Empowering Forestry Extension with Geospatial Technology

Songlin Fei, William Thomas, and Jeffrey Stringer

ABSTRACT

Although geospatial technology has become an essential tool in forestry, it has not been widely applied in forestry extension and continuing education. Geospatial technology can be used to enhance our understanding of extension audiences and improve our ability to strategically plan education and training programs. In this article, we used the University of Kentucky's Cooperative Extension forestry program as an example to illustrate how geospatial technology can assist program planning, monitor and predict trends, identify service gaps, improve information dissemination, and foresee extension opportunities.

Keywords: geospatial technology, extension, nonindustrial private forestland (NIPF), GIS, audience analysis

As one of the three critical missions in land-grant colleges and universities in the United States, Cooperative Extension plays an important role in providing solutions for a dynamic forest resource owned by a changing public. Because of population increase, resource consumption, development and fragmentation, and globalization, our world is changing more rapidly than ever and is increasingly challenged and influenced by human activities. Problems, such as ecosystem degradation, invasion by exotic species, and loss of biodiversity, are affecting almost every forest type. Cooperative Extension becomes increasingly important because it can help address challenges by providing the public with appropriate tools to sustainably manage our forests.

Similar to the business world, effective and successful extension requires good audience analysis. Geospatial technology is being used to model the physical and cultural knowledge of the world, providing us with systematic knowledge, integrative framework and analytic methods, and intuitive visualization (Dangermond 2007). Geospatial technology is an important tool for many forestry and natural resource organizations (National Research Council 2006) and has been widely used in natural resource–related research and education. Although the discussion of applying geospatial technology in extension can be traced back more than a decade (Samson 1995), it has not been widely applied. Existing applications of geospatial technology in extension are almost exclusively concentrated on natural resource planning and policy (e.g., Ellis et al. 2000, Ortigosa et al. 2000, and Milla et al. 2005), and there is a pressing need in audience analysis. Geospatial technology allows extension professionals to understand their audiences in ways that were previously not possible.

This article illustrates possible ways geospatial technologies, such as the geographic information system (GIS), can help strategically and proactively plan and administrate extension activities. In today's rapidly changing world, to effectively deliver educational and training programs and resources to individuals, agencies, businesses, and communities while improving the stewardship and health of forests and associated natural areas and resources, it is critical to understand behavioral patterns, financial and cultural situations, and forest resource distributions and changes. Visualization of the spatial distribution of tabular data allows for quick decisionmaking for extension activities, and geospatial manipulation and analysis of data permit proactive extension programming and information delivery. Examples of both types of data manipulation will be provided using the University of Kentucky's Cooperative Extension forestry database.

Materials and Methods

Data from the University of Kentucky's Cooperative Extension forestry program database were used to illustrate how geospatial technology can be used in extension audience analysis. The database included names and addresses of more than 11,000 nonin-

Songlin Fei (songlin.fei@uky.edu) is professor, William Thomas (billy.thomas@uky.edu) is extension forester, University of Kentucky, and Jeffrey Stringer (stringer@uky.edu) is extension professor, Department of Forestry, University of Kentucky, Lexington, Kentucky 40546-0073. The authors thank the Kentucky Division of Forestry for sharing the data and the very strong working relationship between our organizations. This is Kentucky Agricultural Experiment Station journal article number 07-09-112 and is published with approval of the director.

dustrial private forest (NIPF) owners who have engaged in or indicated interest in forest management from 1998 to 2006. Base maps, including state, county, and zip code, were downloaded from public domain websites. These base maps provide the demarcation data for these units and can be populated with landowner information to illustrate spatial patterns. ArcGIS 9.2 (ESRI, Inc., Redlands, California) was used to analyze and visualize spatial data and spatially related tabular data.

Two general types of geospatial techniques were applied in this project to perform audience analysis. The first is the *Join* technique used when coarse levels of geospatial locations are of interest. This technique is relatively simple and commonly used, which involves the following basic steps: (1) summarize data in tabular format by the unit of interest (e.g., number of landowners per county), (2) add base map in ArcGIS (e.g., a county map or a state map), (3) join the summarized data to the base map with a common key (e.g., county name) using the *Join* function in ArcGIS, and (4) display the map using the summarized data. To guarantee the quality of this *Join* technique, users need to ensure the common key linking the summarized data and the base map matches.

The second is the *Geocoding* technique used when relatively fine levels of geospatial locations are of interest. The *Geocoding* technique requires more GIS expertise and involves the following general steps: (1) organize mailing addresses in tabular format, (2) create an address locator in ArcGIS using street central line data (available from the US Census Bureau), and (3) georeference the mailing addresses using the Geocoding tool in ArcGIS. After georeferencing mailing addresses, analyses such as Euclidean distance and network analysis can be conducted.

The Power of Geospatial Technology in Extension

See the Forest through the Trees. Just as a good business needs to understand its customers and how to reach them, extension should follow the same model for its audiences. Geospatial technology offers a tool to analyze and visualize human and resource distributions. Based on the 11,000 plus records in our database, we estimated the overall distribution of NIPF owners who own Kentucky's forest (Figure 1) with the assumption that our database had a fair rep-
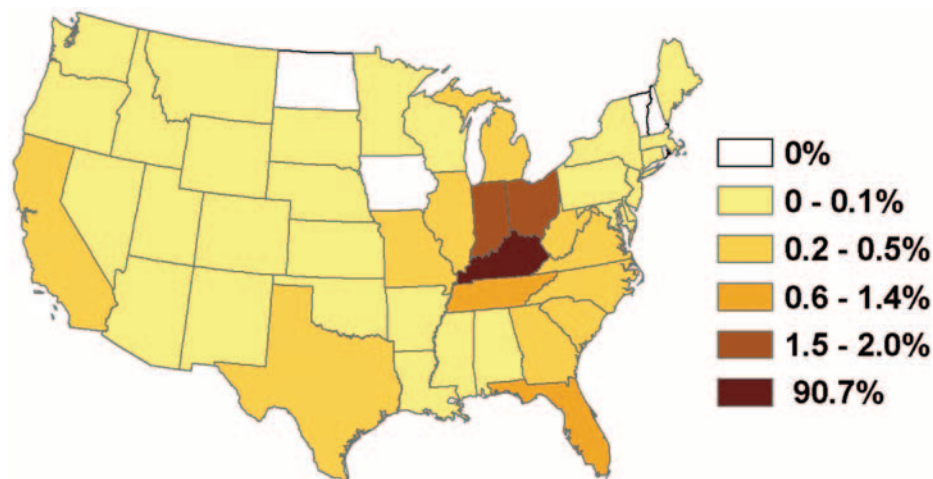

Figure 1. Estimated distribution of owners of Kentucky's private forestland.

resentation of the demographics of the entire NIPF owner population. Not surprisingly, 90.7% of the owners were Kentuckians. Ohio and Indiana had a considerable proportion (2.0 and 1.5%, respectively). Other states such as California, Florida, and Texas also had noticeable percentages.

Based on the records in our database, we also estimated the distribution of NIPF owners within Kentucky. Forest owners were distributed widely across Kentucky with the majority clustered in the central portion of the state (Figure 2a). Similar to forest owner distribution, both forest management activities (Figure 2b) and primary forest industries (Figure 2c; Prestemon et al. 2005) were also clustered in the central portion of the state. However, the distributions of forest owners and forest management activities are in stark contrast to the distribution of forest cover, which is highest in eastern Kentucky (Figure 2d; US Forest Service 2007). The distribution of forest cover is also in contrast to the distribution of the population, which is highest in northern Kentucky (Figure 2e; US Census Bureau 2007). This information is useful in strategically planning information delivery and education and training programs. For example, although one-half of the forests in Kentucky were located in the eastern one-third of the state, there were a proportionally small number of NIPF owners. This discrepancy has significant strategic impacts relative to extension programming and information delivery that will be discussed later.

Another use of the database is to locate engaged absentee owners and determine the proximity to their properties. In-state absentee NIPF owners (defined as owners whose residency and property are not in the same

county) accounted for 9.5% of the database and their residencies were clustered in highly populated counties in northern Kentucky (Figure 3a). Only a very low percentage of absentee owners owned lands in eastern Kentucky, while the majority owned lands in relatively close proximity to their residencies (Figure 3b). Ninety percent of in-state absentee landowners lived within 90 mi linear distance to their properties, and 71% lived within 40 mi to their properties. On average, in-state absentee owners lived 42 mi away from their properties. The aforementioned estimations provide a better understanding of the distribution of potential audiences for extension activities.

Enhance Ability to Monitor and Predict Spatial and Temporal Trends. To proactively plan extension activities in a rapidly changing world, it is useful to predict spatial and temporal trends relative to audience needs. For example, if areas with reforestation or afforestation activities can be located and tracked over time, this can be used to plan the delivery of information and provide training programs in topics associated with postplanting practices such as competition control, insect and disease control, and density management and pruning. Figure 4 was derived from a subset of the database indicating tree seedling purchases from 2002 through 2006 and illustrates a spatial and temporal pattern of past reforestation and afforestation activities. Within the 5-year period, the total amount of purchased tree seedlings increased annually, especially in central Kentucky. Although this particular use of geospatial analysis is visual, these maps convey an important piece of information for determining continuing education needs. By understanding spatial and tempo-
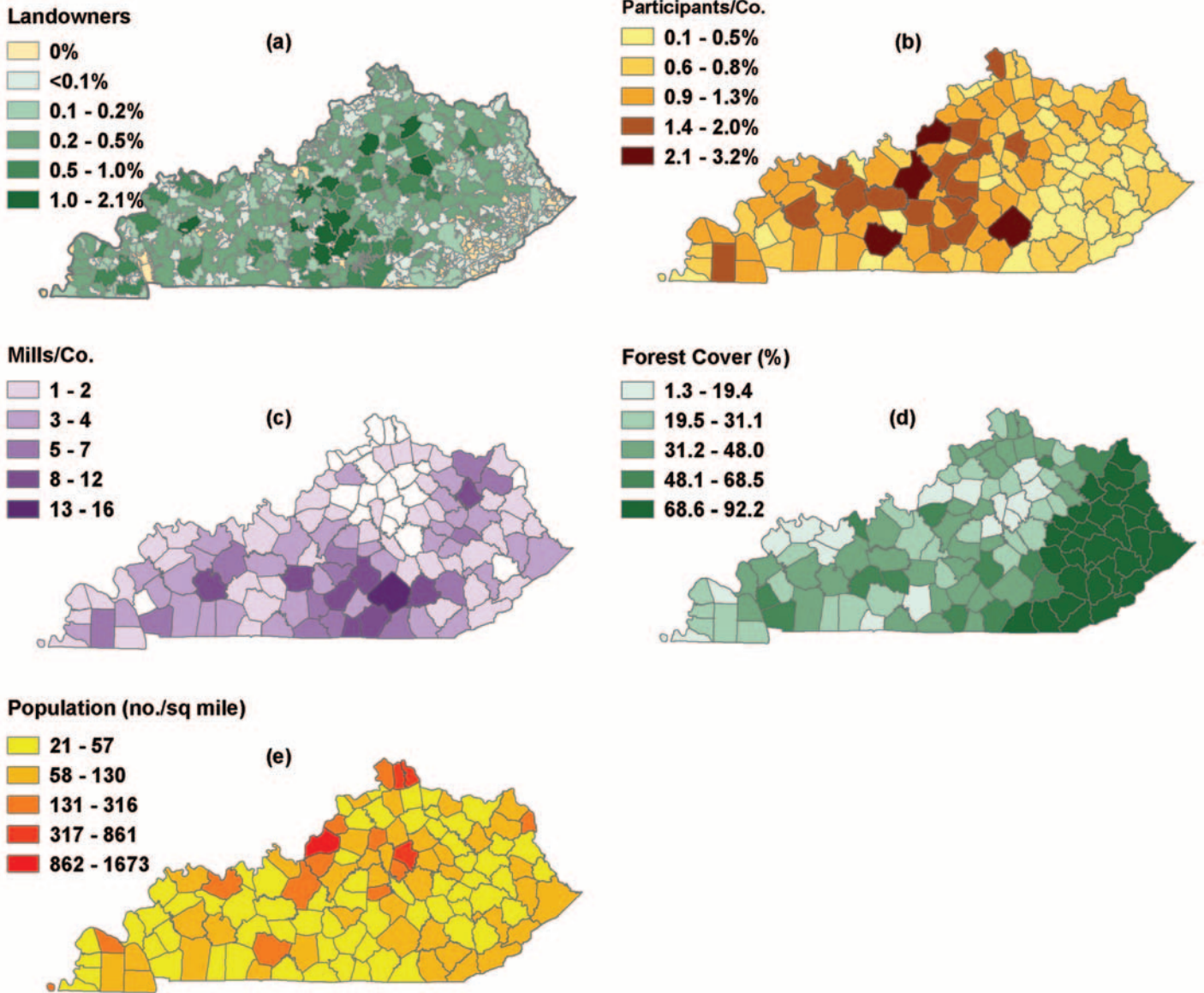
Figure 2. Estimated distribution, by zip code, of (a) in-state private forest landowners and (b) distribution, by county, of the total number of private forest landowners who participated in the Kentucky Division of Forestry stewardship programs from 1998 to 2006, (c) number of wood-using mills, (d) percentage of forestland, and (e) population density.

ral trends, we can deliver more targeted programs.

Identify Service Area Gaps. Without geospatial technology, it is nearly impossible to determine whether there is complete spatial coverage or excessive overlap of extension activities. Fortunately, there are a suite of tools in ArcGIS such as Geocoding and Network Analyst that can be used to address these issues. In our database, there is a subset of records with detailed locations, subject areas, and participation information on continuing education programs for woodland owners. Using geocoding, geographic coordinates can be assigned to each meeting location and attendee address. By adding geocoded addresses into Network Analyst, we

can tell the distance each attendee traveled, calculate average distance traveled for each event, and understand relationships between average travel distance and number of attendees. One of the University of Kentucky's primary continuing education programs for woodland owners is the Woodland Owners Short Course (WOSC). As expected, the number of participants in this program was negatively correlated with travel distance (Figure 5). The average travel distance for attendees in the WOSC was about 90 mi. Assuming a landowner is only willing to travel 90 mi on average, we calculated the service areas that were covered by the past programs. Although service areas for the WOSC were significant, gaps existed in

western, south central, and eastern Kentucky (Figure 6). Some of the gaps and low-intensity service areas might be eased by the participation of absentee landowners in the WOSC offered in other locations. However, as shown in Figure 3, the majority of absentee landowners lived less than 40 mi away from their properties so it is relatively unlikely for them to own forestlands in these gaps and low-intensity service areas. Similarly, we can identify areas that received overlapping coverage from different programs.

Allow for More Proactive and Efficient Information Dissemination. In extension, it is common to produce and deliver newsletters, magazines, and other
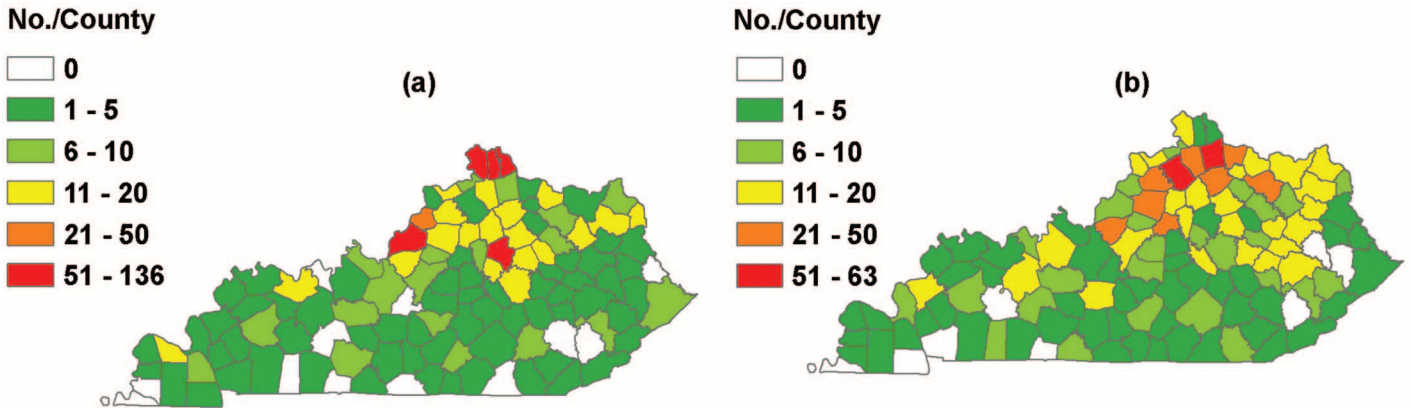
Figure 3. Distribution of in-state absentee landowners who participated in the Kentucky Division of Forestry programs by (a) residential locations and (b) property locations.
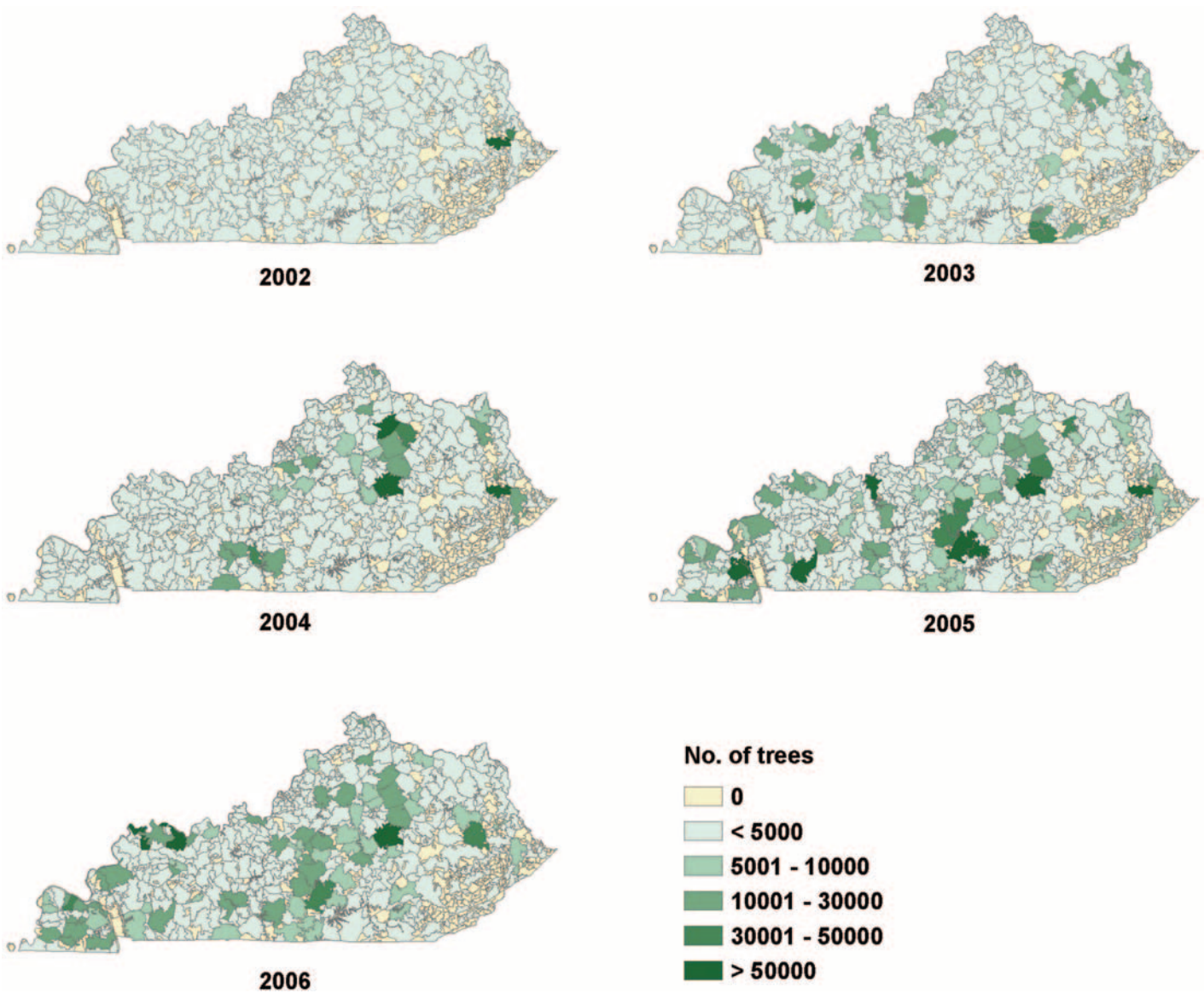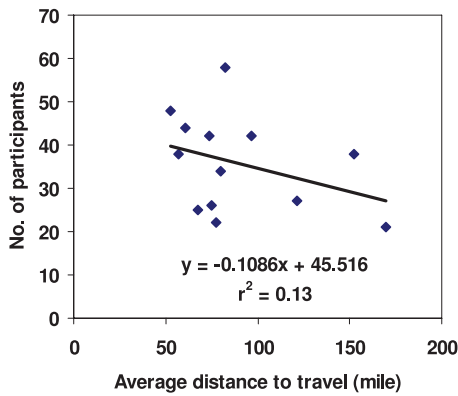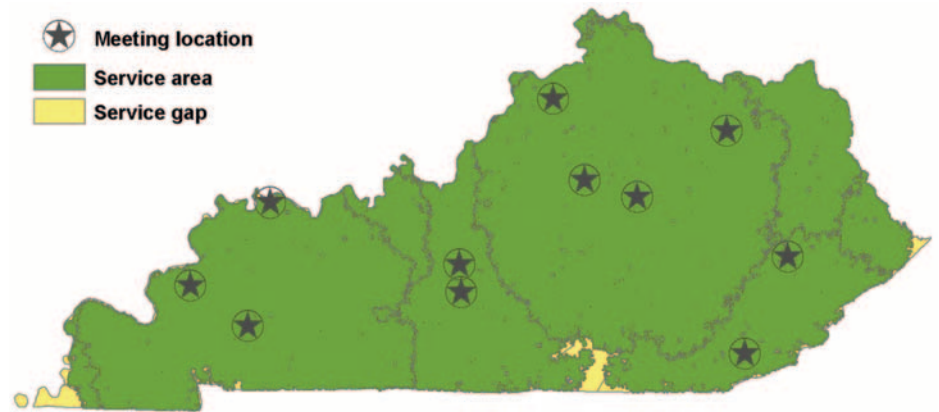

Figure 4. Spatial and temporal patterns of the total number of trees purchased for reforestation and afforestation by zip code from 2002 to 2006 in Kentucky.
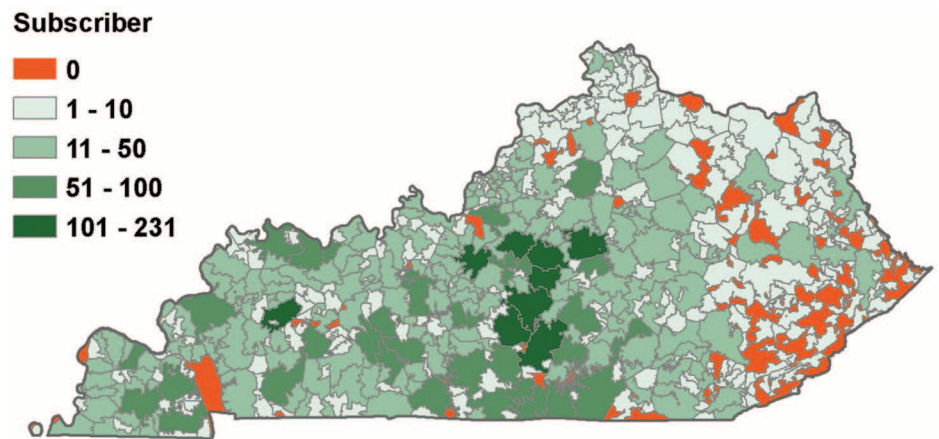
Figure 5. Relationship between the total number of participants and average distance to travel in Kentucky WOSC events.

Figure 6. Service areas (green) and gaps (yellow) of the past Kentucky WOSC events from 2004 to 2007.

Figure 7. The total number of *Kentucky Woodlands Magazine* subscribers in Kentucky by zip code.

educational materials to targeted audiences using direct mailings. This is more expensive than providing Internet resources, and, therefore, it is extremely important to ensure efficient mailings (Rom et al. 1990). However, by simply looking at the mailing list, it is nearly impossible to determine if we have reached our targeted audience completely. By linking mailing addresses to a base map (e.g., a zip code map) in GIS, we can easily identify cold spots where targeted informational mailings may not be reaching forest owners. The identified cold or hot spots can be used to help proactively and efficiently disseminate information in the future. Figure 7 presents a spatial distribution of *Kentucky Woodlands Magazine* (*KWM*) subscribers in Kentucky. This magazine is the primary direct mail communication and education tool to promote stewardship and sustainable management of Kentucky's NIPF. Central Kentucky was the hot spot of *KWM* subscribers, and eastern Kentucky, especially southeastern Kentucky, was the cold spot with few or no *KWM* subscribers. Although southeastern Kentucky had a relatively low number of forest landowners (Figure 2a), it had a high percentage of forested areas (Figure 2d). Again, as shown in Figure 3, it was less likely that absentee landowners who were *KWM* subscribers would have properties in those low subscribed areas. Although heavily forested, this region of the state was apparently lacking in awareness and information transfer. It is clearly a concern that this area had abundant forest resources but limited information. Dissemination of *KWM* to landowners in the southeast could potentially impact Kentucky's forest, both ecologically and eco-

nomically. With knowledge provided in Figure 7, we can plan strategically to introduce *KWM* to forest landowners within the identified cold spots.

Foresee Future Opportunities. By presenting the current spatial pattern, geospatial technology can also help foresee future programming opportunities and define important geographic areas to target. Ecosystem services such as carbon sequestration represent a growing opportunity for forest owners to be compensated for the societal benefits their forests provide. In Kentucky, forest owners are able to capitalize on this emerging opportunity if they meet certain requirements. One of the central requirements is that their forestland must be certified by an approved certifying entity such as the American Tree Farm System (which has been recognized by the Sustainable Forestry Initiative). Figure 8 illustrates the current spatial distribution of tree farms in Kentucky. Tree farms were more concentrated in central Kentucky, coinciding with the dis-

tribution of the state's forest industry. Locating clusters of tree farms helps provide potential sites for more intensive, technical extension programming so forest landowners can learn about potential benefits of carbon credits.

Geospatial technology can help enhance other aspects of extension activities, such as reporting, postprogramming follow-up, and more. In addition, other forest professionals (e.g., service foresters and tree farm inspectors) can also benefit from this emerging geospatial technology.

Discussion

As shown in the examples of the University of Kentucky's Cooperative Extension forestry program, geospatial technology provides promising improvements and opportunities in extension. Similar application can be applied in extension activities in other states and agencies. The forest owner data collected for Kentucky's forestry extension database are not unique and often are avail-
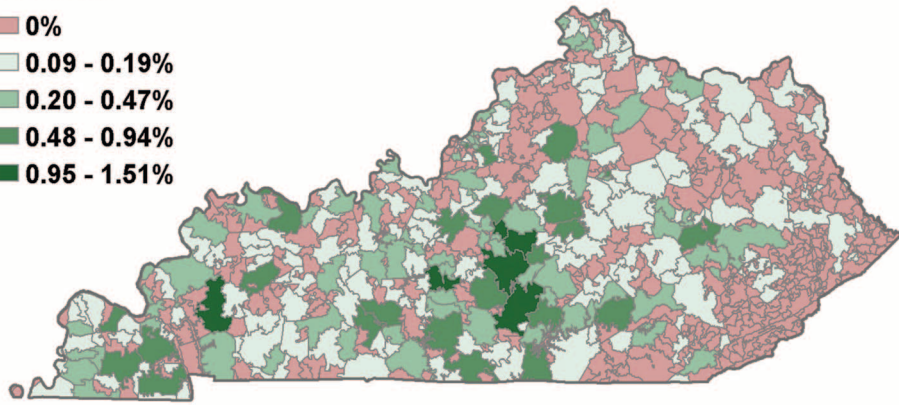
Figure 8. Spatial distribution of estimated percentage of all tree farms by zip code in Kentucky.

able from records of continuing education events and through requests to state forestry agencies. Because of its capability to store, manage, analyze, and display large quantities of spatial and spatially related data, geospatial technology has promising potential in enhancing and empowering extension services. However, as indicated previously, geospatial technology is not the only tool that can be used to assist in decisionmaking. In addition, as with all databases, care must be taken to understand their limitations to ensure proper and effective use. In this article, we assumed our database is a fair representation of the NIPF owners in Kentucky. However, bias may exist because people who participated in forest incentive programs may not be the same as the general population. Although geospatial analysis is useful in identifying spatial patterns, other analyses are needed to determine the causes of these patterns and how to effectively improve awareness, education, and training. Geospatial technology provides a new medium to understand audiences more comprehensively and enhance the ability to plan educational and training programs more proactively and strategically.

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