide geology. Although some parks were established for distinctive geology, many were established for cultural significance, wildlife, ecological value or flora and fauna, as discovered in this survey. Despite these limitations, this exploratory study has identified where geotourism is well promoted and where it can better be promoted at state parks.

For instance, North Carolina should be known for its breadth of landscape from the slowly eroding Blue Ridge Mountains across the hilly river-filled piedmont to the estuaries and sand dunes of the coastal plain. With only a few books published as guides for geology tourism in NC, more must be done to recognize the value of geotourism. The geoheritage discussed in this chapter highlights geotourism assets such as evidence of the Taconic orogeny and associated metamorphic rock formations or the barrier islands that line the coast. These are the resources that can be promoted, which represent the unique types of geotourism opportunities in the state.

Given the discrepancy between the geologic points of interest at state parks and the self-identified lack of geologic knowledge of park managers, the burden of cultivating geotourism infrastructure and interest falls to those who have been geologically trained. The NCGS recognizes this discrepancy and beyond conducting research on state park land, they assist state park staff with educational activities. Furthermore, they have published additional geologic guides to various state parks and protected lands in North Carolina (Bradley, 2007; Carpenter, 1989; Carter et al., 2001; Wooten et al., 2003).

There is great potential for fostering environmental knowledge through tourism, but we must find ways to engage the public for geotourism to flourish. With the large tourism industry and a wide range of natural resources, North Carolina is an ideal backdrop for this agenda. Efforts to engage the public in the enjoyment of geotourism at state parks include a range of interpretive experiences, but new efforts to foster geotourism interest are always needed. Currently one such effort is being made by the NCGS, whose staff is developing a web-based interface for interactive geologic information (Bradley, personal communication). Eno River State Park was chosen as the pilot project for this effort because a significant amount of content already exists (Bradley, 2007). The links for Eno River Interactive can be found at http://www.ncgeology.com/pages/Index_eno.html. The long-term goal is to provide this service for each state park in which geology plays a major role in the significance of the park. The findings from this study will potentially be used in this endeavor.
Concluding remarks

This chapter is a small step toward better understanding of the link between geoheritage and geotourism opportunities in North Carolina. The findings may inform actions taken to better service the geotourism community by increasing availability of interpretation of geologic features and ensuring that the most prominent of geologic features are well represented to the public. This also could include more interactive ways to disseminate information about the geoheritage at state parks such as the Eno River example.

Improving visitor experiences through geotourism promotion will educate and inspire visitors about geoheritage and the value of its protection. When action is taken with the intent of conserving and enhancing geologic and geomorphological features, processes, sites and specimens for the future, it has been termed geoconservation (Burek and Prosser, 2008). Geotourism and geoconservation can be mutually beneficial. The initial activities leading up to geoconservation are in many ways synonymous with the steps leading to cultivating geotourism, such as initial awareness and appreciation of the existence of features, processes, sites and specimens, examination, description, scientific audit and valuing and communication of value with others. A difference occurs in the later steps of geoconservation with the awareness of a threat, conservation audit and protection through policy means (Burek and Prosser, 2008). The development of geotourism can lead to the awareness of threats and the geoconservation efforts at specific sites offering opportunities for geotourism. The use of geoheritage can contribute to the environmental, social and economic pillars of sustainable development through conserving and promoting educationally, scientifically, recreationally and culturally important features.

North Carolina, like the rest of the eastern seaboard of the United States, is on a tectonic passive margin with no ‘flashy’ geologic phenomena such as active volcanoes or large earthquakes. However, there are other very active geologic processes at work which can affect the lives of many who reside in the region such as river flooding, landslides and beach erosion. All of the geologic process, whether previous or ongoing, impact geoconservation and sustainable development objectives. Other issues happening in states such as New Jersey include the problem of urban sprawl obscuring the majority of interesting geological features (Gates, 2006). With increasing levels of population growth and urbanization in North Carolina, its geoheritage may also be threatened by similar pressure. Public support for geoconservation and for sustainable development of geoheritage-based tourism in NC is therefore critical for both to prosper, and, as Hose (2006) warns us, the absence of interpretation at geoconservation sites might lead to threatened geoheritage. Geotourism not only requires an appreciation or learning infrastructure, but it also requires tourists’ interest and their cooperation with respect to appropriate behavior at geoheritage sites.

To understand tourist interest, further studies including visitor surveys may elucidate questions such as how interested is the visiting public in geoheritage and how could geotourism interest be cultivated. These questions would inform the development of tailored and effective interpretive programs to promote scientific understanding and a conservation ethic that would more likely result in positive learning and conservation outcomes. These studies would then help realize the potential to turn regular tourists into geotourists, thereby making mass tourism more sustainable.
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References


Research Article

Who’s Watching Your Food? A Flexible Framework for Public Health Monitoring

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Abstract
By responding to potentially life-threatening emergencies such as foodborne illnesses and water contamination, U.S. public health agencies play a vital role in promoting human health and protecting the environment. Local, state, and federal partners must collaborate to strategically plan initiatives, allocate resources, and evaluate emergency response activities. These collaborative decision-making processes can be improved by using web-based mapping applications for visualization and analysis. We developed a web-based GIS framework which is applied to public health data for North Carolina’s (NC) Department of Health and Human Services. The application visualizes all state-regulated food service facilities and supports query and analysis tools crucial for food recalls or radiation contamination tracking. Built with PostgreSQL/PostGIS, GeoServer, and a customized GeoExplorer map viewer, the framework delivers a web-based mapping tool that is flexible and Open Source. The flexibility of the framework is an important dimension of its scalability, allowing it...
to be customizable, modular, and portable so that it is easily configurable to support additional research and education initiatives. This approach reverses a trend toward application-specific web mapping development in Open Source GIS. To demonstrate flexibility, we configured an additional website for forest landowner management to be used by another state agency, the NC Forest Service.

1 Introduction

Public health organizations use technology and public education to safeguard lives, promote human health, and protect the environment from physical, chemical, and biological threats. Devastating food contamination instances such as the 2006 E. coli outbreak in the eastern United States and the 2010 E. coli outbreak in Europe underline the vitality of rapid information sharing for public health agencies that respond to public health dangers. Protecting public health necessitates rapid response to emergencies such as food contamination, floods, fires, chemical spills, earthquakes and illness related to environmental factors. In these events, timely web delivery of large geospatial databases is essential for disaster intervention and control (Croner 2003). It also is imperative that local, state, and federal partners collaborate to strategically plan initiatives, allocate resources, and evaluate emergency response activities. Unfortunately, many public health agencies’ data repositories only contain physical addresses and they lack any direct means for geographic visualization or analysis. This article discusses the development of a web-based mapping framework and application for the Division of Public Health (DPH) within North Carolina’s (NC) Department of Health and Human Services.

The assessment and control of environmental factors is essential for creating health-supportive environments and preventing disease. Decisions pertaining to potentially life-threatening emergencies such as foodborne illnesses and water contamination fall to U.S. public health agencies. These agencies play a vital role in food safety, as they are instrumental in developing standards, reviewing plans and monitoring enforcement of food-handling facilities and lodging establishments. The identification and quantification of patterns related to food- or water-borne illness can provide the first steps toward control of these illnesses. Spatial analysis also improves surveillance by providing opportunities to reveal undetected patterns by linking previously disparate datasets.

Geographic Information Systems (GIS) provide well-established tools for visualization and spatial analysis. GIS technology is increasingly being used by public health agencies at all levels of government and by the partners that support them, such as universities and consultants. Considering that an estimated 80–90% of all government databases contain georeferenced information (data can be tied to a specific location or place such as area code, latitude and longitude, street address, or political boundary), public health organizations are poised to capitalize on the benefits of GIS (Federal Geographic Data Committee 2002). There is a growing recognition at the highest levels of policy-making that the cost-effective development of, and access to, geospatial information systems is essential to the successful operation of the U.S. Government and the nation (Cahan 2000).

At the same time, emerging technologies are providing more effective ways for diverse user groups to have access to GIS. As the Internet continues to change our perception and use of geographic information, web-based mapping and geoprocessing services are becoming pervasive across many domains (Dragičević et al. 2011). There is
a burgeoning demand for web-based mapping of public health data because geospatial factors are important for decision-making in this domain and web-based maps can deliver geospatial analysis to distributed and diverse groups of public health decision-makers (Dragicević et al. 2011). In fact, in the more general domain of public health, web-based GIS are already routinely being used to model and assess public health-related data (Cinnamon et al. 2009, Kamadjeu and Tolentino 2006, MacEachren et al. 2008, Maclachlan et al. 2007, Moreno-Sanchez et al. 2007, Tiwari and Rushton 2010).

The NC DPH collects and stores permitting, enforcement, inspection, and complaint data from all 86 local health departments within the state. Existing tools for accessing these data do not provide any geographic context. Incorporating geographic location and the ability to analyze data distributions into decision-making will greatly enhance emergency response capabilities. This article describes a web-based GIS framework conceived by the IT/GIS Branch of the NC Department of Environment and Natural Resources to support their data visualization and sharing objectives. Many health departments around the country have similar needs, but they also have severe budgetary issues; therefore, we wanted to create a reusable solution that other groups could deploy in their own departments with minimal startup time and cost. This goal informed the system design and software choices. Beyond public health needs, this reusable framework can be extended to accomplish a variety of web-based GIS objectives for various departments within a large organization. It is this flexibility of the framework that makes it both innovative and significant.

The remainder of this article is organized as follows. Section 2 discusses related work in more detail. Section 3 describes the system design and Section 4 presents the DPH website built on this framework. To demonstrate the flexibility of the framework, it is used in Section 5 to build a website for the NC Forest Service. Section 6 presents conclusions.

2 Background and Related Work

There is a growing need for access to geospatial information among public health professionals, policy makers, managers, researchers, students and the general public (Maclachlan et al. 2007). Beyond access, the ability to easily query, organize, combine, overlay, and plot health data also is needed. Because public health data are integral to surveillance, response, management, mitigation, and prevention of adverse human health events and conditions, timely delivery and analysis of geospatial health data, for routine and crisis circumstances, must be viewed as high public health and national priorities (Croner, 2003). Despite growing concern surrounding the cost of acute and chronic care, insufficient attention has been given to the role that public health data could have on strategies to reduce the burden of disease (Najafabadi and Pourhassan 2009). Recently, a number of applications have been developed to address various aspects of public health, including those related to disease surveillance (Robertson and Nelson 2010). Still, many government organizations lack spatially enabled decision support systems.

The need for GIS in public health is clearly illustrated by a public health emergency that occurred within the jurisdiction of NC DPH in June 2008 in the City of Greenville, NC. City officials detected the presence of fecal coliform bacteria contamination in the city water supply during routine sampling. Due to an inability to locate the precise locus of contamination, approximately 600 facilities supplied by the city’s water service, such as restaurants, meat markets, child care centers, nursing homes, hospital facilities, and
university food service facilities, were required to close. The logistics associated with responding to an event of this magnitude required timely notification via the broadcast media, by telephone, and by site visits. At that time, the regulatory system lacked a geospatial component and therefore, response activities were commensurately lacking in efficiency. A GIS enabled with spatial data layers such as the water supply system network, geocoded facility addresses, utility department service call records, reports of malfunctions, and contaminated water sampling results could have been employed for improved outcomes. A GIS implementation could have provided an efficient plan for deploying the most geographically appropriate response personnel using the most effective trip routing. If the precise locus of bacterial contamination had been identified, components of the city's water network could have been used to isolate and cease water service only to affected sections of the system. The remainder of the city's water customers would have remained unaffected by the boil Water and Closure Orders. This would have greatly lessened the economic, social, and psychological effects of the contamination event.

GIS are powerful communication tools for public health. However, using GIS often requires considerable expert knowledge. Still, many government and private sector organizations are seeking ways to capitalize on the benefits of GIS to improve the health of the public, while controlling for cost. With these goals in mind, the Internet and use of georeferenced public health information is an important development for the nation's public health departments (Najafabadi and Pourhassan 2009). Web-based GIS has emerged as a solution for the problems of access and expertise in that a wider audience with varied computer and GIS knowledge can participate (Cromley 2003, Croner 2003). More specifically, web-based GIS provides opportunities to analyze complex geospatial data, solve problems, and present data in a graphical format that public health decision makers and the public can easily see and understand (Croner 2003). Web-based maps have become omnipresent in recent years, mirroring the advancement of desktop GIS and information technology in general (Cinnamon et al. 2009). The publication and distribution of spatial data are also becoming increasingly important activities enabling organizations to share maps as images over the Internet (Kamadjeu and Tolentino 2006). Global trends in Internet use, along with innovative technology for creating and sharing geographic information through pioneering and often collaborative applications have led to the rapid development of web-based mapping and geographic information (Haklay et al. 2008).

Implementing proprietary solutions may be a limiting factor in the adoption of a public health GIS in a resource-constrained environment (Kamadjeu and Tolentino 2006). Open Source software (OSS) solutions are desirable for health departments who in many cases lack resources for GIS hardware and software as well as other related GIS investments such as training or staff expertise (Richards et al. 1999). OSS components eliminate the need for project developers to pay initially for proprietary software, as well as the recurring licensing fees associated with many of the products, and therefore they increase the potential for adoption and re-use by other agencies. Other benefits of employing OSS include multidirectional development and support, smooth learning curves which make them accessible to more novice developers, and the fact that they do not require high-end computers to perform at a satisfactory level (Moreno-Sanchez et al. 2007). The advancement of OSS allowed for the development of several web-based mapping applications in the public health domain, supporting the notion that there is growing interest in OSS solutions for public health problems. Using OpenGIS-
conformant technology, Boulos and Honda (2006) give a step-by-step tutorial explaining how interested readers can publish their own health maps with Web Mapping Services (WMS) layer adding ability. Driedger et al. (2007) employed participatory design techniques to develop a web-based mapping tool to assist a non-profit (public) health sector organization in improving child developmental health. Kamadjeu and Tolentino (2006) is another example where the authors demonstrated the potential for free and OSS; in their instance, for the dissemination of immunization information to a broad internet audience through interactive maps.

Other public health applications of OSS web-based GIS include cross-border health issues, cancer and injury atlases and disease burden modeling. Moreno-Sanchez et al. (2007) designed a web-based multimedia GIS system for dengue fever monitoring across the U.S.-Mexico border, which uses raster images provided by distributed WMS. MacEachren et al. (2008) develop a web-based cancer atlas to support government cancer-control activities. Another atlas example by Rinner et al. (2011) discussed the data processing and cartographic requirements to integrate publicly accessible map services and protected data layers for a comprehensive look at injury rates and demographic risk factors. Tiwari and Rushton (2010) have developed an environmental health surveillance system that can visualize the spatial patterns of disease outcomes from individual-level data and automatically link environmental data, environmental models, and GIS tasks like geocoding for the purposes of estimating individual exposures to environmental contaminants. Each of these prototypes addresses a different aspect of public health and they all argue the merits of developing OSS interactive online geovisualization tools for public health.

These applications would not be possible without advances in geospatial interoperability, geospatial data transmission, and automated conflation of geospatial databases. Open Geospatial Consortium standards, such as WMS and Keyhole Markup Language (KML), can be used so that the system will have the interoperability required to consume and display mapping services and data from the widest possible variety of sources. OSS web-based GIS have reached a stage of maturity, sophistication, robustness and stability, and user friendliness rivaling that of commercial, proprietary GIS and web-based GIS server products (Boulos and Honda 2006). However, the selection of application implementation tools, such as map server software, can determine the data handling and analytical capabilities available to decision-makers (Rinner et al. 2011). The next section discusses the application choices made in developing this framework and the requirements driving those decisions.

3 Methodology and Design

3.1 System Requirements

Our web-based public health information system is designed to give local, state, and federal public health officials and partnering organizations distributed access to centralized well-maintained, current datasets. It will provide users with the tools for spatially informed planning, analysis, and emergency response. Working with public health specialists and through study of related work, we identified the following functional requirements:

- Connect to tabular and spatial database information;
• View/visualize public health data along with other geographic features to provide locational context;
• Examine public health data attribute values;
• Communicate public health data by creating customized views to store and share for collaboration and emergency response;
• Explore public health data for detecting points which have common attributes, such as selling a flagged product, or identifying points that are geographically proximate;
• Spatial analysis for determining geographic coordinates, returning views of specified regions, finding addresses, and generating routes; and
• Manipulate data by placing new public health data points on a geographic display or moving existing ones.

This list outlines a set of basic data access and analysis tools that address the current usage needs; however, future demands on this system are likely to necessitate additional functionality. A well designed system should be reusable and extensible. The following design decisions are added to support this goal:

• Functionality must be readily configurable. A system administrator can add or remove functionality as desired;
• Preferred use of OSS components. OSS not only relieves the agencies of recurring license fees, it also reveals the source code giving users the ability to modify and supplement the functionality; and
• Support for varied geographic data type display.

3.2 System Design

To meet the functionality requirements specified above, a reusable template or framework was created from which a specific GIS application was developed for pertinent public health data. The components of this system were desired to be OSS due to several issues related to using commercial software to deliver geographic data and provide geo-processing functionality. Anderson and Moreno-Sanchez (2003) highlight the expense and steep learning curve of commercial products. When choosing a back-end GIS application server, ArcGIS Server, arguably the most well-known commercial GIS Application Server, has licenses fees that range from $20k to $40k (depending on functionality level), which are out of reach for many agencies. Additionally, contacts within DPH speak to the fact that a map viewer itself should be a self-contained application, which is not dependent on compiled or proprietary software, to maximize the potential for reuse.

Mindful of the preference for OSS, a framework was created to store, manage, serve, and display data with an interface supportive of analysis. The core software components are a database management system, a web mapping server application, and data viewer/analysis system. For these we use PostgreSQL/PostGIS, GeoServer, and GeoExplorer. PostgreSQL extended with PostGIS provides a spatial database management system to support spatial public health data. Other databases such as Oracle and SQL Server can be loosely coupled with the system as well. GeoServer, a Java-based, community developed application, and Mapserver, a C-based application developed at the University of Minnesota, are two popular OSS web mapping servers. Both applications have strengths and weaknesses and are continuously evolving. Our framework uses GeoServer, which provides a web-based administration tool for easy configuration.
and integrates well with the Agency's other Java-based enterprise application framework, which also runs on the Tomcat servlet container. For visualization and user interface development, we used GeoExplorer, a basic data viewer, which focuses on the display and management of layers (either from a WMS or Web Feature Service), the ability to query and search across these layers, and the display of results. Figure 1 shows the system architecture of these core software components consisting of the database, application, and web presentation tiers.

To develop the map client viewer framework for the presentation tier, we built upon the existing code base provided by GeoExplorer. GeoExplorer is a map viewer application that comes packaged with the OpenGeoSuite Community Edition distribution. GeoExt, Ext, and OpenLayers functionality as well as print preview capability are bundled with the installation of GeoExplorer (Figure 2). GeoExplorer is a modern looking Ajax viewer based on OpenLayers and GeoExt that is not dependent upon proprietary software components that many other modern looking map viewers employ, such as Flash, Flex, or Silverlight. GeoExplorer is entirely Javascript-based. This is more desirable because most government agencies have some in-house Javascript programmers who will be able to maintain and extend the map viewer. Because GeoExplorer is based on OpenLayers, a great many tools have already been developed and are readily available for re-use in the OpenLayers Sandbox (http://dev.openlayers.org/sandbox/). A growing number of other map viewer applications also use OpenLayers (MapFish, GeoMoose, etc.) and tools developed for them can often be re-purposed, as needed.

Tool functionality not included with the preconfigured GeoExplorer external libraries can be added into the code base (Figure 2). For example, the desire for a tool which could select features within a given distance of a certain point required the addition of the Mapstraction Library. Other desired functionality such as geocoding, routing (including multiple stops) and Google Earth view was implemented by inserting and calling additional JavaScript libraries. Additional components added within the GeoExplorer code base include the homepage which calls the appropriate libraries, configuration files to allow for different application functionality and appearance, and files which specify

Figure 1 The basic system architecture: the database (dark grey), server (grey), and web presentation (light grey) tiers, composed of core system components (solid lines) and external resources (dashed lines)
tool-related options such as the centroids for each of the 100 counties needed for a zoom to county tool or color options for highlighting features upon selection.

The configuration files are of particular importance to the modularity and portability of the framework. When the need for a new web mapping instance arises or an existing web mapping application needs to be augmented, the maintainers of the web-mapping framework can address these desires by recreating or editing these files. This functionality allows for the framework to be used in multiple differently "branded" instances of map viewers which can be run on the same server at the same time. Specifically, the self-contained JavaScript configuration file controls what analysis and visualization tools will appear among the top of the map, what data sources will be used to populate the base maps and overlay data, and the display and security provisions employed to protect specific information from being viewed and edited. The desired tools can be chosen from an established list of tools. The ability to customize the "visual branding" on each instance of the client viewer by specifying different colors, graphics, text, overview map, tool choices and toolbar location is controlled by the cascading style sheet (css) configuration file. Editing either configuration file can be accomplished in a standard text editor with no additional code development necessary. If additional tools are required for specific analysis needs, they can be added to the source code bundle and incorporated into the JavaScript configuration file by the developer.

4 Prototype Development and Use

To demonstrate the capabilities of our web-mapping framework, we created the Best Environmental Health Technology System Map (BETSMAP) for NC's DPH. Within
DPH the Food Protection Program (FPP) has many responsibilities related to North Carolina’s retail food protection and other sanitation programs. First, it enforces the state’s food safety statutes for a diverse collection of facilities, including restaurants, food stands, mobile food units, push carts, public and private school cafeterias, hospitals, nursing homes, and child care centers. Second, it works with local public health department specialists who inspect retail food and respond in emergencies. Third, it assists local programs with preparedness as well as response and recovery actions when food-related emergencies occur. Finally, in addition to the local health departments, FPP collaborates closely with other state agencies and federal partners, such as the U.S. Food and Drug Administration, to coordinate response and recovery at all levels of government.

To comply with these responsibilities, FPP maintains a data repository of current and historical information related to facilities and establishments under their jurisdiction. Public health specialists enter inspection scores, violations, and complaint reports for food and lodging facilities, institutions, centers, swimming pools, and tattoo artists in this database. Complaints include illness, adulterated food, improper hygiene, contamination of food or surfaces, undercooked food, unsanitary conditions, water quality, wastewater handling, facility fires, and illegal operation. Originally designed as a tabular data repository, with facility mailing addresses serving as the only location component, our framework addresses the need for improved trend analysis, more rapid threat identification, and geographically focused emergency response capabilities, a need which has become increasingly evident in light of recent serious food-related emergencies affecting both the nation and North Carolina.

Built with an OSS framework, BetsMap is designed to allow users to track and visualize this database of FPP-regulated facilities with the associated inspections and complaints. BetsMap is designed for use by DPH and their local, state, and federal partners to provide users with the tools for spatially informed planning, analysis and emergency response. Additionally, BetsMap can be used to verify database facility location information. To create the spatial database, tabular data had been geocoded; this data may have had incomplete or incorrect addresses which could lead to errors in the geocoded locations. The BetsMap application allows users to move and save data points as needed to correct these errors when identified.

To demonstrate additional BetsMap functionality, we describe two usage scenarios:

Scenario 1: The Shearon Harris Nuclear Generating Station is a nuclear power plant located 22 miles southwest of Raleigh, NC. If the plant were to be damaged somehow, radiation and radioactive particles could be released. Exposing food to radiation does not always make it harmful to human health; however, food products that contain radioactive nuclei can be toxic and/or carcinogenic. While persons occupying food serving facilities will be evacuated by first responders, food at those facilities could have prolonged exposure. To identify potentially affected food for assessment and/or disposal, BetsMap allows users to find all facilities within a given radius of the plant. Figure 3 shows the mapped and tabular findings for this scenario.

Scenario 2: A wide variety of canned goods are recalled nationally for the potential of Clostridium Botulinum contamination. Suppose, for example, there is a recall on all products packaged in #10 cans, the large cans typically found in institutions such as hospitals kitchens, nursing home kitchens, and school cafeterias. These products must be removed immediately from service to prevent severe illnesses from occurring. Thus, specific facilities must be identified, based upon type (e.g. hospital kitchen, school...
cafeteria, etc.) and visited as soon as possible by FPP personnel. Facilities potentially offering this product can be spatially identified using BETSMap by querying facility type, establishment name, category type, county, city, etc. Additionally, local officials can use BETSMap to identify routes for efficient and timely enforcement of recalls and Google Earth to get a ground view of each facility, as shown in Figure 4.

The developed toolset provides the basic functionality desired by FPP. Existing tools can be extended to provide enhanced analysis, for example, a polygon select tool could extend the radius query for more customized boundary selection and the routing tool could implement Dijkstra's shortest path algorithm for more sophisticated routing. The framework is designed to accommodate modifications to the toolset. The next section demonstrates this functionality.

5 Customizable Framework
Designing an application framework which is customizable, modular, and portable and which can easily be configured to support a diverse range of functionality is both practical and economical, particularly for wide distribution within a large organization. One motivation for building a flexible framework is to be able to reuse the framework for different applications in research and education initiatives beyond the environmental health domain. To test the framework's customizability, we configured an additional application. This web-based mapping tool, called ForestMap, is designed for use by the NC Forest Service, a division of the NC Department of Agriculture and Consumer Services, as part of the NC Forest Service Forest Management E-Plan.

NC has over 700,000 non-industrial forest, private landowners, many of whom are in need of forest management advice and services. The NC Division of Forest Resources,
NC Wildlife Resources Commission, NC Division of Soil and Water, NCSU Forestry Extension, and other agencies, as well as private consulting foresters and others natural resources professionals are not able to service this great need effectively. Most landowners live in cities and towns and are unable to coordinate meeting with a forester or natural resource professional. Some North Carolina landowners live in other states and rarely visit their property. The NC Forest Service Forest Management E-Plan website is a way to reach these landowners and provide them with relevant forestry information to help them make informed decisions about their land management.

On the website, landowners can develop a forest management plan by specifying information about their property, such as the stand types (yellow pine, white pine, upland oak, etc.) and age (seedling, sapling, timber, etc.), management objectives (financial/ income, wildlife and fisheries habitat improvement, forest protection, etc.), and so forth. Based on this input, the site provides information about management practices for achieving the landowner’s objectives and generates a Forest Management E-Plan, which can be the basis for remote consultation with foresters or other natural resource professionals. ForestMap provides a tool for mapping the owner’s forest stands, so that the map can be included in the management plan.

ForestMap allows landowners to identify the forested areas they wish to inventory or manage by drawing and editing polygon features to represent forest stands (Figure 5). After management areas are digitized, the application captures a high-quality map for their management plan. The management areas are saved in a spatial database (as vector polygons) for later recall by the landowner and can be redisplayed and edited on return visits to the site, in case corrections or modifications are needed.

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Professional forest managers within the forest service can also access the information if landowner assistance is required at a later time and forest managers can view the managed stands to gauge the effectiveness of the E-Plan at reaching landowners across the state.

The requirements for forestry that differ from those of DPH include:

1. Addressing a non-expert (typically less computer-savvy) user base, which requires “hiding” unnecessary tools to avoid confusion. (No location, routing, query, or 3D tools).
2. Offering measurement options including feet, chains, and acres (conventional units of measurement in forestry).
3. Displaying tracks and management areas/stands (not FPP facilities).
4. Drawing polygons to represent forest management areas/stands and saving these features to PostgreSQL.
5. Editing forest management area/stand polygons.
6. For a given user, only displaying that user’s forest management areas/stands.
7. Capturing an image of the mapped stands to be included in the forest management plan when editing is complete.

These requirements were met by either making small modifications to a configuration file, by adding code to the file responsible for defining tools, or by adding applications to the flexible architecture. To address the first requirement, we were able simply to remove undesired tools from the tool list in a configuration file. For the second requirement, we modified the existing measurement tool to include the desired measurement units. For the third requirement, we simply changed the list of overlay layers in the configuration file. The next three requirements are closely related. Users need to be able to draw forest manage-
ment areas on the map and return to view and modify only those stands they generated. This problem is essentially the same as the facility editing functionality implemented for the BETSMap application, but for this application, it involves editing polygons instead of points. Modifying the list of editable layers in the configuration file fulfilled requirements four and five. When the geometry of the editable layer is polygonal, the editing tool allows the user to add polygons to that layer. The sixth requirement is handled just as point location is handled for the BETSMap application. For the seventh requirement, QGIS was added to the system. Landowners can save the map using the MapFish print functionality of the core framework, but adding QGIS and Common Gateway Interface (CGI) scripts allows the application to automatically generate and store the landowner map. When the user completes the map, a CGI script is triggered to render and capture the scene in QGIS on the website server.

The system architecture customized to accommodate the ForestMap requirements as well as the BETSMap requirements (Figure 6), has few differences from the basic framework architecture of Figure 1. Figure 6 shows the specific web mapping services (WMS) and image tiles being used by the application tier. The addition of QGIS called by CGI scripts in the server tier was discussed above. In the database tier, other databases are included in addition to the PostgreSQL/PostGIS core component. BETS data is housed in an Oracle Locator database, served by GeoServer. The Forestry Stewardship data belongs to a SQL Server database which communicates landowner identification to the ForestMap through the Forest Management E-Plan site. An instance of PostgreSQL that has both Esri’s ArcSDE spatial middleware and the PostGIS spatial extension is used so that a single spatial database repository can accommodate both Open Source GIS and Esri GIS applications. Even though no Esri applications were included in this project, this illustrates that PostGIS and ArcSDE can be used for the same spatial database, thus avoiding duplication of the spatial data layers to support two different application approaches. This makes the system more flexible for other state and county departments who may be using ArcGIS on the

Figure 6  The system architecture configured for both BETSMap and ForestMap

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desktop to maintain data. Replacing Esri applications and substituting GIS OSS may not always be the most cost-effective approach for these agencies. By using a “hybrid” spatial database, agencies can maximize established investments in desktop GIS licenses and staff training without having to purchase additional ArcGIS Server software to have web mapping capability.

Customizing the framework for both the BETSMap and the ForestMap sites demonstrates the flexibility of this economical, reusable template for creating web mapping applications. Preliminary feedback is positive; project managers from the Natural Heritage, Waste Management, Parks and Recreation, and Water Quality programs of North Carolina have expressed interest in adopting the framework for their own web mapping needs. Additional configurations of this framework are being used in academic research endeavors at North Carolina State University, including research in tourism trend evaluation and park location decision-making.

6 Conclusions

The utility of web mapping applications in the public health arena is clear. Geospatial analysis is an important aspect of public health decision-making, a process which is often a collaborative effort across multiple agencies. Web-based mapping provides a means for distributing data, visualizing it, and facilitating analysis tools.

In this research, an OSS web-based framework has been configured and implemented by two different divisions within NC's State Government for two distinct objectives. One web mapping application handles the vital needs for contamination tracking and emergency response scenarios, with query and analysis tools to support these tasks for the Division of Public Health within NC's Department of Health and Human Services. The other web mapping application for the NC Forest Service within NC's Department of Agriculture and Consumer Services allows landowners to identify the forested areas they wish to inventory or manage by drawing and editing polygon features. These two examples of framework deployment demonstrate how diverse objectives can be accomplished with minimal administrative effort, allowing for future web mapping needs to be addressed with minimal startup time and expense. Therefore, organizations with very specific web mapping application needs and budgetary restraints can employ a system that can be easily installed and maintained, and which requires little or no training to operate.

This flexible framework will support future development of web mapping instances as they arise, allowing for tailoring of each new application for specific audiences and analysis objectives. Other NC government divisions including Natural Heritage, Waste Management, Parks and Recreation, and Water Quality have programs which have identified similar needs for web mapping functionality and have expressed interest in adapting this framework. The idea of a framework to support diverse web mapping objectives is far from novel; the team at OpenGeo has pioneered this effort by creating a powerful web mapping software suite that is in itself a flexible framework ("OpenGeo Suite" 2011). Still, despite the ubiquitous nature of web mapping applications, most of those described in the literature are designed for a singular purpose. This effort reverses that trend by deploying a framework that is easily moved and customized to meet specific mapping objectives that serve selected audiences. That is, if an objective cannot be met from the pool of current tool options,
additional tools can be developed at the administrators’ expense. Additional extensions of the framework will be used in multiple university GIS research initiatives as well as in student education, where the rapid growth of web-based mapping requires increased attention. We view this framework not only as a dynamic application that will grow with user contributions, but also as an effective option to serve the web mapping needs of large and small, private and public organizations.

Note

Authors Supak, Luo, and Tateosian contributed equally to this work. All other authors provided guidance for the research and edits to this manuscript.

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FRAMEWORK FOR THE TOURISM PLANNING AND MARKETING WEB MAPPING APPLICATION

Additional Motivation

The combined tourism specific and open source web-mapping experiences detailed in the previous publications helped lay the groundwork for MapMyClients. Other important design considerations were the usefulness of the application to its intended audience and the theoretical contribution of the application. The value of determining spatial demand was made clear to me over the past three years when on multiple occasions I was asked to provide GIS support for my student and faculty colleagues in the Department of Parks, Recreation and Tourism Management at North Carolina State University. The requests were similar in nature and in all instances included the production of maps for visualizing the geographic distribution (origins and groupings) of clients or user groups. Two of these efforts were included in tourism extension reports returned to practitioners to help them address their needs, whether they were to demonstrate the economic impact of collective group of businesses providing similar services (Harrolle et al., 2011) or to aide in increasing demand for their product (Rich, Tomas, Banks, Standish, & Supak, 2010). It became evident that thoughtful visual analysis was needed in these reports; yet, my colleagues had little to no GIS experience and found the need to outsource their creation. These experiences were a major motivating factor behind the design of MapMyClients. To address the needs of my colleagues and the greater tourism community by allowing them to capitalizing on the value of spatial analytics, a GIS tool was needed that does not require specialized GIS training. MapMyClients addresses this application gap and now any user can identify spatial patterns in client distributions, leading to more comprehensive reporting and better marketing and business planning.
Theoretical Contribution

Although the development of MapMyClients addresses practical needs of tourism professionals and researchers, at the same time, it provides a tool with which to test theoretical constructs important to tourism such as market segmentation and tourism flow modeling. Market segmentation is a central concept in both marketing theory and practice (Wedel & Kamakura, 2000). During the Post World War II era, Smith (1956) introduced the concept of market segmentation. The author recognized the existence of heterogeneity in the demand for goods and services, based on the economic theory of imperfect competition (Robinson, 1933). Smith stated: “Market segmentation involves viewing a heterogeneous market as a number of smaller homogeneous markets, in response to differing preferences, attributable to the desires of consumers for more precise satisfaction of their varying wants.” New methodologies of market segmentation continue to evolve and sophisticated modeling techniques currently include clustering methods, mixture models, mixture regression models, mixture unfolding models, profiling segments and dynamic segmentation (Wedel & Kamakura, 2000).

When explaining tourist behavior or tourism observations, market segmentation is often preformed via clustering techniques. The goal of clustering is to partition a dataset into groups, based on observed characteristics so that the observations in a group are as similar as possible to each other and as dissimilar as possible to the observations in all other groups. McKercher (2008) tested the hypothesis that market segments transform unevenly as distance from the source increases by clustering Hong Kong residents who had traveled internationally based on age, household income, education, self-reported level of travel experience and package tour purchase propensity. In this study, distance from the source represented the distance between the residents and 11 international urban destinations. The authors found that aggregate market profiles changed with distance,
becoming generally better educated, older and more affluent with increased distance from the source. In addition, certain market segments identified were found to have increased and decreased through time. These findings have a number of potentially significant implications for destination marketing. This study confirms that the Hong Kong outbound market, like all other geographical regions of tourism demand, is not homogenous. Instead, markets consist of a variety of segments, each with its own unique characteristics that can be better satisfied by some destinations more than others.

One goal behind studies such as McKercher (2008) is to provide practitioners with tourism behavior findings from which they may extrapolate or infer general and specific information that is hopefully applicable to their business. Unfortunately, general findings such as the fact that geographical regions of tourism demand are not homogenous will not help a practitioner to decide where to spend marketing dollars. Conversely, the specific market profile findings about the Hong Kong residents may be applicable to other markets, but previously there existed no good way for a practitioner to determine if distance from a source results in different market segments for their own customers. Conducting cluster analysis for a single business can be impractical because the training and software expense would unlikely offset the marketing revenue related benefits. This cost benefit tradeoff issue also exists for businesses that would like to conduct spatial analysis using proprietary desktop GIS. This issue is discussed in detail in the next section.

MapMyClients provides users a way to test the hypothesis that market segments transform unevenly as distance from the source increases not through complicated clustering techniques, but rather through simplistic visual analysis of market segments. Although MapMyClients does not offer formal clustering techniques, it does present many of the factors included in McKercher’s (2008) market segmentation analysis such as age, household income and education. Through examination of the map layers in MapMyClients, users can deduce how customer profiles change with distance from the source, just as McKercher (2008) did. This ability to provide less formal market segmentation
extends market segmentation theory and provides a tangible link between research and practitioners. In practice, this will lead to destination managers using their marketing dollars more effectively to reach the most likely consumers.

In addition to market segmentation, identifying spatial relationships is often desirable in order to understand, model and forecast tourism flow and other forms of tourism behavior. Building on the importance of geographic distance to marketing theory and modeling, MapMyClients provides users with the ability to investigate models employed by tourism researchers over the past half century. The distance decay model, utilized in recreation and tourism research in the 1960s and 1970s as a proxy for forecasting, predicts an inverse relationship between distance and willingness to travel. This relationship was based on the observed trade-off between the investment of time, money or effort to achieve the travel and the time one can spend at the end destination. More generally, demand will peak at some distance relatively close to a source market and then decline as distance increases. The theory is said to play an important role in the distribution of ideas, technology, time, population and spatial interactions of various types (Mckercher & Lew, 2003). Although it has fallen into disuse of late, distance decay principles are still implicit in current modeling and forecasting of tourist flows (Mckercher & Lew, 2003) and Eldridge & Jones (1991) go as far as to recognize distance decay as one of the key laws of geography.

Tourism demand modeling and forecasting are important areas in tourism research and have attracted much attention from both academics and practitioners (Song & Li, 2008), with 420 studies on the topic published during the period 1960-2002 (Li, Song, & Witt, 2005). Many of these studies attempt to establish forecasting principles that could be used to guide practitioners in selecting forecasting techniques (Song & Li, 2008). Unfortunately these efforts have not been successful according to Witt & Song (2000) and Li et al. (2005) who posit the performance of the forecasting models varies according to the data frequencies used in the model estimation, the destination-origin
country/region pairs under consideration and the length of the forecasting horizons concerned.

Despite these limitations, model development and specification continues largely using secondary data and either time series or econometric techniques. Among the 121 models examined by Song & Li (2008) published since 2000, the tourist arrival variable is still the most popular measure of tourism demand. Specifically, this variable was measured by total tourist arrivals from an origin to a destination. In many cases, the total tourist travel arrival variable is large in scale and represents data aggregation over a large region or entire county (e.g., Falocci, Paniccia, & Stanghellini, 2009; Khadaroo & Seetanah, 2008). While the total tourist arrival variable remains important to tourism flow and forecasting, the level of data aggregation may make these models less relevant to practitioners who are interested in site-specific forecasting.

MapMyClients investigates total tourist arrivals from origins to a destination. The destinations, however, are not on a county or regional scale, but rather on an individual business or attraction scale. Given the sensitivity of forecasting model performance described by Li et al. (2005), the existing suite of models may not provide much benefit to practitioners operating on smaller scales. MapMyClients offers an alternative approach to the conventional forecasting models that is more accessible to tourism practitioners. Although future tourism flows cannot be estimated, many of the factors that would be incorporated into a tourism flow model are visually presented in MapMyClients, such as total tourist arrivals and origin-destination distances. The consideration of these factors is not only useful in understanding the demand for site/event-specific attractions or activities, but future demand can be increased through targeted marketing efforts. Further, MapMyClients can visually test the predictions of the distance decay model by presenting the spatial distribution and frequency of customers relative to the tourism attraction or event. For the Bed & Breakfast example discussed in the next section entitled “An Open Source Web Mapping System for Tourism Planning and Marketing,” the attraction is located in western North Carolina and the total
client count map supports the model that demand peaks at some distance relatively close to the source and then declines as distance from that source increases.

**Community Response**

To examine if the scenario described for the Bed & Breakfast example holds true for other tourism enterprises, a usability and usefulness survey was designed and distributed using SurveyMonkey.com to over 200 tourism practitioners who are members of the Travel and Tourism Research Association (“SurveyMonkey,” 2012). Additionally, the same solicitation was posted on multiple LinkedIn tourism group message boards (e.g. DMAI Convention and Visitors Bureau Network, Travel & Tourism Industry Professionals Worldwide, Travel Media Pros). For the complete survey instrument see Appendix A, and for complete survey results see Appendix B. Although the response rate for the survey has been low, those who did participate provided positive feedback. Survey respondents identified several benefits provided by MapMyClients including the thematic mapping method of visualization, its utility for marketing planning and the variety of supplemental data provided to support their objectives. To illustrate these themes, I have selected a few quotes from the survey results:

"The results confirmed that the target audience for our marketing program was being reached successfully." - Larry Schweinsburg, President, Private Industry

"I could use it for all of my data collected at festivals, events and sporting events." - Jennifer Norman, Executive Director, Destination Management Organization (DMO)

“I will use it to map our client base for all of our channels.” - Brian Jenkins, Director of Business Strategy & Research, Destination Management Organization (DMO)

“I had 2 projects that I needed your application for. The Gary’s South Shore Air Show and 'A Christmas Story Comes Home' (Hammond, IN is the home of Jean Shepherd the author of Christmas Story. The mapping feature was excellent at showing where the visitors were
coming from.” - Robert Victor, Research Manager for a Convention and Visitors Bureau, Destination Management Organization (DMO)

"Great as a free application! Also provides features (polygon fills) that are difficult to do in other free web based mapping software.” - Anonymous

In addition to the survey responses, my colleague and committee member Sam Rozier Rich has personally benefited from this application in her new business venture. She has the following to say:

“MapMyClients is a valuable and easy to use tool for tourism practitioners. I have already used MapMyClients for two projects and it worked perfectly in allowing me to not only visually illustrate where visitors were traveling from but also to identify key demographic features associated with the data. I hope this software continues to be offered to tourism practitioners so data collected can be used to better inform marketing decisions, funding, and support. Thank you for developing and sharing this tool.” - Samantha Rozier Rich, Lead Researcher, Owner - enRiched Consulting, LLC

From the LinkedIn solicitation, positive feedback continues:

“Hi, Stacy, I represent non-profit Tourist sites and know that your program would be very applicable to identifying and visualizing their visitors and where they are coming from. It would help us in making marketing decisions of where we are drawing from now and where we can go to get more of the same. The visualization is particularly important when working with Boards to help them understand why money needs to be spent in different media in varying locations. Their eyes glaze over when you give them lists and numbers.” - Dianne Powell, President SellMark - full service marketing company

After the official survey period ended, Google Analytics tracking was added to the MapMyClients home page. Between January 1, 2013 and February 12, 2013, 63 site visits were made by 34 unique visitors meaning that there were 29 returning visits. This indicates MapMyClients provides a service that is attractive enough to sustain participation. Most visits originated from the southeastern US, although international interest has occurred in both Brazil and Ireland (Figure 3A).
Figure 3. A Total visits to MapMyClients home page by city from January 1, 2013 to February 12, 2013. Raleigh, NC ranks as the city with the highest visitation rate (23 visits) followed by Memphis (5 visits) and Atlanta (4 visits).
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AN OPEN SOURCE WEB MAPPING SYSTEM FOR TOURISM PLANNING AND MARKETING

North Carolina State University

Manuscript in preparation for The Journal of Travel and Tourism Marketing

Abstract

Core retail management functions include defining market areas and profiling customers. For tourism enterprises, a significant percentage of total sales can come from customers who are not permanent residents of the geographic area surrounding stores or attractions, thereby complicating traditional approaches for these activities. The analysis and visualization capabilities of Geographic Information System (GIS) technology is an important business tool in these circumstances because it can effectively model the geographic distribution or dispersion of customers and potential clients. Unfortunately, many businesses may not be able to utilize GIS due to its complexity and associated expense. In these cases, the tourism industry and its corresponding research community need an alternative marketing decision support tool that will afford them use of their own consumer related data to capitalize on the value of spatial analytics. This alternative tool should be customized and easy to use, employ open source software to reduce expense and allow for broad accessibility via web delivery. This study develops such a tool and explores its use for tourism planning and marketing. This implementation gives users the ability to easily determine and visualize the spatial distribution of U.S. client origins and visitation patterns, and it provides other relevant tourism specific and general demographic information. This functionality can be beneficial in developing or augmenting business plans and marketing strategies.

Keywords: Tourism Marketing, GIS, Web Delivery, Open Source
Introduction

Competing for new customers, while retaining current ones, is a priority for all tourism operations regardless of size, industry or ownership. In retail management, market area analysis, customer profiling, and site selection are key functions at the core of best business practice (Applebaum, 1964; Goodchild, 1984; Huff & Sherr, 1967; Huff, 1964). For tourism-dependent retailers, a significant percentage of sales are to customers who are not permanent residents of geographic area surrounding the store or attraction. Therefore, market area definition and subsequent customer profiling should not be accomplished by simply defining distance rings or drive time polygons with respect to an attraction, but rather they should include techniques which account for the geographic dispersion of customers (Miller, 2008).

Given the ability of a Geographic Information Systems (GIS) to analyze the geographic and spatial relationships of various internal and external datasets, it is an important business tool for market area analysis and customer profiling (Bell & Zabriskie, 1978; Elliott-White & Finn, 1998; Grimshaw, 1999; Miller, 2008). The spatial analytic and visualization capabilities of GIS allow for analysis and display of past or current trends, which can provide spatial decision support beneficial in tourism planning and management (McAdam, 1999). Unfortunately, many tourism businesses do not have the capability to capitalize on these systems due to the complexity and/or expense of the GIS software. While efforts to address these obstacles continue to produce new software applications such as ESRI’s Business Analyst Online (BAO), BatchGeo or QGIS (BatchGeo, 2012, ESRI Business Analyst Online, 2012, QGIS, 2012), current software applications remain limited by either one or both of the aforementioned obstacles or lacks some component of desired functionality. Further, the design of these products and their counterparts are not customized for tourism professionals and researchers.
This leaves that community wanting certain functionality and potentially having too much unnecessary functionality. The application described here will address this gap.

GIS can add value to market analysis by enhancing direct marketing and micromarketing endeavors via the conversion of data into client intelligence. Elliott-White & Finn (1998) identify this process as actionable competitive advantage. The travel and tourism industry is well suited for spatial analysis, primarily because most transactions produce a record of client names and addresses (Elliott-White & Finn, 1998), allowing for customer specific spatial origin analysis. Tourism organizations with a database of customer street addresses or zip codes can use GIS to generate maps displaying where their customers live in relation to each other and to destinations. The identification of these spatial relationships among tourist origins and their collective relationship to attractions enables the evaluation and targeting of marketing efforts, customization of visitor packages, development of new opportunities and the discovery of potential collaborative arrangements among partners (Chancellor & Cole, 2008). Additionally, this type of analysis can identify customer clusters useful in determining locations for additional neighborhood level promotions such as newspaper ads or billboards (Hess, Rubin, & West, 2004). Conversely, limited past customer activity from a geographic area or neighborhood could indicate a potential new target market. Using GIS, potential new markets can be compared both geographically and demographically to current high performing neighborhoods helping to form or augment marketing strategies. Organizations employing these techniques can evaluate the effectiveness of marketing and other investment initiatives, can better serve current customers and better compete for new customers.

Despite these considerable benefits, the tourism industry has adopted GIS technology slowly (Chen, 2007). Evidence suggests that in general, the application of GIS has lagged behind other information systems tools in business. Keenan (2005) identifies several factors that have contributed to this lag. These include: 1) hardware requirements, 2) software complexity, 3) data availability and
4) user training. However, the author acknowledges that due to recent developments in each of these areas, GIS technologies are accessible to more organizations. Additionally, emerging technologies provide more effective ways for diverse user groups to have access to GIS (e.g., Supak et al., 2012). Specifically, development of web-based GIS is improving accessibility and reducing complexity, thereby decreasing user training needs and allowing a wider audience with varied computer and GIS knowledge to participate.

Global trends in Internet use, along with technologies for creating and sharing geographic information through pioneering and often collaborative applications have led to the rapid development of web-based mapping (Haklay, Singleton, & Parker, 2008). As the Internet continues to change the perception and use of geographic information, web-based mapping and geoprocessing services continue to spread across many domains (Dragićević, Li, Brovelli, & Veenendaal, 2011), in some cases mirroring the advancement of desktop GIS and information technology in general (Cinnamon et al., 2009). Along with continuously evolving multifunctional desktop systems such as ESRI’s ArcGIS Desktop or GRASS, an explosion of development has occurred in user focused spatial information application software (Giuliani, 2004). Many of these applications are web-based, making them more accessible to broader user groups. For example, Frehner & Brandli (2006) describe a web-based data management and analysis system designed to support an interdisciplinary approach to resource management and environmental decision support. To support this goal, the authors combined distributed ecological data repositories for endangered biospheres and animals as well as the occurrences of moss, fungi and lichen with spatial analysis tools for attribute queries, spatial queries and spatial overlays. In another example, Tiwari & Rushton (2010) developed a modular, web-based spatial analysis system for environmental health surveillance that can visualize the spatial patterns of disease outcomes. For the purposes of estimating individual exposures to environmental contaminants, individual-level data are automatically linked to environmental data and
environmental models by geocoding. These two application examples have less functionality than traditional desktop GIS; however, because these applications are tailored to specific users’ needs and delivered online, they are easier use and access. By limiting the functionality, customized applications allow novice users to perform only the tasks that are critical, thereby removing the complexity of universal multifunctional GIS software. In many instances, the universal multifunctional GIS software may be the only option. Without a customized application, tourism professionals and researchers must find other methods to support planning and marketing objectives.

**GIS Options to Support Tourism Marketing Objectives**

Consider a fictitious tourism business, Western North Carolina Bed & Breakfast (WNC B&B). Assume WNC B&B wants to learn about their current clientele (where do they live, do they cluster, what is their socioeconomic background?) to determine if existing marketing efforts are producing clients and to determine where to spend future marketing dollars. Because their market area is geographically dispersed, the managers at WNC B&B could benefit from visualizing how their client’s origins vary across geographic regions as well as the level of variability within a region (i.e. are there any sub-regions with extremely high client concentrations adjacent to sub-regions of low client concentrations?). One way to accomplish this goal is to create a choropleth map (also called a thematic map), where each spatial unit is filled with a uniform color or pattern representing a single attribute such as client frequency (Figure 3.1).
Figure 3.1 Choropleth/thematic map displaying WNC B&B’s total client count by zip code for the greater Atlanta area. The solid red region in north Atlanta and its suburbs represents an abundance of clients and the lack of shading in south Atlanta represents a dearth of clients. This map gives instantaneous insight as to the effectiveness of geographically targeted current marketing efforts. This intuition also can support the preparation of marketing strategies to inform future campaigns.

If only universal multifunctional GIS options are available to WNC B&B, the managers of the business might choose one of the four example software options shown in Figure 3.2 to examine their client’s geographical distribution. The four programs shown represent two types of software development methodology and two types of software delivery styles. The development methods are proprietary and Open Source Software (OSS) and the delivery styles are desktop or web delivery. Notice only the desktop GIS software provides the ability to produce a choropleth map. This and other limitations as well as advantages for each software product are discussed in the following paragraphs.
Figure 3.2 Example software options for exploring client distributions. Each product has at least one limitation related to cost, complexity or display options. These are all universal multifunctional GIS tools, none of which is tourism specific.

For proprietary desktop GIS, ArcGIS 10.1 for Desktop Basic, ESRI’s most minimal commercial release, has a starting price of $1500 that does not include reoccurring licensing fees applicable after the first year (ArcGIS 10.1 for Desktop Basic, 2012). To produce a choropleth map with this product, WNC B&B must first purchase the product, find the proper geometry shapefile (ESRI’s proprietary data format) and then employ someone who is trained in its multifunctional design. Caution must be taken as erroneous outputs are possible when improper or incomplete procedures are implemented. The software user must choose the correct methodological approach and
isolate the required functions out of hundreds to achieve the objective. Specifically, the approach for this objective includes aggregating and geocoding client data on a spatial scale of interest, while ensuring inclusion of all possible data.

Advancements in OSS have transpired recently for both desktop and web-based mapping applications. QGIS is one example of an OSS universal multifunctional desktop GIS counterpart to ArcGIS Desktop (QGIS, 2012). This program is free for download; however, the software user still must have appropriate hardware and the complexity issues described for ArcGIS Desktop still exist. QGIS has a more limited tool set than its costly competitors, but the OSS community continues to develop and update tools regularly. Therefore, QGIS and other similar programs (e.g., GRASS, uDig, OpenJump, gvSIG) make appealing options for users operating in resource-constrained environments who have GIS skills and no reservations about complex software. WNC B&B would save money using a program such as QGIS when compared to ArcGIS Desktop, but all of the complications described above regarding the intricacies of using ArcGIS Desktop to create a choropleth map would still exist. These complications coupled together with limited software support may present too large a challenge for a casual user.

Universal multifunctional proprietary web-based mapping applications can reduce both the complexity and expense of GIS, but only customized implementations specifically designed for targeted user groups truly minimize complexity. ESRI’s BAO is an example of a proprietary web-mapping application that is somewhat customized in that it has reduced functionality when compared to desktop GIS, but it is not fully customized in that functionality is designed for a broad set of business users (ESRI Business Analyst Online, 2012). To accomplish a varied set of business related tasks, this product offers multiple tabs, functions and interface options which can be overwhelming for novice users. Although both the price and the complexity are greatly reduced when compared to ArcGIS Desktop, as a user can get a single day license for $149 or the most basic annual subscription
for $995 (http://www.esri.com/software/bao/pricing), this tool still may be financially unfeasible for some organizations and limitations still exist in terms of representing users’ personal data. If WNC B&B were to use BAO, managers could easily calculate distance rings or drive time polygons to represent market areas, but this technique would not be appropriate for a tourism business whose clients are dispersed. Alternatively, managers could upload their own client data as a spreadsheet, but they would encounter file size and record number restrictions. Additionally, they could only display their data as points, without the communicative impact of a personalized choropleth map. There is one non-point method to display user data, but it requires an ESRI proprietary shapefile, and it does not support thematic shading. Although this product would provide limited client specific spatial insights for WNC B&B’s, it does provide thematic maps for a huge set of demographic and lifestyle variables at any scale desired.

BatchGeo is an example of a web-based mapping application that utilizes the simple and customizable OSS application program interface Google Map API (BatchGeo, 2012; Crowley, 2011). BatchGeo’s interface is easy to use and there are both a free and professional versions, so a user can choose to eliminate purchase expense entirely. Like BAO, this program offers the ability to input personal client data for geocoding as points, but unlike BAO there is no supporting business data provided to set a user’s information in a broader business context. Additionally, the frequency of clients for any given map point can only be viewed one point at a time by clicking on that point and viewing the pop up window. This product also would leave WNC B&B without the benefit of a choropleth map for understanding the spatial frequency of its clients. As Google and others continue to improve their offerings, a choropleth mapping tool may exist on the horizon. Jackson (2011) believes that OSS will become more common as organizations driving much of the software innovation today are not in the business of selling software. This is important for the adoption of GIS because in resource-constrained environments, proprietary solution implementation has limitations.
For those who lack resources for GIS hardware and software as well as other related GIS investments such as training or staff expertise, OSS solutions are desirable (Moreno-Sanchez, Anderson, Cruz, & Hayden, 2007). The generally common aspects of OSS include transparency of development and the freedom to build more complex systems out of readily available building blocks (Kilamo, Hammouda, Mikkonen, & Aaltonen, 2012). OSS components eliminate the need to initially pay for proprietary software, some of which have reoccurring licensing fees. Moreno-Sanchez et al. (2007) catalog some of the other benefits of employing OSS, including user based community development and support, smooth learning curves that make them accessible to more novice developers and more modest computer hardware requirements. Although there are limitations to the services that OSS can provide, some literature proposes that OSS web-based GIS have reached a stage of maturity, sophistication, robustness, stability and user friendliness rivaling that of commercial, proprietary GIS and web-based GIS server products (Boulos & Honda, 2006).

In summary, when a tourism business such as WNC B&B is interested in examining the geographic distribution of their clients, there exist both proprietary and OSS desktop and web-based mapping GIS tools to support this task (Figure 3.2). Regardless of delivery or development method, all of the tools described above are non-discipline specific. Desires for industry or discipline specific web-mapping applications have led to customized system development using proprietary software (e.g. ArcGIS Mapping APIs) and OSS (e.g. OpenGeo Suite). The literature in many disciplines describes examples of customized web-based mapping applications including those for landscape ecology (Frehner & Brandli, 2006), natural resource management (Kearns, Kelly, & Tuxen, 2003), forest management (Xie et al., 2011), agriculture (Serrano, Jiménez-Hornero, Gutiérrez de Ravé, & Jodral, 2008), public participatory GIS (Hall, Chipeniuk, Feick, Leahy, & Deparday, 2010) and public health (MacEachren, Crawford, Akella, & Lengerich, 2008; Supak et al., 2012).
Currently in the field of tourism, no descriptions of proprietary or OSS web-based mapping applications appear in the literature. A customized web-based mapping tool is needed to address this application gap. Given the complexity of desktop GIS and the limitations of universal multifunctional web mapping applications, an alternative marketing decision support tool is needed that will allow the tourism industry and research community to capitalize on the value of GIS. The MapMyClients application described here supports that effort as an initial OSS contribution for tourism planning and marketing.

**System Requirements and Objectives**

Working with tourism research specialists and through the study of related work, the following tourism planning and marketing GIS functional requirements were identified:

- Upload tabular client or transactional data;
- Aggregate client data on a spatial level of interest to determine spatial frequency;
- Link spatial frequency client data to tourism specific and general demographic data;
- Link spatial frequency client data and demographic data to spatial data;
- Classify and display client frequency data based on classification value as thematic map;
- Support rudimentary customer profiling by providing thematic demographic map layers;
- View/visualize client data along with other geographic features to provide locational context;
- Examine and explore concentrations of desirable or undesirable locations for marketing;
- Confirm if targeted marketing effort are successful;
- Use OSS components to provide these services.

The system must allow tourism professionals and researchers to upload client or transactional data lists as spreadsheets, which are then quickly processed and returned as spatial frequency thematic maps where the area within each U.S. zip code’s tabulated geometric boundary is symbolized by color to represent the total number of transactions or clients originating from that zip code. When overlaid with geographically matched demographic, socioeconomic and consumer behavior data, this thematic map can help the user achieve four objectives:
• A user will learn about his or her current clientele. Answering questions such as: where do they live, do they cluster, what characteristics define socioeconomic background can aide users to better service current clientele;
• A user can determine if existing marketing efforts are producing clients (if the locations of targeted marketing efforts are known);
• A user can determine current clientele profiles to predict future clientele in alternative geographic areas with similar demographics;
• A user can then determine whether to market to existing client neighborhoods or the alternative geographic areas discovered through the analysis, or both.

Prototype Development

To meet the functionality requirements as well as the desired objectives specified above, the MapMyClients customized web-based mapping application was developed. Because the software components on which a web mapping systems are built determine its data handling and analytical capabilities (Rinner, Moldofsky, Cusimano, Marshall, & Hernandez, 2011), selection of these components was thoughtful. Ultimately, OpenGeo Suite Community Edition’s three tiered OSS stack was selected (“OpenGeo Suite,” 2011) because it bundles the key software components necessary to deliver the desired web mapping functionality. These components include a spatial database management system (PostGIS for PostgreSQL), a web map server (Geoserver) and web map application interface software for displaying and manipulating data on the web site (GeoExplorer API). Built with an OSS stack and web delivered, MapMyClients provides ease of access to its users as well possible expansion to mobile devices in the future.

The MapMyClients workflow in Figure 3.3 illustrates how backend data processing steps combined with OSS stack components produce a choropleth map with supplemental demographic layers. Each of the steps in the flow chart are automated using Python (Python, n.d.), thereby removing the necessity for a user to be familiar with GIS methodology and syntax. Because choropleth maps require data aggregation over a defined spatial area, the scale of aggregation was determined prior to prototype development. For the US, the smallest scale of spatial representation is
the census block and the largest is by region (often containing multiple states). The selection of zip code level aggregation allows for the broadest use of the application because some users may only have access to zip code level data and full address data would require aggregation to some spatial unit.

After a user uploads his/her own client data with a valid zip code field, the file is read and the contents of the zip code field are stored for further processing. Both numeric and text data types are acceptable zip code inputs, affording minimal file preparation on the part of the user. Because zip code boundaries are created by the United States Postal Service with an objective of providing efficient mail service (Miller, 2008), there are approximately 10,000 fewer tabulated zip codes boundaries than zip codes with point representation. These zip codes without tabulate boundaries, termed “enclosed zip codes,” belong to specific buildings (e.g. post offices) or clusters of buildings (e.g. universities). These enclosed zip codes have spatial footprints far smaller than their standard zip code counterparts, where the median spatial area is 66.4 square miles. To ensure minimal data omission, enclosed zip codes are automatically swapped out for their parent zip code boundary (i.e. the zip code by which they are enclosed), a step which can easily be overlooked when using traditional desktop GIS.
Figure 3.3 The MapMyClients workflow is automated using Python. The backend data processing steps combined with OSS stack components produce a choropleth map with supplemental demographic layers. Green boxes represent steps where the user can interact and blue boxes are steps that are automated and require no additional effort on the part of the user.

After the replacement of enclosed zip codes, the number of occurrences for each unique zip code with a valid spatial boundary is counted. This count becomes the total client count (frequency) by zip code attribute. All unique zip codes then are matched with supporting data from ESRI’s BAO data repository. The supporting data include six demographic, socioeconomic and consumer behavior metrics: 2010 median age, 2010 median home value, 2010 median income, 2010 percent of population over 25 years with a bachelor’s degree, average annual dollar amount spent on travel and
average annual dollar amount spent on lodging. Additionally, the 2005 population and population density per square mile for each unique zip code is identified. The distributions of client frequency values and supplemental data values are used to classify each of these nine datasets into three categories of symbology. A quantile style classification methodology was selected as it lets users interpret these categories using the common sense notion of even thirds of data. This classification method aims to put an even number of unique zip codes into high, medium and low groupings, while maintaining uniqueness among the groups. This may lead to an uneven distribution among the categories for some datasets.

Both the values and categories of the nine data types of interest then are written to a PostGIS database as a table where each row represents a unique zip code. This table is then served to the web using Geoserver and a layer is created for each attribute of interest. A predefined Styled Layer Descriptor file then is applied to each of the nine layers so that each zip code boundary is shaded according to its specific symbology attribute (high, medium and low). At this time, for each layer, the attribute value for each unique zip code is labeled to give the user more specific information and the ability to see how widely the values range within a symbology category. An additional layer also is included that displays client frequency attribute shading with the zip code as the label to provide identification information for the user. Then these 10 map layers are automatically loaded into a new browser tab and displayed using a modified version of the GeoExplorer API. The map interface includes standard web mapping navigation options such as zoom, pan, zoom to next and previous extents and zoom to full extent as well as specialty tools such as print, measure and a Google Earth plugin to allow ground visualization. To maximize ease of use, only the page provided for data upload and the returned map are viewable by the user.
MapMyClients Prototype Usage Example

The MapMyClients implementation described above is currently a working prototype available to members of the Travel and Tourism Research Association as well as others who have taken an interest in the application as a result of Facebook or LinkedIn promotions. Revisiting WNC B&B demonstrates a typical user experience including the interpretation of results. Remember that WNC B&B wants to learn about their current clientele (where do they live, do they cluster, what characteristics define their socioeconomic background?) to better serve their clients and to determine if existing marketing efforts are producing clients. The answers to these questions also can help determine where to spend future marketing dollars and through what geographically focused channels (e.g. print, radio/TV, the Yellow Pages, direct mail, or trade show booths). Specifically, the managers want to know if there are any regions with extremely high client concentrations. After ruling out the current non-discipline-specific GIS options presented in Figure 3.2, WNC B&B decides to try MapMyClients to answer their questions. While on the home page (Figure 3.4), WNC B&B managers can watch instructional videos detailing how and why to use MapMyClients and they can read simple written instructions for choosing and uploading appropriate client data. Some basic map navigating instructions also are given.
Figure 3.4 The MapMyClients home page (http://152.1.0.195:8888/mapmyclients/index.html). Demo videos and numbered categories help users choose and upload appropriate client data files.

As noted on the home page, appropriate inputs include non-aggregate client data in one of three data formats (xls, xlsx and csv), which contain five-digit or nine-digit US zip codes as text strings or as numbers. If the zip codes are input as numbers, conversion to the string data type insures leading zeros are included for those records with numeric zip code values less than 10000, thereby reducing valid zip code dropping. No limitations on file size or record number limit the application’s
usage, but the word “zip” must appear in the header of the zip code field. Fields other than those with the word “zip” have no influence on the process, so client data file preparation does not require field deletion or any additional user effort. After the managers determine an appropriate file, they only need to click the mouse three times to browse, choose and upload that file. When the managers click the upload button (Figure 3.4), within 20 seconds a new tab will open with a map similar to Figure 3.5.

![Map view of WNC B&B’s clients automatically returned after the data is uploaded.](image)

Figure 3.5 Map view of WNC B&B’s clients automatically returned after the data is uploaded. The client origins are primarily focused in the southeastern US. The table of contents on the left side allow for all ten data layers to be toggled off and on. There are several options for changing zoom level including the drop down menu at the bottom right and the plus/minus navigation bar on top left. The print, measure and Google Earth plugin appear at the top right.

After examining Figure 3.5, the managers at WNC B&B recognize the high concentration of customers residing in the southeastern US and they decide to take a closer look at the Charlotte, Greensboro and Research Triangle Area (Raleigh, Durham & Chapel Hill) in North Carolina (NC), as these areas have the highest client concentrations. The managers then zoom into this central region of the state for a clearer picture of where the client origin concentrations are the highest (Figure 3.6). At
this level of zoom, the color coding of attributes by zip code is discernible as red, green and blue for the high, medium and low values, respectively. In the southern Charlotte metropolitan area, a cluster of 11 zip codes has a total of 105 clients and there is a single zip code among this cluster where 38 clients reside. This visitation pattern would not be discernible by simply looking at the uploaded data file. In the Research Triangle Area, there is a cluster of 34 clients in north Raleigh as well as a cluster of 24 clients in the Chapel Hill area. The Greensboro and Winston-Salem areas have client clusters with lower client frequencies comparatively, but these areas support the pattern observed across central NC of urban and suburban interest in WNC B&B. Investigation of the 2005 population map layer (Figure 3.7) helps elucidate how client clusters are influenced by total population. The noted areas of concentrated clients not surprisingly have some of the highest total populations. If managers are unfamiliar with the region, examination of the 2005 population density map layer (not shown) could help them differentiate which areas are urban, suburban and rural.

Figure 3.6 Total client count (frequency) by zip code for WNC B&B clients in the Charlotte, Greensboro and Research Triangle Area (Raleigh, Durham & Chapel Hill) of NC. Southern Charlotte has a significant client cluster with 105 clients. This visitation pattern would not be discernible by simply looking at the uploaded data file. Geographic areas with high client concentrations could merit neighborhood level promotions such as billboards or newspaper ads.
Figure 3.7 Population by zip code for WNC B&B clients in the Charlotte, Greensboro and Research Triangle Area (Raleigh, Durham & Chapel Hill) of NC. This map layer is useful in determining if/how population influences the total client count. A population density map layer is also available for assessing the level of urbanization.

Once the managers identify the high frequency client clusters, they want to probe deeper into the supplemental map data layers to learn about these clients. Figures 3.8-3.11 show some of the key characteristics of the clients, but do not represent the full set of map layers available to the managers. The average travel expenditure (Figure 3.8) and median household income (Figure 3.9) maps nearly mirror each other, with higher values of each associated with the urban and suburban locations corresponding to high client frequency clusters. One area the managers should flag for future geographical target marketing is western and southwestern Raleigh, where both median income and average travel expenditures are in the highest category but client frequency is currently relatively low. When the managers examine the median age (Figure 3.10) and educational attainment (Figure 3.11) map layers, they find a pattern that complements that of the travel expenditure and median household
income map layers. The same urban and suburban areas with high client frequencies tend to have lower median ages and a higher percentage of the population over 25 years of age with a bachelor’s degree, relative to the surrounding rural areas. Identifying these urban and suburban client clusters where younger, higher income, higher educated people spend more on travel allows WNC B&B to refine its current marketing strategies. These specific areas could benefit from additional neighborhood level promotions such as billboards or newspaper ads or if WNC B&B managers are already employing targeted marketing efforts in these areas, this map could validate their current marketing strategy.

Figure 3.8 Average travel expenditure by zip code for WNC B&B clients in the Charlotte, Greensboro and Research Triangle Area (Raleigh, Durham & Chapel Hill) of NC. This tourism specific map layer shows that the geographic regions of high client frequency are largely the same as the regions where people are willing to spend more on travel related expenses.
Figure 3.9 Median household income by zip code for WNC B&B clients in the Charlotte, Greensboro and Research Triangle Area (Raleigh, Durham & Chapel Hill) of NC. This map layer mirrors that of the travel expenditures map layer. This information intuitively makes sense because higher household incomes translate to more available funds in household budgets for non-necessities such as travel. This map layer does provide new insight about southwestern Raleigh, where both median income and average travel expenditures are in the highest category, but client frequency is relatively low. This area might prove to be a valuable new market.
Figure 3.10 Median age by zip code for WNC B&B clients in the Charlotte, Greensboro and Research Triangle Area (Raleigh, Durham & Chapel Hill) of NC. This map layer shows urban areas have populations with lower median ages.
Figure 3.11 Percent population over 25 years of age with a bachelor’s degree by zip code for WNC B&B clients in the Charlotte, Greensboro and Research Triangle Area (Raleigh, Durham & Chapel Hill) of NC. Managers continue to grow a customer profile after examining this map layer. Their high client count zip codes or customer clusters are in urban and suburban areas where the population is more likely to be highly educated, younger, earn higher incomes, and spend more money on travel.

This prototype has been in place since November 2012. Both Google Analytics and a usability/usefulness survey using surveymonkey.com (“SurveyMonkey,” 2012) are in place to track usage and catalog general feedback that may be helpful for improving future versions of the application. From Google Analytics, repeat visitors represent above 40% of total web traffic for the home page, indicating that MapMyClients provides a service that is attractive enough to sustain participation. The survey results generally support the application is meeting its design objectives with responses such as “[MapMyClients] confirms that the target audience for our marketing program was being reached successfully.” Potential improvements mentioned in the survey include the incorporation of additional demographic and social data such as home ownership, social network usage and presence of children. Additionally, the ability to map other user-specific attributes from the
uploaded data such as the total dollar amount spent or total room nights stayed (for hotel data) was mentioned in one survey response. This option would require more user input for all users and because only some users would have numeric attributes to take advantage of this feature, this functionality was not included in the initial prototype of MapMyClients.

**Constraints & Conclusions**

MapMyClients illustrates the value of determining client frequency clusters and identifying demographic characteristics based on geographic locations for the purposes of understanding existing customers more fully and targeting new prospects more precisely. Aggregating client data on the zip codes scale for choropleth map display allows for the identification of clusters or regions of high interest in tourism services. Additional demographic information associated with these zip codes provides a simplistic method for customer profilling; however, associating demographic characteristics to zip codes is not without weakness. The caveat to the approach of using zip codes scale demographic information is the lack of precision achieved. The substantial assumption that the characteristics of a ZIP code as a whole are homogeneous and a reasonable approximation of each household in that ZIP code may not be valid. See Miller (2008) for a detailed discussion of the benefits and limitations of using zip codes and census block groups for demographic proxies. Given that this tool is fulfilling an application gap with no software expense to the user and it is intended for those who may not have previously utilized GIS due to its complexity or cost, the lack of within zip code demographic precision should not deter potential MapMyClients users. The general demographic pattern of variability from zip code to zip code in conjunction with the client origin concentration results should satisfy the data precision needs of various tourism businesses.

The utility of web mapping applications in the tourism arena is clear. MapMyClients can help to both improve service to existing customers and support highly focused marketing initiatives.
targeted at new prospects potentially leading to new revenue streams. The OSS platform used in this prototype supports these objectives and proves that software innovation does not need to come from organizations in the business of selling software. Further, GIS data driven intelligence does not need to be expensive or complicated to provide an actionable competitive advantage. The added value of GIS is not exclusive to businesses that have geographically dispersed clientele; however, in the absence of the ability to perform simple market area analysis, GIS is a necessity. Other businesses who wish to define market areas and profile customers could also benefit from a client mapping system such as MapMyClients. Although originally designed for tourism professionals, virtually any small business (retailors, medical practices, exercise studios, etc.) could capitalize on a modified version of this application with different industry specific data and the same general demographic information. MapMyClients provides improved accessibility to GIS leading to more spatial pattern identification and improved tourism planning and marketing strategies. The findings of this research improve the empirical understanding of OSS web mapping as a medium to achieve discipline-specific goals and provide an immediate tool for the tourism industry and research community.
REFERENCES


EXPANDED MAP APPLICATION DETAIL, CHALLENGES ENCOUNTERED AND THE FUTURE FOR MAPMYCLIENTS

The internet has profoundly changed the way we derive and share information. With the explosion of web-based mapping and web-based GIS, new instances of customized, cost effective, user friendly applications appear regularly. These applications are described in the literature for landscape ecology (Frehner & Brandli, 2006), natural resource management (Kearns, Kelly, & Tuxen, 2003), forest management (Xie et al., 2011), agriculture (Serrano, Jiménez-Hornero, Gutiérrez de Ravé, & Jodral, 2008), public participatory GIS (Hall, Chipeniuk, Feick, Leahy, & Deparday, 2010) and public health (MacEachren, Crawford, Akella, & Lengerich, 2008; Supak et al., 2012) among other disciplines. Despite the great potential for web-based mapping in field of tourism, no customized web mapping instances appear in tourism literature. Although MapMyClients is a first step to addressing this gap, many improvements can be made to the existing implementation. The inclusion of additional demographic and social data (e.g. home ownership, social network usage and presence of children) was a theme in the survey responses. Also, the application could support more user specific map layers for attributes provided in the uploaded data, such as the total dollar amount spent by clients or total room nights stayed (for hotel data). This option would require more user input for all users and because only some users would have numeric attributes to take advantage of this feature, this functionality was not included in the premier version of MapMyClients.

During the process of designing MapMyClients, I was reminded of the fact that the author of a map or web-mapping schema is responsible for delivering an intended message while considering what is unknown and what if anything is or should be omitted. Influencing the map’s message are choices concerning its orientation, color schema, labeling, supporting data layers and base map. One issue that can affect the message is spatial uncertainty. Both BETSMap and MapMyClients are
subject to spatial uncertainty or the lack of knowledge about an object’s geographic position or value. Spatial uncertainty can be due to varying quality in data collection methods or to errors in the assignment of data values to geographic locations (geocoding). In both mapping applications, data collection occurred outside of the application and by unknown methods, making quantification of spatial uncertainty problematic. For BETSMap, the geographic positions (i.e., longitude, latitude) for the state-regulated food service facilities reside in an Oracle Locator database previously geocoded using an unknown method. For this reason, spatial uncertainty in terms of both data collection and geocoding are potentially large in this application; however, one of the GIS tools developed for BETSMap provides the ability to update the location of any facility on the map and in the database by clicking and dragging the facility map marker to the correct location. Also, additional facilities can be added to the map and database as needed. These functionalities can support map accuracy, reduce spatial uncertainty and promote map completeness through investigation and validation, so that users can better take advantage of the full content of the available data.

As with BETSMap, quantifying spatial uncertainty in MapMyClients is problematic as data collection is conducted externally from the application. Unlike BETSMap, the geocoding process takes place within the application. The geocoding process is largely dependent on the quality of the geometry (spatial vector data) file used for geo-referencing, as well as the assumptions built into it, so there is the potential for introducing significant inaccuracies when geocoding data (Grubesic & Murray, 2007). The geometry utilized by MapMyClients is titled “U.S. ZIP Code Areas (Five-Digit)” and originates from Tele Atlas North America, Inc. although ESRI is the distributor. Metadata for this geometry discusses both its completeness and positional accuracy. The geospatial part of this data set was extracted from many sources and it has undergone a generalization process to reduce the file size by simplifying the features (“U.S. ZIP Code Areas (Five-Digit),” 2006). As stated in the metadata, “the data set was generalized and maintains 90% of the topology for ZIP code polygons while
reducing the file size to within 25% of the size.” Further it states that by generalizing the topology, the positional accuracy is reduced and cannot be determined.

When producing a thematic map that can be used for pattern recognition, spatial uncertainty can not only arise from issues related to data quality and geocoding, but it also can arise from the choice of method to visualize patterns and relationships between variables. Specifically, the choice of classification schemes, the cutpoints (boundaries between categories in a map legend) and the spatio-temporal window for data representation all can effect spatial uncertainty (“Spatial Uncertainty: Data, Modeling, and Communication (R21),” 2011). It is also important to note that the scale of spatial data aggregation can influence pattern recognition. Because BETSMap does not produce a thematic map, these issues will only be discussed for MapMyClients. Please see the Prototype Development section of the manuscript “An Open Source Web Mapping System for Tourism Planning and Marketing” for a discussion of the data aggregation scale choice for MapMyClients.

Quantification of spatial uncertainty related to the spatio-temporal window is not possible for MapMyClients because users determine what dataset to upload for display. Some common methods for visualizing patterns include classifying data by quantiles (each class contains an equal number of observations), equal-interval (divides the range of attribute values into equal-sized subranges) and natural breaks (break points attempt to best group similar values and maximize the differences between classes). Each of these methods has strengths and weaknesses and may only be appropriate for datasets of specific distributions. Statistical assessment of classification accuracy could help quantify spatial uncertainty and employing conditional probabilities of correct classification could help reduce the classification errors endemic to thematic mapping (Mowrer & Congalton, 2000). The use of a univariate scatterplot-histogram could support conditional classification methods, but employing this technique for each dataset uploaded and assigning the appropriate classification method would result in confusion for users who are unfamiliar with GIS and the concept of spatial
uncertainty. In the web-mapping environment, results need to be consistent and streamlined for novice users, so a single classification scheme was adopted.

I chose to use the quantile classification method with only three data classes because application users can easily understand the commonsense notion of even thirds of data, regardless of statistical knowledge. Although the distribution of these categories aims to put an even number of unique zip codes into high, medium or low groupings, maintaining uniqueness among the groups was imperative; therefore, for some datasets, there may be an uneven distribution among the categories. This method performs well when the data are linearly distributed and can be visually misleading when observations with widely different values get placed in the same category. For this reason, labels are used to identify all data value for each US zip code for every map layer, so if widely different values are placed in the same category, a user will be aware of that issue. For the purposes of understanding the origins and clustering of customers, the potential for incorporating population into the result can be desirable, especially if the goal is to identify areas for geographically targeted marketing promotions. However, thematic maps that display count variables can be misleading because they may reveal nothing more than population trends (Monmonier, 2005). To address this issue, both population and population density map layers are presented to the user. Future versions of MapMyClients could include an additional map layer showing the client count normalized by population count for each zip code. Transforming a measure of magnitude (total client count) into a measure of intensity (client count per capita) would allow for neighboring zip codes to be compared on more equal terms.

Further improvements to the MapMyClients prototype have the potential not only to provide better insight for practitioners, but also to support research efforts. From the user’s perspective, the inclusion of a buffer tool could help identify potential markets for future promotion within a certain distance range from the attraction. Using the established distance decay relationship, visitors for an
attraction should peek at some distance near to the attraction and then drop off with increased
distance. Within an applied buffer capturing this peek, high client count locations could be compared
to other locations with observed low client or no client counts. Unfortunately, due to the discreet
nature of client data, comparisons using no client locations within the buffer would not be supported
by the supplemental demographic data provided for areas with at least one client.

Another improvement to MapMyClients would be the inclusion of a model, such as ordinary
least squares (OLS) regression, to identify relevant predictors (demographic attributes) and to
estimate the effect of these predictors on total client count. Unfortunately, spatial data exhibit two
properties that make it difficult to meet the assumptions of traditional (non-spatial) statistical
methods, such as OLS regression. First, geographic features are more often than not spatially auto-
correlated. This means that features near each other tend to be more similar than features that are
farther away, which results in an over-count type of bias. Second, geography is an important factor of
spatial data and often the processes most important to the model are non-stationary, meaning that
these processes behave differently in different parts of the study area. The use of a geographically
weighted regression (GWR) technique specifically developed to be robust to these two characteristics
of spatial data would be preferable to an OLS regression model; however, employing either of these
modeling techniques could increase the complexity for the user. Although customer profile
improvements may be possible, caution must be taken when adding any additional functionality as to
not introduce undue complication.

Beyond supporting practitioners in their own planning and marketing objectives,
MapMyClients could be used as a research tool for data collection. Traditionally, researchers use
secondary data when available to develop and test theories as well as to answer location, time & scale
specific research questions. When desired secondary data is not available to develop or test theories,
researchers can either collect their own data or find ways to use existing secondary data to address
research goals from a different perspective. For location, time & scale specific research questions, additional data collection may be the only valid approach. For example, tourism flow theoretical and methodological validation can be accomplished using secondary data for an almost infinite number of destination-origin pair combinations; however, to determine a precise market’s tourism flow, specific data would need to be collected at the time and expense of the researcher.

MapMyClients could be used to address research objectives through the collection of location, time & scale specific data. If users of the application were to supply the location and type of tourism service provided along with their client data for an identified time frame, similar business types in a single geographic region could be identified and their client data could be aggregated. These aggregated datasets could be considered representative samples of geographically specific business types and they could be useful in understanding specific tourism flow or customer profile questions. For example, for a single specific destination region, aggregated tourist travel arrival datasets for multiple tourism business types could be compared to help determine if business type affects client profile and which business type(s) provide the strongest attraction of customers over the largest distances as well as other destination specific questions. The potential for using MapMyClients as a data collection tool was initially tempered by the desire to generate as much interest in the tool as possible. In an effort to garner trust and promote participation, currently application users are informed that their uploaded data is automatically deleted after their map layers are generated. For MapMyClients to become a data collection tool in addition to planning and marketing support tool, consent would need to be obtained from the users.

In designing and automating the web-mapping system for MapMyClients, many operational challenges presented themselves making the development stages non-trivial. Mastery of all components of the three tiered open source software stack from OpenGeo Suite (“OpenGeo Suite,” 2011) and automation of the full process from user data to client map required extensive effort.
Flawed open source software design often prevented desired system functionality. For example, the labels for the categorical values in the legend of each of the ten map layers returned to the user (high, medium and low) had to be exactly the same because the style code applied independently to each layer would result in a single layer’s legend label (whichever happened to be the first style code in alphabetical order) being applied to all subsequent legend layers. Thankfully, this issue did not affect the actual thematic shading or labeling of the mapped attributes for subsequent layers. Another issue that required attention was a particular log file within the Geoserver program that would grow extremely large extremely fast, often taking up all possible hard drive space, thereby incapacitating the application’s ability to upload user data and return web-maps. Yet another issue encountered was the capturing of all free memory on the server by the java platform, again making the application unable to upload user data and return web-maps. Overall, creating web-mapping applications using open source software can provide a challenge. Eliminating software licensing fees may be essential for future efforts in resource constrained environments; however, development and maintenance of open source systems are not without cost.

In the future, MapMyclients will need to relocate to a new server potentially at my own expense. At that time, a small fee for the service may be necessary to support the maintenance of the server either on a map by map basis or as a service contract. If a fee system is put in place, the current data layers would need to be replaced with non-ESRI data. This could be accomplished using demographic information obtained from the census. Without the tourism specific attribute data, this application could appeal to a much broader audience. Although originally designed for tourism professionals, virtually any small business (retailors, medical practices, exercise studios, etc.) could capitalize on a modified version of this application.
REFERENCES


## APPENDIX A:

### MapMyClients Survey Instrument

1. What industry best describes your current position?
   - Education
   - Private Industry
   - Government
   - Destination Management Organization (DMO)
   - Other
   Please describe your position:

2. Your information is not required if you choose to remain anonymous.
   - What is your name?
   - What is your email?
   - What is your organization’s name?

3. Understanding your clients:
   Options: Yes  No  Not Applicable
   - Is it important to you, your research, or your organization to know where clients live?
   - Is identifying geographic markets important to your marketing strategy?
   - Is identifying and/or understanding geographic markets important for:
     - developing targeted marketing messages?
     - building customized visitor packages?
     - innovation of new tourism offers?
     - identifying collaborative opportunities for supply partners?
   Additionally, what would you like to know about your clients?

4. Data collection and GIS (Geographic Information Systems) in your organization:
   Options: Yes  No  I don’t know
   - Do you keep a client database?
   - Do you collect client Zip Codes?
   - Do you collect full client addresses?
   - Have you ever used Zip Codes in any form of marketing analysis?
   - Are you familiar with the concept of a spatial frequency map?
   - Have you or anyone in your organization ever used GIS?
   - If yes above, have you personally ever used any form of GIS?
   - If yes above, have you personally used any form of GIS within the past year?

5. Which GIS software has been used by:
   - You
   - Someone in your organization
   **Product Type Options:**
   - No use of GIS software
   - A proprietary product (e.g. ESRI’s ArcMap)
   - A free product (e.g. Google Fusion Tables)
   - Both proprietary and free products
I don’t know
Please name the software(s) if you can and what types of analyses have been performed:

6. Evaluation of MapMyClients:
Options:  Yes  No
Did you use the data provided?
If no, did you use data on hand or fabricated data?
Did you obtain results?
Were the result obtained in a timely manner?
Were there any confusing steps?
Did you encounter any problems?
Would you consider this application easy to use?
Please specify confusing points or problems:

7. Your MapMyClients user experience:
Options:  Yes  No
Were you able to understand/interpret the results obtained?
Is the software optimally personalized/customized for tourism users?
Would you use this application as it currently exists?
Is there additional data you would like to have accessible in this application?
Is there missing analysis functionality you would like to have in this application?
Please specify how beneficial the results are to your needs as well as any additional data or analysis functionality you would appreciate if added:

8. Your reaction to MapMyClients:
Overall, how would you rate MapMyClients?
How would you rate this application when compared to its alternatives in terms of ease of use?
How would you rate this application when compared to its alternatives in terms of expense?
Options:
Satisfactory
Somewhat Satisfactory
Neither Satisfactory or Unsatisfactory
Somewhat Unsatisfactory
Unsatisfactory  I don’t know
Please explain your answers, if you would like to clarify your choice:

9. Future Usage:
Options:  Yes  No
Would you consider using MapMyClients again?
If yes, how will MapMyClients help your organization and/or how will you use it again? If no, why will you not use MapMyClients again?

10. Do you have any additional comments or suggestions about MapMyClients?
## 1. What industry best describes your current position?

<table>
<thead>
<tr>
<th>Industry</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>Private Industry</td>
<td>20.0%</td>
<td>2</td>
</tr>
<tr>
<td>Government</td>
<td>20.0%</td>
<td>2</td>
</tr>
<tr>
<td>Destination Management Organization (DMO)</td>
<td>40.0%</td>
<td>4</td>
</tr>
<tr>
<td>Other</td>
<td>20.0%</td>
<td>2</td>
</tr>
</tbody>
</table>

Please describe your position: 10

- **Answered question:** 10
- **Skipped question:** 0

## 2. Your information is not required if you choose to remain anonymous.

<table>
<thead>
<tr>
<th>Question</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is your name?</td>
<td>100.0%</td>
<td>7</td>
</tr>
<tr>
<td>What is your email?</td>
<td>100.0%</td>
<td>7</td>
</tr>
<tr>
<td>What is your organization's name?</td>
<td>100.0%</td>
<td>7</td>
</tr>
</tbody>
</table>

- **Answered question:** 7
- **Skipped question:** 3
### 3. Understanding your clients:

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
<th>Not Applicable</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is it important to you, your research, or your organization to know where clients live?</td>
<td>100.0% (10)</td>
<td>0.0% (0)</td>
<td>0.0% (0)</td>
<td>10</td>
</tr>
<tr>
<td>Is identifying geographic markets important to your marketing strategy?</td>
<td>90.0% (9)</td>
<td>0.0% (0)</td>
<td>10.0% (1)</td>
<td>10</td>
</tr>
<tr>
<td>Is identifying and/or understanding geographic markets important for: -</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--- &gt;1) developing targeted marketing messages?</td>
<td>100.0% (10)</td>
<td>0.0% (0)</td>
<td>0.0% (0)</td>
<td>10</td>
</tr>
<tr>
<td>--- &gt;2) building customized visitor packages?</td>
<td>90.0% (9)</td>
<td>0.0% (0)</td>
<td>10.0% (1)</td>
<td>10</td>
</tr>
<tr>
<td>--- &gt;3) innovation of new tourism offers?</td>
<td>90.0% (9)</td>
<td>0.0% (0)</td>
<td>10.0% (1)</td>
<td>10</td>
</tr>
<tr>
<td>--- &gt;4) identifying collaborative opportunities for supply partners?</td>
<td>100.0% (10)</td>
<td>0.0% (0)</td>
<td>0.0% (0)</td>
<td>10</td>
</tr>
</tbody>
</table>

Additionally, what would you like to know about your clients? 5

**Answered question** 10

**Skipped question** 0
4. Data collection and GIS (Geographic Information Systems) in your organization:

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
<th>I don't know</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you keep a client database?</td>
<td>100.0% (10)</td>
<td>0.0% (0)</td>
<td>0.0% (0)</td>
<td>10</td>
</tr>
<tr>
<td>Do you collect client Zip Codes?</td>
<td>100.0% (10)</td>
<td>0.0% (0)</td>
<td>0.0% (0)</td>
<td>10</td>
</tr>
<tr>
<td>Do you collect full client addresses?</td>
<td>90.0% (9)</td>
<td>10.0% (1)</td>
<td>0.0% (0)</td>
<td>10</td>
</tr>
<tr>
<td>Have you ever used Zip Codes in any form of marketing analysis?</td>
<td>60.0% (6)</td>
<td>40.0% (4)</td>
<td>0.0% (0)</td>
<td>10</td>
</tr>
<tr>
<td>Are you familiar with the concept of a spatial frequency map?</td>
<td>80.0% (8)</td>
<td>20.0% (2)</td>
<td>0.0% (0)</td>
<td>10</td>
</tr>
<tr>
<td>Have you or anyone in your organization ever used GIS?</td>
<td>70.0% (7)</td>
<td>30.0% (3)</td>
<td>0.0% (0)</td>
<td>10</td>
</tr>
<tr>
<td>If yes above, have you personally ever used any form of GIS?</td>
<td>60.0% (6)</td>
<td>40.0% (4)</td>
<td>0.0% (0)</td>
<td>10</td>
</tr>
<tr>
<td>If yes above, have you personally used any form of GIS within the past year?</td>
<td>50.0% (5)</td>
<td>50.0% (5)</td>
<td>0.0% (0)</td>
<td>10</td>
</tr>
</tbody>
</table>

answered question 10

skipped question 0
5. Which GIS software has been used by:

<table>
<thead>
<tr>
<th>Product Type</th>
<th>No use of GIS software</th>
<th>A proprietary product (e.g. ESRI's ArcMap)</th>
<th>A free product (e.g. Google Fusion Tables)</th>
<th>Both proprietary and free products</th>
</tr>
</thead>
<tbody>
<tr>
<td>You</td>
<td>22.2% (2)</td>
<td>44.4% (4)</td>
<td>0.0% (0)</td>
<td>22.2% (2)</td>
</tr>
<tr>
<td>Someone in your organization</td>
<td>42.9% (3)</td>
<td>42.9% (3)</td>
<td>0.0% (0)</td>
<td>0.0% (0)</td>
</tr>
</tbody>
</table>

Please name the software(s) if you can and what types of analyses

6. Evaluation of MapMyClients:

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did you use the data provided?</td>
<td>30.0% (3)</td>
<td>70.0% (7)</td>
<td>10</td>
</tr>
<tr>
<td>If no, did you use data on hand or fabricated data?</td>
<td>87.5% (7)</td>
<td>12.5% (1)</td>
<td>8</td>
</tr>
<tr>
<td>Did you obtain results?</td>
<td>80.0% (8)</td>
<td>20.0% (2)</td>
<td>10</td>
</tr>
<tr>
<td>Were the result obtained in a timely manner?</td>
<td>90.0% (9)</td>
<td>10.0% (1)</td>
<td>10</td>
</tr>
<tr>
<td>Were there any confusing steps?</td>
<td>10.0% (1)</td>
<td>90.0% (9)</td>
<td>10</td>
</tr>
<tr>
<td>Did you encounter any problems?</td>
<td>40.0% (4)</td>
<td>60.0% (6)</td>
<td>10</td>
</tr>
<tr>
<td>Would you consider this application easy to use?</td>
<td>80.0% (8)</td>
<td>20.0% (2)</td>
<td>10</td>
</tr>
</tbody>
</table>

Please specify confusing points or problems: 5

<table>
<thead>
<tr>
<th>Answered question</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skipped question</td>
<td>0</td>
</tr>
</tbody>
</table>
### 7. Your MapMyClients user experience:

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Were you able to understand/interpret the results obtained?</td>
<td>90.0% (9)</td>
<td>10.0% (1)</td>
<td>10</td>
</tr>
<tr>
<td>Is the software optimally personalized/customized for tourism users?</td>
<td>90.0% (9)</td>
<td>10.0% (1)</td>
<td>10</td>
</tr>
<tr>
<td>Would you use this application as it currently exists?</td>
<td>60.0% (6)</td>
<td>40.0% (4)</td>
<td>10</td>
</tr>
<tr>
<td>Is there additional data you would like to have accessible in this application?</td>
<td>80.0% (8)</td>
<td>20.0% (2)</td>
<td>10</td>
</tr>
<tr>
<td>Is there missing analysis functionality you would like to have in this application?</td>
<td>60.0% (6)</td>
<td>40.0% (4)</td>
<td>10</td>
</tr>
</tbody>
</table>

Please specify how beneficial the results are to your needs as well as any additional data or analysis functionality you would appreciate if added: 7

<table>
<thead>
<tr>
<th>Answered question</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>skipped question</td>
<td>0</td>
</tr>
</tbody>
</table>
8. Your reaction to MapMyClients:

<table>
<thead>
<tr>
<th>Response</th>
<th>Satisfactory</th>
<th>Somewhat Satisfactory</th>
<th>Neither Satisfactory or Un satisfactory</th>
<th>Somewhat Unsatisfactory</th>
<th>Unsatisfactory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall, how would you rate MapMyClients?</td>
<td>40.0% (4)</td>
<td>40.0% (4)</td>
<td>10.0% (1)</td>
<td>0.0% (0)</td>
<td>0.0% (0)</td>
</tr>
<tr>
<td>How would you rate this application when compared to its alternatives in terms of ease of use?</td>
<td>70.0% (7)</td>
<td>10.0% (1)</td>
<td>10.0% (1)</td>
<td>0.0% (0)</td>
<td>0.0% (0)</td>
</tr>
<tr>
<td>How would you rate this application when compared to its alternatives in terms of expense?</td>
<td>70.0% (7)</td>
<td>0.0% (0)</td>
<td>0.0% (0)</td>
<td>0.0% (0)</td>
<td>0.0% (0)</td>
</tr>
</tbody>
</table>

Please explain your answers, if you would like to clarify your choices.

answered question

9. Future Usage:

<table>
<thead>
<tr>
<th>Response</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Would you consider using MapMyClients again?</td>
<td>80.0% (8)</td>
<td>20.0% (2)</td>
</tr>
</tbody>
</table>

If yes, how will MapMyClients help your organization and/or how will you use it again? If no, why will you not use MapMyClients again? 

answered question

skipped question
10. Do you have any additional comments or suggestions about MapMyClients?

<table>
<thead>
<tr>
<th>Response</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>answered question</td>
<td>6</td>
</tr>
<tr>
<td>skipped question</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Industry/Position Description</td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>GiS Specialist</td>
</tr>
<tr>
<td>2</td>
<td>Executive Director</td>
</tr>
<tr>
<td>3</td>
<td>Director of Business Strategy &amp; Research, Responsible for keeping research up to date and providing guidance to sales and marketing to make sure they're putting strategies in place that will work.</td>
</tr>
<tr>
<td>4</td>
<td>Analyst</td>
</tr>
<tr>
<td>5</td>
<td>Consultant to airlines, airports, DMOs</td>
</tr>
<tr>
<td>6</td>
<td>Research Manager for a Convention and Visitors Bureau</td>
</tr>
<tr>
<td>7</td>
<td>President</td>
</tr>
<tr>
<td>8</td>
<td>VP, Marketing</td>
</tr>
<tr>
<td>10</td>
<td>Director of Sales and Marketing for SMG/Colorado Convention Center</td>
</tr>
</tbody>
</table>
### Q3. Understanding your clients:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Since we don’t do marketing: I am changing the word &quot;client&quot; to be &quot;observations/sample data&quot; I am changing &quot;marketing strategy&quot; to be &quot;sampling/modeling strategy&quot; I am changing &quot;marketing message&quot; to be &quot;hypothesis/sampling framework&quot; I am changing &quot;visitor packages&quot; to &quot;management decisions&quot; I am changing &quot;tourism offers&quot; to &quot;decision making strategies&quot; in order to make the interface meet my mission needs.</td>
<td>Jan 4, 2013 9:22 AM</td>
</tr>
<tr>
<td>2</td>
<td>Travel Habits Spending Habits</td>
<td>Jan 2, 2013 3:24 PM</td>
</tr>
<tr>
<td>3</td>
<td>How much $ they spend : )</td>
<td>Dec 18, 2012 4:42 PM</td>
</tr>
<tr>
<td>4</td>
<td>Additional demographic and social data -- HHI, home ownership, social network usage, presence of children, etc.</td>
<td>Dec 7, 2012 2:25 PM</td>
</tr>
<tr>
<td>5</td>
<td>organizational affiliations</td>
<td>Dec 6, 2012 1:08 PM</td>
</tr>
</tbody>
</table>

### Q5. Which GIS software has been used by:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>We use GIS software extensively for location analysis for identifying sample locations and analysis of data that we have collected.</td>
<td>Jan 4, 2013 9:22 AM</td>
</tr>
<tr>
<td>2</td>
<td>Microsoft MapPoint</td>
<td>Dec 17, 2012 11:25 AM</td>
</tr>
<tr>
<td>3</td>
<td>Batchgeo.com</td>
<td>Dec 13, 2012 12:37 PM</td>
</tr>
<tr>
<td>4</td>
<td>Microsoft MapPoint</td>
<td>Dec 7, 2012 2:25 PM</td>
</tr>
<tr>
<td>5</td>
<td>Very basic free ESRI software Haven’t used Google yet, but it looks interesting to try</td>
<td>Dec 3, 2012 2:28 PM</td>
</tr>
</tbody>
</table>
### Q6. Evaluation of MapMyClients:

<table>
<thead>
<tr>
<th></th>
<th>Comment</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The text writes over the other text. It would be nice to be able to see both layers of text.</td>
<td>Jan 4, 2013 9:22 AM</td>
</tr>
<tr>
<td>2</td>
<td>The only confusing thing was how to save the information to use in a presentation or to email. After a little looking around I was able to figure out how to save it as a PDF. I also used the snapping tool to save some of the information.</td>
<td>Jan 2, 2013 3:24 PM</td>
</tr>
<tr>
<td>3</td>
<td>The directions said I could use 9 digit zips but I kept getting an error message. I went through my list and removed the +4 digits and it worked after that. No big deal, was just a little time consuming.</td>
<td>Dec 18, 2012 4:42 PM</td>
</tr>
<tr>
<td>4</td>
<td>I had to update Google Chrome, and weed out bad zips (insufficient amount of numbers for zip)</td>
<td>Dec 13, 2012 12:37 PM</td>
</tr>
<tr>
<td>5</td>
<td>Just initially, the map overlays didn’t appear.</td>
<td>Dec 3, 2012 2:28 PM</td>
</tr>
</tbody>
</table>

### Q7. Your MapMyClients user experience:

<table>
<thead>
<tr>
<th></th>
<th>Comment</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>It would be nice to be able to read in a column of data and have it subset into low/med/high for display. Overall very easy to use and fast. Great to be able to display by HUC or other polygon</td>
<td>Jan 4, 2013 9:22 AM</td>
</tr>
<tr>
<td>2</td>
<td>Would love average income and education level for the zips too.</td>
<td>Dec 18, 2012 4:42 PM</td>
</tr>
<tr>
<td>3</td>
<td>MapPoint is valuable as it has all the census data. And the bells and whistles on the latest version work well for client presentations being able to customize what/how place / data names, etc... are shown.</td>
<td>Dec 17, 2012 11:25 AM</td>
</tr>
<tr>
<td>4</td>
<td>I loved using your application. I also am using CDXzip for some analysis. It would be great to incorporate both applications for both mapping and tracking.</td>
<td>Dec 13, 2012 12:37 PM</td>
</tr>
<tr>
<td>5</td>
<td>The results confirmed that the target audience for our marketing program was being reached successfully.</td>
<td>Dec 7, 2012 2:25 PM</td>
</tr>
<tr>
<td>6</td>
<td>This question should have N/A as an option.</td>
<td>Dec 6, 2012 1:08 PM</td>
</tr>
<tr>
<td>7</td>
<td>Would like to be able to filter to see just High, Medium and/or Low. Like if I just wanted to see red. If this is already available, I might've just not been able to find how to do it.</td>
<td>Dec 3, 2012 2:28 PM</td>
</tr>
</tbody>
</table>
### Q8. Your reaction to MapMyClients:

<p>| | | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>1</td>
<td>Great as a free application! Also provides features (polygon fills) that are difficult to do in other free web based mapping software</td>
<td>Jan 4, 2013 9:22 AM</td>
</tr>
<tr>
<td>2</td>
<td>I think MapMyClients could be a great tool for DMOs without the analytical budget we have.</td>
<td>Dec 17, 2012 11:25 AM</td>
</tr>
<tr>
<td>3</td>
<td>Not sure of the cost to use it.</td>
<td>Dec 7, 2012 2:25 PM</td>
</tr>
<tr>
<td>4</td>
<td>Appropriate evaluation of the capabilities of this program were not extensively pursued.</td>
<td>Dec 6, 2012 1:08 PM</td>
</tr>
</tbody>
</table>

### Q9. Future Usage:

<p>| | | |</p>
<table>
<thead>
<tr>
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<tbody>
<tr>
<td>1</td>
<td>If there were more demographic data, I would probably use it it again.</td>
<td>Jan 4, 2013 9:22 AM</td>
</tr>
<tr>
<td>2</td>
<td>I could use it for all of my data collected at festivals, events and sporting events.</td>
<td>Jan 2, 2013 3:24 PM</td>
</tr>
<tr>
<td>3</td>
<td>I will use it to map our client base for all of our channels.</td>
<td>Dec 18, 2012 4:42 PM</td>
</tr>
<tr>
<td>4</td>
<td>I had 2 projects that I needed your application for. The Gary’s South Shore Air Show and ‘A Christmas Story Comes Home’ (Hammond, IN is the home of Jean Shepherd the author of Christmas Story. The mapping feature was excellent at showing where the visitors were coming from.</td>
<td>Dec 13, 2012 12:37 PM</td>
</tr>
<tr>
<td>5</td>
<td>It would help us understand visually where our customers live.</td>
<td>Dec 7, 2012 2:25 PM</td>
</tr>
<tr>
<td>6</td>
<td>Only did a quick overview as we have not, and most likely will not, use this type of software in the immediate future.</td>
<td>Dec 6, 2012 1:08 PM</td>
</tr>
<tr>
<td></td>
<td>Comments</td>
<td>Date</td>
</tr>
<tr>
<td>---</td>
<td>--------------------------------------------------------------------------</td>
<td>--------------------</td>
</tr>
<tr>
<td>1</td>
<td>Good illustration of utility of web-based mapping</td>
<td>Jan 4, 2013 9:22 AM</td>
</tr>
<tr>
<td>2</td>
<td>Thanks!</td>
<td>Jan 2, 2013 3:24 PM</td>
</tr>
<tr>
<td>3</td>
<td>Good luck with the project! Very cool what you have built and how you are applying it.</td>
<td>Dec 17, 2012 11:25 AM</td>
</tr>
<tr>
<td>4</td>
<td>Thank you so much. Your program is excellent. Keep up the great job.</td>
<td>Dec 13, 2012 12:37 PM</td>
</tr>
<tr>
<td>5</td>
<td>It would be nice to be able to select an area and export just that area.</td>
<td>Dec 7, 2012 2:25 PM</td>
</tr>
<tr>
<td>6</td>
<td>I think this is a great system. While I have no need for this application in my current position, I wouldn’t hesitate to try it if I did. From previous experience, this seems like a neat system for basic analysis and I applaud you for exploring this and offering it out to the industry.</td>
<td>Nov 28, 2012 11:27 AM</td>
</tr>
</tbody>
</table>