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EVALUATION OF LAND USE MAPPING FROM ERTS IN THE SHORE ZONE OF CARETS*

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ABSTRACT

ERTS imagery of the Atlantic shoreline zone of the Central Atlantic Regional Ecological Test Site (CARETS) was evaluated for classifying land use and land cover, employing the USGS Geographic Application Program's land use classification system (Geological Survey Circular 671). ERTS data can provide a basis for land cover and land use mapping within the shoreline zone, however because of the dynamic nature of this environment, two additional terms are considered: vulnerability of classes to storms and progressive erosion, and sensitivity of the classes to man's activities.

INTRODUCTION

ERTS-1 imagery of the CARETS region is being evaluated for use in classifying land use on the barrier islands of the mid-Atlantic Coast using the United States Geological Survey's Land Use Classification (Circular 671). Changes in this fragile environment occur on a variety of temporal and spatial scales, many of which are commensurate with the sampling possible from ERTS-1. Response of the islands to storms and long-term trends results in changes in the dimensions and distributions of the land use classes. ERTS-1 imagery offers, therefore, the possibility of monitoring the immediate and long-term response of the barrier islands to the processes, both human and natural. Since the barrier islands are subject to rapid and destructive change, the implications if this ability to monitor land cover types is potentially great.

*This research is being conducted within the CARETS Research Program, Geography Programs, United States Geological Survey.

The purposes are (1) to provide an initial evaluation of ERTS imagery for mapping land use on the barrier islands, and (2) to estimate the potential of ERTS for measuring the vulnerability and sensitivity of the land cover classes to change caused by man and nature. The area of investigation spans the coast from Atlantic City, New Jersey to Cape Lookout, North Carolina with the focus of the study centered upon landscape seaward of the Pleistocene/Recent contact.

REGIONAL DESCRIPTION

Barrier islands are biophysical complexes consisting of sand beaches, sand flats, dunes, and marshes. The islands rarely exceed one mile in width, range in length from one to twenty miles and are separated from each other by tidal inlets. The distances from the islands to the mainland may range from less than one-half mile to more than twenty miles. The principal physical processes occurring include the sand transport by tide, wind and wave generated currents, eolian transport, tidal inundation of the marshes, and storm surge overwash of the beach, dune and marsh areas. The ecology of the islands is fragile, with changes in the marsh and dune grasses rapidly masking change associated with the physical processes.

Erosion problems are critical along the CARETS coastline, especially in areas where man has intensely developed the landscape. Temporal scales of erosion include long-term trends due to eustatic sea level rise, short-term changes due to individual storms, and change associated with tidal cycles. When the dunes are breached and surges of seawater penetrate the interior of the island, damage can be inflicted upon public and private property. The flooding can disrupt transportation and communication, isolating sections of the islands. Overwash is a beneficial process, however, when it occurs in the natural landscape. It moves nutrients into the marsh, and has been suggested as the means by which the islands maintain themselves when sea level rises.

Recent research suggests that a hierarchy of shoreline landforms exists, with size ranging from beach cusps to capes (10 meters to 100 kilometers) and with the elements of this hierarchy dynamically linked to particular nearshore processes (Fig. 1). This system of landforms is important because the severity of the erosion that a locale experiences from a storm depends not only upon the intensity and duration of the storm, but also upon the position of the locale with

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respect to the hierarchy of shoreline landforms. The presence or absence of elements of this system along the coastline can signify areas with a potential for rapid change; therefore, their appearance on the imagery can provide an indication of trouble areas.

CLASSES OF LAND COVER

The United States Geological Survey's Land Use Classification provides for two levels of classification based on two levels of remote sensing data (Table I). Level I is for use with satellite imagery and Level II is for use with satellite and high-altitude imagery combined with topographic maps. The following classes are frequently apparent on imagery of the mid-Atlantic barriers.

Forest Land--In general, the forest lands are evergreen or mixed.

Water--Streams and waterways are present, but bays and estuaries dominate.

Nonforest Wetland--All Level II elements are present.

Barren Land--The two Level II elements present are beaches and sand deposits other than beaches. Sand other than beaches will include both dunes and sand flats.

For the purpose of this report only Level I classification was mapped, although some Level II imagery was used to check the accuracy at Level I. Initial surveys indicate that color IR imagery at a scale of 1:60,000 was more than sufficient to accomplish Level II mapping with the exception of urban development classification.

ANALYSIS

Landmarks and features on the imagery that are important in delineating the land cover classes include the interfaces between sand flats and marshes, marsh and lagoon, and beach and ocean; turbidity patterns in the oceans and estuaries, and vegetation distributions. The following is an assessment of the individual ERTS-1 bands utility:

MSS-4 Sand surfaces are evident, as are sand to vegetation transitions. The band is not

Table 1

Land-Use Classification System for Use With Remote Sensor Data

Level I	*Level II*
01. Urban and Built-up Land.	
	01. Residential.
	02. Commercial and services.
	03. Industrial.
	04. Extractive.
	05. Transportation, Communications, and Utilities.
	06. Institutional.
	07. Strip and Clustered Settlement.
	08. Mixed.
	09. Open and Other.
02. Agricultural Land.	
	01. Cropland and Pasture.
	02. Orchards, Groves, Bush Fruits, Vineyards, and Horticultural Areas.
	03. Feeding Operations.
	04. Other.
03. Rangeland.	
	01. Grass.
	02. Savannas (Palmetto Prairies).
	03. Chaparral.
	04. Desert Shrub.
04. Forest Land.	
	01. Deciduous.
	02. Evergreen (Coniferous and Other).
	03. Mixed.
05. Water.	
	01. Streams and Waterways.
	02. Lakes.
	03. Reservoirs.
	04. Bays and Estuaries.
	05. Other.
06. Nonforested Wetland.	
	01. Vegetated.
	02. Bare.
07. Barren Land.	
	01. Salt Flats.
	02. Beaches.
	03. Sand Other Than Beaches.
	04. Bare Exposed Rock.
	05. Other.
08. Tundra.	
	01. Tundra.
09. Permanent Snow and Icefields.	
	01. Permanent Snow and Icefields.

good for the differentiation of marsh vegetation types, or of the beach from the surf zone (Fig. 2A).

MSS-5 The sand to marsh transition is best indicated on this band. Turbidity is easily observed. As with band MSS-4, marsh to water and shore to water transitions are not well-defined (Fig. 2B).

MSS-6 Both water to land boundaries and vegetation transitions are evident. This band is poor for sand to marsh transitions (Fig. 2C).

MSS-7 This band is the best for water to land transitions, and in particular, for discerning the shoreline. Dune ridges and vegetation patterns also show well. Similar problems as MSS-6 for sand/vegetation transitions exist (Fig. 2D).

The land cover of the mid-Atlantic barrier islands from Atlantic City, New Jersey to Assateague Island, Maryland and from the Virginia-North Carolina border to Cape Fear, North Carolina have been mapped at Level I. Examples are given in Figure 3. The problems encountered in mapping for each land cover and land use class are discussed in the following list.

Urban and Built-up Areas--These areas are difficult to distinguish on barrier islands unless the development is intense because of large areas of unvegetated sands that remain between the buildings. This problem is easily removed at Level II. Areas where marshes have been dredged and filled for development are easily recognized from ERTS-1 imagery.

Forest Lands--Areas of heavy evergreen or mixed cover are readily evident on MSS-6 or MSS-7. The only areas on the barrier islands that have this type of land cover are usually older, high-standing dunes. On the false color imagery the forests appear a brighter red than marshes. Level II imagery should be sufficient to answer any questions that arise in Level I mapping.

Water--Water/land transitions are best delineated on MSS-6 and MSS-7. No particular problems were encountered in mapping at Level I.

Nonforest Wetland--Sand to marsh transitions are best indicated on MSS-4 and MSS-5, marsh to water is best on MSS-6 and MSS-7. Some differentiation of wetland types is evident, but Level II imagery is necessary for accurate identification.

Barren Land--The barren lands of barrier islands are primarily the beaches, dunes, and sand flats. The beach areas are separable from sand flats and dunes by their lack of vegetation on Level I. Level II imagery may be necessary for accurate separation of sand flats from dunes.

EVALUATION

ERTS-1 imagery is sufficient for identifying Level I classes of land cover and land use and can be used for rapid assessment of the distribution of the land cover on a regional scale. Elements of the Level II classification are also evident, but more work is required before it will be possible to assess whether or not the majority of Level II classifications can be carried out without extensive use of high-altitude underflights. The combination of resolution, regional coverage and sampling interval makes ERTS imagery desirable when large-scale assessments of change, such as after a major storm, or longer-term changes in distribution of land cover and land use are needed.

Changes in distributions of land use classes on the barrier islands signify the response of this environment to natural and man-caused processes. Therefore, a shift in the relative distribution of vegetated dunes and sand flats may be indicative of an erosion trend, or a decrease in marsh area may represent increased dredge and fill or significant storm generated overwash.

The barrier islands are one of the most dynamic and sensitive environments inhabited by man. The interconnections among the processes and the equilibrium form of the land is such that changes in any one part of the island can be rapidly transmitted to other areas. For purposes of

of planning in this environment measures on the vulnerability and sensitivity of the different land cover classes are needed if the use of the islands is to be properly planned.

Environmental vulnerability can be defined as the possibility that a land cover class may undergo significant change. The vulnerability of a beach may, therefore, be very high when compared to a marsh area. Vulnerability can also vary between sites within a particular land cover class. For planning purposes, vulnerability indicates the risk of damage from storms or other environmental changes.

Sensitivity can be defined as the degree of possible damage to the land class from actions of man. Barrier dunes and marshes may, therefore, be more sensitive than beaches and sand flats. Sensitivity gauges the possible effect of man upon the land class.

Vulnerability and sensitivity can be estimated from repetitive coverage of long reaches of CARETS coast. ERTS imagery has sufficient resolution and adequate repetitive coverage to accomplish the task. Some high-altitude imagery and supportive field work is necessary to calibrate the interpretative decisions.

By monitoring land cover distributions on undeveloped islands, and then estimating vulnerability and sensitivity, the natural dynamics of the barrier island environment can be estimated. The information gained can then be applied to areas already developed or areas planned for development. This system of analyses can then serve to forecast where serious environmental problems will likely occur.

SUMMARY

ERTS imagery can be used to map Level I land cover and land use distributions on the barrier islands of the CARETS region. Mapping of some elements at Level II is also possible. It appears that vulnerability and sensitivity of the land cover classes can be estimated from the investigation of ERTS imagery with some supportive underflights and field work. These additional data should provide a planning base for future development of the sand beaches and barrier islands of the mid-Atlantic Coast.

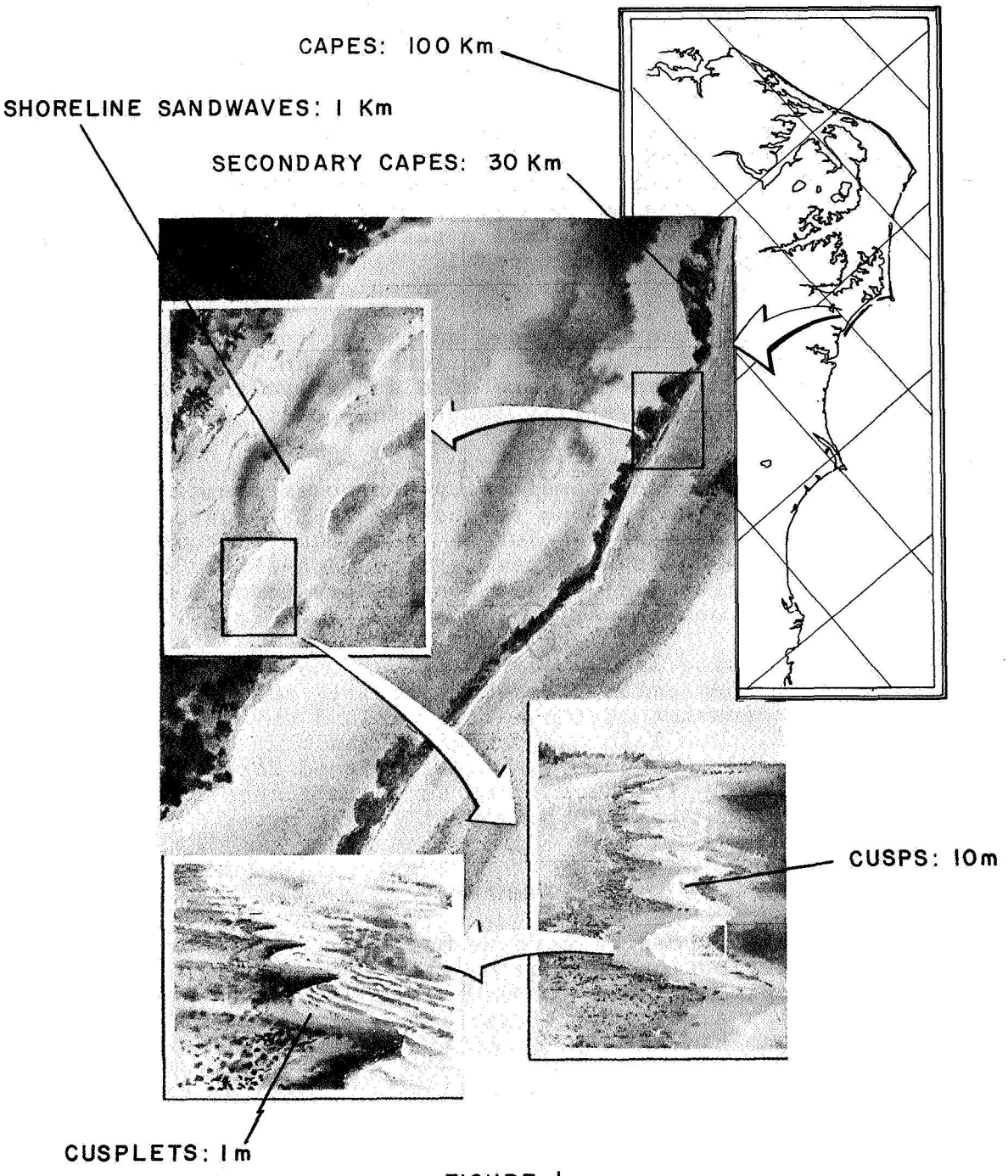

FIGURE 1

HIERARCHY OF CRESCENTIC AND RHYTHMIC COASTAL LANDFORMS

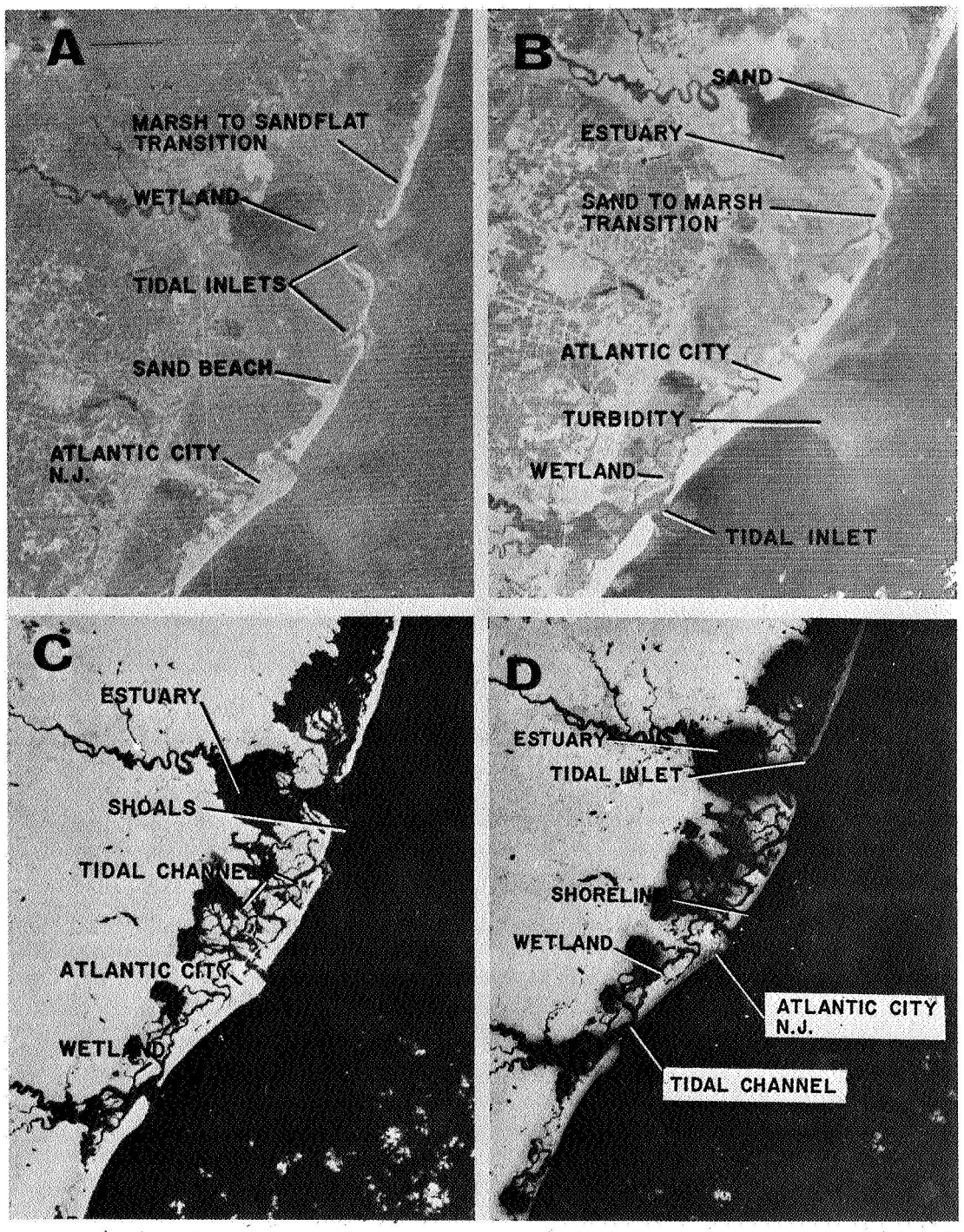

FIGURE 2
UTILITY OF MSS BANDS

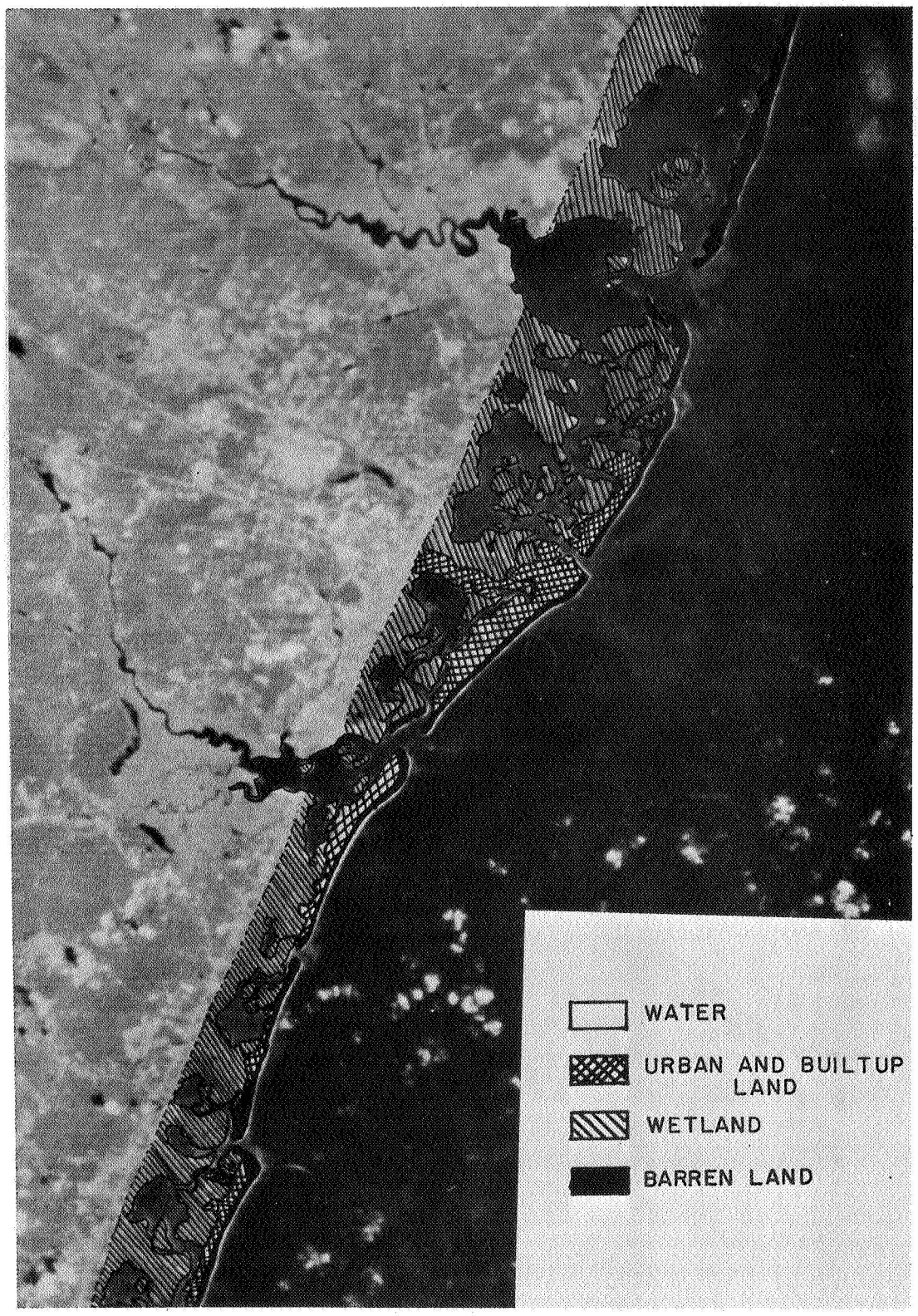

FIGURE 3
COASTAL LAND USE, ATLANTIC CITY, NEW JERSEY
(ERTS E 1024 - 15073-5, AUGUST 16, 1972)