MAPPING DYNAMIC HYDROLOGIC CONDITIONS OF SURFACE WATER CHANGES IN SOUTH FLORIDA USING REPETITIVE ERTS-1 DATA INTERFACED WITH DCP'S

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Description of the Area and Problem:

The Loxahatchee National Wildlife Refuge was established on June 8, 1951, under authority of the Migratory Bird Conservation Act of 1929. The refuge encompasses 145,635 acres of Everglades and is situated west of U.S. Highway 441 in Palm Beach County, Florida, 10 miles inland from the Atlantic Ocean. The Everglades, ecologically unique with wet prairies, sawgrass communities, aquatic sloughs, and tree islands, represents one of the largest freshwater marshes on the North American Continent. It began as a Pliocene sea bottom and originally covered an area approximately 100 miles long by 40 miles wide. The Everglades basin is bounded on the east and west by narrow coastal sand ridges, rising to 25 feet above sea level.

Land elevations vary from 11 feet mean sea level at the southern boundary to approximately 17 feet mean sea level at the northern. Tree islands, rising some 2 feet above the surrounding marshes, are interspersed over much of the refuge. These tree islands are oriented in a north-south direction and vary in size from less than 1 to over 300 acres.

Ninety-eight percent of the refuge is marshlands containing aquatic vegetation composed largely of dense stands of sedges and rushes. Interspersed throughout these stands are numerous "open-water" areas. The tree islands support mixed stands of redbay, wax myrtle and holly. Numerous other wetsoil and aquatic plants occur in varying stands depending on existing environmental conditions.

Seventy percent of the 62 inches of rainfall on the refuge occurs from May through October. Winds prevail from the southeast, and the relative humidity averages 75 percent. Summer temperatures hover in the 90's during the day and cool to the 70's during night periods. Temperatures remain moderate during the winter months, even though two or three light frosts may occur. The refuge is occasionally in the path of tropical storms, especially during late summer and early fall.

Under natural conditions, surface water flows from north to south through the refuge. Water levels in the refuge are regulated by the Central and Southern Florida Flood Control District through a series of pumping stations and floodgates located along the boundary canals.

Land elevations within the refuge play a significant role in the water storage capacity, movement of water, alignment of vegetative zones, and distribution of wildlife. A contour map was prepared in 1965 by the Corps of Engineers, Central and Southern Florida Flood Control District, and the Bureau of Sport Fisheries and wildlife for purposes of enabling agencies to better understand water management in the refuge.

The contour map disclosed a course of water from north to south along the eastern half of the area. Higher elevations along the eastern and to a lesser extent the western edge of this water course were found to converge at the southern end to form an effective barrier to water flow, thereby forming lake and slough areas.

The problem is that land elevations may respond to water level fluctuations and undergo significant subsidence because of frequent exposure to oxidation and fires. Consequently, an updated understanding of changes in these contours is required for water management in the refuge.

The purpose is to process ERTS-1 imagery to demonstrate the capability of mapping from space, surface water changes that are thought to occur in the Everglades during three ERTS cycles, 36 days of water level decline. These water changes are to be delineated by analyzing specially processed ERTS-1 imagery and ground truth information of water levels in the refuge telemetered by DCP's (Data Collection platforms) at the time of ERTS overpass. The surface water changes will be used to revise land elevation contours for those areas that may have undergone subsidence since 1965. These revised contours will be used to update water depths and volume for better water management in the refuge.

ANALYSIS

ERTS-1 multispectral scannery (mss) imagery were collected over the refuge during three consecutive ERTS cycles, 11 (February 14, 1973), 12 (March 4, 1973) and 13 (March 22, 1973). During this time DCP's were transmitting by the NASA communication line to the Miami office of the U. S. Geological Survey ground-truth water-level information that showed that the refuge was in a period of water-level decline. The imagery and DCP data were processed and analyzed for purposes of defining surface-water changes that occurred during the 36-day period of water-level decline. The imagery and DCP data were processed and analyzed for purposes of defining surface-water changes that occurred during the 36 day period of water-level decline. Information obtained from this study is to be used to delineate areas of land subsidence that may have occurred since 1965 and update the contour map for purposes of enabling agencies to better understand water management in the refuge.

The imagery were first processed on Stanford Research Institute's Mark II Electronic Satellite Image Analysis Console (ESIAC) to extract spectral information useful for delineating surface water changes in the refuge. All spectral bands of ERTS-1 imagery of the three cycles were electronically stored into the ESIAC library for retrieval, comparison and spectral analysis. The ESIAC library was used as a microdensitometer to prepare radiance profiles along specific transects for analysis of radiance differences and for comparison of these differences with ground-truth information. Binary thematic masks were displayed to compare the radiance differences between the spectral bands and changes between the cycles to determine what spectral regions would be most useful for analysis of

surface-water conditions. After analysis, it was concluded that the longer wave length (band 7) would be more useful for the ESIAC to process to delineate surface-water conditions in the refuge than other single or combinations of spectral bands.

However, many changes occurred in the refuge during the 36-day period for the three ERTS cycles. During this period, the area of the refuge covered by surface water diminished and the marsh bogs once containing submergent vegetation became exposed to the hot tropical sun. Eventually, large soggy areas of dead and dying vegetation began to dry up, and grasses and shrubs began a sparse growth in the soggy bottoms. Atmospheric and climatic conditions had changed and the changing sun angle had shifted the incidence of light rays on the refuge. All these changes effected spectral changes that were registered in the ERTS imagery and after analysis with ground-truth information, they obscured and confused the analysis of delineating surface-water changes.

For purposes of analysis and to differentiate surface-water changes from others, the obscuring effects of atmospheric differences and sun angle changes were edited out of the three cycles of imagery. Two areas were chosen to represent standards of quasi spectral stability for the three cycles. A deep ponded area and roads and levees in the southwest part of the refuge had remained relatively unchanged and were assumed to have maintained a relatively constant spectral reflectance in band 7 during this period. Cathode-ray-tube images of the refuge for all cycles in band 7 were analyzed by the ESIAC processor and manually edited and "rolled" until the scene of lower reflectance of the ponded area appeared to have the same spectral reflectance or density for all cycles. Scenes of

higher reflectances, the roads and levees, were treated in the same manner. By this editing process, images of unity of band 7 were produced for all three ERTS cycles of the refuge. Spectral differences in these images of unity were now assured to be more comparable and more representative of surface water changes in the refuge and not as affected by atmospheric and sun angle differences. The grey scales representing unity for the transformed images were displayed along with the images of unity for the three cycles and photographed for processing and analysis.

The photographic negatives of the ESIAC images were then processed on the I^2S Digicol processor at the Earth Resources Office at Kennedy Space Center for purposes of enhancement, display of radiance differences, and comparison with ground truth information. The negatives were simultaneously displayed on the I^2S processor, with instrument settings the same for all cycles to eliminate bias, photographed, and analyzed.

SUMMARY AND CONCLUSION

Surface water conditions that occur in the Loxahatchee National Wildlife Refuge during three ERTS cycles, a period of water level decline, are registered as tones of grey that are different in the imagery of each cycle, and with ground-truth information these differences may be interpreted as surface water changes. The tones indicative of water conditions were found to be more marked in the longer wavelength, band 7, than other single or combinations of bands. However, tones that may indicate surface water conditions and changes between cycles may be obscured by the effects of atmospheric, sun angle, and vegetative changes that also occur during and between cycles.

These obscuring effects were edited from the imagery prior to the delineation processing and interpretation of surface water conditions and changes in the refuge. A ponded area located in the southwest part of the refuge was assumed to have undergone relatively no changes during this 36 day period sufficient to cause a wide variance in reflectance between cycles. Roads and levees in the same vicinity were also considered to have remained relatively constant in reflectance during this time. These scenes in all cycles of the original imagery were transferred to imagery of spectral unity by Stanford Research Institute's ESIAC processor. The imagery was then processed and analyzed for delineating surface water conditions in the refuge.

For purposes of enhancement, analysis and display of radiance differences, the transformed imagery was processed on the I^2S Digicol viewer and photographed at the Earth Resources Office at Kennedy Space Center, Florida.

After analysis of these images, it was concluded that radiance differences in the transformed imagery could be interpreted along with ground-truth (DCP) information and used to delineate surface water changes in the refuge. The DCP information confirmed that areas of lower radiance were wetted during the first cycle and became progressively higher in radiance and more dry toward the last cycle for the period of water decline in the refuge.