Paper E 8

IDENTIFICATION OF MARSH VEGETATION AND COASTAL LAND USE IN ERTS-1 IMAGERY

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ABSTRACT

Coastal vegetation species appearing in the ERTS-1 images taken of Delaware Bay on August 16, and October 10, 1972 (Observation I.D. Nos. 1024-15073 and 1079-15133) have been correlated with ground truth vegetation maps and imagery obtained from high altitude RB-57 and U-2 overflights. The vegetation maps of the entire Delaware Coast were prepared during the summer of 1972 and checked out with ground truth data collected on foot, in small boats, and from low-altitude aircraft. Multispectral analysis of high altitude RB-57 and U-2 photographs indicated that five vegetation communities could be clearly discriminated from 60,000 feet altitude including, 1) salt marsh cord grass (Spartina alterniflora), 2) salt marsh hay and spike grass (Spartina patens and Distichlis spicata), 3) reed grass (Phragmites communis), 4) high tide bush and sea myrtle (Iva species Baccharis halimifolia), and 5) a group of fresh water species found in impoundments built to attract water fowl. All of these species are shown in fifteen overlay maps, covering all of Delaware's wetlands prepared to match the USGS topographic map size of 1:24,000.

Major communities of 1) Spartina alterniflora, 2) Spartina patens and Distichlis spicata, and 3) Iva frutescens and Baccharis halimifolia can be distinguished from each other and from surrounding uplands in ERTS-1 scanner bands #6 and #7. Similarly, major impounded areas, built to attract water fowl, can be identified. Mosquito control drainage ditches and plant species such as Phragmites communis which naturally occur in small, dispersed patches are impossible to discriminate within the resolution capability of the ERTS-1 scanner. In disturbed

marshes of northern Delaware Bay. Phragmites communis does occupy large enough expanses of marsh to be detected. In summary, it appears from preliminary analysis that spectral discrimination capabilities of ERTS-1 imagery compare favorably with those of aerial infrared photography and that spatial resolution is the dominant factor limiting the potential for detailed vegetation mapping using ERTS-1 imagery.

INTRODUCTION

Coastal wetlands of the type found along the entire East Coast of the United States are well suited to remote sensing techniques, particularly multispectral analysis. Use of high altitude RB-57 and U-2 color-infrared imagery in the mapping of vegetation in Delaware's saline marshes was highly successful and indicated that such mapping was possible. Some of the characteristics which make coastal marshes particularly suitable for multispectral sensing from high altitudes are:

1) The lack of topographic relief eliminates shadows and variations in sun angle across the marsh.
2) The relatively low diversity of major plant species simplifies photo-interpretation.
3) Environmental changes generally take place over large horizontal distances in the marsh; therefore, zones of relatively uniform vegetation are usually large enough to be discernible even on very high altitude imagery.
4) Each of the primary species is morphologically different enough to produce easily discriminated reflectance characteristics, particularly in the infrared portion of the spectrum.

Few natural situations afford such an opportunity to evaluate the optimum multispectral discrimination capabilities of present equipment while providing useful data on plant species distribution and land use over large areas of the coastal regime.

GROUND TRUTH

Data on the distribution of vegetation species and recent dredge-fill construction in Delaware's coastal wetlands was collected during the spring and summer of 1972. Reconnaissance on foot, in small boats, and from low altitude aircraft aided in the interpretation of high altitude RB-57 and U-2 imagery. Color and color-infrared photographs obtained by these aircraft from an altitude of 60,000 feet were analyzed by human interpreters and by automated multispectral data processing equipment. The results showed that five individual species or groups of associated species could be clearly discriminated on the basis of high altitude color-infrared imagery. In addition, construction of housing, marinas, impoundments and other alterations of the marsh were clearly discernible. The discrimination classes selected were:

1) Salt marsh cord grass (Spartina alterniflora).
2) Salt marsh hay and spike grass (Spartina patens and Distichlis spicata).
3) Reed grass (Phragmites communis).
4) High tide bush and sea myrtle (Iva frutescens and Baccharis halimifolia).
5) Fresh water impoundments built to attract water fowl.
6) Dredge fill construction since the last revision of the topographic maps.

During August of 1972, maps of all of Delaware's 115,000 acres of coastal wetlands were compiled at a scale of 1:24,000. These maps show the distribution of the six vegetation and land use classes described above (See Figure 1) and may be overlayed onto USGS topographic maps of the area. The percentage cover of each vegetation species was calculated by the GEMS computer for each of the boxed-in areas on the basis of false color enhancements made utilizing the GEMS analogue analysis capability (See Figure 2).

patches of vegetation are not distinguished from their surroundings. The tall reed grass Phragmites communis generally grows in patches too small for detection by ERTS-1 scanners and so is rarely visible in the imagery. In the industrialized northern portion of the Delaware Bay, dredge-fill operations appear to have facilitated the growth of Phragmites communis far beyond its usual limits with the result that some small marshes have become infested, often to the exclusion of other marsh plants. These marshes can be identified in ERTS-1 imagery (See Figures 3 and 8).

CONCLUSION

While ERTS-1 imagery does not appear to be applicable to detailed mapping tasks in tidal marshes due to resolution limitations, its usefulness in gross mapping and inventorying operations is evident. Complete inventories of marsh extent, dominant species distribution, and human alterations of the marsh could be performed over large areas in a very short time, making it possible to conduct such surveys frequently and at small expense.

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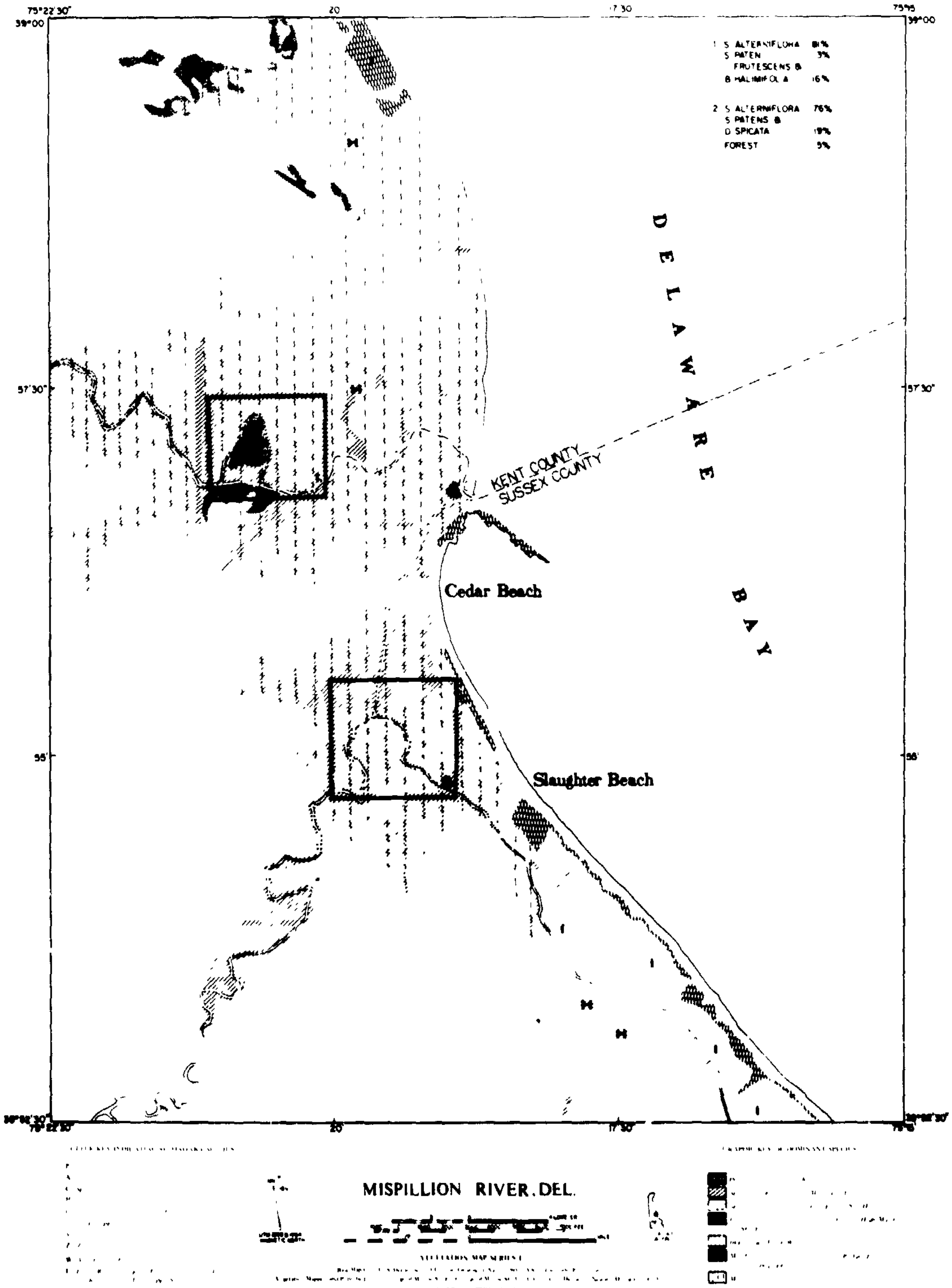

Figure 1 Overlay map of wetlands in the Mispillion River area showing four types of vegetations communities, fresh water impoundments, mosquito control ditching and marsh lost to development. Fifteen such ground truth maps were prepared, covering most of Delaware's wetlands, using NASA RB-57 imagery and multispectral analysis techniques. Note the appearance of *Phragmites communis* near developed areas. The boxed-in areas were analyzed to obtain computer print-outs of the percentages of minor vegetation species present.

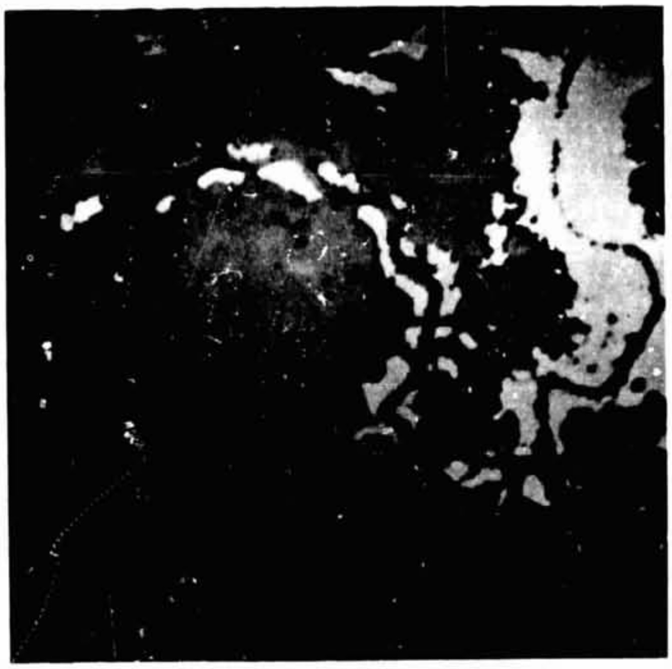

Figure 2 GEMS multispectral enhancement of area enclosed in Box #2,
Figure 1. Dark grey - Spartina alterniflora
Light grey- Spartina patens and Distichlis spicata
Black - water and upland trees.

CORRELATION OF ERTS IMAGERY

As expected, the same characteristics of coastal marshes which facilitate mapping through the use of aerial imagery and multispectral analysis also make possible the discrimination of marsh vegetation species and land use from space. ERTS-1 scanner bands 6 and 7 (.7-.8 microns and .8-1.1 microns) in images 1024-15073 and 1079-15133 (August 16 and October 10, 1973) were used to identify coastal marsh areas and to distinguish the major vegetation types within them. (See Figure 3). Areas dominated by Spartina alterniflora are clearly distinguished from those dominated by the often associated species - Spartina patens and Distichlis spicata (See Figures 3 and 4). The communities dominated by the low shrubs Iva frutescens and Baccharus halimifolia can be distinguished from adjacent communities of S. patens and D. spicata on one side and dune-beach or upland forest regimes on the other (See Figures 3 and 5). The pattern that emerges is that of the detailed topographic and tidal inundation characteristics of the marsh as seen in the horizontal zonation of those plant species sensitive to their elevation relative to mean high tide. The major tidal marsh environments and their associated plant communities may be generally identified as:

1) "Low Marsh" - Areas inundated twice daily for considerable periods of time by the high tides. Spartina alterniflora dominates in this zone.
2) "Marsh Meadow" - A transitional zone, still inundated regularly but not to as great an extent as the low marsh. In the Delaware marshes this area is dominated by Spartina patens and Distichlis spicata either individually or together.
3) "High Border" - A zone rarely reached except by the highest tides but still requiring a certain degree of salinity tolerance of its inhabitants. Thus, the name "high tide bush" given to Iva frutescens, the low shrub which, along with Baccharus halimifolia, dominates in this region. Beyond this zone is found either the beach-dune or upland forest regimes.

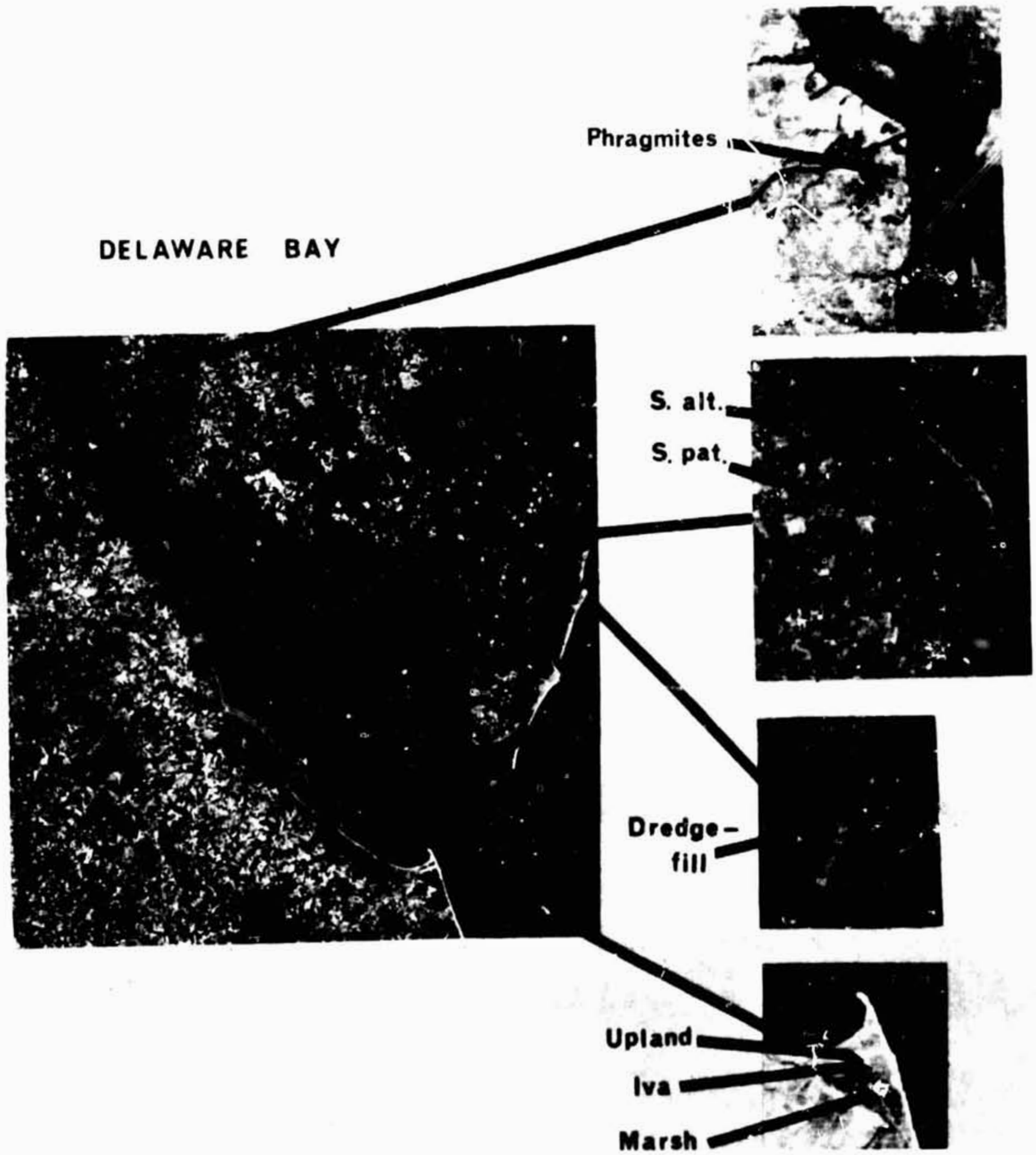
DELAWARE BAY
Phragmites
S. alt.
S. pat.
Dredge-fill
Upland
Iva
Marsh

FIGURE 3

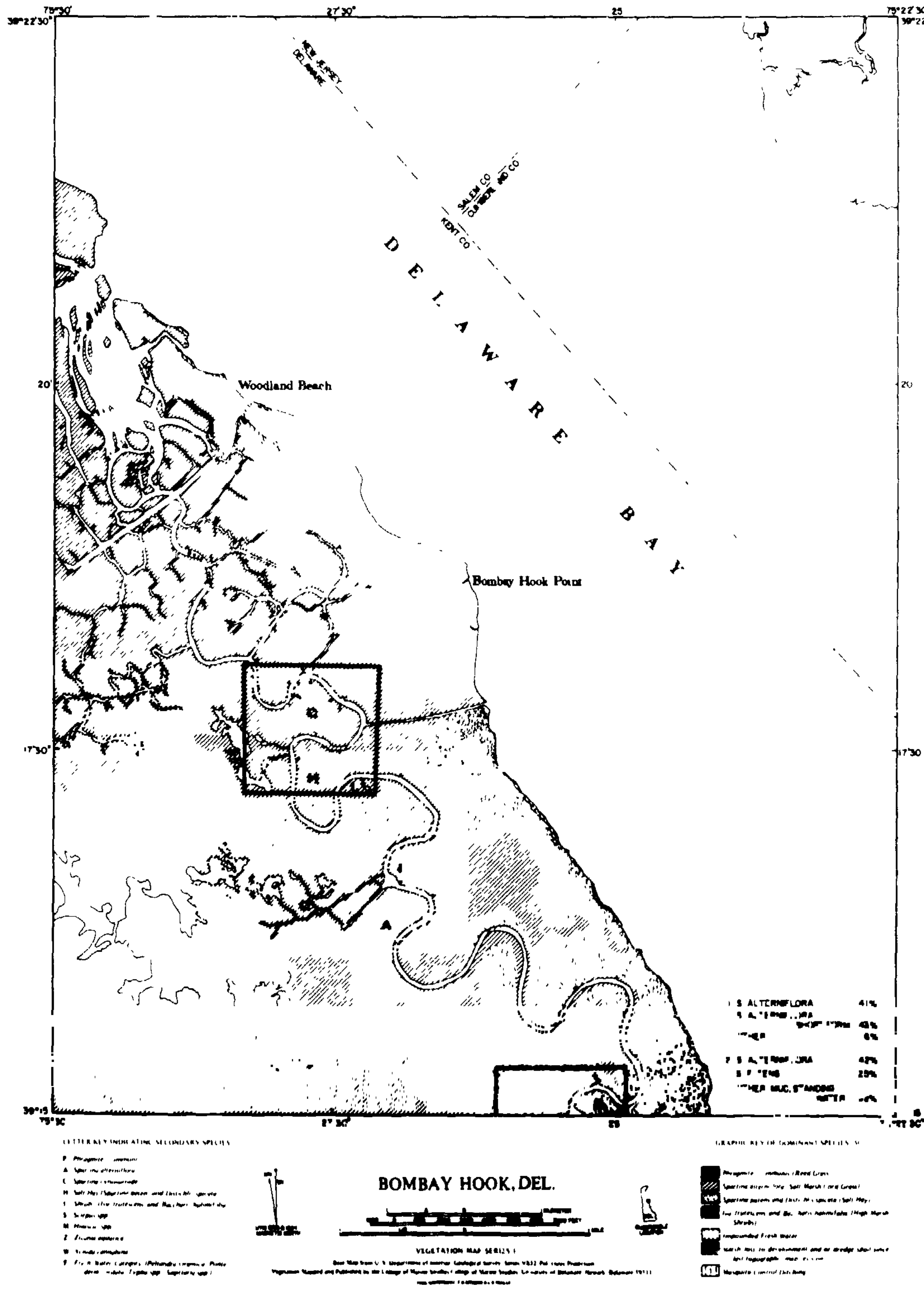

Figure 4 The large communities of Spartina alterniflora and Spartina patens shown in this map of the Bombay Hook area, can be identified in the ERTS-1 image in Figure 2.

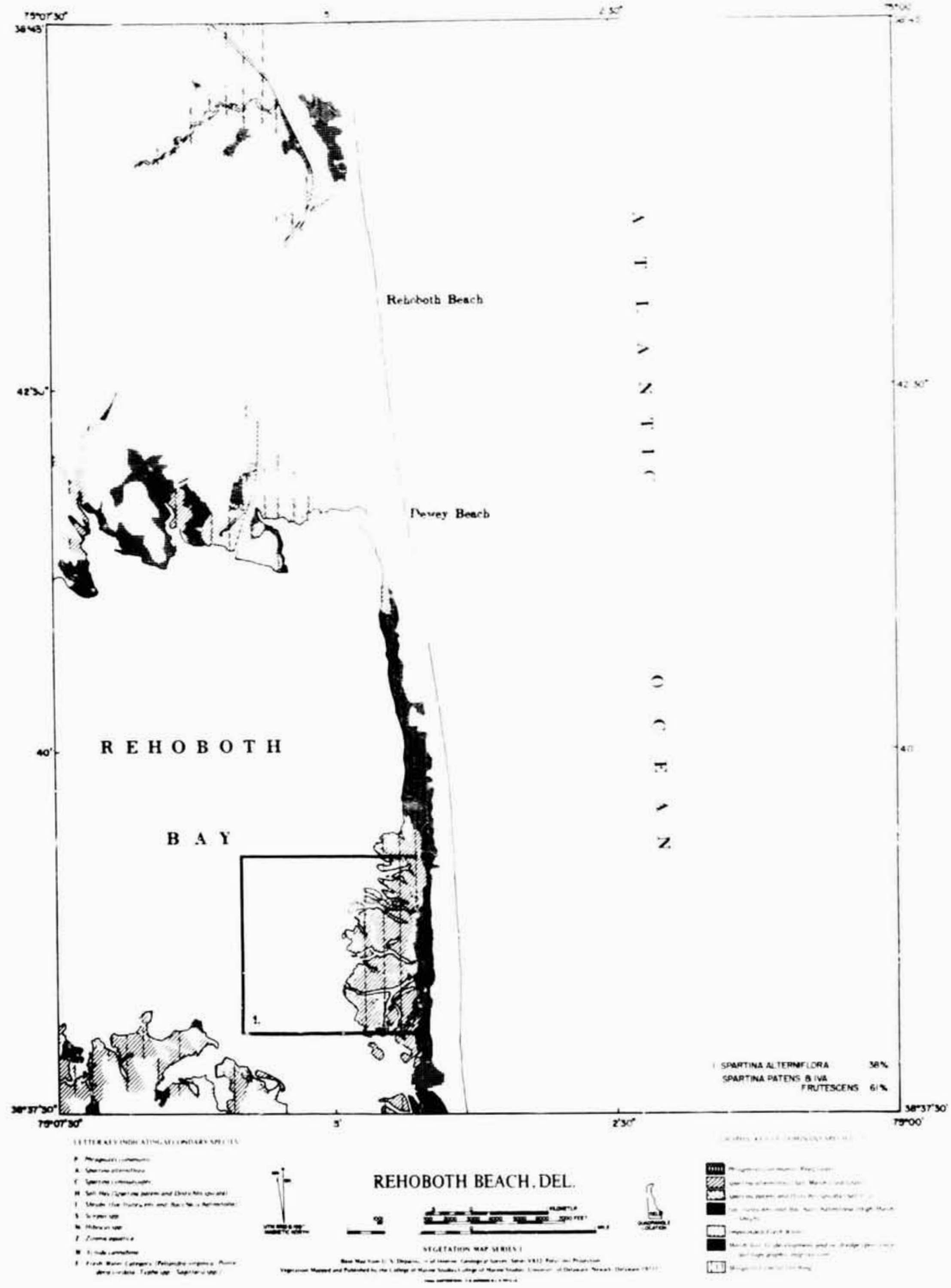

Figure 5 The strips of Iva frutescens and Baccharis halimifolia, shown in this map of the Rehoboth Beach area, can be identified in in the ERTS-1 image in Figure 2.

All three regimes are not necessarily always present but where any are found they are distinguishable from each other and from the non-marsh environments surrounding them. It should be noted that in all cases, spectral identification is a matter of relative reflectance properties, one species to another, and so ground truth is required. Identification of plant species through absolute spectral characteristics where no ground truth is available is difficult and unreliable due to atmospheric perturbations of the reflected light. Species identification becomes quite easy, however, if the interpreter has some general knowledge of the species distribution in the area of interest. Reconnaissance field work or even observations made from a light plane at low altitude is sufficient in most cases. Automated multispectral analysis performed using the General Electric Multispectral Data Processing System was found to be a useful tool in enhancing vegetation species and land use types on the basis of their spectral signatures. Delays in the acquisition of composite multispectral imagery have limited the application of this promising technique to date.

Large fresh water impoundments built to attract water fowl are readily identifiable as areas of standing water (no matter what the tidal stage) within the marsh, usually with straight, man-made boundaries (See Figure 3). Likewise, the straight boundaries and general lack of vegetation identify dredge-fill alteration of the marsh (See Figure 3). Multispectral enhancement of small portions of ERTS image I.D. 1024-15073 are shown in Figures 6 and 7. Note the clear discrimination between wetlands, uplands, sand and dredge-fill.

The major limitation of ERTS-1 imagery in surveying coastal marshes appears, not surprisingly, to be resolution. Objects or areas of vegetation must be of sufficient horizontal extent to be within the resolution capabilities of the ERTS-1 scanner. For this reason, small scale characteristics such as drainage ditching are not visible and small

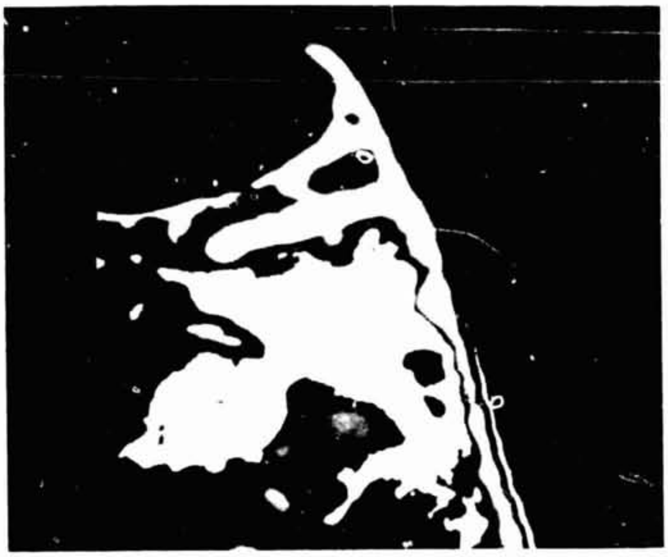

Figure 6 Multispectral enhancement of ERTS-1 image of Cape Henlopen discriminating wetlands from uplands and sand. (I.D. 1024-15073). White - wetlands dark grey - uplands light grey - sand black - water

Figure 7 Multispectral enhancement of ERTS-1 image of Stone Harbor, N.J., identifying wetlands, dredge-fill and sand. white - wetlands
light grey - adjacent to wetlands - dredge fill
darker grey in center of island - sand
black - water

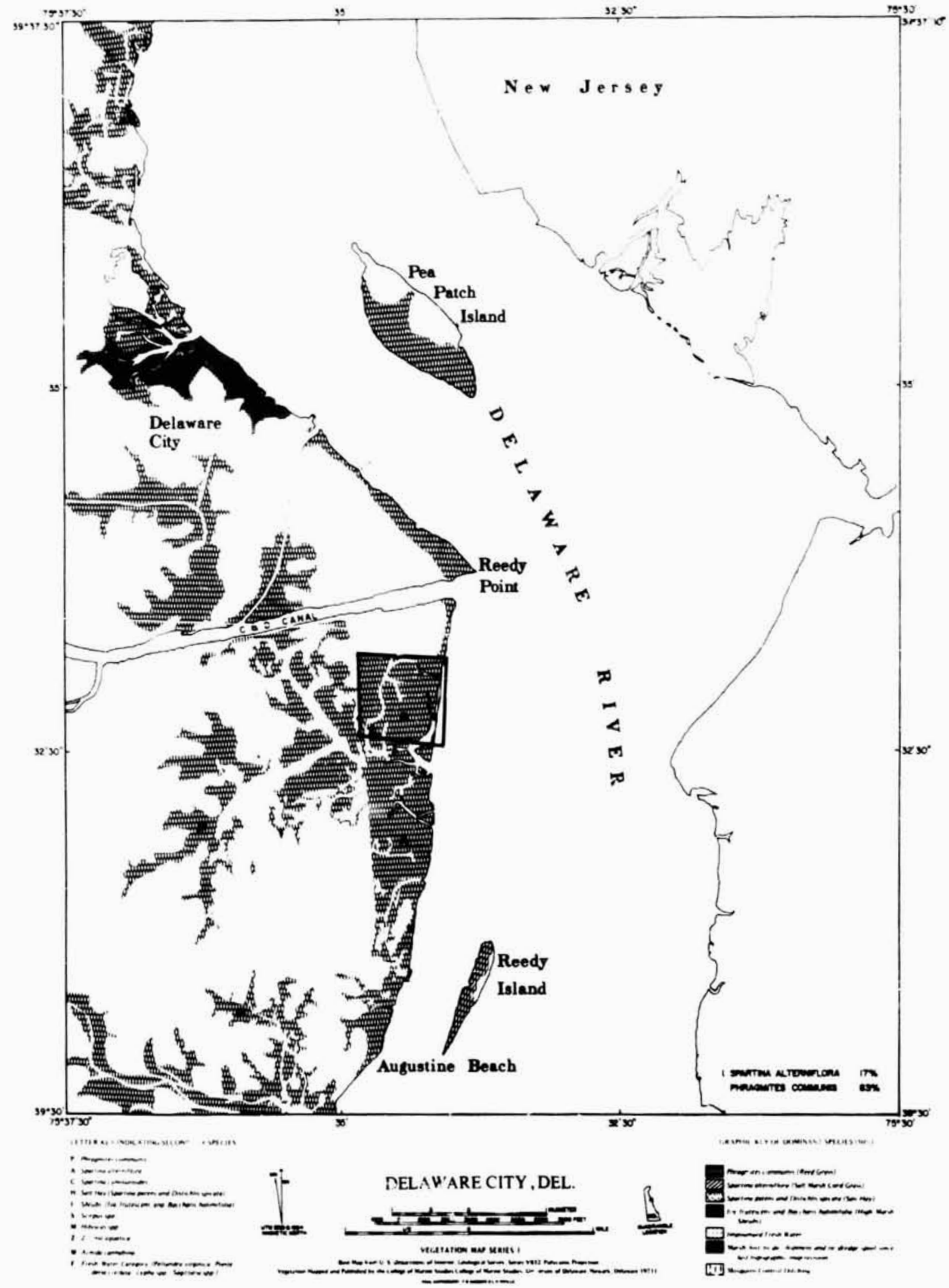

Figure 8 Heavily developed regions in northern Delaware, such as the area around Delaware City, show large concentrations of *Phragmites communis* and marshes lost to development.