United States
Environmental Protection
Agency

Environmental Monitoring
Systems Laboratory
Las Vegas, NV 89193-3478

Research and Development

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Project Summary

Wetlands Detection Methods Investigation

K. H. Lee

The purpose of this investigation was to research and document the application of remote sensing technology to wetland detection and mapping. Various remote sensing sensors and platforms are evaluated (1) for suitability to monitor specific wetland systems; (2) for their effectiveness in detailing the extent of wetlands; (3) for their capability to monitor changes; and (4) for the resulting relative cost-benefits of implementing and updating wetlands databases.

The environment to be monitored consists of physiographic and ecological wetland resources affected directly or indirectly by anthropogenic activity. Aircraft and satellite remote sensing can be used to record and assess the condition of these resources. Monitoring of environmental conditions is based on the observation and interpretation of certain landscape features. Although some forms of monitoring are continuous, resource monitoring from aircraft and satellite platforms is periodic in nature, with change being documented through a series of observations over a given span of time.

This report summarizes the findings of a bibliographic search on the methods used to inventory and/or detect changes in wetland environments. The bibliography contains numerous citations and is not intended to be all-inclusive. Books, major journals, and symposium proceedings were examined. The findings documented will provide the potential user with a basic understanding of remote sensing technology as it is applied to wetland monitoring and trend analysis.

This Project Summary was developed by EPA's Environmental Monitoring Systems Laboratory, Las Vegas, NV, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

The purpose of this report is to present an overview of wetlands mapping procedures, emphasizing the role of satellite and aircraft imagery and their interpretation; field verification; and compilation of all these data. The procedures for mapping changes in the extent and types of wetlands is generally based on a comparison of earlier (historical) remote sensing imagery to recent imagery.

The detail, accuracy, and precision of the mapping depends on what results are desired from the final report; the availability of the necessary remote sensing data; the technical personnel and equipment on hand; and the specific budget for the project.

Wetlands are difficult to map because of (1) water level fluctuations, (2) the many differing types of wetland settings, (3) the difficulties of ground travel in placing geographic control point markers in this soggy terrain, and (4) the changes in the boundaries of wetlands types caused by variations in the hydrologic cycle with its seasonal, annual, and long-term fluctuations. Furthermore, other changes may have been created by anthropogenic factors,

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To avoid the problems associated with seasonal changes in wetland boundaries, both the remote sensing data and the field verification data should be collected at the same time of the year so that the same boundaries will be in the same geographical positions.

Procedures

The major part of mapping the wetlands is generally done through the interpretation of remote sensing imagery. This is considered here to be the satellite imagery, airborne radar imagery, airborne multispectral digital imagery, vertical overlapping aerial photographs (black and white, color, and color infrared [CIR]), and to a minor extent color photographs (in hand-held cameras) and video tapes taken from aircraft.

Satellite imagery has a small scale, and generally cannot be viewed stereoscopically. This contrasts with aerial photographs which have a much larger scale, ranging normally from about 1:10,000 to 1:58,000, and which can be viewed stereoscopically.

The larger scale of the aerial photographs with its smaller mapping units of wetlands cannot be correlated directly with the larger units of the satellite imagery. This problem can be largely overcome by combining the smaller units (from the aerial photographs) until they correspond to the larger units of the satellite imagery. This correspondence has been as high as 90 percent in some studies.

Several different types of satellite imagery are available: the MSS (Multispectral Scanner) has four spectral bands: visible green, visible red, and two reflectance infrared bands having about an 80-meter ground resolution.

The TM (Thematic Mapper) satellite has six spectral bands with a 30-meter resolution, and a thermal infrared band with a 120-meter resolution. Both these satellites are in polar orbits and can collect spectral information every 16 days over the same surface area.

TM is better suited for wetlands mapping than the MSS because of better spatial resolution (30 m), seven narrower spectral bands sensitive to differences in spectral reflectance of vegetation, and a higher level of quantization (i.e., digital numbers for TM = 256, for MSS = 128).

SPOT satellite imagery (a French satellite) has a 10-meter black and white resolution, and a 20-meter resolution for three-band multispectral images; this is a finer resolution than the LANDSAT MSS and TM images, but it has a fewer spectral bands and a smaller areal coverage. This satellite can be oriented during its orbit so as to produce stereoscopic coverage; it has a repeat cycle of 26 days. SPOT data can be integrated with LANDSAT TM data to provide a composite view, upgraded by the finer spatial features of SPOT and the finer spectral resolution of TM.

One advantage of satellite imagery is color enhancement of scenes to emphasize certain features of the landscape, such as different types or stages of vegetation, etc; this procedure is useful in wetlands interpretation. Conversely, the stereoscopic exaggerated relief (normally about three or four times) observed in the stereo images of the normal aerial photographs can help to delineate the low-lying areas of wetlands.

Many series of aerial photographs are available for most areas in the States. Typical scales normally range from around 1:10,000 to 1:58,000. An ongoing program by the USGS will cover the entire United States with small-scale CIR 1:58,000 aerial photography. The CIR photography seems to be the preferred type for most landscape characterization (which includes wetlands mapping).

The above indicates the many options in remote sensing imagery available, and the planning necessary to select the most advantageous imagery for primary baseline mapping. To map the changes over time in wetland areas, historical aerial photographs are generally used; these can extend back as much as 50 years. A series of these older photographs can show the development and trend of the present status of the wetlands now being mapped.

Side-looking radar is little used for wetlands mapping but has been successful. Video imagery has been little used, its resolution less than aerial photography. Further work on optimizing spectral bands must be done before video can be used as an additional data source.

Previous Mapping

Previous mapping of wetlands provides information on any later changes in the character of the wetlands. However, three serious problems in integrating previous wetlands data into current mapping are:

1) The classifications can be based on different criteria so that the units mapped previously are not the same as those being mapped for the present project.
2) The areal precision of ground control points predating Global Positioning Systems (GPS) is usually poor for correlating any specific feature, point, or contact with later mapping. Compilation of such data is not feasible in many cases.
3) The differences in scales between the previous mapping and later mapping may make correlations difficult if not impossible; this may also control the differences in the ground or spectral criteria included in the various wetlands classifications.

A classification system developed by the USGS in 1976 covers all remotely-sensed resource data, not just the wetlands. A wetlands classification system (Cowardin System) was developed by the Forest Service in 1979 to replace a 1955 system, and is largely used or modified.

Field Verification

Until recently, the problem of locating field geographic control points exactly has been a major problem. The seasonal or annual changes in this water-dominated environment, plus even changes by individual storms and the general thick vegetation cover, together with the difficulties of field personnel movement within the wetlands, can prevent the establishment of adequate recognizable control points.

The one outstanding technical development which apparently overcomes much of this problem is the development of GPS developed by the US military.

At the present time, the satellite data are available only during a certain few hours in the day so that field work must be coordinated to take advantage of the specific schedules of the satellites to receive their transmissions for site control.

Geographic Information System

The Geographic Information System (GIS) is distinguished from other data management systems by its ability to perform spatial analyses with multiple levels of data in a selected geographic area. The GIS is a convenient and organized method for analysis of wetlands and allows for a cohesive database into which additional information can be incorporated and refinements made.

Computerized GISs are widely utilized to store, query, retrieve, display, and manage large amounts of digital data assembled from many sources. The ability to geometrically transform and integrate multiple data types is very important when accounting for differences in scale, map projections, spatial resolutions, and cartographic coordinate systems.

Both the raster and vector systems are used in the GIS. For example, geometric or overlay (point) operations are easier to

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