An Assessment of Geographic Information System Skills Used by Field-Level Natural Resource Managers

Krista L. Merry, Pete Bettinger, Mike Clutter, Jeffrey Hepinstall, and Nathan P. Nibbelink

ABSTRACT

Geographic information systems (GIS) have become a standard tool to assist with mapping and spatial analysis needs of natural resource managers. Most recent graduates of university-level forestry and natural resource programs are required to complete a course in this area, and many employers expect recent graduates to have been exposed to the technology. Over the past 20 years, surveys of spatial technology have been conducted to assess needs of employers and capabilities of educational systems but have fallen short of identifying the needs of end users. We present one of the first surveys of end users, a set of recent graduates who are employed in natural resource management-related positions. The survey identifies the types of GIS software used by respondents, illustrates the processes and databases typically used, and highlights methods used to locate assistance when needed. Additionally, we discuss how to adapt GIS education to meet the needs of natural resource managers.

Keywords: survey, education, geospatial technologies

Geographic information systems (GIS) and remote sensing have become important tools for natural resource managers. Advances in both software and hardware over the past 20 years have improved user-friendliness, affordability, and, ultimately, the ability to manage spatial information. Weir (1989) suggested almost 20 years ago that forestry departments should not hesitate to embrace teaching spatial information technology. Furthermore, Weir suggested that educational efforts be shared among university departments, such as engineering and geography, which at the time had more experience with spatial technology applications. Because of applied needs of natural resource majors, today, many natural resource programs provide students with courses in GIS (Sader and Vermillion 2000, Wing and Sessions 2007). However, it is not clear if the content of GIS courses in natural resource programs is meeting the needs of employers and whether recent graduates have the GIS skills necessary for their positions in natural resources and forestry. Several surveys have been conducted regarding different aspects of GIS education in natural resource management. These surveys range from assessing the capabilities of producers (educational systems) to assessing the needs of consumers (employers). Little has been reported on the actual use of GIS by end users (employees). This article reports the findings of a survey we conducted in 2006 to discover actual use and assess the potential consequences for curriculum changes.

In the late 1980s, Sader et al. (1989) conducted a survey of university faculty members with expertise or experience in remote sensing technologies and who were employed in forestry departments at universities in the United States and Canada. The survey examined whether the rapid accep-

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Krista L. Merry (kmerry@warnell.uga.edu) is research coordinator, Pete Bettinger (pbettinger@warnell.uga.edu) is associate professor, Mike Clutter (mclutter@warnell.uga.edu) is professor and dean, Jeffrey Hepinstall (jhepinstall@warnell.uga.edu) is assistant professor, and Nathan P. Nibbelink (nate@warnell.uga.edu) is assistant professor, Warnell School of Forestry and Natural Resources, University of Georgia, Athens, GA 30602.

tance of the need to teach digital geospatial technologies in forestry departments had forfeited students' capabilities to perform conventional aerial photo analysis. Also, the survey focused on several aspects of remote sensing curriculum, including aerial photo interpretation and photogrammetry, GIS, and nonphotographic remote sensing. At the time of this survey, the majority of the universities (88%, $n = 44$) did offer a remote sensing class within their forestry department, but 12% ($n = 6$) did not. Seventy-five percent of US universities required remote sensing. Of those, 7% did not offer the class within forestry or natural resources department and students enrolled in universities not offering a remote sensing class within their departments had to take the classes in other departments outside of forestry and natural resources to fulfill this area. Of the remote sensing courses offered in forestry departments, close to one-half of the coursework emphasized aerial photo analysis and nearly one-third focused on photogrammetry. Courses offered outside of forestry departments focused less on photo interpretation and photogrammetry than those classes offered within forestry departments.

A follow-up survey conducted in 1998 (Sader and Vermillion 2000) contained similar content and sought to identify any significant changes in remote sensing education since the 1989 survey. In the 1988 survey, 75% of forestry departments required a remote sensing class and in the 1998 survey 80% of departments required the course in their curriculum. In this later survey, only one forestry program that required a course in remote sensing did not offer the course within their department. Both surveys reported median values of 40% of geospatial curricula focused on photo interpretation, 10% focused on nonphotographic remote sensing, and 30% focused on photogrammetry. The level of GIS education in the curricula increased from 5% in 1988 to 10% in 1998.

In 1994, the Occupational Competencies Study Group within the Society of American Foresters (SAF) sought to assess the quality of training of recent college graduates (Brown and Lassoie 1998). The survey was sent to government agencies, consulting groups, and private corporations. Respondents were asked to identify which skill requirements were considered essential, highly desirable, desirable, or not necessary for entry-level foresters. Local and state government agencies along with consulting groups and private corporations identified spatial information systems (remote sensing, aerial photo interpretation, and GIS) as highly desirable skills for entry-level foresters to have obtained in college. All survey groups identified aerial photo interpretation as a highly desirable skill, with consulting groups ranking it as the most important of the geospatial skills. Federal agencies and consultants indicated that satellite imagery interpretation was a desirable skill for entry-level foresters. All groups indicated GIS management as a desirable skill set, with state and local agencies, private industry, and consulting groups ranking it higher in importance than federal agencies.

Sample et al. (1999) surveyed 500 private industry employers in a manner similar to Brown and Lassoie (1998). This survey included spatial skills and abilities described within a larger set of professional skills (written communications, teamwork, and leadership) to determine how prepared recent graduates were for their first natural resource positions. Overall, employers indicated that recent graduates were well-prepared to perform GIS and landscape analysis tasks and that these skills were quite important in ensuring future success in forestry careers (Sample et al. 1999). Nearly 50% of private industry employers expected employees to be trained in GIS and landscape analysis during their undergraduate education. Recent graduates surveyed had completed their degrees within the past 6 years. Those surveyed indicated that approximately 60% were trained in GIS and landscape analysis during their bachelors' education.

Recently, the University Consortium for Geographic Information Science developed a "body of knowledge" for higher education geospatial curriculum. This "body of knowledge" attempts to provide a detailed description of conceptual comprehension and skills critical in developing students' geospatial aptitude. This includes foundations of geospatial sciences, cartography and cartographic visualization, geospatial analysis, project design, data set types, and modeling. The goal was to develop guidelines for an appropriate geospatial curriculum through a "top-down design," which compartmentalizes educational goals in terms of testing and teaching. These guidelines serve in helping educational institutions develop geospatial curriculum that can meet the needs of various levels of proficiency. Additionally, these guidelines attempt to acknowledge the multidisciplinary nature of geospatial sciences (DiBiase et al. 2007).

As we indicated earlier, a largely missing piece of information is how, and to what extent, recent graduates are using GIS in their jobs as natural resource professionals. An informal, ongoing, online survey of people using GIS (GISjobs.com, LLC 2007), found that over 80% of more than 600 foresters, hydrologists, and resource managers from the United States indicated that they use Environmental Systems Research Institute (ESRI) GIS software (ArcView, ArcInfo, and more). Approximately 10–20% of the survey participants indicated that they also (or only) use Autocad, Erdas, Intergraph, or MapInfo products. However, the level and extent of software use is unknown, and one can speculate as to the characteristics and potential biases of survey respondents.

Only one survey was identified in our literature review (Applied Geographics, Inc., 2002) addressing the level and extent of use of GIS. Here, a wide group of Maine Public Library stakeholders, which generally included municipal officials and other state government employees, as well as privately employed individuals, were surveyed to understand their level of GIS use and their most pressing analytical needs. However, the survey was not limited to recent graduates of university programs, and the targeted audience was municipal employees.

We surveyed a group of recent university graduates to determine trends in GIS software, processing, and database applications. The group contained graduates from a forestry and natural resource program who were hired into positions within natural resource organizations after graduation. Survey questions also were intended to assess how recent graduates used GIS technical support resources. We discuss how the results of our survey might help us adapt GIS education to better meet the needs of natural resource professionals.

Methods

Alumni from the Warnell School of Forestry and Natural Resources at the University of Georgia who graduated between 2000 and 2006 were surveyed to assess their use of GIS on the job. A database of recent graduates was obtained from the University of Georgia Alumni Association. The list included employer information but was incomplete because this information is volunteered by alumni. Therefore, we began our survey by requesting support from people whose employment information clearly indicated that they held natural resource management positions. We subsequently sent requests via e-mail to all others in the database who provided an e-mail address asking them to participate in the survey if they currently held natural resource positions. Those who responded favorably were sent directions for the online survey. Those undergraduate alumni that were currently enrolled in graduate school programs were excluded from the survey.

Survey questions were designed to ascertain the level of use of GIS in each participant's job and to characterize the type of GIS processes and databases used. The first set of questions was intended to gather background on each survey participant in three areas:

1. The primary field of work (fisheries, forestry, hydrology, recreation, soils, wildlife, and others).
2. The length of time survey participant has been in current position.
3. The level of GIS use in their current position (every day, every other day, and so on).

The second set of questions assessed how GIS was used in each respondent's work activities:

4. The type of GIS software being used.
5. The prevalence of use of an extensive set of GIS processes.
6. The prevalence of use of several types of GIS databases.
7. The types of products that the survey participants created themselves using GIS.

The final question assessed the type of GIS user support participants relied on when problems arose. Support services included those readily available within their organization and those requiring some creativity and ingenuity, such as web-based searches and discussion groups.

One limitation of this survey is that it was conducted by surveying one group of recent graduates from one forestry and natural resources department. Therefore, the sample size is small and may not be a representative sample of all recent graduates from all universities. Additionally, the group consisted of graduates working in several different natural resources fields. Responses may

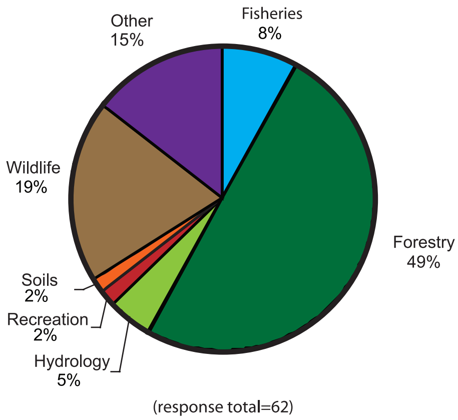

Figure 1. Primary field of work for GIS survey respondents.

be skewed because of the majority of respondents being forestry and wildlife professionals. Regardless, this survey does begin a dialogue concerning the role of GIS education in natural resources. Its strength lies in contributing ideas on if and how GIS curricula can be better suited to meet the needs of students in natural resource programs. Furthermore, survey results may encourage similar research at other institutions regarding GIS education in natural resource programs.

Results

Our survey assessing GIS use by recent graduates in natural resource professional jobs was offered to 108 Warnell School of Forestry and Natural Resources graduates via e-mail. Excluding undeliverable surveys and graduates no longer working in natural resources, 57% ($n = 62$) of the graduates surveyed chose to participate. The majority of respondents (60%) held Bachelors of Science degrees, 21% held Masters of Forest Resources degrees, and 19% held Masters of Science degrees. Respondents identified themselves as currently employed in various natural resources positions (Figure 1). One-half of respondents (49%) indicated that they worked primarily in the field of forestry. Other respondents worked primarily in wildlife (19%) or in other natural resource fields (15%), which included ecology, nonpoint source pollution, environmental economics, land conservation, forestry and wildlife consultancy, and natural resource advocacy. The remaining 17% of respondents worked in fisheries, hydrology, soils, or recreation fields. Nineteen percent of respondents had been working in their current position for less than a year, 35% for between 1 and 2 years, 18% between 2 and 3 years, 5% between 3 and 4 years, and 23% for 4 years or more.

The frequency with which respondents used GIS was relatively evenly distributed among responses from "never" to "every day" (Figure 2). Forty-three percent of respondents indicated that they used GIS applications either every day or every other day. Twenty-three percent used GIS applications once a week, 15% used GIS applications once a month, and 19% said they never used GIS in their current position.

ESRI's ArcMap and ArcView software products were the most commonly used GIS software packages (Table 1). It is clear from our responses that more than one GIS software program was used by respondents. Nearly 9% of respondents reported using applications developed by their organization, 7% reported MapInfo, and 2% reported Erdas Imagine. Twenty-nine percent of respondents reported using other commercial software packages for their work applications. Those that provided additional information about these commercial software packages identified software from Davey Resources, Google Earth, DeLorme, Landmark Systems' SoloField CE, and Forestry GIS (fGIS). Although the survey listed other software packages to choose from (i.e., Grass, Idrisi, GeoMedia, ILWIS, and more), none of the respondents indicated that they

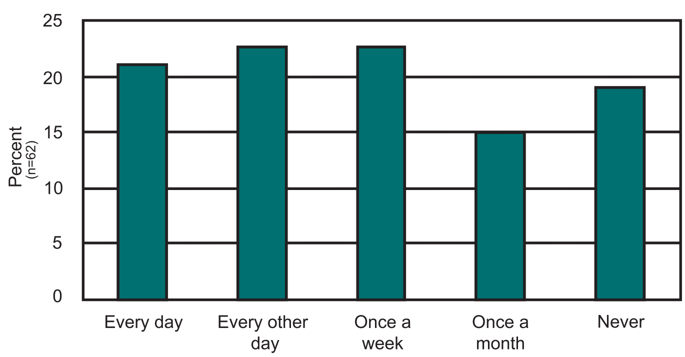

Figure 2. Frequency of use of GIS applications.

Table 1. Software packages used by recent graduates in their work as natural resources management professionals.

Software packages	Response (%)
ArcInfo	15
ArcView (ArcView 3.2–3.3)	59
ArcMap (ArcGIS 8+)	57
Erdas Imagine	2
MapInfo	7
An application developed by your organization	9
Other commercial software	29

currently used these. These results may have arisen because (a) the ESRI products are emphasized in the University of Georgia geospatial information courses and graduates may not have been exposed to other software alternatives or (b) the organizations in which graduates are employed have adopted the ESRI software and require its use. In either case, we did not discern the preference of use of GIS software products.

Heads-up digitizing, manual editing of attributes, manual editing of spatial positions, and querying of tabular attributes were the most frequently used GIS processes by respondents (Table 2). Combining features, erasing processes, spatial queries, and splitting processes also were used moderately. Over 40% of respondents indicated that they performed these processes sometimes, often, and frequently. Clipping, erasing, buffering, merging, and identity processes were used by 34% or more of respondents. GIS processing of digital elevation models (DEM), including developing contour intervals, shaded relief maps, and slope and aspect maps, were rarely used. Approximately 75% of respondents indicated that they never performed these processes. Three-dimensional fly-throughs of DEMs were rarely performed by respondents, with 85% of respondents indicating that they never performed this type of GIS process in their current positions.

The set of processes and the GIS databases that were offered in questions 5 and 6 were developed by the authors based on their experiences teaching GIS concepts and using GIS for natural resource management purposes. Survey participants were unable to add additional processes at this step in the survey but were allowed to provide additional comments at the end of the survey. Future surveys may involve a modified list of processes and databases, although survey responses indicated no additions were necessary.

Table 2. Frequency of respondents using GIS processes.

	Never	Rarely	Sometimes	Often	Very frequently
	(%)				
Traditional digitizing (using digitizing tables)	69	6	16	8	0
Heads-up digitizing	43	10	19	14	14
Manual editing of attributes	23	8	21	36	12
Manual editing of the spatial position of features	35	2	17	35	11
Attribute query of features	32	13	19	25	11
Spatial query of features	35	17	20	24	4
Buffering of features	44	20	24	6	6
Clipping of features	41	15	31	11	2
Erasing features	34	22	21	21	2
Combining features	37	16	15	30	2
Splitting polygons	39	13	20	22	6
Merging two or more spatial databases	39	24	24	11	2
Identity of two spatial databases	45	21	18	14	2
Intersect two spatial databases	47	29	14	10	0
Union of two spatial databases	46	29	19	4	2
Joining tabular data to a spatial database	45	23	15	9	8
Linking tabular data to a spatial database	45	23	15	9	8
Developing contour intervals from a DEM	75	11	13	0	0
Developing shaded relief maps from a DEM	74	15	9	2	0
Developing slope and aspect maps from a DEM	74	15	11	0	0
Performing a viewshed analysis	75	19	2	4	0
Performing a three-dimensional fly-through using a DEM and other databases	85	11	4	0	0

Respondents indicated that culverts and other water diversion features along with water sources were very frequently used vector point data sets (Table 3). Fifty-eight percent of respondents indicated using political point databases (i.e., towns, cities, and more). Respondents also indicated regularly (or more heavily) using water sources (53%), research plot locations (48%), home locations (42%), and recreational areas (41%) GIS databases. Fire ignition points, fire towers, and water towers were the least-used point databases. The most frequently used vector line databases were roads (52%) and streams (39%; Table 4). A large proportion of respondents indicated low use of contour line or recreational trail vector line data sets, perhaps because of the demographics of the survey respondents (primarily forestry and wildlife), or, on the other hand, perhaps because of the fact that topographic relief may not be a major issue in the locations where the survey respondents work.

Of the vector polygon GIS databases, ownership boundaries, forestland compartment boundaries (subsets of a larger property), and vegetation polygons were the most frequently used (Table 5). Over 50% of the respondents at least sometimes used the following polygon databases: ownership boundaries, land classifications, watersheds, other political databases (counties, states, and so on), lakes, vegetation polygons, and forestland compartment boundaries. Less frequently used were congressional boundaries, fire perimeters, and recreation-related databases, again, perhaps because of the demographics of the respondents.

Digital aerial photos were the most commonly used raster databases with 46% of respondents indicating that they used these data sets very frequently (Table 6). Twenty percent of respondents suggested that they used digital line graphs with high frequency. An overwhelming percentage of respondents (80%) indicated that they never used light detection and ranging (LIDAR) remote sensing data, although this is a relatively new and interesting set of data, with limited availability for most areas. Additionally, 46% indicated that they never used DEMs.

Basic stand location maps were identified as the most commonly created maps or databases by respondents (Figure 3). Other commonly created maps or databases were clearcut harvest maps, planting maps, and thinning area maps, all useful for on-the-ground management of forests. Forty-seven

Table 3. Frequency of respondents using vector point databases.

	Never	Rarely	Sometimes	Often	Very frequently
	(%)				
Culverts, other water diversion features	53	9	19	8	11
Fire ignition points	72	7	15	6	0
Fire towers	75	13	8	4	0
Home locations	41	18	18	17	6
Hunting camps	58	17	9	11	4
Mines	76	13	7	4	0
Political (towns, and more)	37	5	30	26	2
Recreation areas (boat ramps, and more)	41	18	13	24	4
Research plot locations	51	2	21	19	7
Wildlife observations	40	26	17	11	6
Water sources (springs, and more)	33	13	20	22	11
Water towers	72	22	4	2	0

percent of respondents indicated that they developed other databases or maps than the examples provided in the survey. Examples of these databases include prescribed fire locations and burn plans, conservation easements, invasive species distributions, soil maps, and wildlife location maps.

When asked to provide information on the extent to which respondents used various forms of GIS support, 25% relied on their organization's GIS manager with moderate frequency to answer GIS-related questions or to help address analytical issues (Table 7). Twenty-three percent often used the available software "help" topics for troubleshooting problems, and 17% often used books or manuals. Surprisingly, approximately 79% of respondents never used online discussion groups to aid in their GIS work, and 51% never used online technical support. Companies such as ESRI have extensive online help topics as well as discussion groups that cover every topic from software updates to specific processing errors along with tutorials for basic GIS processing. If students have not been exposed to these forums, they may be unaware that they exist or unaware of the degree to which they can effectively troubleshoot problems or answer questions.

Survey respondents were offered an opportunity to comment on their GIS work after graduation. Of those that chose to answer, responses included the following: (a) had to relearn GIS, primarily through instruction from a coworker (3%); (b) had to rely on the organization's GIS manager for maps and other analyses (3%); and (c) had to attend continuing education courses to refresh or enhance their GIS skills (2%). One respondent suggested more coursework focusing on ArcView extensions, and another suggested more work with Global Positioning Systems (GPS).

Discussion

Although it is enlightening to learn what types of data and GIS processes are used by recent graduates, a limitation of this survey is that the questions focused on how they use GIS but not on how they need to use GIS or whether they would use it more with increased skill sets. In addition, the questions we posed limit our ability to determine whether recent graduates are using GIS efficiently. Although we have no information to confirm this, it is possible that certain tasks performed frequently may be the result of respondents not being aware of more efficient methods. For example, a user may be spending a considerable amount of time manually editing spatial features to edge-match other features when an automated clipping or erasing process would suffice. Also, joining and calculating processes reduce time and lower potential for error over manual editing. If users frequently performed manual tasks that have automated analogs, it would suggest that GIS curricula include additional emphasis on understanding the multiple processing options for obtaining the same results. However, most introductory courses of geospatial technologies (GIS, GPS, image interpretation, and remote sensing) do not have sufficient time to cover any one topic in increased depth. This may suggest that in addition to allocating time toward the GIS processes that are most often used by recent graduates, an educational strategy might be to apply some time toward the introduction of alternative approaches within GIS that enable one to arrive at the same solution more efficiently or from different processing directions.

We suggest at least two geospatial techniques courses should be provided for undergraduates in natural resources fields. The first course would be an introductory course as described previously. The second course would be a series of optional topics that would provide a more in-depth investigation of particular topics including GIS analytical techniques and projects, applications of remote sensing, and interpretation of aerial photos.

One area of study that may be overlooked by educational organizations is the area of technical support. Many organizations offer books and manuals to assist with the learning process and the troubleshooting process; however, our results suggest that some forms of support are relatively unknown to our recent graduates. List serves, online discussion groups, and online support are several areas that are generally free of charge and could become a great asset to a person's GIS knowledge development. These forms of support could be introduced in classes, along with a brief introduction to software help topics and help improve students' confidence and professionalism.

Survey results have encouraged us to more strongly consider how we can improve GIS curricula in natural resource programs to better serve our students. One educational strategy would be to spend a significant amount of time on the GIS processes that respondents indicate are used most often. Although editing spatial features, editing tabular data, and heads-up digitizing are basic database manipulation processes, they could be given more emphasis in GIS courses. The drawback is that this strategy would effectively reduce the amount of time spent on learning processes that would en-

Table 4. Frequency of respondents using vector line databases.

	Never	Rarely	Sometimes	Often	Very frequently
	(%)				
Contour lines	31	18	15	19	17
Recreational trails	48	15	17	13	7
Roads	13	7	13	15	52
Streams	20	6	13	22	39

Table 5. Frequency of respondents using vector polygons databases.

	Never	Rarely	Sometimes	Often	Very frequently
	. . . .	. . .	.(%). . .	. . .	. . . .
Compartments with an ownership	34	11	9	19	26
Congressional boundaries	64	17	13	4	2
Conservation districts	56	23	17	2	2
Fire perimeters	60	8	9	13	9
Geology	58	17	19	6	0
Lakes	31	13	19	26	11
Land classifications	32	11	23	26	8
Land exchanges	62	13	15	9	0
Other political databases (counties, states, and more)	28	15	20	26	11
Ownership boundaries	30	4	9	19	38
Recreation opportunity spectrum	64	13	19	4	0
Soils	43	17	15	13	11
Vegetation polygons (management units and stands)	30	15	13	15	26
Watersheds	31	11	20	22	15
Wildlife management areas	39	17	28	7	9
Visual quality areas	62	23	13	2	0
Wilderness areas	56	25	19	0	0

Table 6. Frequency of respondents using raster databases.

	Never	Rarely	Sometimes	Often	Very frequently
	. . . .	. . .	.(%). . .	. . .	. . . .
Digital air photos	15	15	6	18	46
DEMs	46	22	19	9	4
Digital line graphs (digital versions of USGS topographic maps)	35	4	22	19	20
LIDAR	80	12	6	2	0
Satellite images	33	13	16	19	19

USGS, US Geological Survey.

courage critical thinking with geospatial data and methodologies. Such concepts include linking databases together, using DEMs to create other GIS databases, and performing three-dimensional analyses, all of which are interesting and valuable to certain management efforts but are used less widely by respondents working in natural resource positions. Another strategy could be to increase the credit load of GIS-related courses in natural resource management, which would add emphasis to certain areas without reducing coverage of others. However, given the pressure on credit hour requirements in natural resource majors, this strategy may be more difficult to implement. An additional strategy could be to provide elective courses including more sophisticated geospatial techniques and experience.

The role of a university education in geospatial technology comes to the forefront in the discussion. The need of respondents seems to be mainly toward the technical side of GIS, editing and processing spatial data, versus the analytical side of GIS. Although these technical skills are provided in university courses, they also can be obtained through technical schools, independent work, or continuing education courses. The role of a university, however, is to expand the knowledge and experience of students by exposing them to analytical and problem solving skills (or other academic areas) through lectures and exercises related to advanced techniques. Therefore, a tradeoff could be made to concentrate less on the technical aspects and more on advanced topics that expand their reasoning and interpretation skills.

Neither this survey nor its authors can provide a definitive answer to the question of balance between technique and theory, simple and complex, and current versus up-and-coming applications. However, we would propose that a proper balance is our goal and even our obligation for instruction in higher education. Although there is a necessity to teach in preparation for the job market, graduates of higher education institutions should not only be able to use current tools and apply learned skills, but also be able and motivated to critique current approaches and to anticipate and even push for new tools and ideas (Teichler and Kehm 1995). Others are more direct in this debate and suggest that universities should focus on the core functions of research and learning rather than "act as an employment agency" (Kivinen and Ahola 1999). Although there may be as many opinions on this subject as there are educators (and students), we should not shy away from the discussion and expand on surveys like this one to seek a better balance in geospatial technology education for natural resources and other fields.

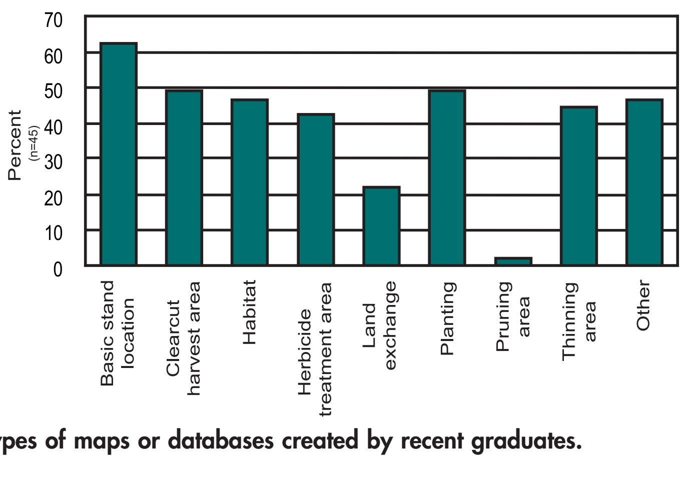

Figure 3. Types of maps or databases created by recent graduates.

Conclusions

Understanding how GIS is being used by field-level natural resource professionals helps fill a void in our understanding of the role of GIS in society. Previous surveys of employer's perspectives on the academic institution's capacity to provide educational experiences need to be balanced with how and to what extent the practitioners actually use the tool. Survey results indicated that our sample of end users of GIS spends a significant amount of time on basic tasks, such as editing and creating vector-based GIS databases. This may be explained partially by the amount of time these professionals allo-

Table 7. Types of GIS technical support used for problems and questions in your organization.

	Never	Rarely	Sometimes	Often	Very frequently
	(%)				
Books and manuals	28	21	28	17	6
My organization's GIS manager	38	15	15	24	8
Online technical support	51	17	13	17	2
Online discussions groups	79	11	8	2	0
Software "help" topics	32	17	24	23	4
Telephone technical support	50	17	15	12	6

cate to GIS given their other natural resource management responsibilities. Some GIS overlay processes are being used to support natural resource management, but few of the integrated vector/raster processes are being used, with the exception of using digital aerial photographs as a backdrop for heads-up digitizing or for map production purposes. Although some standard technical support services are used with moderate frequency, some of the more advanced online support services remained underused. As GIS evolves through new software or through new applications of spatial analyses, it becomes important for educational institutions to not only provide the appropriate training for basic tasks but also to empower professionals to apply GIS/spatial analysis methodologies efficiently or critically.

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