The Everglades: A Perspective on the Requirements and Applications for Vegetation Map and Database Products

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Abstract

A collaborative effort by the National Park Service South Florida Natural Resources Center at Everglades National Park, the Center for Remote Sensing and Mapping Science at The University of Georgia, and the South Florida Water Management District has resulted in a seamless and complete GIS vegetation database of the southern Everglades using color-infrared (CIR) aerial photographs and a single vegetation classification system. This database contains spatial data for the vegetation communities within approximately 1.2 million hectares (ha) of South Florida's wetlands. The area covered includes Everglades National Park, Big Cypress National Preserve, Biscayne National Park, the Florida Panther National Wildlife Refuge, and the south Florida Water Management District Water Conservation Area 3. This detailed delineation of vegetation in the preserved lands of south Florida allows for the first time a quantitative analysis of Everglades vegetation data at the plant community level. In addition to this spatial database, several subset study areas have been identified in areas of special environmental interest for interpretation of large-scale aerial photographs and the development of high-resolution vegetation data sets. Together, these Everglades vegetation mapping efforts provide a baseline for establishing trends and monitoring changes related to the restoration and preservation of the Everglades.

Introduction

The Everglades is a vast wetland that occupies most of the southern peninsula of Florida and extends southward from Lake Okeechobee to Florida Bay (Figure 1). Comprised mainly of freshwater marshes and coastal mangrove estuaries that are continuously flooded for periods ranging from 3 to 12 months, this unique area has historically supported a rich diversity of plants and animals and, today, is a refuge for many endangered species (Kushlan, 1990; Fennema *et al.*, 1994). Threatened by the encroachment of human activities in and around the Everglades that began in the late 1800s, a number of federal and state parks have been designated over the years to protect this valuable area. The first, Everglades National Park, was established in 1947 and has the distinction of being designated an International Biosphere Reserve, a World Heritage Site, and a Wetland of International Importance (Davis and Ogden, 1994). Other federal parks and preserves include Big Cypress National Preserve, Biscayne National Park, and the Florida Panther National Wildlife Refuge. The South Florida Water Management District Water Conservation Areas 1 (also known as the A.R. Marshall Loxahatchee National Wildlife Refuge), 2, and 3 were originally designed for flood control and water supply but are now recognized for their ecological value and are part of the Everglades Protection Area (see Figure 1).

In spite of land being set aside for preservation, past and present human activities have dramatically changed the Everglades ecosystem. One of the most altered components is the quantity, quality, timing, flow, and distribution of water in south Florida. By 1917, the state of Florida dissected the Everglades from Lake Okeechobee to the Atlantic Ocean with four major canals. The U.S. Army Corps of Engineers, beginning in the early 1950s, continued to improve and use these canals to manage and impound water in the Everglades (Light and Dineen, 1994). The extensive system of canals, pumping stations, and levees, collectively called the Central & Southern Florida (C&SF) project, was intended to reduce flooding and to encourage agricultural and urban development. As a result, the original Everglades hydrology was radically altered and, over the past century, the Everglades has been frequently subjected to unnatural and extreme fluctuations in water levels. These modifications to the hydrology have caused dramatic changes in the composition and structure of plant communities (Alexander and Crook, 1973; Davis *et al.*, 1994). Pollution, primarily through phosphorus enrichment from surrounding agriculture, also has altered microbial function and plant and animal community composition (Kolipinski and Higer, 1969; McCormick *et al.*, 1996; Doren *et al.*, 1997a; Turner *et al.*, 1999). As a consequence of these and other ecological impacts, the Everglades have been declared "endangered" by the United Nations International Union for the Conservation of Nature (IUCN) (R. Cook, pers. comm.).

For scientists concerned with the preservation and restoration of this unique habitat, documenting and managing change is vital to insuring the sustainability of the Everglades. With approximately 8 to 9 billion dollars of federal and state funds planned for restoration of natural hydrologic flows in the Everglades, emphasis needs to be placed on developing a thorough understanding of how past changes in hydrology have affected Everglades plant and animal com-

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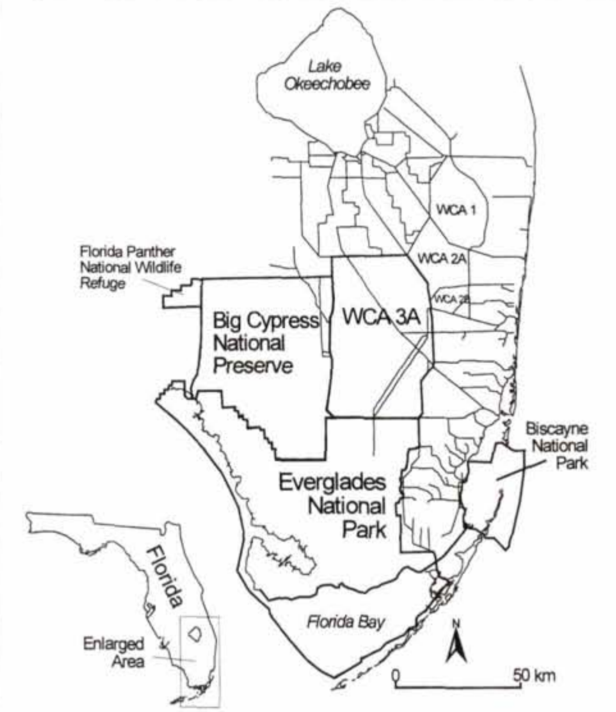

Figure 1. A location map showing the general extent of the existing Everglades ecosystem and the areas covered by this vegetation mapping project. These areas include Everglades National Park, Big Cypress National Preserve, Biscayne National Park, Florida Panther National Wildlife Refuge, and Water Conservation Area 3.

munities (South Florida Ecosystem Restoration Task Force, 1993). Spatial data such as maps and images are key factors required to document change in the Everglades.

Today, in almost any endeavor involving natural resource management, it is usually assumed that detailed and accurate maps on which to base management decisions are readily available, along with current aerial photographs or satellite images for assessing change. In the Everglades, however, relatively few maps exist and available maps are often dated or inconsistent in terms of completeness and accuracy. Because an accurate and detailed Everglades vegetation map is essential for documenting base conditions to which future changes can be compared, a joint effort by the Everglades National Park's South Florida Natural Resources Center and The University of Georgia's Center for Remote Sensing and Mapping Science was initiated to fill this gap. Simultaneously, a mapping program planned by the South Florida Water Management District to produce a detailed vegetation database for Water Conservation Area 3 was linked to the South Florida Natural Resources Center/Center for Remote Sensing and Mapping Science efforts. The two projects have proceeded in parallel and are nearing completion of a seamless geographic information system (GIS) database for Everglades vegetation using the same vegetation classification system and consistent mapping procedures.

Details on constructing the Everglades vegetation database and associated map products are provided in the articles of this issue of *Photogrammetric Engineering & Remote Sensing*. Together, these articles demonstrate the tremendous advantage of integrating remote sensing, GIS, the Global Positioning System (GPS), and multimedia techniques for developing spatial data critical for resource management and restoration of the Florida Everglades. The objectives of this paper are (1) to present an overview perspective on the efforts involved in initiating and conducting this ambitious mapping/database development project, and (2) to provide insight into potential applications of the Everglades vegetation database for research/restoration endeavors.

Characteristics of the Everglades Study Area

The original Everglades extended from above Lake Okeechobee in the north to Florida Bay in the south, covering an area of over 10,000 km^2 (Figure 1; Maltby and Dugan, 1994). The predominant vegetation consists of freshwater wetlands dominated by vast graminoid marshes and coastal estuaries of mixed mangrove forests. Inland marshes are interspersed with plant communities that include hardwood forest, pineland savannas, long-hydroperiod marshes dominated by sawgrass (*Cladium jamaicense*) or spike rush (*Eleocharis cellulosa*), short-hydroperiod prairies dominated by muhly grass (*Muhlenbergia filipes*) and bayheads (with species such as sweet bay (*Magnolia virginiana*) and red bay (*Persea borbonia*)), and cypress (*Taxodium ascendens* and *T. distichum*) forest. These vegetation communities have been classified as part of this mapping program, resulting in a new Everglades Vegetation Classification System suitable for use with color-infrared (CIR) aerial photographs (Jones *et al.*, 1999; Madden *et al.*, 1999).

Historically, rainfall and subsequent floodwaters passed from Lake Okeechobee through a continuous expanse of freshwater wetlands extending to the tidal estuaries of Florida Bay and the Gulf of Mexico. The water moved slowly over a shallow limestone table formed under marine conditions with resulting low-nutrient or oligotrophic waters giving rise to assemblages of plant communities distinctive of the Everglades (Kushlan, 1990; Davis, 1991). In recent years, the C&SF project has led to extensive urban and agricultural developments between Lake Okeechobee and the lands managed by the National Park Service and the South Florida Water Management District (Figure 2) (Doren *et al.*, 1997a). These developments have caused dramatic and unnatural changes in Everglades hydrology which, in turn, have caused equally dramatic changes in Everglades vegetation structure and composition (see Davis and Ogden, 1994).

The current Everglades Restoration effort, being conducted by a number of federal and state agencies and known as the "Restudy" of the C&SF project, is focused on ways to restore the natural hydrology (i.e., timing, flow, distribution, quantity, and quality of water delivery) to the remaining Ev-

Figure 2. Photograph illustrating urban development and agricultural encroachment into the Everglades.

TABLE 1. SUMMARY COMPARING THE MAJOR CHARACTERISTICS OF 70.5-KM² MAP SUBSETS REPRESENTED IN PLATE 1, INCLUDING THEIR TITLE, PRODUCER, SOURCE MATERIAL, DATE, SCALE, NUMBER OF POLYGONS IN EACH MAP, NUMBER OF CLASSES IN EACH SUBSET, AND A GENERAL EVALUATION OF THEIR VALUE FOR EVERGLADES VEGETATION ANALYSIS.

Title	Producer	Source Material	Date	Scale	Number Polygons	Number Classes	Overall Usefulness
JH Davis	JH Davis	B&W aerial photographs	1940	1:40,000	35	5	Broad, historical vegetation patterns
NWI	USFWS	CIR aerial photographs	1985	1:58,000	197	7	Generalized wetland types and classes
FLUCCS	State of Florida	CIR aerial photographs	1994/1995	1:40,000	184	5	General land-use identification
GAP	State of Florida	Landsat Thematic Mapper imagery	1994	30-m resolution	N/A	11	Broad natural land-cover classes
Everglades Vegetation Database	NPS CRMS SFWMD	CIR aerial photographs	1994/1995	1:40,000 1:24,000	382	8*	Vegetation community analysis

*Although polygon attributes were generalized to eight dominant classes for easy visual comparison with other maps, the data set also contains secondary and tertiary vegetation information.

erglades. A major focus of the Everglades Restoration Restudy includes improving our scientific understanding of the structural characteristics and processes of the Everglades ecosystem. Accurate spatial data on vegetation distributions are key to understanding and detecting changes in ecosystem function at the local and landscape level (Olmsted and Armentano, 1997). These data are also critical for correlating and extrapolating findings from field-level studies to larger areas in order to answer broad-scale vegetation questions.

Previous Maps of the Everglades

Although the Everglades is now the focus of national and international attention, until the current effort, the vegetation of the Everglades had never been completely and accurately mapped. In the past, portions of the Everglades were mapped for particular research interests (for example, McPherson (1973), Gunderson and Loope (1982), Olmsted *et al.* (1983), and Rose and Draughn (1991)). The South Florida Water Management District also has used satellite image data of moderate resolution to map land cover in the Water Conservation Areas (Rutchey and Vilchek, 1994; Jensen *et al.*, 1995).

Four mapping programs have included the larger Everglades ecosystem and encompass the same geographic area as the current mapping project. These include the J.H. Davis map; the U.S. Fish and Wildlife Service (USFWS) National Wetland Inventory (NWI) map and the Florida Land Use and Cover (FLUCCS) map, all of which were based on aerial photographs (Table 1; Davis, 1943; FLUCCS, 1985); and the recently completed Gap Analysis Project (GAP) conducted by the Florida Cooperative Fish and Wildlife Research Unit based on Landsat Thematic Mapper (TM) satellite image data (Table 1; FBDP, 1996). These mapping efforts utilized different classification systems specifically tailored to their objectives. Additionally, the resulting maps were not intended for vegetation characterization and analysis at the community or individual plant species level, even though they are often used this way.

The current Everglades database/mapping effort was linked to these previous mapping projects to provide a basis for comparison between the different methods and classification systems, and to illustrate the importance of accurate and detailed vegetation delineation. In Plate 1, the vegetation boundaries and classifications of the four previous mapping efforts (Plates 1a through 1d) were compared to the current Everglades vegetation data set (Plate 1e) for a 70.5-km² area that corresponds to a portion of the U.S. Geological Survey's (USGS) Pa-Hay-Okee Lookout Tower 7.5-minute quadrangle within Everglades National Park.

The Davis (1943) vegetation map (Plate 1a) does not depict the level of landscape complexity shown by the other map representations (Plates 1b through 1e). The forested features (tree islands) also appear to have no geographic correspondence compared with the other map representations. This map is, in fact, a more detailed revision of one of the first descriptions of vegetation of the Everglades region by Harshberger (1914) and provides the first comprehensive vegetation map utilizing a classification system describing the vegetation communities of south Florida. Black-and-white aerial photographs of 1:40,000 scale, acquired in 1940 by the U.S. Soil Conservation Service, and field reconnaissance information were used to produce the map. This map provides the only regional perspective of the vegetation prior to development of the C&SF Project (Light and Dineen, 1994). The Florida Department of Environmental Protection, Florida Marine Research Institute, and the South Florida Water Management District georeferenced and converted this historical analog map to digital format for incorporation into a GIS database.

Plate 1b depicts a portion of the USFWS NWI map created using 1984/1985 color-infrared (CIR) USGS National High Altitude Photography Program (NHAP) photographs of 1:58,000 scale. The NWI maps produced at 1:24,000 scale employed an existing classification system that characterizes wetland areas based on hydrology, geomorphology, and vegetation structure (Cowardin *et al.* 1979). This map is part of a USFWS effort to conduct a national inventory of wetlands of the United States. Although more detailed in the delineation of vegetation features, the maps are based on a vegetation classification system that does not include specific plant communities of the Everglades environment.

The first Florida Land Use and Cover (FLUCCS) map was produced in the mid 1980s by a committee of eight Florida State agencies using the CIR NHAP aerial photographs and a classification system called the Florida Land Use and Cover

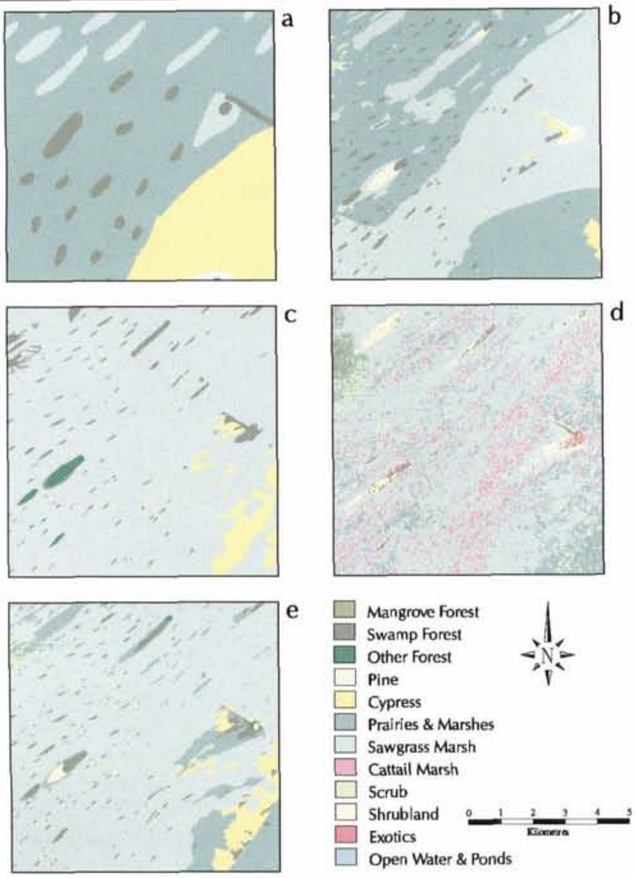

Plate 1. Vegetation maps comparing the same geographic location for a 70.5-km^2 portion of Everglades National Park near the Pa-Hay-Okee Lookout Tower. This figure compares the same location using the 1940 Davis Map (a), the U.S. Fish and Wildlife Service National Wetland Inventory Map (b), the Florida Land Use and Cover Map (c), the Florida Cooperative Fish and Wildlife Research Unit GAP Analysis Project Map (d), and the current CRMS-NPS Everglades vegetation mapping database (e).

Classification System to produce a land-use map of Florida (FLUCCS, 1985). While this map contains information on natural areas including the Everglades, it was intended for a wide variety of users and purposes with limited application for vegetation delineation. Primarily a land-use map, it was updated in 1997 (shown in Plate 1c) using the same 1994/1995 CIR NAPP photographs employed for the current Everglades vegetation database project, represented by Plate 1e. Although similar to one another, the current vegetation map (Plate 1e) contains twice as many polygons as the FLUCCS map (Plate 1c), indicating a higher level of detail tailored specifically to the vegetation communities of the Everglades.

As part of the Gap Analysis Project, The Florida Cooperative Fish and Wildlife Research Unit produced a map of developed and natural areas of the entire state of Florida based on 1992–1994 classified Landsat TM imagery (Plate 1d; FBDP, 1996). This project incorporated 40 land-use/land-cover classes following The Nature Conservancy (TNC) International Classification of Ecological Communities: Terrestrial Vegetation of the Southeastern United States and was intended to identify natural areas within Florida and locate "ecological gaps" in lands set aside for preservation (TNC, 1994). Although useful for regional-scale and state-wide resource management, this database was not designed to specifically examine the natural vegetation of south Florida. The "salt-and-pepper" appearance of the classified raster satellite image data presents a confusing picture of map detail compared to that of the other mapping efforts. It also should be noted that a substantial portion of this area has been classified in the GAP project as cattail marsh, while none of the other maps indicate any cattail marsh (Plates 1a, 1b, 1c, and 1e). Rutchey and Vilchek (1994; 1999) have documented the inherent problems of using satellite remote sensing data and automated computer classification techniques for classifying Everglades vegetation. They found that classified satellite data, when compared to photointerpreted aerial photographs, overestimated the extent of cattail and resulted in other inaccuracies, concluding that air photo interpretation is the preferred tool for Everglades vegetation mapping.

A small portion of the current Everglades vegetation database is depicted in Plate 1e with polygon attributes generalized according to the dominant vegetation for easy visual comparison with the other map products. Each polygon is, in fact, labeled with up to three levels of vegetation information specified as dominant, secondary, and tertiary vegetation using the Everglades Vegetation Classification system created for this mapping project (see Madden *et al.* in this issue).

A brief review of the detail and richness of the current vegetation GIS database is presented here in order to appreciate the potential value of this database when compared to the other maps. Procedures for the GIS database development (Welch *et al.*, 1995; Welch *et al.*, 1999) and the current classification system used in Plate 1e were developed specifically for quantitative delineation of south Florida plant communities. Classification systems used to produce the maps illustrated in Plates 1a through 1d, on-the-other-hand, were based on more generalized categories encompassing state-wide or national vegetation types. The Everglades Vegetation Classification system contains 89 plant communities and land-cover classes specifically defined as associations of species that occur in southern Florida. In addition to the three-level attributing convention for each polygon (i.e., dominant, secondary, and tertiary), one or more of 13 numeric modifiers can be added to each vegetation label to indicate factors affecting vegetation distributions such as altered drainage, abandoned agriculture, heavy off-road-vehicle (ORV) use, and hurricane damage. If needed, this hierarchical system can be collapsed for comparisons with other vegetation classification systems.

Overview of Current Mapping Effort

While collaborating conceptually in the past, the National Park Service South Florida Natural Resources Center, Center for Remote Sensing and Mapping Science, and South Florida Water Management District mapping efforts were essentially independent prior to Hurricane Andrew in 1992. The effort to build the vegetation database resulted from a special congressional appropriation of research funds to study the effects of Hurricane Andrew on the Everglades. After the hurricane, Congress appropriated approximately $50 million to the National Park Service for the hurricane recovery effort and set aside nearly $4.5 million for ecological research related to the hurricane. The prior conceptual collaboration was fortuitous as the National Park Service hurricane research funding made it possible for Everglades National Park to enter into a cooperative agreement with The University of Georgia's Center for Remote Sensing and Mapping Science and to implement the larger mapping effort in conjunction with efforts by the South Florida Water Management District. As a result of this collaboration, database development has

Figure 3. An outline map of Everglades National Park, Big Cypress National Preserve, Biscayne National Park, and the Florida Panther National Wildlife Refuge showing the locations of the high-resolution study sites intended for the production of detailed vegetation databases.

been very cost efficient (approximately $0.62 per hectare) (South Florida Natural Resources Center, financial records; Ken Rutchey, pers. comm.).

One issue that was both controversial and critical in planning this mapping project was identifying the level of detail at which the vegetation data would be collected (as determined by the type and scale of the primary data source) and stored in the database (as indicated by the smallest feature mapped or minimum mapping unit (MMU)) (Obeysekera and Rutchey, 1997). It was apparent, in early discussions during the planning phase, that most of the end users did not fully appreciate the high cost, computational requirements, and effort involved in acquiring extreme detail in vegetation distributions over such a large area. As a result, two discrete but integrated mapping efforts were realized: (1) production of a detailed vegetation database and associated 1:15,000-scale map products covering the entire study area, and (2) a number of high-resolution subset databases/maps providing detailed information on vegetation distributions for specific locations within the study area. Although the data sources and procedures used in the Everglades vegetation database and high-resolution mapping efforts are well documented in Welch *et al.*, Rutchey and Vilchek, and McCormick in this issue of *Photogrammetric Engineering & Remote Sensing*, it is appropriate to present here an overview of the project.

During the first year of the current database/mapping project, CIR NAPP photographs at 1:40,000 scale acquired by the USGS in 1994/1995 became available and were identified as the primary data source for the National Park Service-Center for Remote Sensing and Mapping Science portion of the Everglades vegetation database. Using 4× enlarged prints of the NAPP photos at 1:10,000 scale, an MMU of 1 hectare (ha) was established for the project, with significantly smaller polygons also included in areas where it was important to annotate features (such as hardwood tree islands) less than one ha in size (Welch *et al.*, 1995). The South Florida Water Management District acquired 1:24,000-scale CIR air photos of WCA 3 and similarly employed a 1-ha MMU with smaller polygons added for important vegetation features. The South Florida Water Management District plans to continue this mapping effort to include WCA 2 and lands adjacent to the Everglades National Park east boundary.

Development of the high-resolution data sets also required special acquisition of large-scale CIR photos at a scale of 1:7,000 to allow added differentiation of vegetation detail and a smaller MMU of 0.02 ha (or 14 by 14 m). Altogether, aerial photographs were flown for 31 "high-resolution" sites, each approximately 1 by 7 km in size (Figure 3). Due to a change in the scope of work, however, digital databases and maps were developed for only three of the sites. The article by McCormick in this issue discusses one of these sites and demonstrates the value of incorporating nested subsets of detailed vegetation within the Everglades GIS database. Investigations that had been targeted for some of the other high-resolution study sites included evaluation of endangered Cape Sable Seaside Sparrow habitat (Bass, pers. comm.), relating macrophyte changes to agricultural runoff and phosphorus enrichment (Doren *et al.*, 1997a), and mapping reference plant communities for change analysis following hydrologic restoration (Doren *et al.*, 1997b). In addition, a prototype multimedia approach was developed to determine the value of multimedia technology for linking vegetation information in the Everglades vegetation database to descriptive text, scanned images, and sound for enhanced use of the database by Park visitors and scientists (Hu, 1999).

Applications of the Database for Everglades Research and Restoration

Probably the most important application of the Everglades vegetation database and the high-resolution data sets is providing a baseline of conditions for future comparison and detection of change. The Everglades vegetation database may be used to track vegetation changes associated not only with continued human impact, but also with the comprehensive alterations that will result from the planned restoration of Everglades hydrology. The restoration planning process calls for performance measures to help determine if restoration actions are successful. In order to verify restoration success or failure, a scientifically rigorous and extensive research-monitoring program must be established. The spatial vegetation database produced by this Everglades vegetation mapping effort provides a complete and comprehensive basis for long-range research such as a potential Everglades Long Term Ecological Research (LTER) program similar to those funded by the National Science Foundation (NSF). Detailed information on vegetation patterns is essential to understanding spatial and temporal changes in vegetation cover related to environmental factors following hydrologic restoration.

In addition to documenting vegetation changes, the Everglades vegetation database will provide important information for ecological modeling. Modeling is considered critical to the Everglades Restoration Restudy effort because many management decisions are being made in spite of insufficient recent or prior research (South Florida Restoration Task Force, 1993). Modeling will serve a vital role in helping to forecast the ecological consequences of these changes. However, because model predictions are only as good as the data and assumptions they use, vegetation data of this detail and quality will enhance model development, calibration, and validation. The vegetation databases are useful for setting factors such as hydrologic roughness coefficients, initial biomass, and estimates of evapotranspiration. These data are also critical as co-variant indicators of ecological processes including nutrient loading, hydrologic alterations, soil processes, and wildlife habitat utilization, all processes that will need to be monitored during the implementation of Everglades restoration.

The Everglades vegetation database offers macro- and meso-scale coverage at an affordable cost. While the overall database contains all physiographic provinces for the southern Everglades region according to Craighead (1971) and Gunderson and Loftus (1993), the proposed high-resolution data sets cover prioritized segments of selected communities and habitats (see Figures 1 and 3). These segments (or sites) are relatively inexpensive to photograph and photointerpret (depending on the level of detail desired) compared to commercial estimates averaging $7.20 per hectare for the development of a boundary-to-boundary vegetation map covering Water Conservation Area 1 (Rutchey, pers. comm.). If the latter commercial estimate were extended to the area covered by the current Everglades vegetation database, a total cost in excess of $14,000,000 is computed.

Conclusions

Comprehensive GIS databases may be considered as a spatial framework for long-term ecological monitoring and research. Some remote sensing techniques, such as those used for the development of this database, are capable of providing consistent and repeatable quantitative data on a broad spatial scale that are comparable to those collected in conventional field-level studies at a very fine spatial scale. It is anticipated that, in the future, on-going technological improvements will facilitate the integrated use of aerial photographs, airborne hyperspectral data, and high-resolution commercial satellite images, along with GIS, GPS, and the enhanced computational capabilities of personal computers. In this study, cooperation among state and federal agencies in establishing procedures for combined use of remote sensing, GIS, and GPS, as well as defining the projected uses of the Everglades vegetation database and associated map products, was instrumental to the completion of a seamless vegetation map.

The Everglades vegetation database constitutes the first extensive spatial delineation of Everglades vegetation patterns at the community and sub-community level. To this end, the mapping program has the potential to serve as a catalyst for the development of a future Everglades LTER program. However, such an all-embracing program must have rigorous peer review, consistent funding, and long-term support. Scientists involved in such extended natural resource programs must be provided a high level of commitment and stability in order to provide sound information upon which decisions affecting the management and restoration of natural areas will be based. There is concern, however, based on the current Everglades vegetation mapping project, that adequate resources may not be allocated to (1) maintain and update the vegetation database or (2) fully exploit potential applications of the Everglades vegetation database and high-resolution data sets.

In the above context, current South Florida Everglades Restoration funding by state and federal agencies is approaching $70 million per year with over $1.6 billion appropriated since 1993 (South Florida Ecosystem Restoration Task Force, 1998a). While enormous financial resources are being committed for all restoration purposes, only a small fraction has been made available for research (South Florida Ecosystem Restoration Task Force, 1998b). It is clear from the funding focus of the Everglades Restoration Restudy effort, as well as trends of past research funding, that large contextual research programs often do not have sufficient or consistent resources to support long-term field-level research and monitoring programs, which in this case would be 20 to 50 years or more. By incorporating remote sensing and database strategies *a priori*, as was done in the development of this Everglades vegetation database, research and monitoring efforts can be effective in addressing a broad range of questions over a sufficiently large area to begin the restoration and ultimate preservation of the South Florida Everglades.

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