Geovisualization of Socio-Spatial Data on Outdoor Activities and Values in the Southern Appalachians

Diane M. Styers, Western Carolina University, Cullowhee, USA
G. Rebecca Dobbs, Western Carolina University, Cullowhee, USA
Lee K. Cerveny, United States Forest Service, Seattle, USA
Isaac T. Hayes, Clemson University, Clemson, USA

ABSTRACT

This article describes how GIS is increasingly being used to explore, analyze, and visualize qualitative social data across space. The authors applied a number of geovisualization and analysis approaches to spaces identified on maps by survey participants, in the context of a Human Ecology Mapping (HEM) project in western North Carolina. HEM is an applied research endeavor that has been used in a number of other locations to tease out relationships between people and landscapes by identifying both the activities people do in certain locations and the values they hold about those locations. The authors' western NC project gathered location information through participant sketch mapping, and activities, values, and social/demographic data in a survey. They combined these in a GIS and present a selection of visualization and analyses that demonstrate the effectiveness of GIS techniques in understanding places, how they are used, and which people use them for what purposes.

KEYWORDS

Appalachia, Environmental Planning, Geovisualization, Human Ecology, Landscape Values, Qualitative GIS, Recreation, Sketch Mapping

INTRODUCTION

The use of GIS to visualize and analyze qualitative research data represents a growing trend within the broad and expanding range of geospatial technologies applications. Qualitative data take many forms and are collected in a number of different disciplines, with greater or lesser levels of inherent spatiality. While some qualitative projects require that researchers make inferences in order to spatialize their data, or come up with ways to represent humanistic aspects of place within a GIS setting, quite a few qualitative researchers are making use of informants' own understanding of conditions in space. This may be accomplished by methods such as having informants mark on paper or digital maps as part of a broader data collection process involving surveys or interviews. Researchers can then combine the collected spatial and survey or interview data in a GIS as shapes and attributes respectively, preparing the way for creative employment of GIS techniques to find meaningful patterns in the ways that people perceive or use spaces. In this paper, we report on our use of various GIS approaches to visualize and analyze such patterns in data derived from surveys and sketch maps in a Human Ecology Mapping (HEM) project in mountainous southwestern North Carolina. We argue

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that applying relatively simple GIS techniques to spatialized qualitative data can result in insights whose value far exceeds the complexity of the GIS methods employed.

Human ecology is the interdisciplinary study of the relationships and patterns of interactions between people and their natural, social, and built environments (Hens et al., 1998; Steiner and Nauser, 1993; Wyrostkiewicz, 2013). Human values, behaviors, resources, life-styles and products have effects on the natural environment. Conversely, the physical and biotic environments affect how people live, where they go, and what they do on the landscape (McDonnell and Pickett, 1990). Human ecology mapping explores the dynamic interaction between people and the natural environment using an array of socio-spatial approaches (McLain et al., 2013b). Natural landscapes can be culturally and socially constructed and appeal to individuals in various meaningful ways (Stedman, 2003). Landscapes embody a variety of symbolic meanings and practical benefits for people (Ardoin et al., 2014; Tuan, 1977). Bound up in place meanings are a mix of commodity and non-commodity values, some tangible, some intangible (Cheng et al., 2003). Meanings are formed both through direct personal or collective experiences of a place or the rendering of stories or histories about a place which may or may not have been actually visited (Zube, 1987). Through direct engagement with the natural environment, humans form relations with ecosystems that take on multiple meanings (Fish et al. 2016). Meanings people attach to places can influence attitudes towards resource management (Eisenhauer et al., 2000; Kil et al., 2014). Resource managers and environmental planners concerned with making decisions about natural places benefit from understanding the complex web of meanings attached to places by myriad social groups and stakeholders and the values that underlie them (Kruger, 2008; Williams et al., 2013; Yung et al., 2003).

The Human Ecology Mapping (HEM) Project is a set of applied research studies in North America designed to understand complex human-ecological relationships by mapping human activities and values relevant to natural resource management for use in planning and decision-making. We applied the HEM approach in western North Carolina to analyze resident and visitor interactions near and within Great Smoky Mountains National Park and Nantahala National Forest. The project's primary goal was to explore landscape values, resource uses, and other human dimensions of land use near large, resource-based national parks and national forests using mapping surveys to gain a better understanding of the spatial extent of where people live, work, and play in western North Carolina. This information will aid in land use and resource management planning and decision-making practices, and assist in our understanding of how these activities affect natural resource stewardship at local to global levels.

In this western North Carolina HEM project, data were gathered using a convenience sample approach at five public events in the fall of 2014 (n = 116) resulting in 419 areas identified throughout the study region. Respondents represented a range of demographic characteristics and years of residence in the area; they also included a mix of year-round residents, seasonal residents, and visitors. Respondents assigned attributes, including values and activities, to areas they sketched on a map. The resulting conjunction of spatial, demographic, values, and use data makes GIS an exceptionally strong tool for understanding the nuances and complexities of these data across the region, and in local places within the region. In this paper we present visualizations of selected patterns and trends among various data combinations from the study by using different analysis tools in GIS. This selection of visualizations illustrates the value of this approach in determining overlapping meanings and complex relationships of different stakeholders and social groups across a landscape.

HUMAN ECOLOGY MAPPING AND GIS

The HEM research approach used here builds on the work of previous scholars that have engaged in public participatory GIS (PPGIS) at a landscape (bio-regional) scale that includes multiple jurisdictions and a predominance of federal, state, and tribal land management agencies as well as private landowners (McLain et al., 2013a; Besser et al., 2014; Cerveny et al., 2017; McLain et al., 2017). The approach builds on the ideas of spatial attribute mapping using a landscape values typology, in which place-specific values are attached to particular landscapes by the public, and involves use of a values typology with a list of defined values (Brown, 2004; Brown and Reed, 2009). Respondents assign values to special places on a map of a designated landscape by drawing polygons or placing colored dots that represent each value onto a map (Brown, 2012; 2008; 2006). These data can be digitized and spatially analyzed. Maps generated by this technique demonstrate how values are distributed across the landscape and can identify "hotspots" of high-density values as well as diversity of values at particular sites. This technique has been broadly used in environmental planning and resource management applications (Beverly et al., 2008; Brown and Raymond, 2007; Brown, 2008; 2006; Raymond et al., 2009; Brown et al., 2015). The variety of approaches to participatory mapping and its many applications have been well synthesized (Brown and Kytta, 2013; Brown, 2012; McLain et al., 2013; Sieber, 2006).

Understanding different meanings and uses people have of the landscape is important for developing and supporting natural resource management plans that are socially and ecologically sustainable (Fagerholm et al., 2012). However, place-based attitudes and values likely differ based on demographics, as well as between residents of an area and its visitors (McLain et al., 2017; Williams et al., 2017). These disparities can affect community perceptions, and perhaps ultimately guide policy decisions about resource- versus amenity-based landscape management practices. These decisions can then potentially lead to conflict based around land ownership and use, creating challenges that can persist across management boundaries. Previous studies that have used socio-spatial approaches have demonstrated that variations exist among socio-demographic groups and stakeholders. Socio-demographic dimensions along which differences among subgroups have been found in the types and locations of activities, values, or management preferences mapped include: livelihood occupation (Brown et al., 2015), community of residence (Alessa et al., 2008; Beverly et al., 2008; Ramirez-Gomez et al., 2016), stakeholder group (Brown et al., 2004), self-reported familiarity with the area (Brown and Weber, 2011), income (Brown and Weber, 2011), and proximity of primary residence (Brown et al., 2015). These studies underline the importance of disaggregating landscape values mapping results by socio-demographic characteristics when reporting findings.

Our use of GIS with the qualitative data from the western North Carolina HEM project builds on growing GIS traditions. The area of "qualitative GIS" grew out of "critical GIS" concerns that began in the late 1990s; qualitative GIS achieved solid recognition in its own right with the publication of a 2009 volume edited by Cope and Elwood. Although in their introduction (Elwood and Cope, 2009) they cover a number of ways in which GIS work can be qualitative, some essential characteristics from our perspective are a focus on inductive visualization and the use of data which are qualitative. Qualitative data are first and foremost non-numerical, but beyond that include contextual detail and perhaps interpretive perspectives. When such data are used with GIS, it might be with fully theorized and reflexive qualitative methods such as Elwood and Cope (2009) and several of their contributors discuss. On the other hand qualitative researchers often focus on visualization in the GIS environment and sometimes quantify aspects of their qualitative data and visualize those quantities in GIS. Pavlovskaya (2004), for instance, uses geolocated graduated pie charts to show number and composition of economies in Moscow households according to her ethnographic fieldwork.

Further, Pavlovskaya (2009) argues that while people tend to associate GIS with quantitative data and quantitative analysis, we should not confuse computerization and computational functions that the software performs for us with true quantitative operations. In broad terms, as she argues, most analysis that GIS does is based on computations related to location in space, and will operate in the same way whether the locations have qualitative or quantitative attributes associated with them. Thus, functions like density computation are often performed on non-quantitative data and produce a pattern for visual interpretation. For example, Cooper and Gregory (2011) use a density function to elucidate aspects of place-naming in their "literary GIS" of the Lake District (UK).

In the body of qualitative GIS literature most relevant to our project, qualitative data is used to illuminate one or more of three spatial themes. One theme involves routes of movement through space (Kwan and Ding, 2008; Mennis et al., 2013), and sometimes narratives about what happened along that path (Watts, 2010). A second theme also involves movement through space but with emphasis on the distances and complexities of movement that people's ordinary lives entail; Matthews et al. (2005) for instance use both route mapping along streets and origin-destination line visualizations to make evident the burdens that some individuals and families must shoulder in negotiating their social conditions, while Boschmann and Cubbon (2014) map the complex bus travel that may be needed to get to work. The third spatial theme focuses on the location of spaces that informants identify with certain characteristics, such as safety, personal meaning, or other subjective perceptions (Boschmann and Cubbon, 2014; Mennis et al., 2013; Schoepfer and Rogers, 2014), or where certain activities happen (Boschmann and Cubbon, 2014; Brennan-Horley and Gibson, 2009; Mennis et al., 2013). Some of these projects focus on spot locations (point geometries) while others are concerned more with areas (polygon geometries). In an example of the latter, Brennan-Horley and Gibson (2009) used GIS operations to create a cumulative data surface to visualize areas of concurrence, in much the same way we identified hotspots of activity in our study.

An important question in this kind of research is that of how locations become incorporated within the data being collected. Bagheri (2014), in doing ethnographic fieldwork on women in public spaces in Tehran, recorded the location of each interview and represented the interviewed person as a point at that location in her GIS. Mennis et al. (2013) asked informants to list places and perceptions verbally during interviews, and these were later geocoded to city mapspace by the researchers. In contrast, many researchers ask informants to add locations to paper or electronic maps themselves. Schoepfer and Rogers (2014) developed a technique using a tablet with a custom app in combination with qualitative interviews; advantages of this method include informants being able to zoom in and out, and researchers being able to transfer the digital data to the GIS directly. On the other hand, a number of researchers chose paper maps on which informants would draw, sometimes with colored pens or markers associated with specific interview questions or types of elements (Besser et al. 2014). While at times this choice is made for reasons of cost or concerns about technological barriers with some informants (Brennan-Horley and Gibson, 2009), Boschmann and Cubbon (2014) observed that a paper map can exert a calming influence on informants being interviewed, and can also disrupt the power relations associated with GIS technologies. With both digital and paper map involvement, however, researchers found that integrating a map with the interview or survey administration helped generate data that would otherwise have been missed, as the maps got informants more engaged in thinking through or remembering relevant places and experiences (Boschmann and Cubbon, 2014; Brennan-Horley and Gibson, 2009; Schoepfer and Rogers, 2014).

The informants' act of drawing spatial locations or perceptions has often been called interchangeably by a number of terms, including mental maps, cognitive maps, perceptual maps, and sketch maps. Boschmann and Cubbon (2014), however, examine the roots and characteristics of mental maps and sketch maps and establish a clear distinction for the first time. Mental maps are drawn from scratch by informants to express the ways they see space around them, such as a neighborhood. Researchers using this approach, typically from a behavioral geography perspective, might compile mental maps from several informants to help them understand a collective perception of an urban environment. In contrast, sketch mapping is most closely associated with qualitative GIS and the various forms of participatory/public participation GIS, and involves drawing on, adding stickers to, or writing labels on a base map to get at informants' lived spatial experiences. Most of the projects discussed above as well as our own use this latter approach in one form or another, even when using a different term. Notably, Brennan-Horley and Gibson (2009) describe a process that Boschmann and Cubbon (2014) would call sketch mapping, but call it mental mapping.

Our uses of GIS in the western NC HEM project echo a number of the approaches discussed above and also extend the scope of GIS work within the realm of qualitative data by integrating some of our data visualization with physical geography and by including spatial descriptive statistics to visualize intersections of social and spatial characteristics. Overall, conducting these analyses in a geographic information system (GIS) allowed visualizations of activity space data across the landscape in ways that will allow natural resources managers and environmental planners a unique opportunity to study human ecology interrelationships from a visual perspective. In this sense, the GIS work we have done enables managers and planners to link resource-based activities, places and otherwise disparate information to each other in space, and give them context by placing them into a more comprehensive picture. This project represents a highly adaptable method for spatializing and visualizing survey data in a GIS, with a goal of informing the decision-making processes of land managers and planners.

METHODS

Study Area

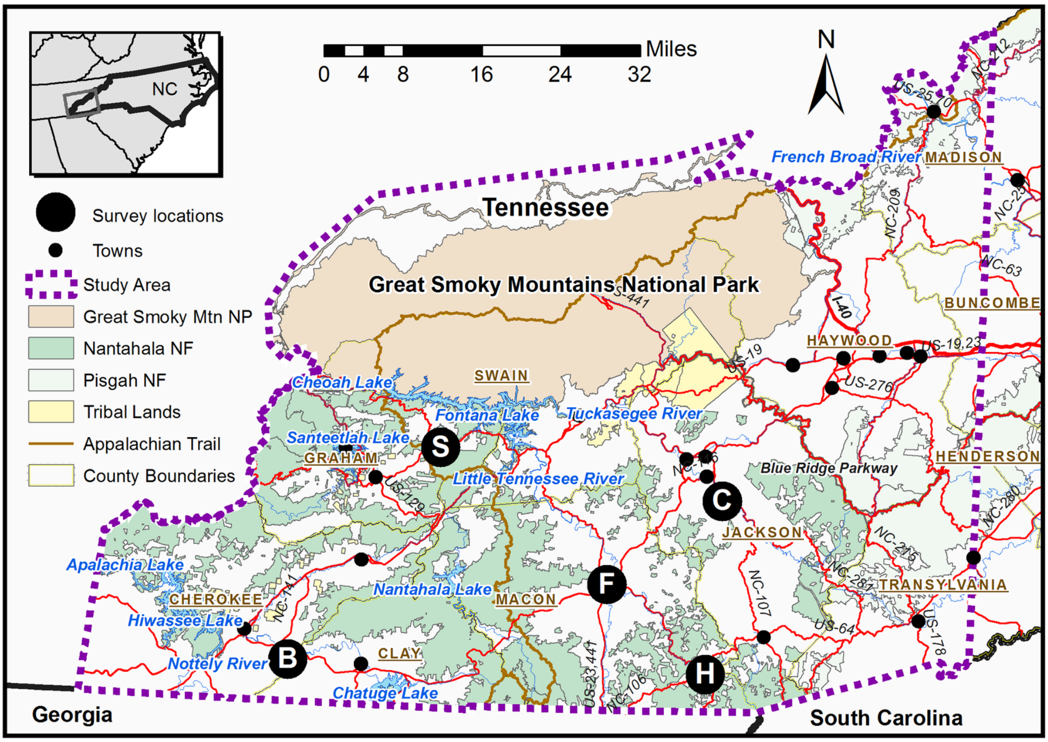
The study was conducted in the mainly rural far southwestern corner of North Carolina. Administratively the region comprises seven whole counties (Cherokee, Clay, Graham, Haywood, Jackson, Macon, and Swain) and parts of others, but at the same time is dominated by public lands, including Great Smoky Mountains National Park[1], Nantahala National Forest, and Pisgah National Forest; state forests and game lands; and tribal lands, notably the Qualla Boundary which is the main trust land of the Eastern Band of Cherokee Indians (EBCI). The seven counties listed above encompass 802,511 ha and were home to 194,102 people in 2010 (U.S. Census Bureau, 2010), yielding a population density of approximately 25 people per square kilometer of land area as compared to a statewide average of about 76 and a value of 678 for Mecklenburg, the state's densest county. The physical geography of the study area encompasses forests, meadows, rivers and streams, granite walls with waterfalls, and mountain balds, including the highest peaks in the eastern U.S., with 43 measuring more than 1800 m above sea level. Historically, logging of the old-growth forests was the economic mainstay of the region, but at present the economy is more diversified. Agriculture and manufacturing have joined a much-diminished logging industry, while tourism is a major economic driver in the region. The area also attracts seasonal and second-home owners from nearby urban areas, including Atlanta, GA, Charlotte, NC and Greenville, SC. The influx of new homeowners or 'amenity migrants' to the area is changing the composition of the area, while bringing in new wealth (Bennett, 1993; Fagan and Longino, 1993; Haas and Serow, 1993).

The stunning beauty of the region's rugged landscapes, in combination with public access to the variety of protected areas, makes it a major destination for visitors, especially those seeking outdoor adventure. Together, the Great Smoky Mountain National Park and the Blue Ridge Parkway attracted 26.5 million visitors in 2016, making this the most visited destination in the National Park System (Cullinane and Koontz, 2017). There are 321 miles of the Appalachian Trail in North Carolina (225 of them along the Tennessee border). The Appalachian Trail draws 3 million visitors each year (Appalachian Trail Conservancy, 2017). The Pisgah and Nantahala National Forests, totaling some 1 million acres, are two of the most visited national forests in the U.S., and collectively attracted around 6 million visitors in 2016 (Chávez, 2017). North Carolina State Parks, Forests, and Recreation Areas also attract many visitors annually. Cherokee, the main town within the Qualla Boundary and seat of the EBCI tribal government, solicits and receives large numbers of tourists as well. In all, the millions of visitors this region hosts each year bring both great economic impact and considerable pressure on natural resources. The need to know where people go in western North Carolina, and what they do there, is correspondingly great.

Sampling

Data gathering locations were chosen with a view toward good accessibility to the public across the region. All communities in western North Carolina that hosted large festival events were considered.

Figure 1. Western North Carolina, Great Smoky Mountains National Park, and the HEM study area and survey sites



Our intent was to gather data at an event within the Qualla Boundary to include Cherokee values and activities in our results, but we were unable to arrange that. Ultimately, we settled on five fall festival events in communities throughout the region during a popular tourism season, located respectively in Brasstown, Cullowhee, Franklin, Highlands, and Stecoah (see Figure 1 and Table 1). In the fall of 2014, the study team visited each community and set up an information booth at the public event. We used a convenience sampling approach, talking to those who stopped by the booth. A total of 116 respondents participated. Table 1 breaks down the distribution of respondents across the five sites and indicates the number of mapped polygons deriving from the respondents of each site.

The study design emphasized an intercept approach as a deliberate means to include a diverse range of visitors and residents to western North Carolina. Approaches that have emphasized online

Table 1. The five survey locations, with numbers of respondents and resulting mapped polygons for each. Code letter refers to symbols in Figure 1

Label in Figure 1	Location name	Respondents	Polygons
B	Brasstown	36	111
C	Cullowhee	42	150
F	Franklin	10	40
H	Highlands	13	55
S	Stecoah	15	63
Total		116	419

mapping and community workshops have tended to attract stakeholders, user groups, or advocacy groups with a particular set of resource interests (McLain et al., 2017). Intercept studies that focus on public events in developed communities attract a wide range of participants with varying interests in or awareness of public lands and outdoor recreation activities, making this an interesting way to reach populations not typically represented in resource planning efforts.

Survey Instruments

Participants who stopped at the booth were given an 11" x 17" paper color map of the study area that the authors created using ArcGIS, and a short questionnaire that included questions about the participant's resident or visitor status including zip code, frequency and length of stay of visits to national parks and/or national forests in western North Carolina, gender, race/ethnicity, age, education, and household income.

In contrast to previous PPGIS studies that asked respondents to assign an array of landscape values across a map (Brown 2004; Brown and Reed 2009), our study utilized a special places approach to identifying sites of high interest to participants, from which they were asked about place-based activities and values attached to those places. Participants were asked to identify up to five places in western North Carolina that are important to them, to mark these places on the map of western North Carolina as accurately as possible using a point, line, or polygon, and to label each location with a number 1 - 5. They were then asked, for each location they identified on the map (1 - 5), to list all of the outdoor activities they do there. Lastly, they were asked to provide input about why the areas they identified are important to them by associating up to three landscape values with each of the areas they marked on the map, in order of importance. A list and description of 14 pre-selected values from which they could choose, based on the work of Brown and Reed (2009), was available on the back of the questionnaire; these are defined in Table 2.

Digitizing and Data Entry

All activity polygons created by the survey respondents were digitized in ArcGIS. The original survey map was created (and projected) in ArcGIS, thus allowing us to digitize features directly in geographic space more accurately. A shapefile was created for every individual activity location, for a total of 419 shapefiles. Tabular survey data representing the activities and values respondents identified in relation to each shape on the map were then entered into a spreadsheet, along with their demographic data, zip code, and visitation information. These tabular data were then linked to a merged shapefile of all 419 activity locations for the purpose of geospatial visualization and analysis.

Geospatial Data Analysis

After digitization of respondents' mapped areas into polygon shapefiles, the first step in using GIS to understand regional patterns in the data was to build a comprehensive geospatial dataset that would reflect both intensity and spatiality of use. We accomplished this in ModelBuilder by rasterizing each polygon individually, and then using local cell statistics to sum the number of times each pixel across the study area was included in a polygon. Further processing to convert NoData cells to a value of 0 and to apply a study area mask produced a raster surface from which we could identify thirteen "hotspots" of high intensity use as well as lower-intensity patterns outside of high-density locations. Figure 2 shows this raster in 2D with some minimal locational context (top); a 3D rendering that supports visual interpretation of intensity as height (center); and a representation of the thirteen hotspots as vector points on a regional map (bottom). The hotspots are identified by location name in Table 3.

Due to the rich array of attribute data associated with the respondents' polygons, a variety of analysis approaches were possible to tease out spatial patterns in terms of who is using what areas for what purposes (i.e., values, activities). In working with both values and activities data, we found it helpful to further group these attributes into categories (see Table 4 for values groupings and Table 5 for activities groupings) to allow us to focus on broader patterns. We did this by identifying commonalities among the individual values and activities, respectively, and grouping them according to a logic based on those common essential characteristics. The attribute groupings were added to the tabular data for the polygons. In the case of values, since respondents were asked to prioritize their values by listing them in order, we experimented with weighting for the varying priorities but eventually settled on using only the groupings on the first values column; thus, in our analyses one values grouping is expressed per polygon. For activities, because order did not represent priority, we selected across all activities columns with the result that multiple activities could be mapped per polygon.

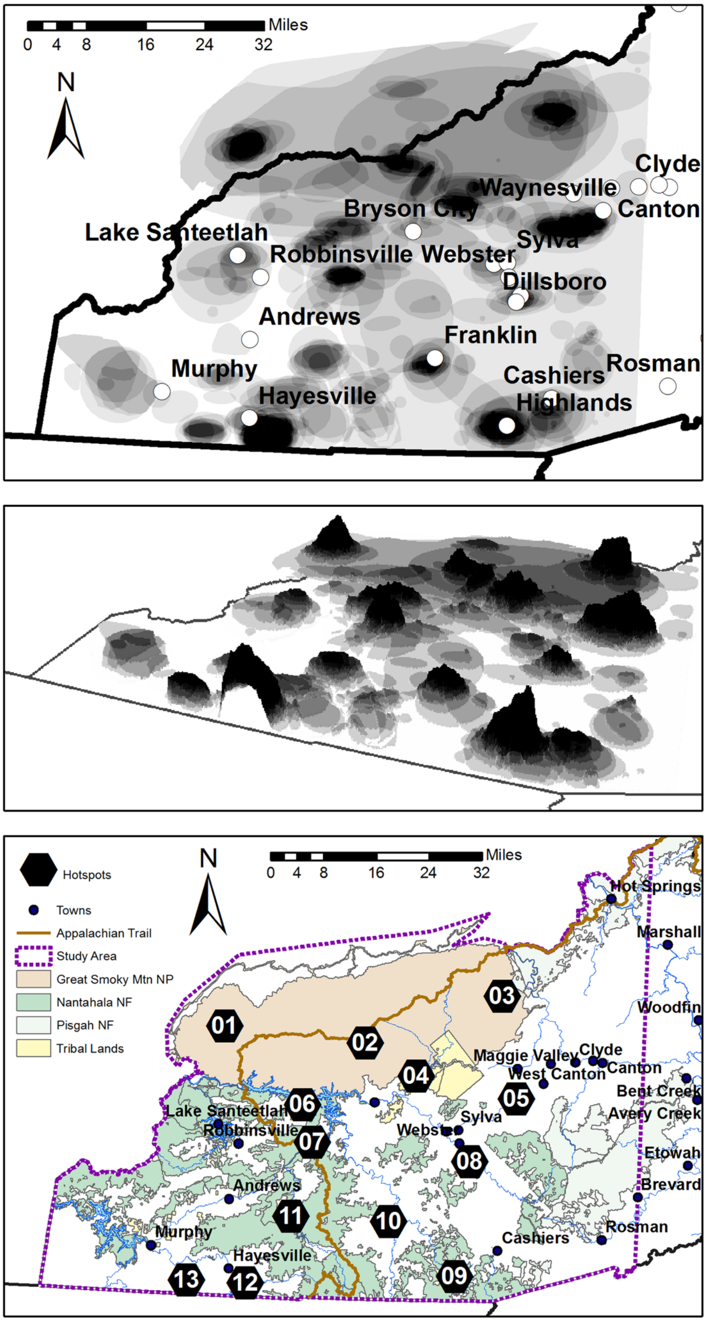
We explored a number of possibilities in GIS for visualizing the spatial patterns associated with our rich qualitative attribute data. In this paper we focus on four basic geospatial analysis approaches on our activities, values, and demographic attributes in order to demonstrate the potential for this kind of data visualization. These four approaches are:

- Kernel density patterns for different attributes, using centroids of the respondents' polygons,
- Descriptive spatial statistics summarizing polygons by different attributes,

Table 2. Landscape values provided in our survey instrument for respondent use; after Brown and Reed 2009

1	ECOLOGY/ENVIRONMENT I value this place because it provides habitat for a variety of plants and animals, which may not be found in other places
2	ECONOMIC I value this place because it creates jobs and provides income through forest products, mining, tourism, agriculture, fishing, etc
3	EDUCATION/LEARNING I value this place because it provides a place to learn about, teach, or research the natural environment
4	ENTERTAINMENT I value this place because it provides diversion, amusement, or cultural expression
5	FAMILY/SOCIAL I value this place because it provides opportunities for getting together with my family and friends
6	FUTURE GENERATIONS I value this place because it allows generations that will follow us to know and experience it as it is now
7	HEALTH I value this place because it makes me feel better physically and/or mentally
8	HERITAGE I value this place because it has natural and human history that matters to me and it allows me to pass down the wisdom, knowledge, traditions, or way of life of my ancestors
9	HOME I value this place because it is familiar, comfortable, and welcoming
10	RECREATION I value this place because it provides opportunities for outdoor activities
11	SCENERY/NATURAL BEAUTY I value this place for the scenery, sights, smells, or sounds
12	SPIRITUAL I value this place because it is sacred, religious, or divinely special to me
13	SUSTENANCE or HARVEST I value this place because it provides food and other products to sustain my life and that of my family
14	WILDERNESS I value this place because it is not developed or significantly altered by people

Figure 2. Spatiality and intensity of respondent locations, illustrating 13 "hotspots" of activity. Shown here as a 2D raster (top), 3D raster data surface (middle), and vectorized hotspot location points (bottom)



- Graduated pie charts representing attributes at hotspots, and
- Origin-destination lines from respondent home locations to hotspots.

Table 3. Names of hotspot locations and their code numbers as shown in Figure 2 (bottom)

Hotspot number	Hotspot location name
01	Cades Cove
02	Clingman's Dome
03	Cataloochee
04	Cherokee
05	Blue Ridge Parkway at Balsam
06	Fontana Lake
07	Nantahala Gorge
08	Cullowhee
09	Highlands
10	Franklin
11	Nantahala Lake
12	Chatuge Lake
13	Brasstown

Table 4. Categories derived from individual values attributes to facilitate visualization of broader patterns. The value associated with education and learning was kept separate due to the high number of respondents affiliated with the university located at one of the survey sites.

	Values used in survey	Value grouping used in GIS work
1	Ecology/Environment	Nature
11	Scenery/Natural Beauty	
14	Wilderness	
2	Economic	Economic
13	Sustenance or Harvest	
3	Education/Learning	Education
4	Entertainment	Recreation
5	Family/Social	
10	Recreation	
6	Future generations	Home
8	Heritage	
9	Home	
7	Health	Health
12	Spiritual	

Table 5. Categories derived from individual activities attributes to facilitate visualization of broader patterns

Activities listed by respondents	Activity grouping used in GIS work
Antiques History Art Group meeting Arts & crafts Looking for old homesteads Class Music Cultural activities Picture Education Photography Folk school Program at Cowee School Galleries Wheels through Time Museum	01 Arts & Culture
Backpack Ski Camp Snowboard Explore Trail running Hike Walk Run Trail maintenance	02 Trail, Tent, Snow
4th of July Ghost town Casino Jared House Concert Opossum Drop Eat Shop Entertainment Tennis Farmers market Town Festivals Town square Food Zipline Football	03 Entertainment
Fish Hunt	04 Hunting & Fishing
Family Summer home Home Work Live	05 Home Life
Biking Ride motorcycles Horseback riding	06 Active Locomotion
Activities Outdoor activities Activity Special events Business Stuff Doctor Visit	07 General Activity
Drive Ride train Mountain Scenery Parks Sightsee Picnic Tour Ride Train Ride Parkway Waterfalls	08 Scenery
Boat Paddling Canoe Raft Floating Swim Jet ski Tube Kayak Water activities Lake activities Water sports	09 Water Activities
Animal rescue Nature ID Birdwatching Plant ID Elk sighting Watch Elk watching View wildlife	10 Wildlife & Nature
Church Relax Meditating Sit	11 Reflection & Religion
None	12 Not stated

In the section below we illustrate and discuss the most interesting results from these four GIS approaches.

GEOSPATIAL ANALYSIS RESULTS AND DISCUSSION

Kernel Density Patterns

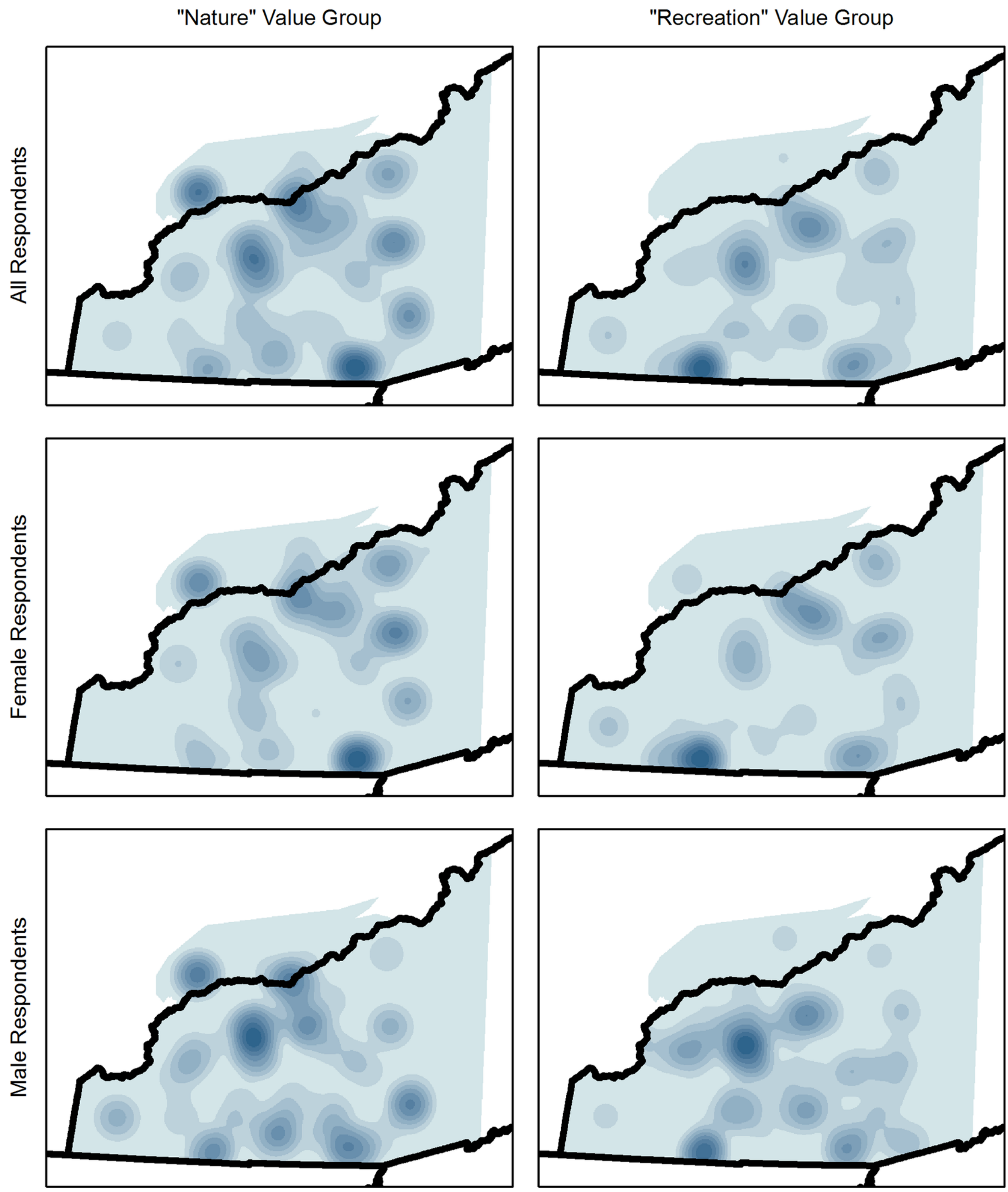
Kernel density surfaces were constructed by first creating centroids for each polygon, with centroids inheriting all attribute data. Reliance on centroids for this analysis approach results in a loss of the area dimension of respondents' locations, but that dimension is replaced with a spatial proxy by way of the kernel density process. This process is much quicker to set up and run than the rasterization process discussed above and can produce a number of analysis surfaces in a short amount of time. Centroids meeting specified criteria were extracted in ModelBuilder, and kernel density functions were run for both the main values and activities groups alone and as they intersected various social attributes. Each kernel density process was set to use the same search radius and output cell size (40,000 square feet and 800 respectively).

Figure 3 presents kernel density surfaces for the two largest values groupings (Table 4), which together represent nearly 70% of first-priority values responses. These groups are "Nature" and "Recreation." The top row in Figure 3 demonstrates that respondents use many of the same areas for both value groups, although "Nature" values are more prominent within Great Smoky Mountains National Park and at Highlands, while "Recreation" values are more prominent at Chatuge Lake. Breaking down the analysis of these two value groupings by gender reveals some especially interesting patterns, however. For both groupings, male respondents identified locations across the region, while female respondents identified a more select group of locations, as well as some differing areas and emphases from the male respondents.

We also draped the "Nature" and "Recreation" values grouping kernel density surfaces over elevation to tease out associations between these values and mountainous terrain. Figure 4 displays these results. This was accomplished in ArcScene by setting the base heights of the 1 arc second DEM (from the National Elevation Dataset) to float on its own elevation values, with a vertical factor of 20. The kernel density surface we stacked on top of the DEM and offset it without setting it to float on the elevation values, to give the best possible visual reading while approximating an appropriate height above sea level for this area . Results suggest that respondents associate "Nature" values with mountaintop and plateau settings more so than lowland or valley settings, yet associate "Recreation" values more with the valley locations (especially if flooded to form a lake).

In a similar fashion we draped pairs of activity groupings (Table 5) kernel density surfaces over elevation to both compare locations between sets of activities, and again to see which were associated with mountaintop versus valley settings. Figure 5 compares Activity Code 02 (Trail, Tent, and Snow) with Activity Code 08 (Scenery), while Figure 6 compares Activity Code 04 (Hunting and Fishing) with Activity Code 10 (Nature and Wildlife). In the latter, it appears that hunting and fishing activities tend to take place in much more accessible locations and largely in valley areas, near popular locations and towns. In contrast, people whose interests are in wildlife and nature have a different focus, which might make it necessary to go to sites deep in the mountains, at higher elevations, and presumably more wild. In comparing the very active pursuits of hiking, camping, and so on in Code 02 with the likely passive appreciation of scenery, Figure 5 suggests that the active group finds places to do these activities over much of the region, while the more passive group sticks to fewer locations and more constrained areas; both groups appear to carry out their activities in a range of topographical settings, however.

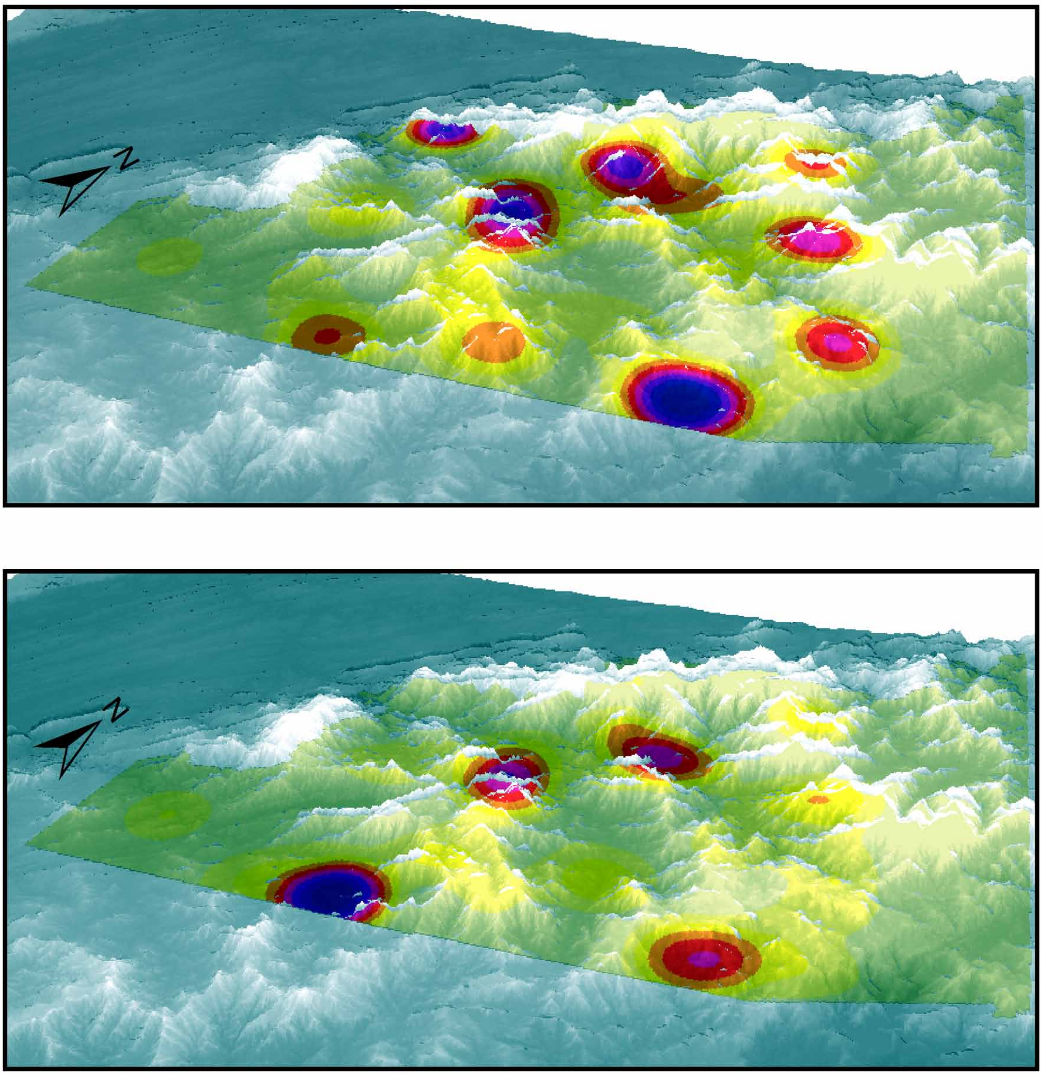
Figure 3. A matrix of kernel density surfaces illustrating our two main values groupings, "Nature" and "Recreation," alone and as they intersect respondent gender



Descriptive Spatial Statistics

Some of the social categories show interesting kernel density patterns as well, but these can also be demonstrated through other approaches. Returning to the original digitized polygons, we ran the descriptive spatial statistics functions of mean center and directional distribution (standard deviational ellipse) to get some indications about trends within the polygon dataset. The ellipses

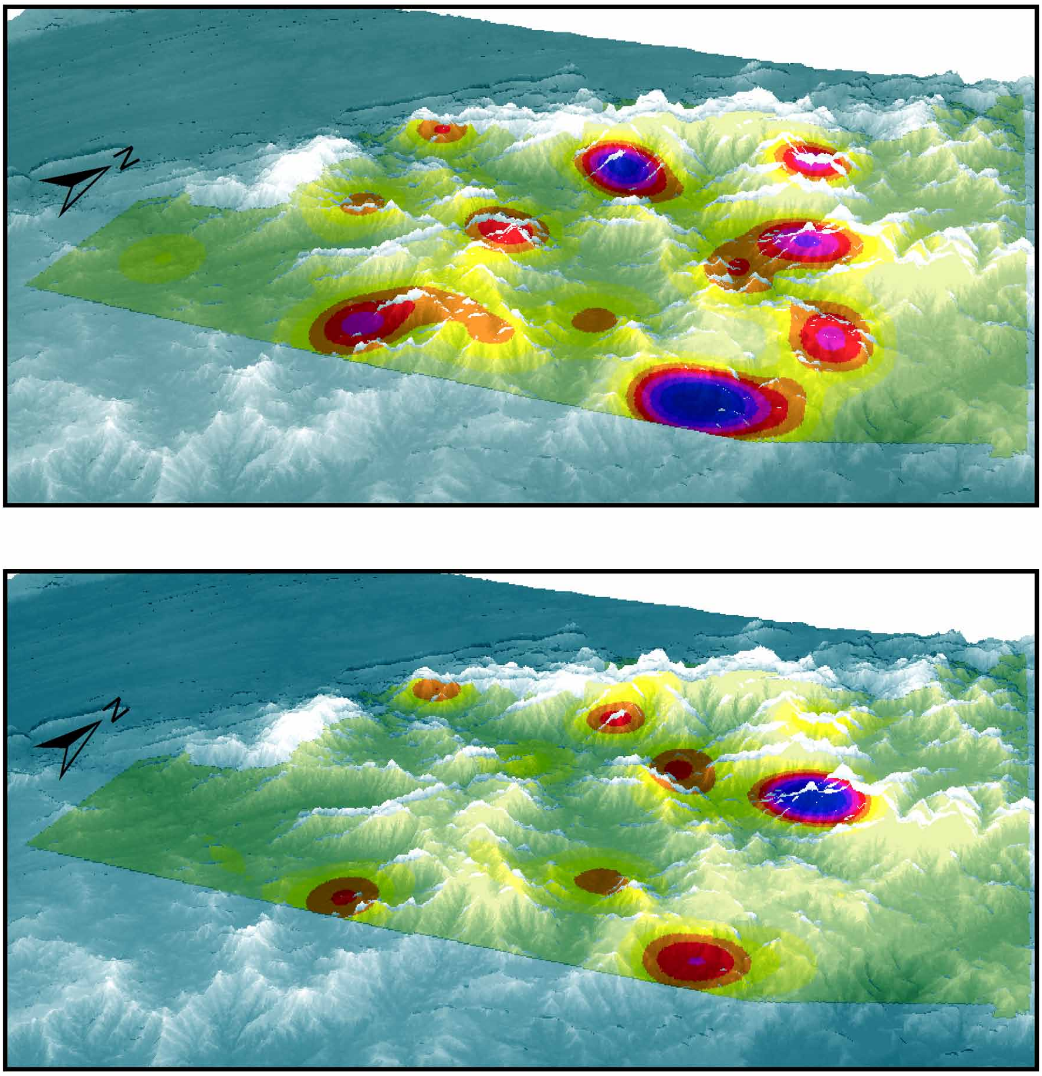
Figure 4. The two main values groupings ("Nature" on top; "Recreation" at bottom) kernel density surfaces draped over elevation in ArcScene to visualize possible relationships between values and different aspects of the mountainous terrain



were not especially instructive but the mean centers highlighted some important differences in the ways different groups use the region.

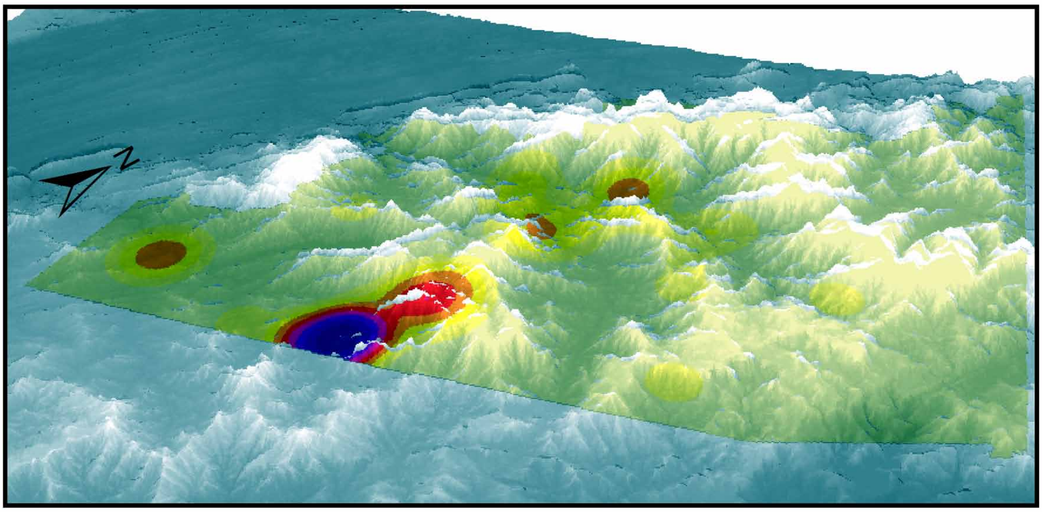
Figure 7 shows four examples of weighted mean centers as visualizations of patterns in social categories within the survey data. In the upper left map, we see that while the location of the mean center for each age group has no obvious significance, when those mean centers are weighted by area the variation in the size of each age group's ecumene within the region is striking. Those of the two oldest age groups are markedly larger than the others' and the two youngest groups have the smallest areas by far. In other words, respondents of upper middle age or older utilize more of the region than younger respondents do. The story in the lower left map, in contrast, is more about location than size even though some variation in size is evident from the area-weighting. Here, mean centers for household income groups display a marked locational pattern in that the three lowest categories trend to the west and north of an imaginary diagonal and the three highest categories trend to the

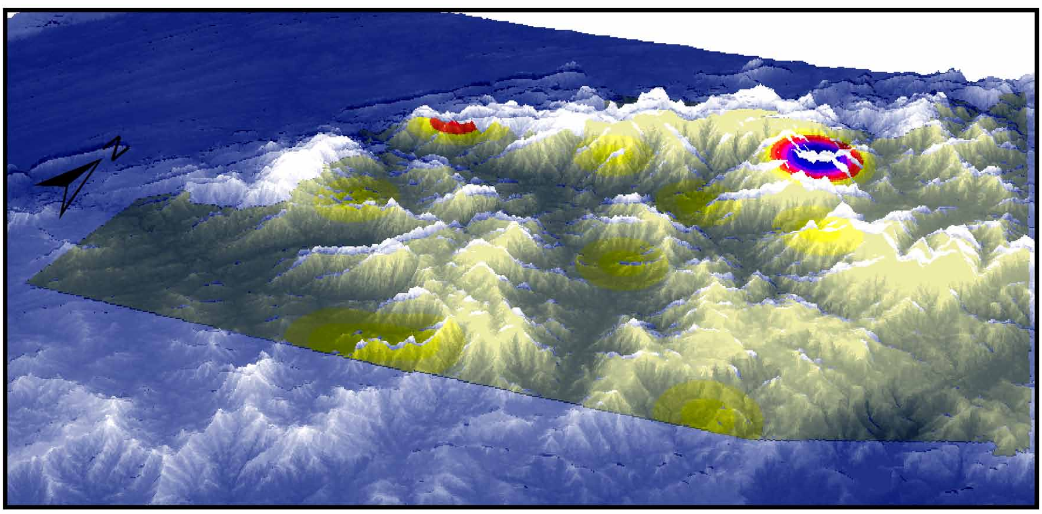
Figure 5. Activity Codes 02 (Trail, Tent, and Snow, top) and 08 (Scenery, bottom) draped over elevation in ArcScene



south and east of that line. This puts the lower incomes deeper into mountainous areas and farther from major settlements. The upper right map, visualizing respondents' residence categories (resident, visitor, or seasonal resident) demonstrates significance in both size and location. Residents have the largest regional ecumene of the three groups, and visitors the smallest, with seasonal residents in between, suggesting a correlation with length of time spent in the region. Residents and visitors share a mean location to the north and west, in more mountainous and less connected areas, while seasonal residents' mean location is again closer to major settlements. Lastly, the lower right map complements the gendered kernel density maps by showing that male and female respondent polygon mean centers differ slightly in terms of both location and size. This result would be worth following up in terms of the income and residence category attributes due to their locational patterns, and in comparison to the activity space spread and concentrations shown in the density maps.

Figure 6. Activity Codes 04 (Hunting and Fishing, top) and 10 (Nature and Wildlife, bottom) draped over elevation in ArcScene

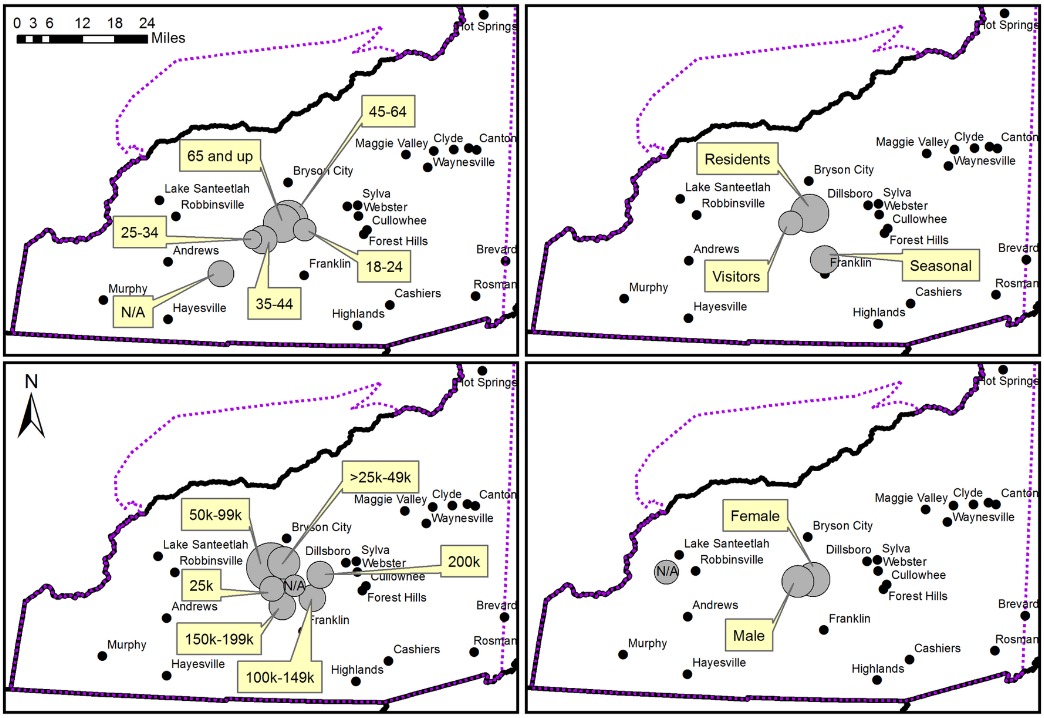




Graduated Pie Charts

While the spatial statistics approach described above utilized all polygons, we also analyzed certain attributes of those polygons that participated in a hotspot, and produced graduated pie charts mapped to each vectorized hotspot center. As the top map in Figure 8 illustrates, this approach reinforces and expands our understanding of the resident/seasonal/visitor patterns. Seasonal residents are most strongly represented in the Highlands area (Hotspot 9) and to the south and east of the imaginary diagonal in general, with apparent forays north and west of that diagonal only at selected sites. Interestingly, Nantahala Gorge (Hotspot 7) was utilized by none of our seasonal respondents at all, forming an interesting contrast that we will explore in future work analyzing hotspots at the local scale. The lower map in Figure 8 visualizes respondents' engagement in different mixes of activities at the different hotspots. While the multiple activity codes make these pie charts difficult to read in detail, what can be clearly seen is the dominance of one primary activity, or sometimes two, at most of the hotspots, and that the dominant activity varies from site to site.

Figure 7. Area-weighted mean centers for age (upper left), income (lower left), resident/visitor category (upper right), and gender (lower right)



Origin-Destination Lines

Our final analysis approach was to use origin-destination lines (XY to Line tool) to help us think about where people were traveling from to each hotspot, and why. This process used zip code data supplied by respondents, with origin points defined as the centroids of the respective zip code areas and destination points as the vectorized hotspot centers. As Figure 9 shows, most people using the hotspots come from within or near the western North Carolina region (some from very close to the hotspot of interest), while a number come from other parts of the Southeast, and a few from farther afield and other directions. Interestingly, none of our respondents came from the relatively nearby Midwest or even Tennessee.

At the local scale, we adjusted the lines coming into each hotspot so that individual lines could be seen even if they no longer point precisely to the zip code centroid. In this way we could symbolize lines by attributes and visually interpret both the size of groups coming to the hotspot from different areas and also why they visit those locations, as illustrated in Figures 10 and 11. Figure 10 compares Hotspots 9 (top) and 7 (bottom) and elucidates the resident/seasonal/visitor pattern we saw above. The relatively few visitors to Nantahala Gorge (Hotspot 7) appear to come from parts of the South other than metropolitan Atlanta, while most of the people utilizing that site come from within the region, as expected. In contrast, Highlands (Hotspot 9) receives non-local people from a wide area and many of these are from the Atlanta area, with some of them likely seasonal residents. Highlands draws quite a lot of people from the western North Carolina region as well, though from nearby rather than across the region as is the case at Nantahala Gorge. In terms of the values groups, Highlands is valued by our respondents for reasons across the spectrum, while Nantahala Gorge is pretty evenly divided between “Nature” and “Recreation” with little else identified.

Figure 8. Graduated pie charts representing resident/visitor category (top) and activity groups (bottom) among polygons participating in each hotspot

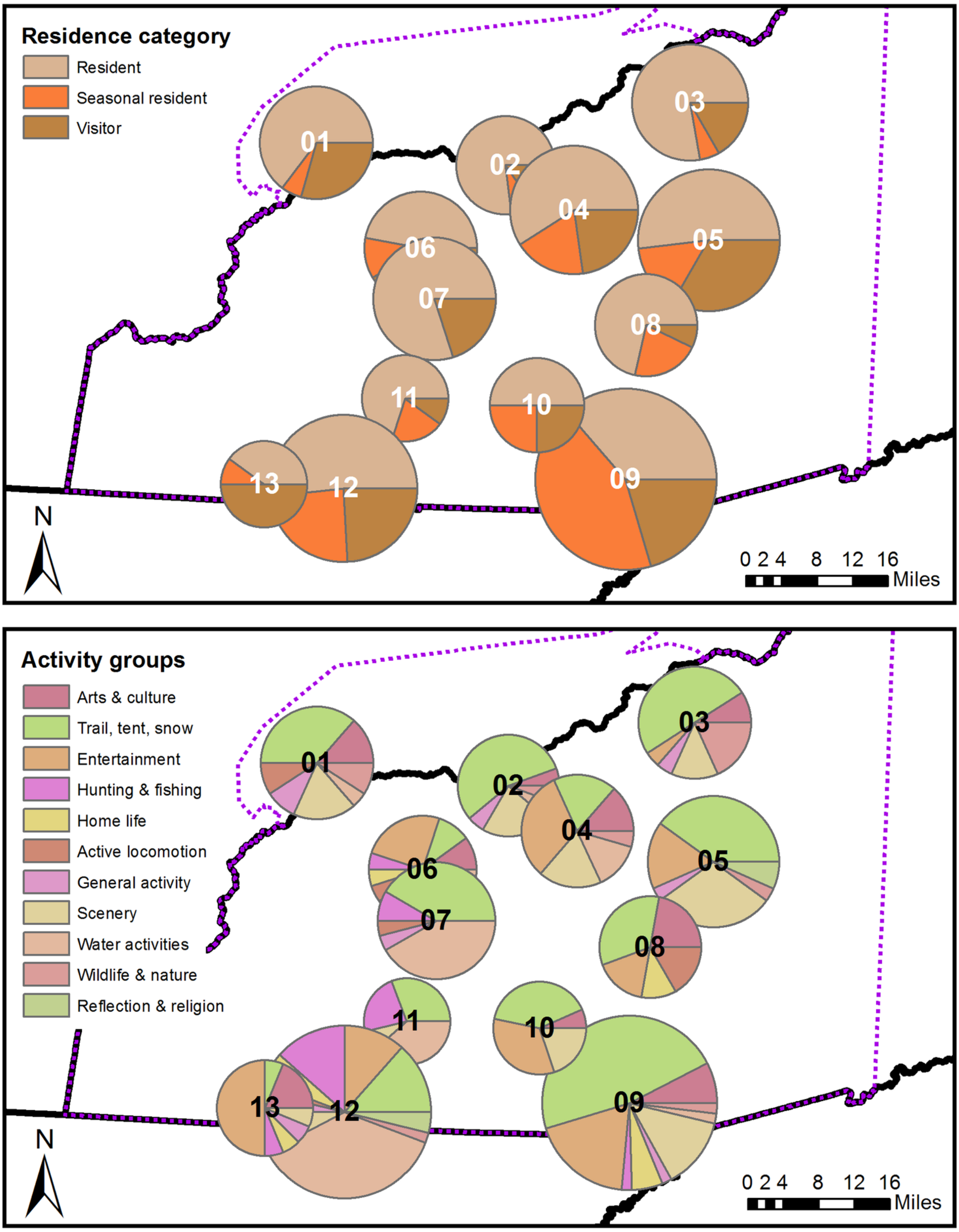
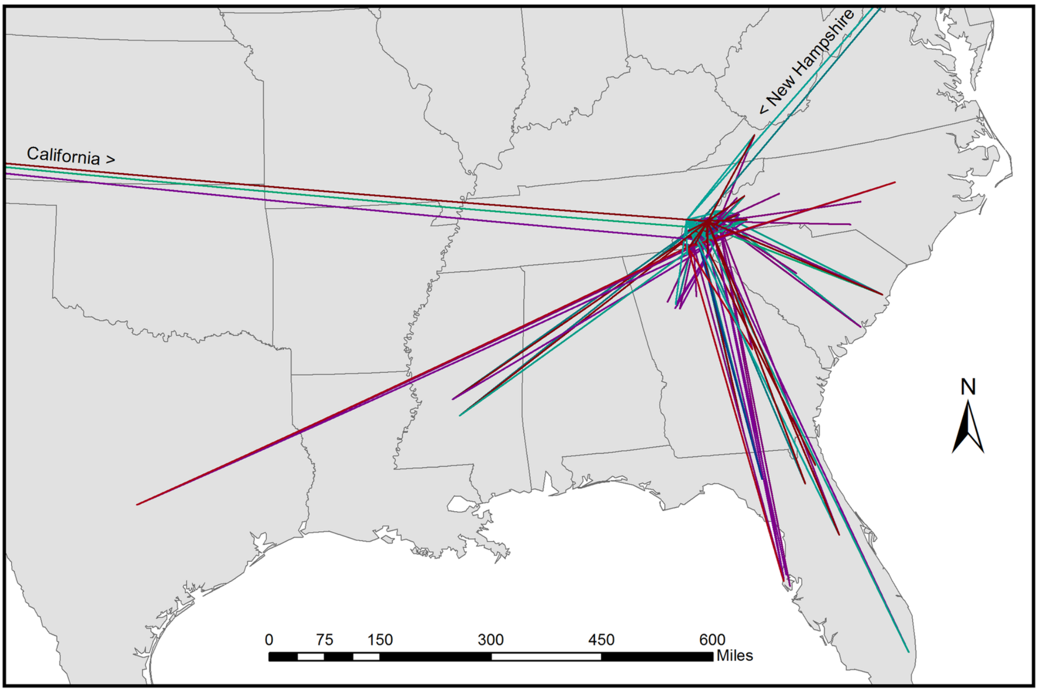


Figure 11 compares four additional hotspots in terms of origin and values. Cades Cove (Hotspot 1; upper left) appears to draw people who assign it a "Nature" value and a variety of "other" values, but appears to have little attraction for "Recreation" values uses. People visit there from within the region but not the immediate vicinity, and also from farther away. Cherokee (Hotspot 4; upper right)

Figure 9. Origin-destination lines from respondents' home zip codes to hotspots they visited

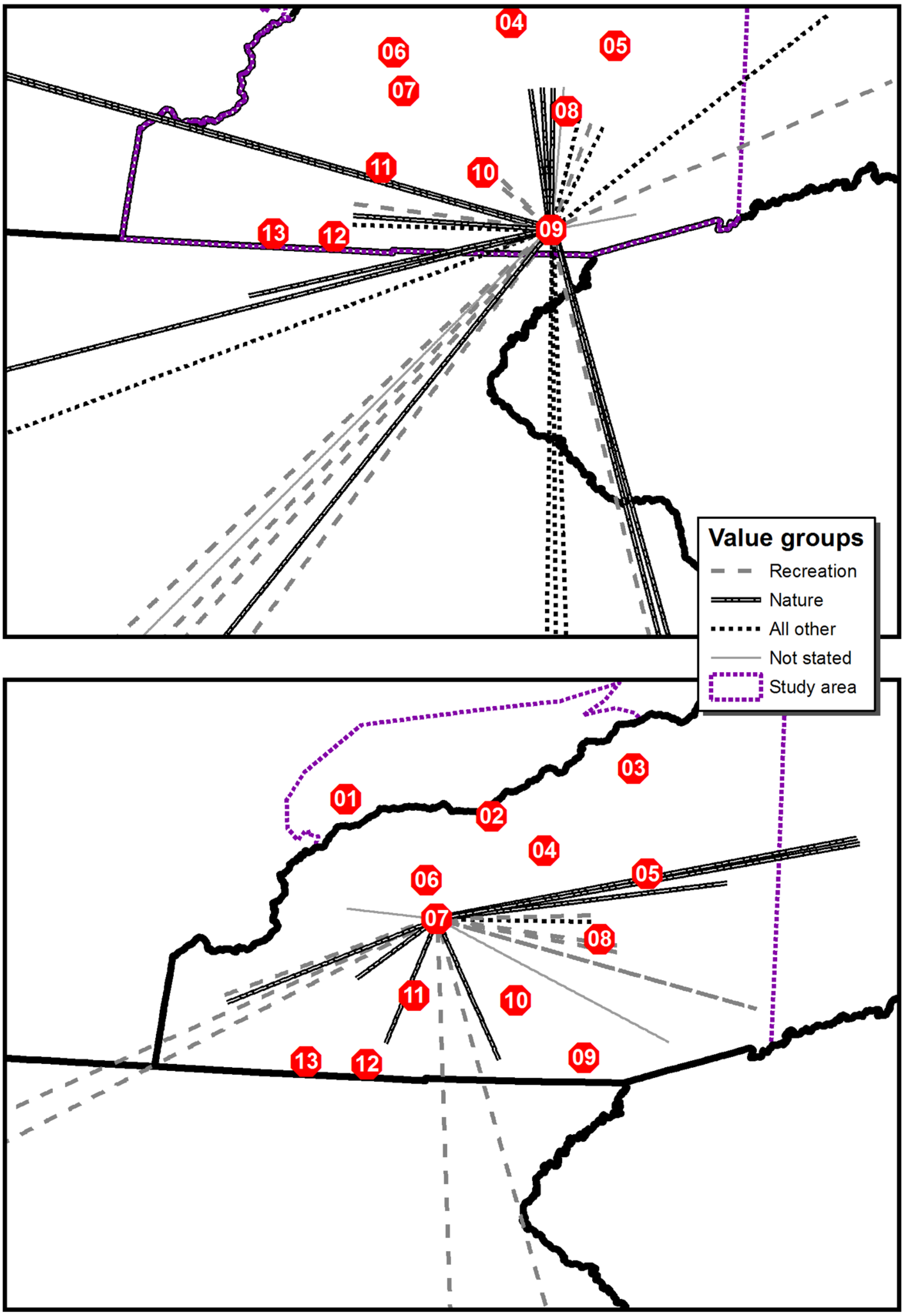


has visitors from a wide radius and varied distances, and is associated with a greater diversity of values ("Nature," "Recreation," and "other"). The Blue Ridge Parkway at Balsam (Hotspot 5; lower left) again draws people identifying a range of values, and from close by, around the region, and far afield. Chatuge Lake (Hotspot 12; lower right) stands out among all the hotspots for the dominance of the "Recreation" values group, even though "Nature" and "other" are present, and also for the large number of very local users as shown in the inset (in addition to many from other distances). Using origin-destination lines to visualize values and origins together, as we see here, offers considerable promise for helping build an understanding of who uses sites and why.

CONCLUSION AND FUTURE DIRECTIONS

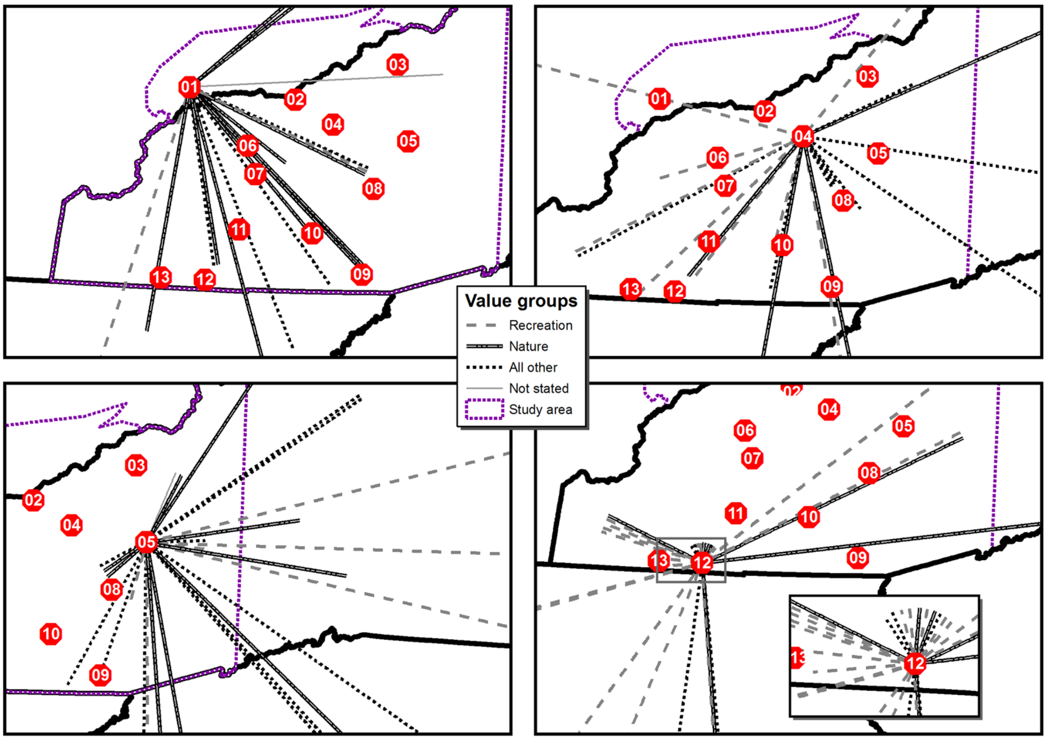
These four approaches and the resulting visualizations are illustrative of the many ways that GIS can be used in the analysis of spatialized qualitative survey data. Each example here has things to tell us about how the region is used, by whom, and why, that could not have been gleaned from a non-spatial analysis of the survey data. Kernel density analysis has proven an effective method of visualizing overall regional patterns of attributes alone or in combination, and could easily be viewed as 3D surfaces with height based on the value of each pixel. Draping the kernel density surface over elevation also shows promise, bringing the qualitative data into the physical geography context in a direct way. Descriptive spatial statistics have helped elucidate spatial trends (in relation to both size and location) among respondents' polygons according to different socio-demographic data, and could be used to tease out such spatial trends for values and activities polygons as well. Graduated pie charts, long a staunch classic in thematic cartography, are here shown to effectively visualize volume of and categories within different types of respondent data at hotspot locations. Origin-destination lines demonstrate considerable promise in understanding patterns regarding where people come to

Figure 10. Origin-destination lines approaching Hotspots 9 (Highlands; top) and 7 (Nantahala Gorge; bottom), symbolized by value groups. Origin ends of the lines are adjusted for visibility



each hotspot from, and why. Each of these GIS outcomes, then, contributes to the larger goals of the broader HEM approach. In the case of this western North Carolina project, these data visualization examples can inform the region's resource managers and environmental planners something of the

Figure 11. Origin-destination lines approaching Hotspots 1 (Cades Cove, upper left), 4 (Cherokee, upper right), 5 (Blue Ridge Parkway at Balsam, lower left), and 12 (Chatuge Lake, lower right), symbolized by value groups. Origin ends of the lines are adjusted for visibility



nuance and complexity of how places and environmental resources are used and by whom, and what intangible human needs they satisfy.

At the same time, the visualization outputs created during this project help stimulate further questions and suggest future approaches within a GIS. Some of the general patterns illuminated in broad strokes and at the regional scale call for closer examination of social factors and constraints, notably in relation to gender and to residence categories. GIS will also be key in bringing accessibility into the HEM picture in this mountainous region through network analysis. Given that some mountain highways are broad thoroughfares engineered for traffic moving at speed through the region, while some are local roads that are intense, slow to drive, or even dangerous, distance alone is not sufficient to understand patterns of visits to particular sites. And lastly, we envision future analysis of individual hotspots across a wide range of physical, environmental, and spatial parameters to help understand their appeal among the different permutations of demographics and purposes, and also to give managers and planners a basis for promoting alternate sites that might have similar appeal if original sites are suffering degradation from overuse. Such local-scale analysis can draw on the panoply of available GIS data including detailed terrain, hydrology, biotic, access, urban proximity, and more. In sum, GIS approaches using a range of individually simple analytical processes have produced important insights about the spatialized qualitative data this western North Carolina HEM project, and show potential for work with human landscapes more broadly.

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REFERENCES

Alessa, N., Kliskey, A., & Brown, G. (2008). Social-ecological hotspots mapping: A spatial approach for identifying coupled social-ecological space. *Landscape and Urban Planning*, *85*(1), 27–39. doi:10.1016/j.landurbplan.2007.09.007

Appalachian Trail Conservancy. (2017). Explore the Trail. Retrieved June 22, 2017, from http://www.appalachiantrail.org/home/explore-the-trail

Ardoin, N. M. (2014). Exploring sense of place and environmental behavior at an ecoregional scale in three sites. *Human Ecology*, *42*(3), 425–441. doi:10.1007/s10745-014-9652-x

Bagheri, N. (2014). What qualitative GIS maps tell and don't tell: Insights from mapping women in Tehran's public spaces. *Journal of Cultural Geography*, *31*(2), 166–178. doi:10.1080/08873631.2014.906848

Bennett, D. G. (1993). Retirement migration and economic development in high-amenity, nonmetropolitan areas. *Journal of Applied Gerontology*, *12*(4), 466–481. doi:10.1177/073346489301200405

Besser, D. T., McLain, R., Cerveny, L., Biedenweg, K., & Banis, D. (2014). Mapping landscape values: Issues, challenges, and lessons learned from field work on the Olympic Peninsula, Washington. *Environmental Practice*, *16*(2), 138–150. doi:10.1017/S1466046614000052

Beverly, J. L., Uto, K., Wilkes, J., & Bothwell, P. (2008). Assessing spatial attributes of forest landscape values: An internet-based participatory mapping approach. *Canadian Journal of Forest Research*, *38*(2), 289–303. doi:10.1139/X07-149

Boschmann, E. E., & Cubbon, E. (2014). Sketch maps and qualitative GIS: Using cartographies of individual spatial narratives in geographic research. *The Professional Geographer*, *66*(2), 236–248. doi:10.1080/00330124.2013.781490

Brennan-Horley, C., & Gibson, C. (2009). Where is creativity in the city? Integrating qualitative and GIS methods. *Environment & Planning A*, *41*(11), 2595–2614. doi:10.1068/a41406

Brown, G. (2004). Mapping spatial attributes in survey research for natural resource management: Methods and applications. *Society & Natural Resources*, *18*(1), 17–39. doi:10.1080/08941920590881853

Brown, G. (2006). Mapping landscape values and development preferences: A method for tourism and residential development planning. *International Journal of Tourism Research*, *8*(2), 101–113. doi:10.1002/jtr.562

Brown, G. (2008). Social-ecological hotspots mapping: A spatial approach for identifying coupled social-ecological space. *Landscape and Urban Planning*, *85*(1), 27–39. doi:10.1016/j.landurbplan.2007.09.007

Brown, G. (2012). Public participation GIS (PPGIS) for regional and environmental planning: Reflections on a decade of empirical research. *Journal of the Urban and Regional Information Systems Association / URISA*, *25*(2), 7–18.

Brown, G., & Kyttä, M. (2014). Key issues and research priorities for public participation GIS (PPGIS): A synthesis based on empirical research. *Applied Geography*, *46*, 122–136. doi:10.1016/j.apgeog.2013.11.004

Brown, G., & Raymond, C. (2007). The relationship between place attachment and landscape values: Toward mapping place attachment. *Applied Geography*, *27*(2), 89–111. doi:10.1016/j.apgeog.2006.11.002

Brown, G., Raymond, C. M., & Corcoran, J. (2015). Mapping and measuring place attachment. *Applied Geography (Sevenoaks, England)*, *57*, 42–53. doi:10.1016/j.apgeog.2014.12.011

Brown, G., Smith, C., Alessa, L., & Kliskey, A. (2004). A comparison of perceptions of biological value with scientific assessment of biological importance. *Applied Geography*, *24*(2), 161–180. doi:10.1016/j.apgeog.2004.03.006

Brown, G., & Weber, D. (2011). Public Participation GIS: A new method for national park planning. *Landscape and Urban Planning*, *102*(1), 1–15. doi:10.1016/j.landurbplan.2011.03.003

Brown, G. G., & Reed, P. (2009). Public participation GIS: A new method for use in national forest planning. *Forest Science*, *55*(2), 166–182.

Cerveny, L. K., Biedenweg, K., & McLain, R. (2017). Mapping meaningful places on Washington's Olympic Peninsula: Toward a deeper understanding of landscape values. *Environmental Management*. PMID:28608035

Chávez, K. (2017). Getting outdoors is good for the WNC economy, too. *Asheville Citizen-Times*. Retrieved June 22, 2017, from http://www.citizen-times.com/story/news/local/2017/05/08/getting-outdoors-good-wnc-economy-too/101283486/

Cheng, A. S., Kruger, L. E., & Daniels, S. E. (2003). "Place" as an integrating concept in natural resource politics: Propositions for a social science research agenda. *Society & Natural Resources*, *16*(2), 87–104. doi:10.1080/08941920309199

Cooper, D., & Gregory, I. N. (2011). Mapping the English Lake District: A literary GIS. *Transactions of the Institute of British Geographers, 36 NS*, 89-108.

Cullinane, T. C., & Koontz, L. (2017). *2016 national park visitor spending effects: Economic contributions to local communities, states, and the nation* (Natural Resource Report NPS/NRSS/EQD/NRR—2017/1421). Fort Collins, CO: National Park Service.

Eisenhauer, B. W., Krannich, R. S., & Blahna, D. J. (2000). Attachments to special places on public lands: An analysis of activities, reason for attachments& community connections. *Society & Natural Resources*, *13*(5), 421–441. doi:10.1080/089419200403848

Elwood, S., & Cope, M. (2009). Introduction: Qualitative GIS: forging mixed methods through representations, analytical innovations, and conceptual engagements. In M. Cope & S. Elwood (Eds.), *Qualitative GIS: A mixed methods approach* (pp. 1–10). London: Sage.

Fagan, M., & Longino, C. F. Jr. (1993). Migrating retirees: A source for economic development. *Economic Development Quarterly*, *7*(1), 98–106. doi:10.1177/089124249300700109

Fagerholm, N., Käyhkö, N., Ndumbaro, F., & Khamis, M. (2012). Community stakeholders' knowledge in landscape assessments-Mapping indicators for landscape services. *Ecological Indicators*, *18*, 421–433. doi:10.1016/j.ecolind.2011.12.004

Fish, R., Church, A., & Winter, M. (2016). Conceptualising cultural ecosystem services: A novel framework for research and critical engagement. *Ecosystem Services*, *21*, 208–217. doi:10.1016/j.ecoser.2016.09.002

Haas, W. H. III, & Serow, W. J. (1993). Amenity retirement migration process: A model and preliminary evidence. *The Gerontologist*, *33*(2), 212–220. doi:10.1093/geront/33.2.212 PMID:8468014

Hens, L., Borden, R. J., Suzuki, S., & Caravello, G. (Eds.). (1998). Research in human ecology: An interdisciplinary overview. Brussels, Belgium: Vrije Universiteit Brussel (VUB) Press.

Kil, N., Holland, S. M., & Stein, T. V. (2014). Place meanings and participatory planning intentions. *Society & Natural Resources*, *27*(5), 475–491. doi:10.1080/08941920.2013.842274

Kruger, L. (2008). Place-based planning: Innovations and applications from four western forests. In J. O. Farnum & L. E. Kruger (Eds.), *Gen Tech Rep PNW-GTR-741)*. Portland, OR: USDA Forest Service, Pacific Northwest Research Station.

Kwan, M.-P., & Ding, G. (2008). Geo-narrative: Extending geographic information systems for narrative analysis in qualitative and mixed-method research. *The Professional Geographer*, *60*(4), 443–465. doi:10.1080/00330120802211752

Matthews, S. A., Detwiler, J. E., & Burton, L. M. (2005). Geo-ethnography: Coupling geographic information analysis techniques with ethnographic methods in urban research. *Cartographica*, *40*(4), 75–90. doi:10.3138/2288-1450-W061-R664

McDonnell, M. J., & Pickett, S. T. A. (1990). Ecosystem structure and function along urban-rural gradients: An unexploited opportunity for ecology. *Ecology*, *71*(4), 1232–1237. doi:10.2307/1938259

McLain, R., Banis, D., Todd, A., & Cerveny, L. (2017) Multiple methods of public engagement: Disaggregating socio-spatial data for environmental planning in western Washington, USA. *Journal of Environmental Management*. PMID:28858676

McLain, R., Cerveny, L., Besser, D., Banis, D., Todd, A., Rohdy, S., & Kimball-Brown, C. (2013a). *Mapping human-environment connections on the Olympic Peninsula: An atlas of landscape values* (Occasional Papers in Geography No. 7). Portland, OR: Portland State University, Department of Geography.

McLain, R., Cerveny, L., Biedenweg, K., & Banis, D. ((in review). b) Values mapping and counter-mapping in contested landscapes: An Olympic Peninsula (USA) case study. *Human Ecology*.

McLain, R., Poe, M., Biedenweg, K., Cerveny, L., Besser, D., & Blahna, D. (2013b). Making sense of human ecology mapping: An overview of approaches to integrating socio-spatial data into environmental planning. *Human Ecology*, *41*(5), 651–665. doi:10.1007/s10745-013-9573-0

Mennis, J., Mason, M. J., & Cao, Y. (2013). Qualitative GIS and the visualization of narrative activity space data. *International Journal of Geographical Information Science*, *27*(2), 267–291. doi:10.1080/13658816.2012.678362 PMID:26190932

Pavlovskaya, M. (2004). Other transitions: Multiple economies of Moscow households in the 1990s. *Annals of the Association of American Geographers*, *94*(2), 329–351. doi:10.1111/j.1467-8306.2004.09402011.x

Pavlovskaya, M. (2009). Non-quantitative GIS. In M. Cope & S. Elwood (Eds.), *Qualitative GIS: A mixed methods approach* (pp. 1–10). London: Sage.

Ramirez-Gomez, S. O., Brown, G., Verweij, P. A., & Boot, R. (2016). Participatory mapping to identify indigenous community use zones: Implications for conservation planning in southern Suriname. *Journal for Nature Conservation*, *29*, 69–78. doi:10.1016/j.jnc.2015.11.004

Raymond, C. M., Bryan, B. A., MacDonald, D. H., Cast, A., Strathearn, S., Grandgirard, A., & Kalivas, T. (2009). Mapping community values for natural capital and ecosystem services. *Ecological Economics*, *68*(5), 1301–1315. doi:10.1016/j.ecolecon.2008.12.006

Schoepfer, I., & Rogers, S. R. (2014). A new qualitative GIS method for investigating neighbourhood characteristics using a tablet. *Cartographica*, *49*(2), 127–143. doi:10.3138/carto.49.2.1810

Sieber, R. (2006). Public participation geographic information systems: A literature review and framework. *Annals of the Association of American Geographers*, *96*(3), 491–507. doi:10.1111/j.1467-8306.2006.00702.x

Stedman, R. C. (2003). Is it really just a social construction? The contribution of the physical environment to sense of place. *Society & Natural Resources*, *16*(8), 671–685. doi:10.1080/08941920309189

Steiner, D., & Nauser, M. (Eds.). (1993). *Human Ecology: Fragments of anti-fragmentary views of the world*. London, New York: Routledge. doi:10.4324/9780203414989

Tuan, Y. F. (1977). *Space and place: The perspective of experience*. Minneapolis, MN: University of Minnesota Press.

U.S. Census Bureau. (2010). 2010 Census. Census 2010 Summary File 1, Geographic Header Record G001.

Watts, P. R. (2010). Mapping narratives: The 1992 Los Angeles riots as a case study for narrative-based geovisualization. *Journal of Cultural Geography*, *27*(2), 203–227. doi:10.1080/08873631.2010.494401

Williams, D. R., Stewart, W. P., & Kruger, L. E. (2013). The emergence of place-based conservation. In W. P. Stewart, D. R. Williams, & L. E. Kruger (Eds.), *Place-based conservation* (pp. 1–17). Netherlands: Springer. doi:10.1007/978-94-007-5802-5_1

Williams, K., Biedenweg, K., & Cerveny, L. (2017). Understanding ecosystem service preferences across residential classifications near Mt. Baker Snoqualmie National Forest, Washington (USA). *Forests*, *8*(5), 157. doi:10.3390/f8050157

Wyrostkiewicz, M. (2013). *Human Ecology. An outline of the concept and the relationship between man and nature*. Lublin, Poland: Wydawnictwo KUL.

Yung, L., Freimund, W. A., & Belsky, M. (2003). The politics of place: Understanding meaning, common ground, and political difference on the Rocky Mountain front. *Forest Science*, *49*(6), 855–866.

Zube, E. H. (1987). Perceived land use patterns and landscape values. *Landscape Ecology*, *1*(1), 37–45. doi:10.1007/BF02275264

ENDNOTES

1 Great Smoky Mountains National Park straddles the North Carolina-Tennessee boundary, with roughly half in each state. We extended our study area to include the entire Park (see Figure 1) although for simplicity we discuss the study area mainly in terms of North Carolina.

Diane M. Styers is an associate professor in the Department of Geosciences and Natural Resources at Western Carolina University. She received her MA in Geography from Georgia State University, her PhD in Forestry from Auburn University, and then completed a postdoctoral fellowship in the Remote Sensing and Geospatial Analysis Lab in the School of Environmental and Forest Sciences at the University of Washington. Her research involves using remote sensing and geospatial approaches to analyze patterns of social and ecological processes that drive landscape changes affecting Earth's resources.

G. Rebecca Dobbs is the Geography Instructor at Western Carolina University, within the Department of Geosciences and Natural Resources, where she teaches most of the human geography courses and promotes the geography minor program. She earned a PhD in Geography from University of North Carolina at Chapel Hill and has keen interests in historical geography, historical and qualitative uses of GIS, Indigenous peoples, Australia, and the American South, especially North Carolina. She has guest-edited two special issues of IJAGR, one on historical GIS and one on Indigenous peoples and geospatial approaches.

Lee K. Cerveny is a Research Social Scientist with the US Forest Service Pacific Northwest Research Station based in Seattle. Cerveny is an anthropologist whose research explores human interactions with natural resources using socio-spatial approaches. She has conducted several studies using Human Ecology Mapping on national forests and other federal lands in the western United States.

Isaac T. Hayes earned his BS in Environmental Science at Western Carolina University in May 2017. He began work on his PhD in environmental engineering at Clemson University in August 2017. Within the field of environmental engineering, Hayes is interested in using GIS and Remote Sensing tools in order to solve complex environmental problems, specifically related to water quantity and quality.