Integrated Multimedia Approach to the Utilization of an Everglades Vegetation Database

Shunfu Hu

Abstract

An approach for integrating multimedia data with a geographic information system (GIS) database was developed for an area corresponding to the U.S. Geological Survey (USGS) Long Pine Key and Pa-Hay-Okee Lookout Tower 1:24,000-scale topographic quadrangles in Everglades National Park. The multimedia database contains descriptive text, ground photographs, digital video clips, and audio segments highlighting the characteristics of Everglades plant communities, individual species, and invasive exotics, as well as plant-animal interactions, hurricane damage, and post-fire vegetation succession. It is linked to a GIS database that includes detailed vegetation maps, SPOT panchromatic imagery, and scanned National Aerial Photography Program (NAPP) 1:40,000-scale color-infrared (CIR) aerial photographs. The integrated multimedia approach was implemented in two steps: (1) an interactive multimedia system designed to manipulate multimedia information such as hypertext, hyperlinks, scanned photographs, digital video, and sound was developed in a Microsoft Visual Basic programming environment; and (2) a GIS application program to manipulate spatial data was constructed using Visual Basic and Environmental Systems Research Institute (ESRI) MapObjects software. The interactive multimedia approach provides a unique way to represent geographic features and associated information on interrelationships between flora, fauna, and human activities in Everglades National Park.

Introduction

Over the last ten years, interest in utilizing multimedia in the form of text, photographs, digital video, sound, and computer animation in a spatial information system has escalated (Openshaw and Mounsey, 1987; Lewis and Rhind, 1991; Lang, 1992; Shiffer and Wiggins, 1993; Fonseca and Gouveia, 1995; Delgado *et al.*, 1995; Hughes, 1996). To-date, however, there have been relatively few attempts to integrate multimedia and geographic information systems (GIS) technologies because, for the most part, commercial GIS software packages do not allow the integrated use of text, video, sound, and photographs. Now, with fast personal computers (PCs) providing advanced multimedia and GIS capabilities, integration is a logical step forward in the processing of spatial information.

The objectives of this research were to merge multimedia and GIS technologies and to demonstrate their potential for generating improved understanding of the natural environment, including relationships between flora, fauna, and human activities in Everglades National Park. The integrated multimedia approach described in this paper is intended to be a prototype and is based on interactions between the following components (Figure 1):

- an interactive multimedia system created in a Microsoft Visual Basic programming environment designed to manipulate text, ground photographs, digital video, sound, and animation;
- a GIS application program developed using Visual Basic and the Environmental Systems Research Institute (ESRI) MapObjects software to manipulate spatial data such as ESRI ARC/INFO coverages of vegetation patterns, SPOT satellite images, and scanned color infrared aerial photographs; and
- a user interface through the Microsoft Windows 95 operating system.

Study Area

This study focuses on an area corresponding to the U.S. Geological Survey (USGS) Long Pine Key and Pa-Hay-Okee Lookout Tower 1:24,000-scale topographic quadrangles centrally located within Everglades National Park (Figure 2). This area is characterized by flat, wetland terrain covered by graminoid prairie and interspersed with shrub and hardwood forest tree islands. In addition, the Long Pine Key quadrangle contains some of the only remaining areas of pine savanna vegetation, making it especially important from an ecological and conservation perspective. Although the remnant pine savanna is dominated by south Florida slash pine (*Pinus elliotti* var. *densa*), the understory can contain nearly 200 species, making it the most diverse plant community in Everglades National Park (Gunderson, 1994).

Data Sets

The data for this study have two distinct components: (1) a GIS database and (2) individual multimedia databases for each plant community found in the study area. As part of on-going work at the Center for Remote Sensing and Mapping Science at The University of Georgia, a detailed GIS database has been developed for Everglades National Park (Welch *et al.*, 1999). This Everglades database includes digital vegetation maps in ARC/INFO format, SPOT panchromatic images of 10-m spatial resolution, and scanned National Aerial Photography Program (NAPP) 1:40,000-scale color infrared (CIR) aerial photographs. Locational references and detailed

Center for Remote Sensing and Mapping Science, Department of Geography, The University of Georgia, Athens, GA 30602.

S. Hu is presently in the Department of Geography, University of Wisconsin, Oshkosh, WI 54901 (hus@uwosh.edu).

Photogrammetric Engineering & Remote Sensing, Vol. 65, No. 2, February 1999, pp. 193–198.

0099-1112/99/6502–193$3.00/0

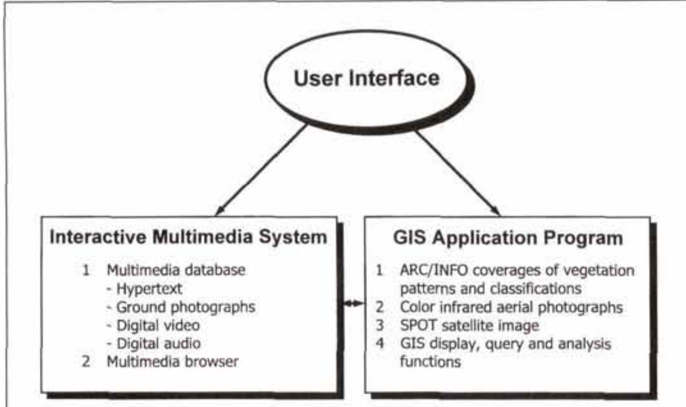


Figure 1. Integration of the interactive multimedia system and the GIS application program.

information on the distribution of vegetation within the study area are thus provided. For this project, coverages corresponding to the Long Pine Key and Pa-Hay-Okee Lookout Tower quadrangles were extracted from the larger digital vegetation database (Plate 1).

A portion of a geocoded panchromatic SPOT image mosaic of 10-m spatial resolution corresponding to the study area was employed as a background data set. The CIR NAPP aerial photographs recorded during 1994 and 1995 provide detailed information, including vegetation patterns, hydrographic features, and cultural features (e.g., roads and trails), and are the primary remote sensing data for the Everglades mapping project (Welch *et al.*, 1995). Eight of these photographs were needed to cover the study area. The positive transparencies were scanned at 250-µm (100-dpi) resolution, equivalent to 10-m pixel resolution on the ground, using a UMAX Powerlook color scanner equipped with a transparency unit. Although a higher scanning resolution (e.g., 25 to 100 µm) might be preferred, the 250-µm scanning resolution was selected as a trade-off between file size and information content, and appears quite satisfactory for the purpose intended. The scanned aerial photographs were saved as 24-bit (RGB) Tagged Image File Format (TIFF) images and each has a file size of about 2 megabytes (Mb).

In order to remove the geometric distortion from the scanned aerial photographs and register them to a map coordinate system, each CIR aerial photograph was rectified individually using a set of well-defined ground control points (GCPs). Features such as road intersections, tree islands, and small ponds were identified on both the CIR aerial photographs and the geocoded SPOT image. The UTM ground coordinates (North American Datum of 1983) of these features were then transferred from the geocoded SPOT image to the CIR aerial photographs. Finally, the ERDAS Imagine 8.3 software package was employed to conduct image rectification using a second-order polynomial and nearest-neighbor resampling. An assessment of the planimetric coordinate errors for each rectified aerial photograph of reduced resolution produced root-mean-square error (RMSE) values ranging from ± 0.5 to ± 1.0 pixel (± 5 m to ± 10 m), with the average RMSE for the eight photographs equivalent to ± 0.9 pixel (± 9 m). The geocoded CIR aerial photographs were assembled as a mosaic, and a subset was created for the region corresponding to the study area (see Plate 1).

Five plant communities listed in the Everglades Vegetation Classification System for South Florida National Parks were identified in the Long Pine Key and Pa-Hay-Okee Lookout Tower quadrangles (Jones *et al.*, 1999; Madden *et al.*, 1999). These communities included pine savanna with hardwood understory (abbreviated as SVPIh), subtropical hardwood forest (FT), bayhead (FSb), cypress (FSc), and sawgrass (PGc). Multimedia materials in the form of descriptive text, photographs, analog video, and audio sound were collected to provide comprehensive information about the flora and fauna of the study area. In all, approximately 100 pages of text information describing the major characteristics of these plant communities, including the dominant plant species, understory species, exotic species, plant-animal interactions, and hurricane damage, were assembled. The text information is supplemented by hundreds of 35-mm color photographs recorded from the ground and helicopter. These photographs were scanned at 100-µm (250-dpi) resolution and the results saved as Windows 8-bit bitmap (.BMP) files. A separate multimedia database was then constructed from these materials for each of the five vegetation communities.

Multimedia Technology and Hypertext

Multimedia in the 1970s meant that a sound track was synchronized to one or more slide projectors equipped with automatic timers (Olson, 1997). Today, however, the term multimedia implies the use of a PC with information presented through some combination of text, graphics, digital video, digital audio sound, and animation (Bill, 1994). In general, components of multimedia technology include specialized hardware, software, and programming techniques. The primary hardware component is a PC with multimedia capability, stereo speakers, and a high-resolution color monitor. Additional hardware may include a color scanner, an analog-to-digital digitizer for converting analog video and audio, a video camera or videocassette recorder (VCR), and a compact disc (CD) writer. Software and specialized programming tools produced by companies such as Macromedia, Asymetrix, and Microsoft are useful for developing multimedia products and applications under the Windows operating system. In this study, all programming was accomplished using Microsoft Visual Basic and the multimedia components of the Windows 95 operating system.

The conversion of analog video into digital format requires specific hardware and software. One can attach a TV, camcorder, or VCR to a computer through a video capture card (i.e., an analog-to-digital converter) and employ software utilities to save the incoming video signals as digital num-

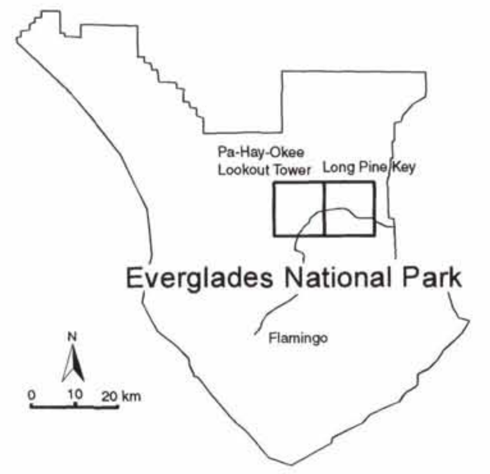


Figure 2. Location of the Pa-Hay-Okee Lookout Tower and Long Pine Key quadrangles within Everglades National Park.

bers. The resulting digitized video can then be edited and otherwise manipulated on a frame-by-frame basis (McFedries, 1996). For this study, analog video clips were captured from videocassette tape using the Media 100 QuickTime Video System connected to an Apple Macintosh computer. The digital video files were then converted to Windows 95-compatible format using Intel SmartVid software.

A digital video file, however, requires a large amount of computer hard disk space. For example, one minute of 24-bit color video displayed at a rate of 30 frames per second (fps) and a screen resolution of 1024 pixels by 768 lines creates a file 4 gigabytes (Gb) in size. If CD quality sound is needed, an additional 5 to 12 Mb should be added. Obviously, it may be necessary to reduce the file size at the expense of image quality. The following techniques are commonly employed to reduce the digital video file size: (1) decrease the number of colors in the image (e.g., from 24-bit color to 8-bit), (2) reduce the physical size of the play window (from full screen to as small as 1/16th of the full screen), (3) slow the frame rate from 30 to 15 fps or less, and (4) use industry-standard image and video compression techniques. For this project, file size was reduced through the use of a small playback window.

Analog audio files, including background music and narration, were created by connecting a cassette tape player directly to the sound card in the PC. The Windows Sound Recorder program was then employed to convert the analog files to digital Wave Sound (.WAV) files which were compatible with the Sound Player software in Windows. With 16-bit encoding, a minute of high quality stereo sound requires about 10 Mb of disk storage. This same file, however, can be reduced to about 1.2 Mb by saving it in lower quality 8-bit mono mode.

Integration of Multimedia with GIS

In recent years, there has been increased interest in utilizing multimedia information in a GIS. In this context, multiple data sources such as maps, aerial photographs, ground photographs, text, digital video, and sound are associated with a GIS database to help the user better understand the spatial problems of interest (Shiffer, 1992). An interactive multimedia system utilizes the concepts of interactivity, non-linear information retrieval, and hypertext to organize and display text, scanned photographs, digital video clips, and sound. Traditional structures such as those employed in relational and hierarchical databases are not suitable for the multimedia data. Instead, a hypertext database structure is more appropriate for organizing the multimedia data into a so-called "multimedia database." A hypertext user interface is, in effect, a multimedia browser, and allows interaction with the database. Therefore, the system includes two components: (1) the multimedia browser and (2) a multimedia database.

The multimedia browser is an application program to display the multimedia database and provide the user with an interactive tool to explore multimedia information. In the multimedia browser, separate windows are provided for the text, photograph, digital video, and audio files associated with a single hypertext node. Consequently, two display windows, "Text" and "Graphics," are required. No specific display window is required for the digital video or sound because these functions are supported by standard utilities running under the Windows operating system.

Although user interaction is not the essence of a multimedia system, it is a feature of a hypertext-based system. Interactive multimedia combines the ideas from both multimedia and hypertext systems. A hypertext system is comprised of hypertext (nodes) and hyperlinks (relationships) (Nielsen, 1990). Each hypertext node may have pointers, called hyperlinks, whose function is to redirect the reader to other nodes. The number of hyperlinks depends on the content of each node: some nodes are related to many others and will have many hyperlinks, while other nodes serve only as destinations for hyperlinks and have no outgoing hyperlinks of their own. When users follow the hyperlinks around the hypertext network, they will often have a need to return to some previously visited node. This function is provided by a backtrack facility. In contrast to the sequential organization of traditional text, therefore, there is no single order that determines the sequence in which hypertext can be read.

Descriptive text information about the plant communities is the heart of the multimedia database. In this database, hypertext is employed to highlight key features and to facilitate access via hyperlinks to detailed text information about these features. In the multimedia browser, hypertext is displayed in blue and underlined, as is typical of the similar documents found on the World Wide Web (WWW). The development of a hypertext document on the WWW requires the use of the Hypertext Markup Language or HTML, which is a simple programming language for publishing text-based documents on the Internet. For example, the HTML syntax used to set up the hypertext and hyperlink for "pine" is as follows:

```
<A HREF="pine_hyperlink">pine</A>
```

where the "pine_hyperlink" in the quotation marks indicates a hyperlink. The "pine" after the quotation marks and before </A> will be displayed as blue hypertext, as viewed by the multimedia browser. In addition to the text information, ground photographs and digital video clips can be accessed to highlight the characteristics of plant communities and individual plant species. In other words, hypertext can be linked to text, photographs, video clips, and/or sound (Figure 3).

The multimedia databases were stored in Microsoft Access 7.0 format and maintained using a Visual Basic utility called Visual Data Manager. Each multimedia database highlights the major characteristics of a single plant community through the use of descriptive text, photographs, digital video, and audio sound. For example, the hyperlink field of the first record of the south Florida slash pine (SVPIh) multimedia database contains the value of "Main," indicating that it is the main page of the database. The text field contains the HTML document and the media field contains the file name of the scanned photograph for the panoramic view of a typical SVPIh plant community.

In practice, the multimedia database is selected, loaded, and processed. In the example of the SVPIh multimedia database, the scanned photograph of the vegetation community would be displayed in the "Graphics" window and the associated text information and hypertext would be displayed in the "Text" window. The user can then explore more information by clicking any blue, underlined hypertext phrase within the "Text" window. For instance, if the user clicks on hypertext "pine," the photograph and descriptive text about the pine species will be displayed. Clicking on hypertext "deer" launches a digital video clip of a whitetail deer that will be played back in the Video window with accompanying audio description of deer in the Everglades environment. At any time, the user can switch focus back to the GIS/mapping component or choose to explore the vegetation database further. This feature permits the user to delve as deeply into the database as necessary to retrieve relevant information.

Development of a GIS Application Program with Visual Basic and MapObjects

Visual Basic is a state-of-the-art rapid applications development (RAD) programming environment that combines an interactive design tool with an object-oriented programming

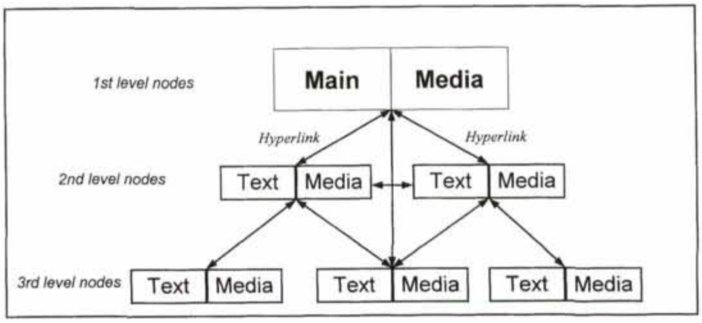


Figure 3. A hypertext network for a multimedia database includes Text and Media fields as well as hyperlink information.

language (Microsoft, 1994). In this environment, extended capabilities can be added to the standard Visual Basic functions through the use of ActiveX custom controls. This feature also has permitted companies to offer components with specific functionality tailored to applications such as GIS. MapObjects is ESRI's professional library of mapping and GIS software components for embedding spatial visualization and analysis in custom-written GIS applications (ESRI, 1996). The major features of MapObjects include (1) support for ARC/INFO and ArcView vector data and a wide variety of raster image formats; (2) ability to display, pan, and zoom throughout multiple layers of data; (3) feature rendering using thematic methods such as value maps; (4) text labeling and positioning; (5) feature attribute selection and query using SQL expressions; and (6) feature spatial selection. These functions were employed with Visual Basic in the development of the GIS application program.

The user interface includes a menu bar, tool bar, map display window, and status bar. Menus provide direct interaction between the user, application software, and database. The Everglades Vegetation Classification System can be accessed through the Help menu of the application program. It contains detailed information about major vegetation types, associated plant community classes, and special modifiers. For each plant community, a list of individual species is included to reflect dominant and associated species. Clicking on a plant species name then retrieves close-up photos of key identifying features such as leaf structure, flowers, and fruits. Additional user-interface controls include a toolbar for accessing specific functions (e.g., zoom or display map), and a status bar to echo the map coordinates of the current mouse position and display scale.

A few basic GIS functions were developed to manipulate the satellite images, aerial photographs, and digital vegetation maps and to query the GIS database. The GIS application program starts with an overview map of the study area with the vector boundaries of Everglades National Park and the USGS 7.5-minute map quadrangles superimposed. Next, the aerial photographs and vegetation maps can be displayed. The user can then manipulate all image/vector data sets using the menus or tool bar. It is also a simple task to query the database for a particular vegetation category.

The rectified SPOT panchromatic image, CIR aerial photographs, and digital vegetation maps, which are geocoded to the same UTM coordinate system, can be displayed in three separate map windows and linked together. By zooming and panning within one of the three map windows, the other two correspondingly display the same area at the same scale. This provides the user an opportunity to visually compare the three data sets. The link between the GIS database and the multimedia databases is established by clicking a button in the attribute window. The user is then redirected to the

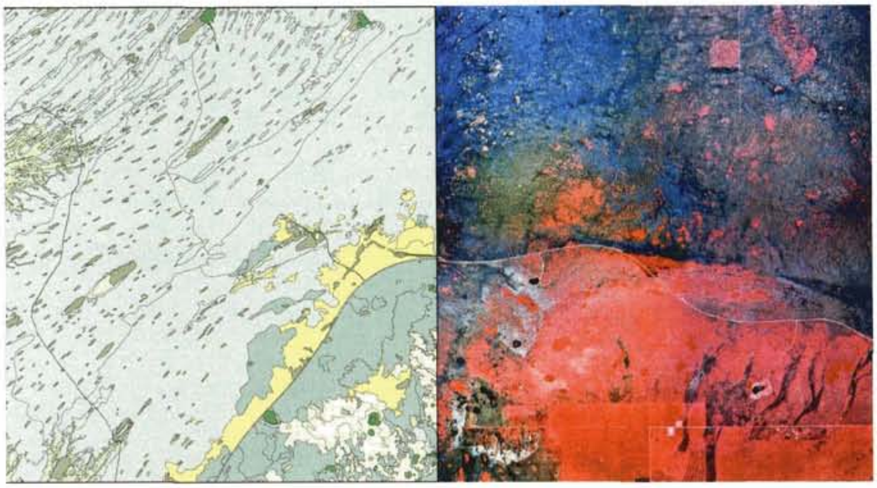
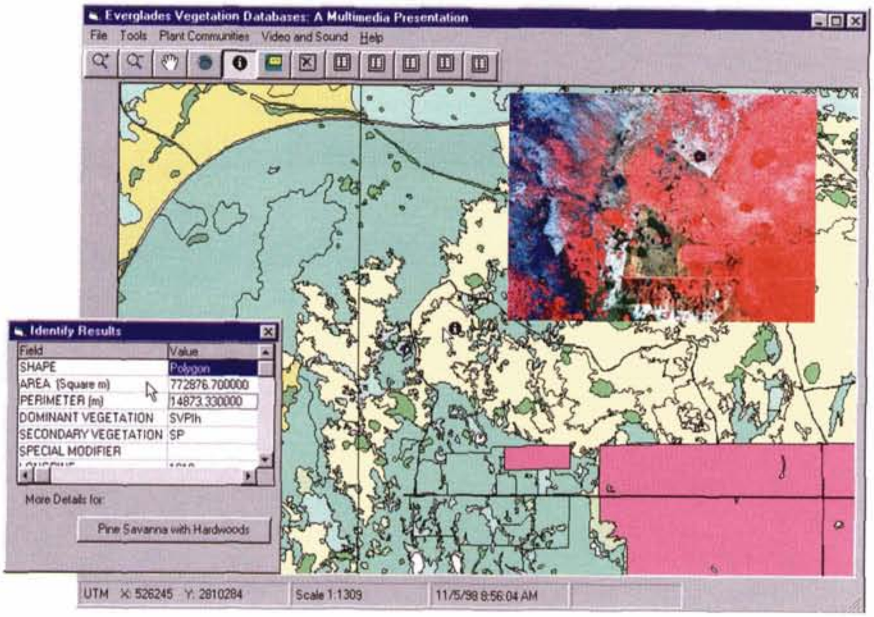


Plate 1. Vegetation map for Pa-Hay-Okee Lookout Tower (left) and CIR aerial photograph of Long Pine Key (right) quadrangles.



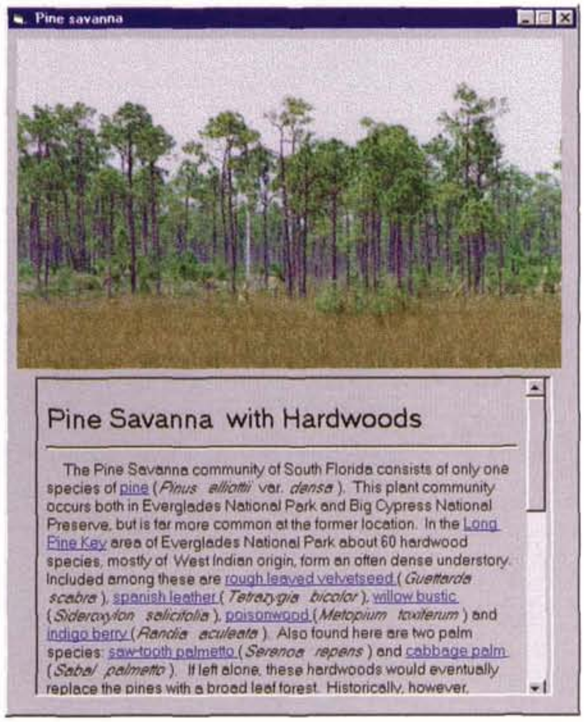


Plate 2. A query is initiated by clicking on a polygon in the vegetation map (top). The arrow (i) indicates the polygon of interest. Attributes for the particular vegetation class are then displayed along with a link to the multimedia database record for that class (right).

multimedia browser and the database for that community (Plate 2). This provides the end user easy access not only to the conventional GIS raster/vector data and attribute information, but also to the associated multimedia information. In addition, it creates a simplified method for cross-referencing relationships between the map, the source air photos, and the actual features as they appear on the ground.

Conclusion

The interactive multimedia approach described above provides a unique way to represent geographic features in a spatial framework using a combination of spatial data in image/vector format; attribute data in alphanumeric format; and multimedia data in descriptive text, photograph, digital video, and sound formats. Consequently, the development of a GIS database for natural resource management does not need to be limited to the current data models (i.e., raster and vector data models), but also can incorporate multiple formats of information. Although interactive multimedia is not a commonly employed option within standard commercial GIS software packages, Visual Basic can be used to integrate the MapObjects GIS and interactive multimedia functions to minimize the problems of data integration and software compatibility.

It is also appropriate, in light of the current state-of-technology, to extend these developments to utilize World Wide Web-based protocols entirely. Many of the capabilities developed in this study are now available in the current versions of Internet web browsers or can be installed as "add-on" components. Consequently, it is feasible to adapt HTML-based datasets to a Web environment.

It is anticipated that the multimedia approach described for the Everglades can be successfully applied in other areas such as tourist management, urban planning, environmental planning, and education. In this instance, the integration of multimedia information and GIS databases was designed to provide enhanced understanding of the interrelationships between flora, fauna, and human activities in Everglades National Park.

Acknowledgments

Support for this project was provided by the Center for Remote Sensing and Mapping Science and the Department of Geography at The University of Georgia. In particular, the author would like to acknowledge the contributions of Rick and Jean Seavey of Field Guides, Inc., Homestead, Florida, in providing the photographs and associated descriptive text of Everglades vegetation used in building the multimedia databases. Mr. Robert Doren, then Assistant Research Director, South Florida Natural Resources Center (SFNRC), Everglades National Park, was instrumental in developing this project. The author appreciates the efforts of Roy Welch and Thomas R. Jordan of the Center for Remote Sensing and Mapping Science who reviewed the draft manuscript and made helpful editorial comments. Specific commercial products mentioned in this article are proprietary and trademarked by their respective parent companies.

References

Bill, R., 1994. Multimedia GIS — Definition, requirements and applications, *European GIS Yearbook*, Blackwell, Oxford, pp. 151–154.

Delgado, B.J., M. Ruiz, and J.M. Segui, 1995. Designing multimedia GIS for territorial planning: The ParcBIT case, *Environment and Planning B: Planning and Design*, 22:665–678.

Environmental Systems Research Institute, 1996. *MapObjects - GIS and Mapping Components*, ESRI, Redlands, California, 202 p.

Fonseca, A., and C. Gouveia, 1995. Environmental impact assessment with multimedia spatial information systems, *Environment and Planning B: Planning and Design*, 22:637–648.

Gunderson, L.H., 1994. Vegetation of the Everglades: Determinants of community composition, *Everglades: The Ecosystem and Its Restoration* (S.M. Davis and J.C. Ogden, editors), St. Lucie Press, Delray Beach, Florida, pp. 323–340.

Hughes, J.R., 1996. Technology trends mark multimedia advancements, *GIS World*, 9(11):40–43.

Jones, D., M. Madden, J. Snyder, and K. Rutchey, 1999. *A Vegetation Classification System for Southern Florida's National Parks and Preserves*, South Florida Natural Resources Center Technical Report, Everglades National Park, National Park Service, U.S. Department of Interior, Homestead, Florida (in press).

Lang, L., 1992. GIS comes to life, *Computer Graphics World*, 15(10): 27–36.

Lewis, S., and D. Rhind, 1991. Multimedia geographical information system, *Mapping Awareness*, 5(6):43–49.

Madden, M., D. Jones, and L. Vilchek, 1999. Photointerpretation key for the Everglades Vegetation Classification System, *Photogrammetric Engineering & Remote Sensing*, 65(2):171–177.

McFedries, P., 1996. *Windows 95 Unleashed*, SAMS Publishing, Indianapolis, Indiana, 1316 p.

Microsoft, 1994. *Microsoft Visual Basic: Programmer's Guide*, Microsoft Corporation, Seattle, Washington, 857 p.

Nielsen, J., 1990. *Hypertext and Hypermedia*, Academic Press Professional, Boston, Massachusetts, 296 p.

Olson, J.M., 1997. Multimedia in geography: Good, bad, ugly, or cool? (Presidential Address), *Annals of the Association of American Geographers*, 87(4):571–578.

Openshaw, S., and H. Mounsey, 1987. Geographic information systems and the BBC's Domesday Interactive Videodisk, *International Journal of Geographical Information Systems*, 1(2):173–179.

Shiffer, M.J., 1992. Towards a collaborative planning system, *Environment and Planning B*, 19:709–722.

Shiffer, M.J., and L.L. Wiggins, 1993. *The Union of GIS and Multimedia, Profiting from a Geographic Information System* (G.H. Castle, editor), GIS World, Inc., Fort Collins, Colorado, pp. 336–341.

Welch, R., M. Remillard, and R.F. Doren, 1995. GIS database development for South Florida's national parks and preserves, *Photogrammetric Engineering & Remote Sensing*, 61(11):1371–1381.

Welch, R., M. Madden, and R.F. Doren, 1999. Mapping the Everglades, *Photogrammetric Engineering & Remote Sensing*, 65(2): 163–170.