GPS SURVEYS, DEMS AND SCANNED AERIAL PHOTOGRAPHS FOR GIS DATABASE CONSTRUCTION AND THEMATIC MAPPING OF GREAT SMOKY MOUNTAINS NATIONAL PARK

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ABSTRACT

Detailed vegetation mapping of the Great Smoky Mountains National Park (GRSM) is being undertaken by the Center for Remote Sensing and Mapping Science (CRMS) at The University of Georgia in support of the All-Taxa Biodiversity Inventory (ATBI) survey. An accurate base map is needed to reference the massive data collection effort associated with the ATBI. For this reason, a combination of Global Positioning System (GPS) surveys, softcopy photogrammetry and geographic information system (GIS) procedures are being employed to produce digital orthophotos and corrected interpretation overlays in the construction of a vegetation database for the National Park.

1 INTRODUCTION

The use of GPS surveys, scanned aerial photographs and digital elevation models (DEMs) for the development of digital orthophotographs, GIS databases and various map products has evolved rapidly over the last 10 years – particularly for areas of flat to moderate terrain relief. However, applications of these technologies by agencies responsible for monitoring natural resources on vast tracts of remote, protected and often rugged terrain has been handicapped by a lack of familiarity of technical procedures and the absence of equipment and trained personnel with which to undertake mapping tasks.

The Center for Remote Sensing and Mapping Science (CRMS) at The University of Georgia is working with the National Park Service (NPS) to create a digital vegetation database for Great Smoky Mountains National Park (GRSM) located in Tennessee and North Carolina, USA. The GRSM encompasses approximately 2,000 square kilometres of rugged, southern Appalachian Mountains with a total relief of almost 2,000 metres. In addition, there is almost continuous forest cover with few roads and rivers. Detailed vegetation mapping of the Park is being undertaken by the CRMS/NPS in support of the All-Taxa Biodiversity Inventory (ATBI) being carried out to inventory all of the life forms present in the GRSM. An accurate base map is needed to reference the massive data collection effort associated with the ATBI.

2 CONSTRUCTION OF DIGITAL ORTHOPHOTOS, VECTOR DATABASES AND THEMATIC MAPS

In previous studies, the CRMS and the NPS cooperated in developing a detailed vegetation database and associated 1:15,000-scale paper map products for Everglades National Park, Big Cypress National Preserve, Biscayne National Park and the Florida Panther National Wildlife Refuge, wetland areas occupying approximately 10,000 square kilometres at the southern tip of Florida, USA (Welch et al, 1995; Welch and Remillard, 1996). Implementation of mapping and database construction for this vast, poorly mapped wetland area lacking road networks and dry, firm terrain required the use of satellite images and aerial photographs in combination with GPS, mapping and GIS technologies (Welch et al, 1999). In contrast to mapping the very flat terrain of South Florida where relief varied by only one metre over much of the study area, mapping the GRSM requires the integrated use of GPS surveys, softcopy photogrammetry and GIS procedures in combination with DEMs and available air photos of 1:12,000 to 1:40,000 scale to construct digital orthophotos, vector databases, full-color thematic maps and terrain perspectives using a low-cost personal computer.

Challenges encountered in the photogrammetric process included the use of over 1,000 existing large-scale (1:12,000) color infrared (CIR) aerial photographs recorded during leaf-on times of the year, the near-complete lack of cultural features traditionally employed for control points and the extreme relief within single photos. The solution involves the use of scanned aerial photographs in combination with existing digital orthophoto quarter quads and DEMs to establish control points, and to use PC-based aerotriangulation techniques with natural features as pass points to extend control over blocks of photographs corresponding to areas covered by U.S. Geological Survey (USGS) 1:24,000-scale topographic quadrangles (Welch and Jordan, 1996). Overlays containing the vegetation information are then orthocorrected using the Desktop Mapping System (DMS) software package, converted to vector format and integrated into a GIS database. As compared to more conventional approaches, these techniques provide an accurate, low-cost means of developing a control base and map products for this remote area.

3 DEVELOPMENT OF A VEGETATION CLASSIFICATION SYSTEM

Mapping the floristically diverse GRSM also required the development of a detailed classification system suitable for interpreting the large-scale (1:12,000) color CIR aerial photographs covering the mountainous area. Employing techniques similar to those used to develop the Everglades Vegetation Classification System (Madden et al, 1999), detail interpreted from the aerial photographs was used to define a hierarchical classification system for the entire GRSM. Effort also was made for the system to be compatible with the newly released USGS Biological Resources Division/National Park Service (BRD/NPS) National Vegetation Classification System developed by The Nature Conservancy (TNC) as part of the USGS BRD/NPS Vegetation Mapping Program for a pilot study area within GRSM (TNC, 1999).

The resulting classification system includes eight major vegetation categories that are stratified by elevation-range (e.g., Sub Alpine Forest) and growth form (e.g., Heath Balds) and contains over 80 association-level classes (e.g., Sub Mesic to Mesic Oak Hardwoods). Individual polygons in the database are attributed with a primary or dominant vegetation class, and where appropriate, a secondary and tertiary vegetation type. Numerical modifiers can then be added to any class to indicate additional information such as insect damage, post disturbance recovery or human influence. A digital GRSM vegetation key correlating air-photo signatures with vegetation classes is currently being constructed for use in training new interpreters. Personnel from the CRMS, TNC and the NPS are conducting GPS-assisted fieldwork to further refine the classification system and improve the accuracy of the GRSM vegetation database.

4 FINAL PRODUCTS

Final products of the mapping project include a seamless GIS database of detailed vegetation communities for the entire Park, along with 25 hardcopy maps corresponding to the USGS quad sheets and plotted at 1:15,000 scale. Each map sheet contains a color-coded legend and brief description of all GRSM vegetation classes. In addition to the maps, digital orthophoto mosaics, produced from the CIR 1:12,000-scale air photos, will be provided to Park personnel as required for use in resource management activities.

5 CONCLUSIONS

The procedures employed in the construction of a vegetation database for the GRSM have required a suite of GPS, GIS and softcopy photogrammetry techniques in order to account for the high relief and continuous forest cover of this ecologically diverse National Park. The integration of these technologies has proven to be successful and it is envisioned that the methodologies established in this study can be extended to similar mapping efforts in other remote areas of the world.

REFERENCES

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

The Nature Conservancy, 1999. BRD-NPS Vegetation Mapping Program: Vegetation Classification of Great Smoky Mountains National Park (Cades Cove and Mount Le Conte Quadrangles), Final Report, The Nature Conservancy, Chapel Hill, North Carolina, 195 p.

Welch, R. and T. Jordan, 1996. Using scanned aerial photographs, In: S. Morain and S. Lobez Baros (Eds.), Raster Imaging in Geographic Information Systems, pp. 55-69.

Welch, R., Madden, M. and R. Doren, 1999. Mapping the Everglades, Photogrammetric Engineering and Remote Sensing, 65(2), pp. 163-170.

Welch, R. and M. Remillard, 1996. GPS, photogrammetry and GIS for resource mapping applications, In: Clifford W. Greve (Ed.), Digital Photogrammetry: An Addendum to the Manual of Photogrammetry, American Society for Photogrammetry and Remote Sensing, Bethesda, Maryland, pp. 183-194.

Welch, R., M. Remillard and R. Doren, 1995. GIS database development for South Florida's National Parks and Preserves, Photogrammetric Engineering and Remote Sensing, 61(11), pp. 1371-1381.