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# MAPPING ATLANTIC COASTAL MARSHLANDS, MARYLAND, GEORGIA, USING ERTS-1 IMAGERY*

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## ABSTRACT

Eastern coastal marshes are the most extensive and productive in the United States. A relatively low cost, moderately accurate method is needed to map these areas for management and protection. Ground-based and low-altitude aircraft methods for mapping are time-consuming and quite expensive. The launch of NASA's Earth Resources Technology Satellite has provided an opportunity to test the feasibility of mapping wetlands using small scale imagery. The test sites selected were in Chesapeake Bay, Maryland, and Ossabaw Island, Georgia. Results of the investigation indicate that the following may be ascertained from ERTS imagery, enlarged to 1:250,000: (1) upper wetland boundary; (2) drainage pattern in the wetland; (3) plant communities such as *Spartina alterniflora*, *Spartina patens*, *Juncus roemerianus*; (4) ditching activities associated with agriculture; (5) lagooning for water-side home development. Conclusions are that ERTS will be an excellent tool for many types of coastal wetland mapping.

## INTRODUCTION

Eastern coastal areas are receiving increasing pressure from a variety of sources, mainly due to population growth. The northeastern coast is under the most pressure at the present time, but laws regulating development have been passed in several of the states. The southeastern coastline (except Florida) has had less developmental pressure, mainly from agriculture and some industry. Dredge and fill operations have altered some portions of the coastline. The prognosis is for a tremendous increase in pressure in this area during the next decade. Laws regulating development are helpful but usually require costly mapping of coastal resources. A relatively low cost and moderately accurate method for mapping these areas, including wetlands, mud flats, drainage patterns, impact of man and vegetation productivity would be very attractive to states and assure that at least a portion of this valuable ecosystem would be preserved.

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Investigators such as Anderson (1) and Reimold (3) have shown the reliability of using aircraft remote sensing techniques to do a variety of wetlands studies, including species mapping and vegetation productivity. Ground based ecological studies in wetlands have produced maps of relatively small areas with a high degree of accuracy. These have been valuable in developing remote sensing techniques but the process is too slow and costly for large areas. Low altitude (2,000 meters) aerial photography has been applied in New Jersey to produce wetland maps which meet national map accuracy standards. This is a relatively rapid method, but the cost may be prohibitive for some states. In order to decrease the time and cost involved in wetland mapping, it will be necessary to reduce the accuracy somewhat. It appears from this research that ERTS-1 data may be applied to rapid, relatively low cost wetland mapping on broad regional scales.

ERTS positive transparencies at a scale of 1:1,000,000 have high resolution and excellent contrast. Unfortunately, processing procedures at Goddard Space Flight Center favor the more highly reflective, upland features. Due to the high moisture content in marshlands, reflectance values are lower and are quite dark on all ERTS MSS bands. Special processing is required to bring out detail in coastal features. Detail in uplands is lost when optimum processing techniques for coastal areas are used.

The marsh-water interface and the upper wetland boundary are clearly seen on MSS bands 6 and 7. Large plant associations or communities can also be detected on either MSS band 7 or on color composites made using the Diazo subtractive color technique. In bands 4 and 5 (visible: green and red), all marsh species have a low overall average reflectance and appear very dark in tone as does the dryland vegetation. As the coastal marshes become fresher, the spectral reflectance of the species composing these marshes is higher and approaches that of dryland vegetation making the boundary less clear. It may be necessary to develop special processing techniques where wetland grades to dryland in order to clearly define this boundary.

## CHARACTERISTICS OF THE TEST SITES

Figure 1 is a map of the Chesapeake Bay area showing the location of the northern test sites. The smaller areas outlined are two test areas examined in detail in the following pages. Area 1 is a salt marsh complex located at the mouth of the Chincoteague Bay in Virginia. Area 2 is a large, near-saline marsh at the mouth of the Nanticoke River in Dorchester County, Maryland. Maryland has approximately 300,000 acres of wetlands, 250,000 of which lie on the Eastern Shore, or what is commonly called the Delmarva Peninsula. Virginia has approximately 330,000 acres of wetlands, over half of which also lie on the Delmarva Peninsula.

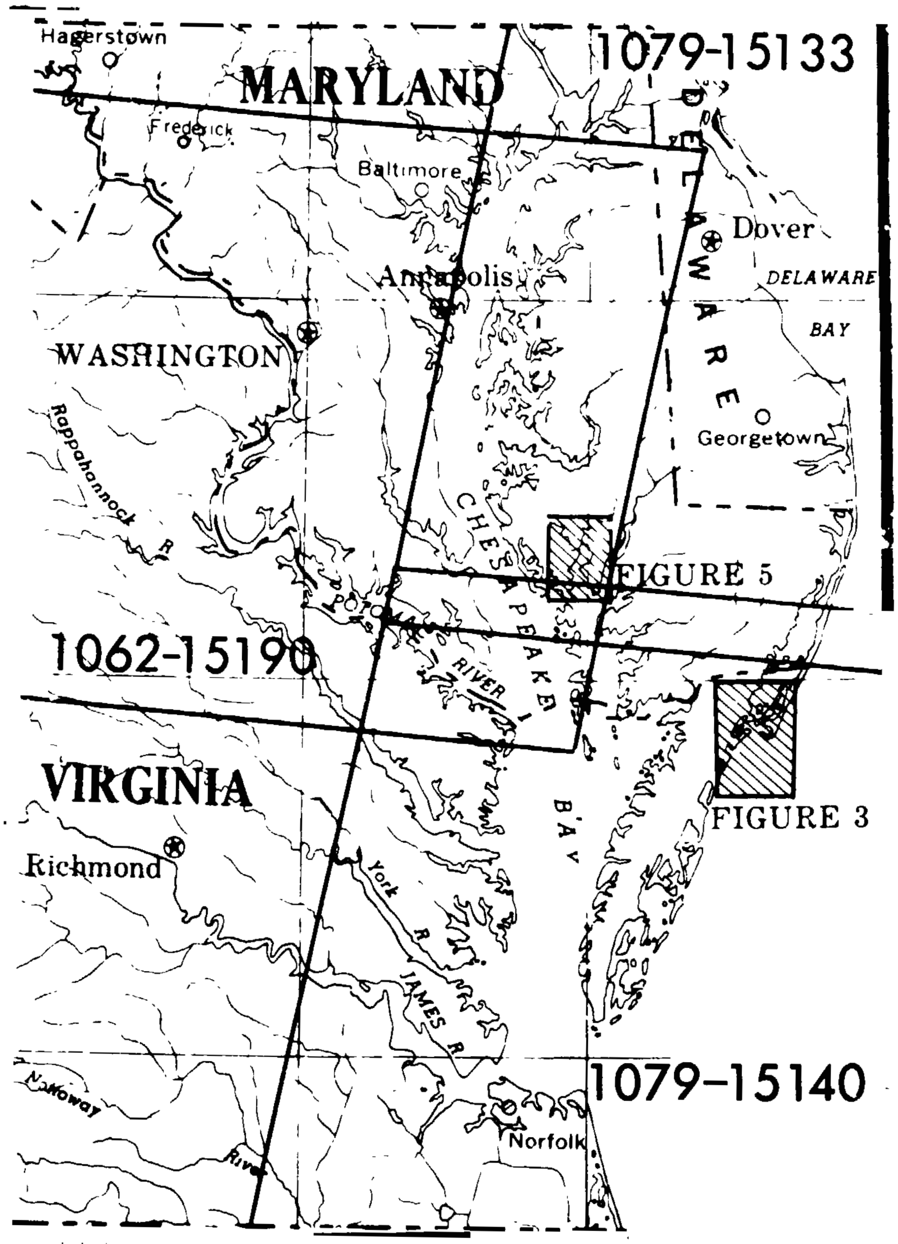


Fig. 1. Map of Chesapeake Bay area showing location of ERTS images (1079-15133, 1062-15190, 1079-15140) and smaller test areas 1 (Fig. 3 - Chincoteague marsh) and 2 (Fig. 5 - Nanticoke marsh).

The coastal marshes from North Carolina and southward represent the best development of saline marshes in the United States. Those in South Carolina and Georgia (the southern test site) are particularly well developed (Fig. 2). Cooper (2) has summarized the current knowledge of eastern coastal areas. Vegetational composition is quite similar along most of the coast but grades to mangrove swamps in Florida. Tidal amplitudes vary from two feet in some portions of North Carolina to eight feet in South Carolina and Georgia.

The two major community types which dominate the marshes of this area are *Spartina alterniflora* and *Juncus roemerianus*. These species are restricted to areas with frequent tidal inundation. *S. alterniflora* occurs as at least two and in some areas three growth forms. This is apparently related to tidal inundation and soil aeration. High growth (to 2 meters) is found along the banks of creeks where the substratum is very soft and tidal inundation is for the longest period of time. The next growth form (to 1 meter) grows at slightly higher elevations in a more firm substrate. The third growth type (less than 1 meter) is at the highest elevation for *S. alterniflora* in a firm substrate where other species may mix with it occasionally. *Juncus roemerianus* occurs as small to large zones mostly at the next highest elevation and where the water is somewhat fresher.

Higher, less frequently tidally inundated portions of these marshes contain several species which grow as mixed communities or in relatively small single species zones. These include *Spartina patens* and *Spartina cynosuroides*, *Distichlis spicata*, *Baccharis halimifolia* and *Borrichia frutescens*.

The specific southern test site was bordered on the south by Saint Catherine's Island, Georgia, and on the north by Charleston, South Carolina. The southern portion of the test site around Ossabaw Island, Georgia, was studied intensively due to the availability of good ERTS imagery.

The vegetation of this area is characteristic of the southern coastline in general. There are large zones of high and low growth *S. alterniflora* and *J. roemerianus*, and smaller zones of *S. cynosuroides*, *B. frutescens* and *S. patens*. There is marshland ditching in Ogeechee River related to agriculture and "lagooning" for water-side homes on the Vernon River.

## RESULTS

### A. Northern test site

Use of a Bausch and Lomb Transfer Scope in combination with 1:1,000,000 scale ERTS format permits enlargement of the image and

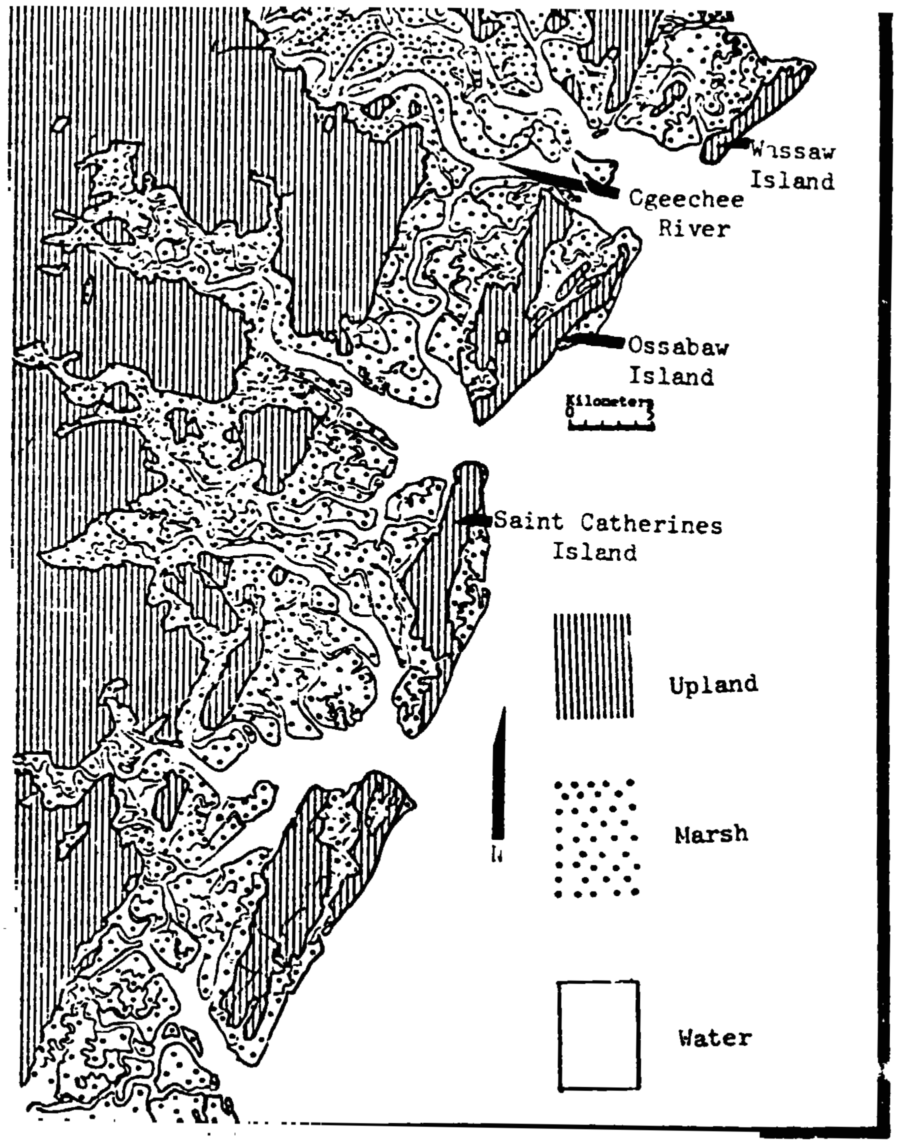


Fig. 2. Map of portion of Georgia coastline showing areas of intensive analysis.

and construction of maps and overlays to a scale of 1:250,000. Figure 3 is a 1:250,000 enlargement of an ERTS MSS 7 (1079-15140) image of the Chincoteague salt marsh complex. Figure 4 is a 1:250,000 map of the same area showing four categories; (1) upland vegetation and beach, (2) water, (3) Spartina alterniflora/Salicornia sp. association, and (4) Spartina patens/Distichlis spicata/Iva frutescens association. The spectral reflectance of the Spartina alterniflora/Salicornia sp. association is generally low, in part because of the wet mud or peat background below the vertically oriented vegetated layer which averages 7-14 inches in height. The reflectance of the mudflats and water in this band is still less. The relatively high reflectance of Spartina patens permits sufficiently large areas of the Spartina patens/Distichlis spicata/Iva frutescens association to be delineated. The upper wetland boundary is generally sharp except where broad transition zones exist. The marsh-water interface is sometimes difficult to determine in areas interlaced with numerous small tributaries or sparse patches of vegetation. Sand and marsh at the mouth of Chincoteague Bay (Figure 3: A) are not shown on the USGS 1:250,000 map published in 1966. Area C is a recent spoil fill at the tip of Chincoteague Island. Spoil areas may be easily separated from reflective vegetation by referring to bands 4 and 5 or by using a color composite since they are highly reflective in all four bands. Areas labeled D are fresh water impoundments in the Chincoteague Wildlife Refuge. The striped area at the south end of the map (B) is an area where old spoil banks are partially revegetated. It is quite distinctive in the band 7 image as a light area extending from Wallops Island to the mainland.

Figure 5 is a 1:250,000 scale enlargement of the Nanticoke marsh (MSS band 7, ERTS image 1079-15133). Species composition in this marsh is typical of a near-saline environment. The marsh area shown here is approximately 10 miles long and 5 miles wide. Figure 6 is a 1:250,000 map of the same area made by overlaying the 1:1,000,000 scale image enlarged with an overhead projector. A number of tree islands dot the marsh, the largest of which contains the small community of Elliots' Island. The marsh vegetation includes a Juncus roemarianus/Scirpus sp./Spartina alterniflora association in the lower marsh areas and a high marsh community, Spartina patens/Distichlis spicata/Iva frutescens/Baccharis halimifolia, primarily located along the edges and near the single road. Toward the northern end of the marsh, the water becomes more brackish and less saline. Stands of Spartina cynosuroides occupy the stream margins within this portion of the marsh. Isolated stands of Phragmites communis occur, but they are generally too small to be detected on the ERTS imagery. Because the signature of the dominant low marsh species Juncus roemarianus is close to that of water, it is difficult to delineate the marsh-water interface within the marsh itself.

Mapping at a scale of 1:250,000 is adequate for the general delineation of large marshes and for rather gross plant species associations. Enlargement of the imagery to a scale of 1:125,000 provides

Fig. 3. 1:250,000 enlargement of Chincoteague salt marsh (1079-15140-7).

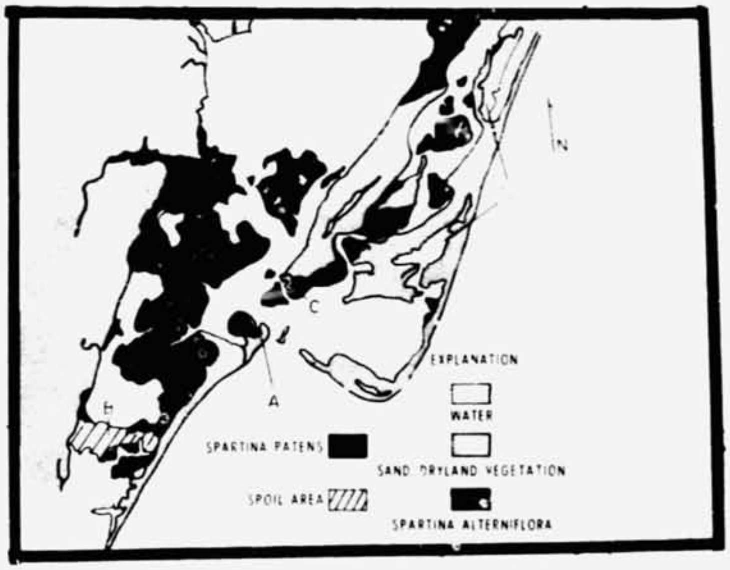


Fig. 4. 1:250,000 map of Chincoteague salt marsh. A - sand/marsh area; B - old spoil area; C - recent spoil fill; D - fresh water impoundment.

Fig. 5. 1:250,000 enlargement of Nanticoke R. salt marsh (1062-15190-7).

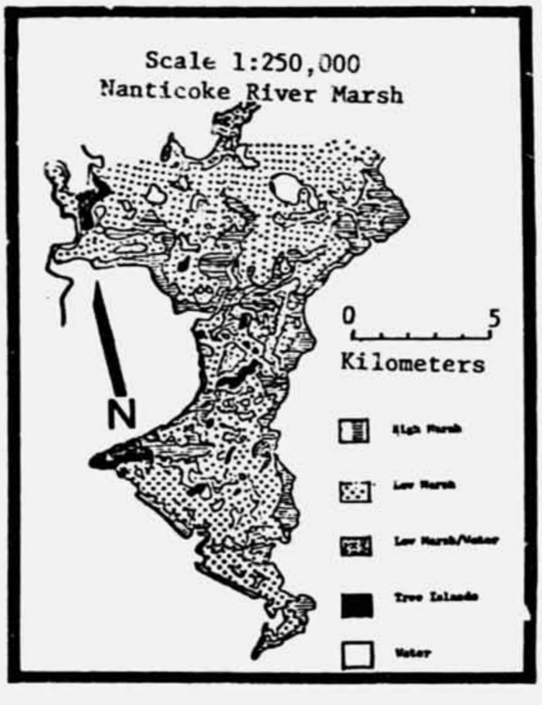


Fig. 6. 1:250,000 map of Nanticoke River marsh.

additional information when processing is done to enhance the contrast in the denser part of the image. Overlays can be made directly from the prints which show the marsh-water interface and upper wetland boundary clearly. Where broad successional zones exist, these can also be mapped. Smaller plant communities, occasionally less than 25 meters in diameter, can be identified. In addition, open and vegetated ditches dug for drainage or agriculture can be recognized and indicated on the map.

The Nanticoke marsh was experimentally enlarged from the 1:1,000,000 scale to approximately 1:24,000. All the boundaries seen in the other scales became blurred. It appears that unless the optics of the enlarging system are exceptionally good, this scale would only be useful for theme extractions such as upland, dry marsh, wetmarsh and open water where placing of boundaries is not critical.

B. Southern test site

Figure 7 is a 1:250,000 scale reprocessed enlargement of MSS band 7 (No. 1046-15324, Sept. 7, 1972) of the test site. Note good tonal differentiation in the coastal marshland but loss of detail in the upland. The upper wetland boundary is clearly seen in most of the image although patchy clouds may be mistaken for upland or tree islands in the marsh. Lagooning for water-side home development is visible near Burnside, Georgia, on the Vernon River. Of possible greater significance is the marshland ditching visible in the Fort McAllister area of the Ogeechee River. Ditching causes drying out and accelerates vegetational succession to dryland species and is therefore undesirable as currently practiced for mosquito control and agriculture in many areas. It has been assumed that the resolutional limitation of ERTS imagery would not allow definition of ditching practices. At least in this area that assumption was incorrect.

Various vegetational features are also clearly shown. Tonal characteristics of marshland vegetation in Ogeechee River are considerably different from the nearby Medway River. On the ground investigations have shown that Juncus roemerianus is the dominant vegetation in the Red Bird Creek area. The lighter tones of this species contrast nicely with the darker tones of Spartina alterniflora which makes up the bulk of the vegetation in Medway River.

Tonal structure in the Bear River marshes indicate that separation of at least two growth forms of S. alterniflora will be possible. The tall form along the creeks images lighter than the shorter forms. It appears that gross productivity estimates may be made from the imagery. The lightest tones in these marshes are at the "loop" in the Ogeechee River (Spartina cynosuroides) and off Kilkenny Creek near Belle Island (mixed populations of Borrichia frutescens and Spartina alterniflora on slightly elevated ground).


Fig. 7. ERTS image, Band 7, enlarged to 1:250,000 scale. A - "lagooning" for water-side homes; B - wetland ditching with Spartina cynosuroides; C - zone of Juncus roemerianus; D - Spartina alterniflora high growth form along creek edges (interior dark areas are low growth form of this species); E - berm with Spartina alterniflora and Borrichia frutescens; F - upland-wetland border.

## CONCLUSIONS

ERTS-1 imagery (enlarged to 1:250,000) is an excellent tool by which large area coastal marshland mapping may be undertaken. If states can sacrifice some accuracy (amount unknown at this time) in placing of boundary lines, the technique may be used to do the following:

(1) Estimate extent of man's impact on marshes by ditching and lagooning.

(2) Place boundaries between wetland and upland and hence estimate amount of coastal marshland remaining in the state.

(3) Distinguish among relatively large zones of various plant species including high and low growth S. alterniflora J. roemerianus, and S. cynosuroides.

(4) Estimate marsh plant species productivity.

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