

COASTAL VEGETATION OF DELAWARE

Coastal Vegetation of Delaware, the Mapping of Delaware's Coastal Marshes. June 1973; DEL-SG-15-73; College of Marine Studies, University of Delaware, Newark, Delaware, 1971; This work is partially a result of research sponsored by NOAA Office of Sea Grant, Department of Commerce, under Grant No. 2-35223.

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COASTAL VEGETATION OF DELAWARE

**The Mapping of Delaware's Coastal
Marshes**

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University of Delaware**

March, 1973

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INTRODUCTION

The commitments to environmentally sound coastal land management that have been generated in federal and state governments over the past few years have produced a demand for accurate and complete bodies of scientific data on which to base policy decisions. Coastal wetlands in particular have been the subject of much controversy and litigation, and the lack of survey-type information over broad areas of wetland is apparent. Accurate maps showing the boundaries of tidal wetlands are required for the enforcement of existing coastal zoning laws, while more detailed information about tidal marsh environments is necessary if more comprehensive zoning is to be formulated in the future. For this reason a baseline mapping project was undertaken in Delaware's coastal wetlands as a prelude to an evaluation of the relative value of different parcels of marsh and the setting of priorities for use of these marshes.

In view of severe limitations of time and manpower, the mapping approach used relied heavily on aerial photography and multispectral analysis, utilizing conventional ground reconnaissance only to aid and check the photo-interpretation. Work such as that of Kolipinski¹, Garvin², Wobber³, and others has shown that multispectral image analysis can significantly help, yet not replace, the human interpreter. Suitable imagery from NASA and other sources was available, and access to General Electric's Multispectral Data Processing System was obtained.

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. The uniform flatness of marsh topography eliminates variations in reflectance due to sloping surfaces and shadows. The most common marsh plant species are few in number, thus simplifying photo-interpretation. 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. Finally, the major plant species are different enough in their morphologies to have distinct reflectance characteristics, particularly in the near-infrared portion of the spectrum. The net result is that multispectral imagery can be used to make detailed wetlands maps showing vegetation growth patterns which are related to local environmental factors.

DESCRIPTION OF DELAWARE'S WETLANDS

There are approximately 115,000 acres of tidal wetland in the state of Delaware, forming an almost continuous band along the western shore of Delaware Bay from Cape Henlopen north to Wilmington.⁴ The width of this band varies from a few hundred yards to three to four miles with an average width on the order of one mile. In addition, there are small fringes of marsh associated with the barrier beach-lagoon complexes along the Atlantic Shore in the southern portion of the state. The most abundant plant species found in the marshes are salt marsh cord grass (*Spartina alterniflora*), salt marsh hay (*Spartina patens*), spike grass (*Distichlis spicata*), reed grass (*Phragmites communis*), high tide bush (*Iva frutescens*), and sea myrtle (*Baccharis halimifolia*). There are, of course, many other species present but in most cases their occurrence is limited to small patches scattered within areas dominated by one or more of the above-mentioned primary species.

As previously stated, the major species display distinct morphologies allowing them to be distinguished from one another on the basis of reflectance characteristics. A brief description of the preferred environments, morphology and resulting reflectance of each species category follows.⁵

Major Categories:

1. *Spartina alterniflora* (Salt marsh cord grass).

The dominant marsh grass species of the Eastern United States, *S. alterniflora*, occupies the low or wettest portion of the marsh. Two ecotypes are distinguished in Delaware: a tall form which inhabits the borders of the tidal creeks and drainage ditches, and a short form found over great expanses of the remaining low marsh areas.⁷ The narrow stalks and leaves of *Spartina alterniflora* provide a relatively sparse reflecting surface when viewed from above with the result that this species appears darker than the other major species in color infrared imagery. (See Figure 2.) The tall form provides a slightly more dense reflecting surface than the short form, allowing discrimination of the two ecotypes.

2. *Spartina patens* and *Distichlis spicata* (Salt marsh hay and spike grass).

These two species occupy areas of marsh topographically higher than those occupied by *Spartina alterniflora*. Although short with thin stems, both species grow in a very dense mat which produces high reflectance in the infrared. (See Figure 2.) Often, but not always, the two species are found together and are indistinguishable on color infrared imagery. Because they appear to occupy very similar environmental niches, the two species are lumped together into one category.

3. *Phragmites communis* (Reed grass).

Naturally found in small patches on mounds and other topographic highs within the marsh, *Phragmites* now occupies extensive areas where artificial filling or drainage has produced a suitable environment. Growing up to ten feet high with broad leaves, *Phragmites* has the highest reflectance of any of the marsh grasses and thus appears lightest on the photos.

4. *Iva frutescens* and *Baccharis halimifolia* (High tide bush and sea myrtle).

These low shrubs are generally found in a narrow band just above the reach of the highest tides. They are frequently found together, and their broad leaves and sparse growth pattern combine to give them distinct reflectance characteristics in the infrared.

5. Fresh water impoundments.

Built to attract ducks and other water fowl, these areas are generally identified by their straight, artificial boundaries and the continuous presence of standing water. They contain many fresh water plants including species of *Peltandra* (Arrow arum), *Typha* (Cattail), *Pontederia*, and *Sagittaria* (Arrowhead).

It should be noted that these groups were identified on the basis of reflectance in three color bands (green, red and infrared) and not simply in the infrared as might be inferred from the general descriptions above.

MAPPING APPROACH

The primary imagery used in compiling vegetation maps was obtained by a NASA RB-57 aircraft in September of 1970 (Mission 144, Site 244). Of the various types of imagery available from Mission 144, it was decided that nine-inch color infrared photos would provide optimal discrimination of vegetation types. Visual interpretation was performed on color infrared prints obtained with a Zeiss RMK 30/23 camera at a scale of 1:60,000. (See Figure 2.) For automated analysis it was found that color infrared transparencies taken with a Wild Heerbrug RC-8 camera at 1:120,000 scale had better light characteristics and thus yielded better results despite the larger scale. Resolution in these high altitude photographs was sufficient to produce first generation vegetation maps registered onto U.S.G.S. topographic maps at a scale of 1:24,000 and for more detailed automated pattern recognition at considerably smaller scales. A more detailed second generation set of maps is being compiled from low altitude (11,500 feet) NASA imagery obtained in August, 1972.

To collect ground truth for the interpretation of the NASA photographs, visits to field sites on foot and by small boat were carried out throughout the summer of 1972. In addition, low altitude aerial photography was obtained from light planes. Taken from altitudes of 500 to 2,000 feet, this imagery was sufficiently detailed for easy identification of major plant communities and thus provided ground truth over larger areas than it was possible to obtain on foot or by boat. In some areas detailed field work, including measured transects, was used as a check of automated pattern recognition capabilities.

The classification scheme used in mapping developed naturally from the structure of the marsh plant communities and from the discrimination capability of the imagery used. Therefore, the five major categories described not only represent the dominant species and communities present in the marshes of Delaware, but also are the vegetation types which are most readily discriminated in the imagery used for interpretation.

In areas where a significant amount of another species than that shown as predominant in the NASA imagery was present, this is noted on the maps by capital letters. These were identified by field observation, although further studies may show that some such associations can be identified from aerial imagery.

In addition, mapping categories were established for areas ditched for mosquito control, and for marsh areas lost to dredge-fill operations after the most recent revision of the U.S.G.S. topographic maps. Marshes lost to development were easily identified on NASA imagery while Department of Agriculture photos at a scale of 1:20,000 (See Figure 3) were used to delineate ditched areas.

AUTOMATED ANALYSIS

While the discrimination and mapping of gross vegetation features are most readily accomplished by a human interpreter, detailed interpretation can benefit from the use of automated multispectral analysis. Such automated analysis was performed utilizing the General Electric Multispectral Data Processing System (GEMSDPS), which is an analogue-digital hybrid designed as an analysis tool to be used by a human operator and benefit from his observations.⁶

This accurate and highly flexible system has been designed to allow the operator to adjust the signature analyzer and other processing units for optimum discrimination and to see the results of these adjustments immediately. He can thus very rapidly combine his knowledge of the scene gained in the field with precise, unbiased electronic analysis and thereby measure the spectral characteristics of a region of any size in the scene; he can search the scene for regions with similar characteristics and read out the percentage of the total scene occupied by areas with the specified spectral signature. By repeating the same procedure for other areas in the scene, the operator can quickly produce a composite photo-map enhancing all of the spectrally classified areas of interest.

MAPS OF DELAWARE'S WETLANDS

The fifteen maps of Delaware's coastal zone which follow were prepared to show the dominant species or groups of species of vegetation present. Five such categories of vegetation are used indicating marshes dominated by 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 and *Baccharis halimifolia*), and 5) a group of fresh water species found in impounded areas built to attract water fowl. In addition, major secondary species are indicated where appropriate. Multispectral analysis and enhancement were performed on selected areas thought to be representative of the relative species abundance and growth patterns present in the surrounding marsh. The enhancements themselves, then, are small-scale inserts designed to supplement the generalized vegetation maps by showing detailed growth patterns and the relative abundance, in percentages of each species present. Figure 3b, for example, is an enhancement of the area enclosed by box #1 on the Little Creek quadrangle. Zonation of different vegetation species which could not be displayed on the large scale map is shown with *Spartina alterniflora* forming an outer fringe and *Spartina patens* occupying the higher, center portion of marsh. The original maps were at a scale of 1:24,000 registered to U.S.G.S. topographic and soil maps. Inserts show those areas which were automatically analyzed, and the results of that analysis, providing a general picture of Delaware's coastal vegetation and a detailed description of selected marsh areas.

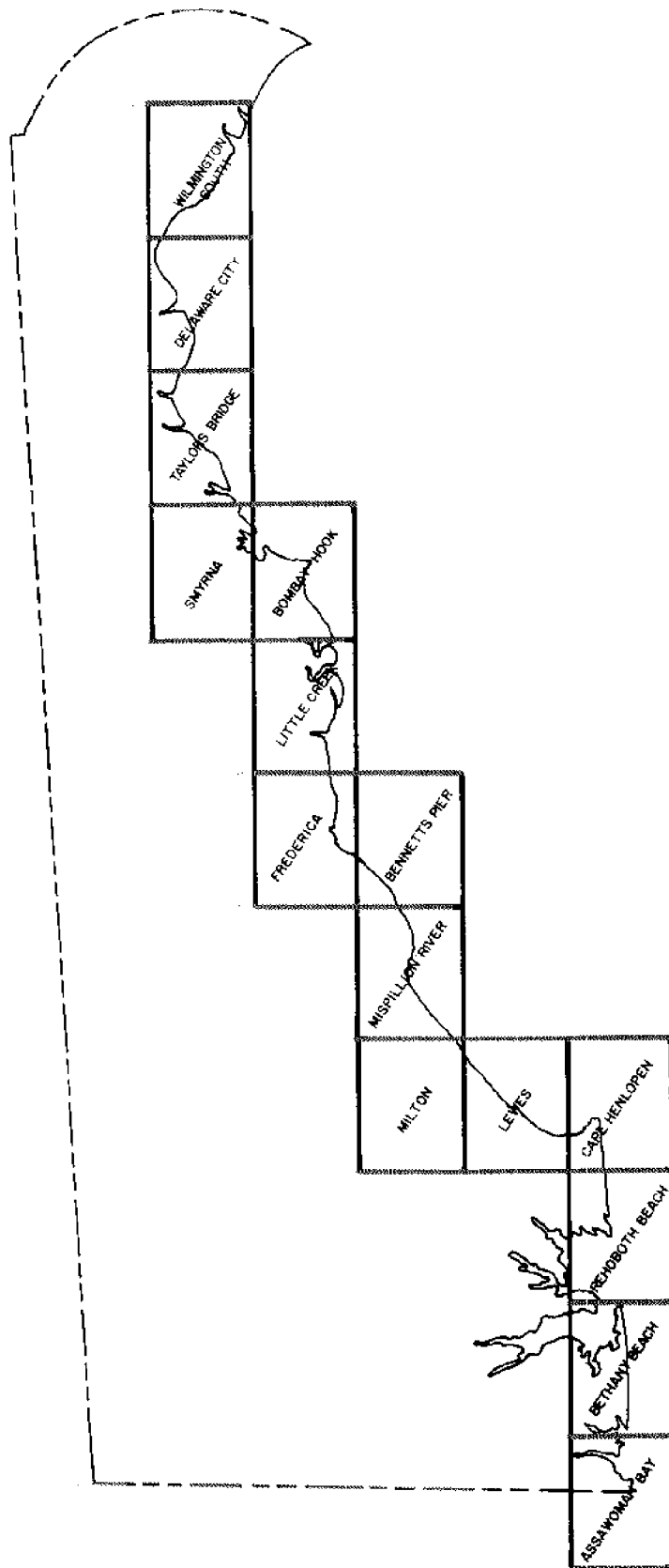
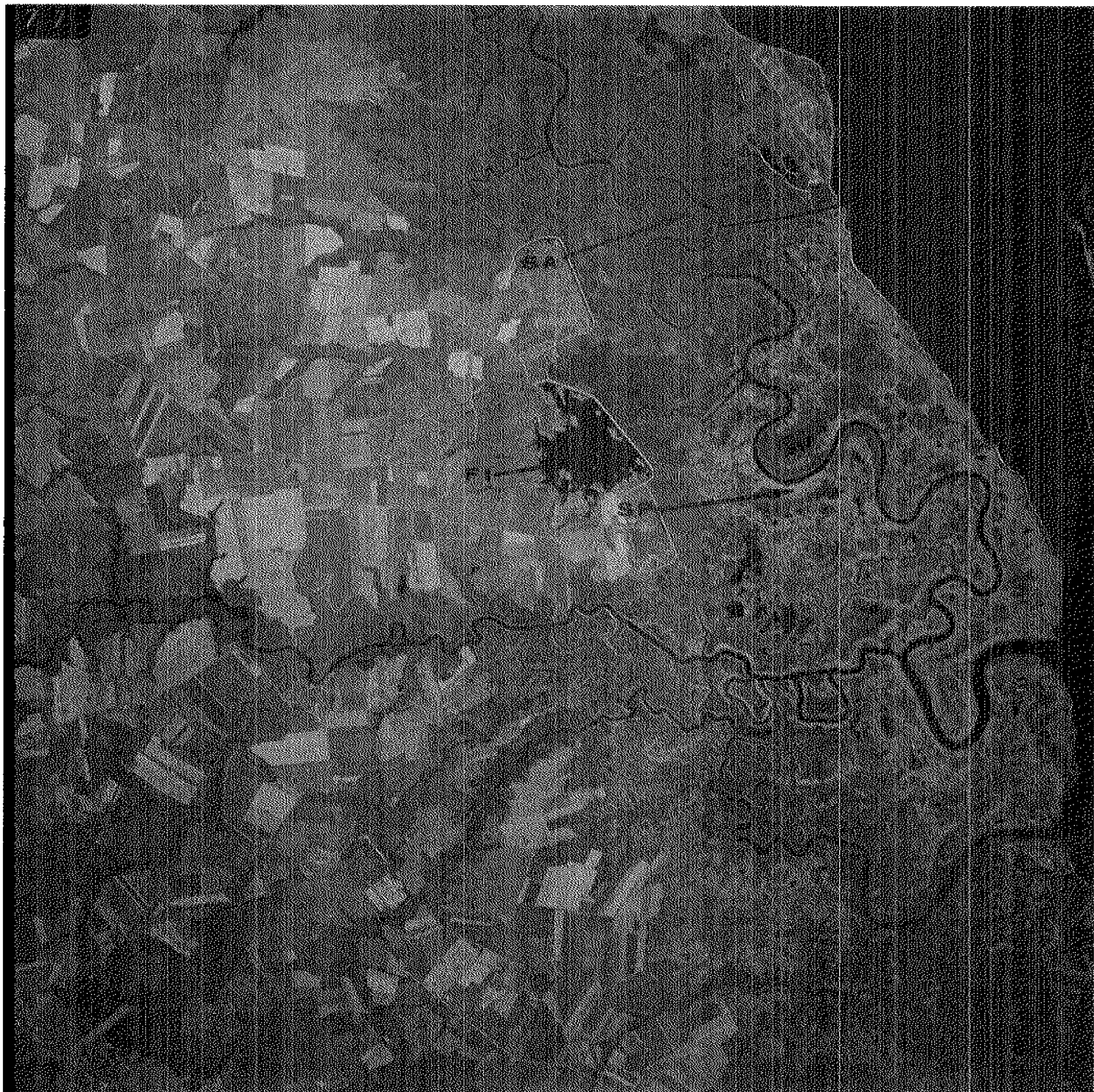


FIGURE 1

Index Map Showing
Map Quadrangles

FIGURE 2



Sample NASA-RB-57 Color-infrared Photograph

Original size 9" x 9"
Original scale 1:60,000

- SA - *Spartina alterniflora*
- SP - *Spartina patens*
- F1 - Fresh water impoundment

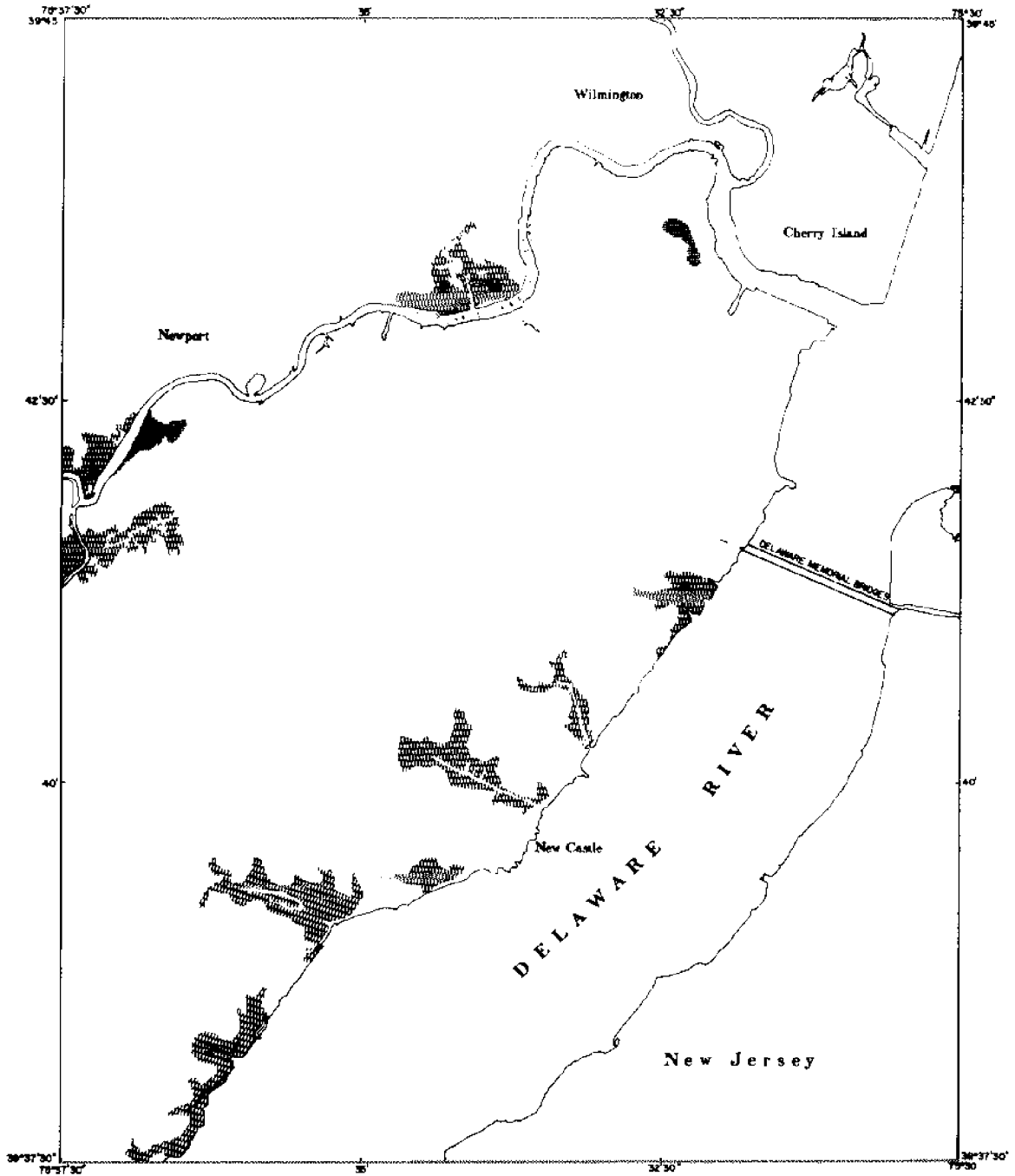


FIGURE 3

Sample: Black and White Dept. of Agriculture Photo

Original size 9" x 9"

Original scale 1:20,000

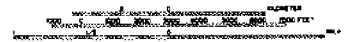


LETTER KEY INDICATING SECONDARY SPECIES

- P. *Phragmites communis*
- A. *Spartina alterniflora*
- C. *Spartina cynosuroides*
- H. *Spartina patens* and *Distichlis spicata*
- I. *Spartina patens* and *Distichlis spicata*
- J. *Spartina patens*
- M. *Muhlenbergia*
- T. *Typha sp.*
- H. *Arundo donax*
- F. *Fragaria virginiana*, *Trifolium repens*, *Trifolium pratense*, *Trifolium repens*



WILMINGTON SOUTH, DEL.

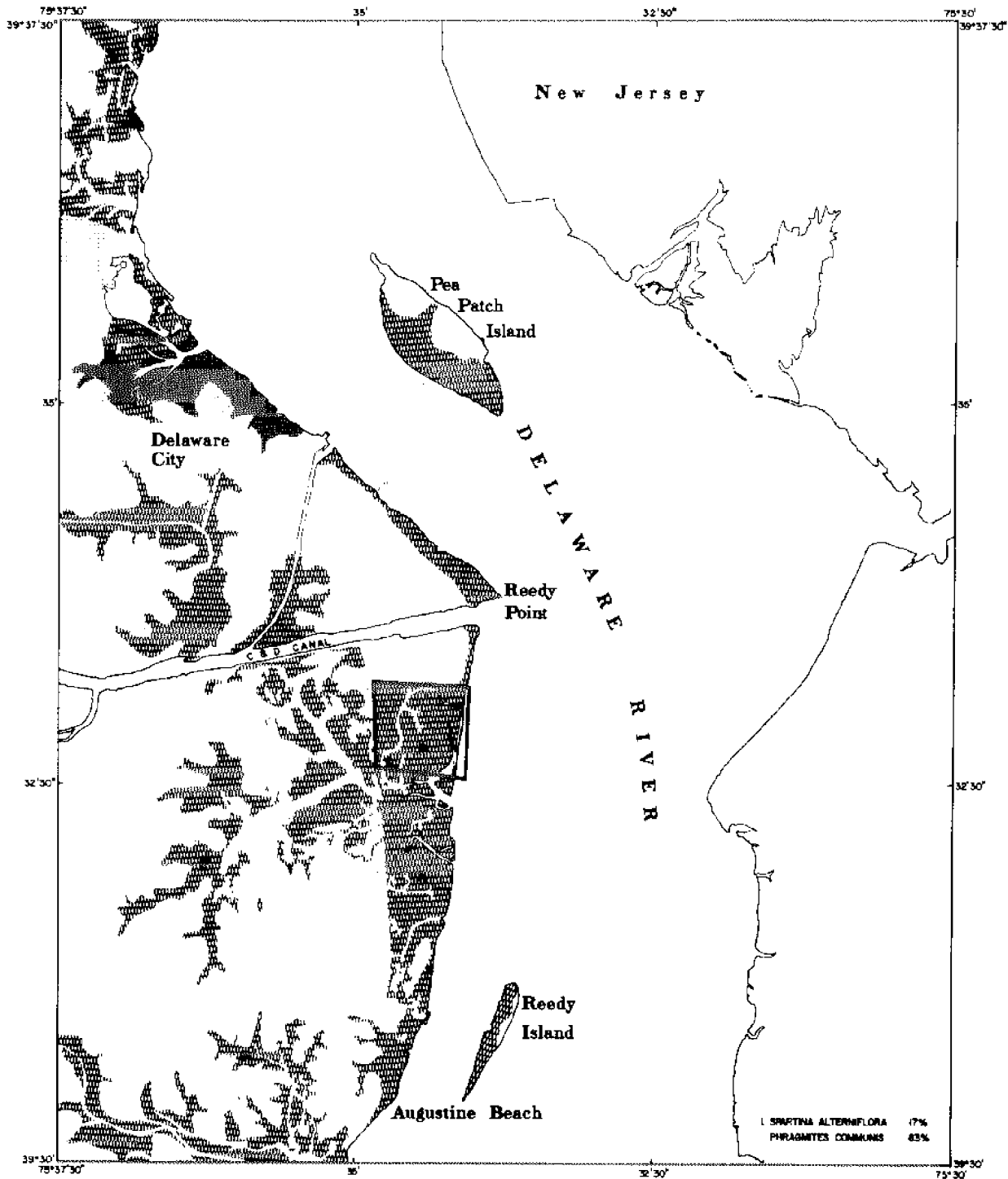


VEGETATION MAP SERIES I

Map No. 1012, a Department of Natural Resources, Delaware, Series I, Plantation, Plantation
 Vegetation Map and published by the College of Marine Studies, University of Delaware, Newark, Delaware 1971
 www.dnr.state.de.us

LETTER KEY INDICATING SPECIES

- *Spartina alterniflora* (Panicum)
- *Spartina patens* (Panicum)
- *Spartina cynosuroides* (Panicum)
- *Spartina patens* and *Distichlis spicata* (Panicum)
- *Spartina patens* (Panicum)
- *Muhlenbergia* (Panicum)
- *Typha* (Panicum)
- *Arundo donax* (Panicum)
- *Fragaria virginiana*, *Trifolium repens*, *Trifolium pratense*, *Trifolium repens* (Panicum)



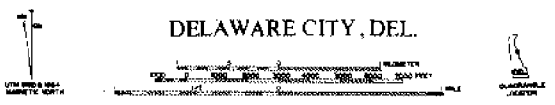
LETTER KEY INDICATING SECONDARY SPECIES

- P. *Phragmites communis*
- A. *Spartina alterniflora*
- L. *Spartina patens*
- H. Salt marsh *Spartina patens* and *Spartina alterniflora*
- I. *Spartina patens* and *Spartina alterniflora*
- S. *Spartina patens*
- M. *Spartina patens*
- E. *Spartina patens*
- A. *Spartina patens*
- F. *Spartina patens*

GRAPHIC KEY OF DOMINANT SPECIES (50%)

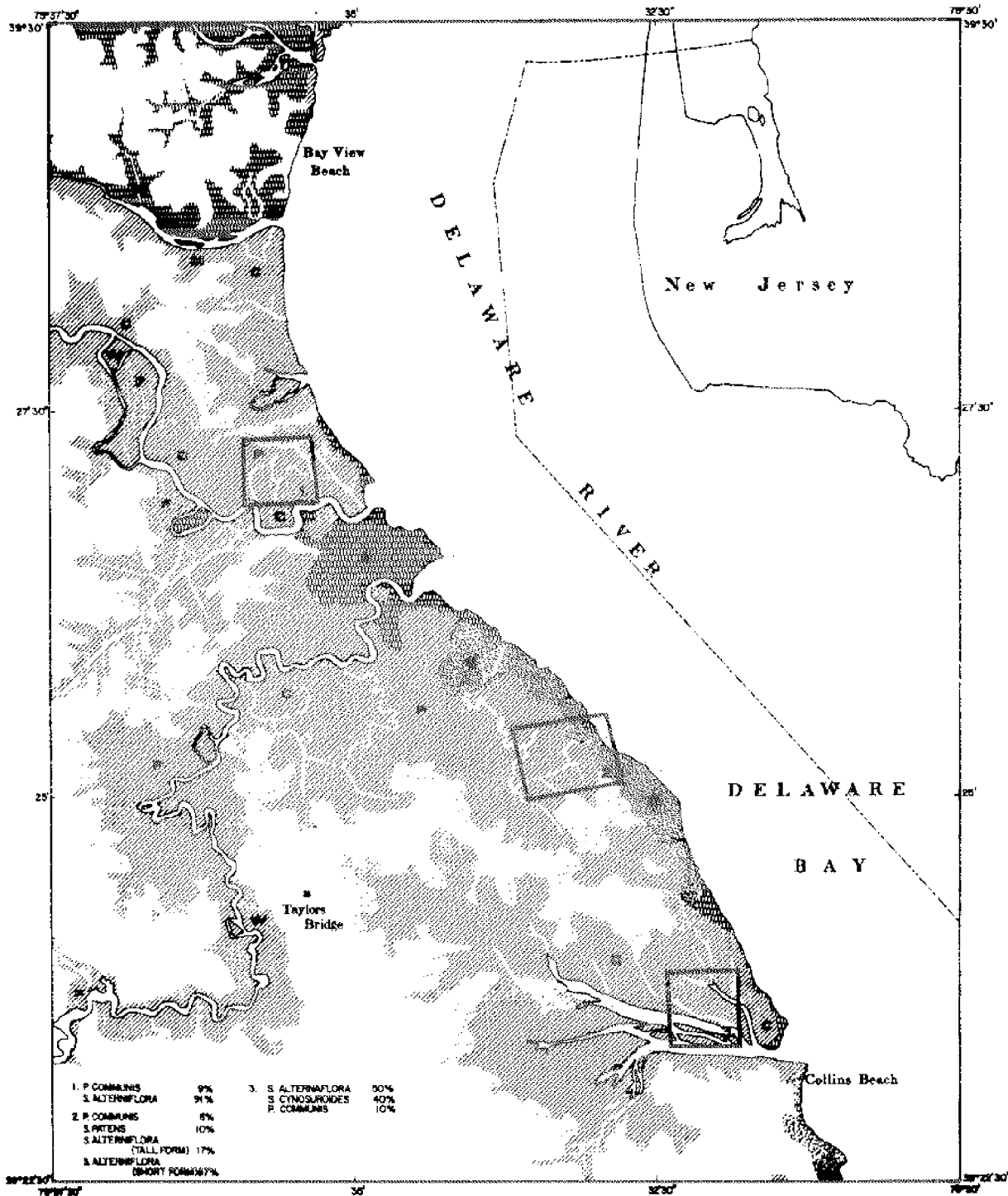
- [Pattern] *Phragmites communis* (Rice Grass)
- [Pattern] *Spartina alterniflora* (Salt Marsh Cordgrass)
- [Pattern] *Spartina patens* and *Spartina alterniflora* (Salt Marsh)
- [Pattern] *Spartina patens* and *Spartina alterniflora* (Salt Marsh)
- [Pattern] *Spartina patens* and *Spartina alterniflora* (Salt Marsh)
- [Pattern] *Spartina patens* and *Spartina alterniflora* (Salt Marsh)
- [Pattern] *Spartina patens* and *Spartina alterniflora* (Salt Marsh)
- [Pattern] *Spartina patens* and *Spartina alterniflora* (Salt Marsh)
- [Pattern] *Spartina patens* and *Spartina alterniflora* (Salt Marsh)
- [Pattern] *Spartina patens* and *Spartina alterniflora* (Salt Marsh)

DELAWARE CITY, DEL.



VEGETATION MAP SERIES I

Prepared by the U.S. Department of the Interior, Geological Survey, under contract to the U.S. Environmental Protection Agency, Office of Research and Development, Delaware River, Delaware, 1971.



LETTER KEY INDICATING SECONDARY SPECIES:

- P. *Phragmites communis*
- A. *Spartina alterniflora*
- C. *Spartina cynosuroides*
- H. *Spartina patens* (Spartina patens and Spartina patens)
- I. *Spartina patens* (Spartina patens and Spartina patens)
- S. *Spartina sp.*
- M. *Maritima sp.*
- Z. *Zostera marina*
- W. *Alacris communis*
- F. *Fragaria virginiana*, *Phlox pilularis*, *Thalictrum flavum*, *Thalictrum flavum*, *Thalictrum flavum*

TAYLORS BRIDGE, DEL.

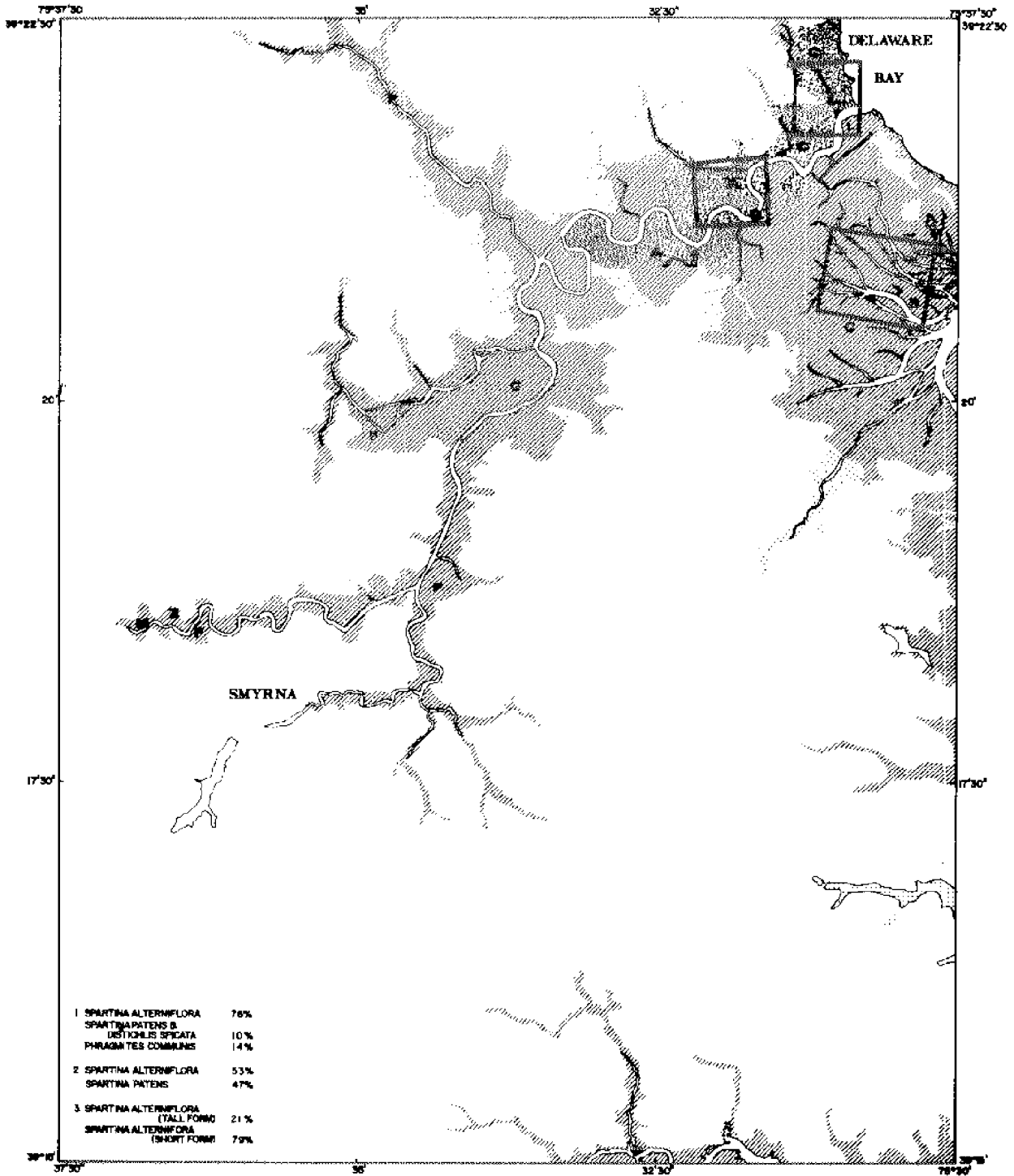


VEGETATION MAP SERIES I

Prepared by: U. S. Department of Interior, Geologic Survey, Series 1912, Bureau of Reclamation
 Vegetation Map and Published by the College of Marine Studies, University of Delaware, Newark, Delaware 19711

GRAPHIC KEY OF DOMINANT SPECIES (50%):

- Phragmites communis* (Tall Grass)
- Spartina alterniflora* (Salt Marsh Cord Grass)
- Spartina patens* and *Spartina cynosuroides* (Salt Hay)
- Spartina patens* and *Spartina patens* (Tall Marsh Spartina)
- Spartina sp.*
- Maritima sp.*
- Zostera marina*
- Alacris communis*
- Fragaria virginiana*, *Phlox pilularis*, *Thalictrum flavum*, *Thalictrum flavum*, *Thalictrum flavum*



LETTER KEY INDICATING SECONDARY SPECIES

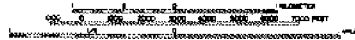
- P. *Phragmites communis*
- A. *Spartina alterniflora*
- C. *Spartina cynosuroides*
- H. *Spartina patens* (tall form)
- I. *Spartina patens* (short form)
- S. *Spartina alterniflora* (tall form)
- M. *Muhlenbergia floridana*
- Z. *Zizania aquatica*
- N. *Najas*
- F. *Fragaria virginiana*

GRAPHIC KEY OF DOMINANT SPECIES CODES

- 100% *Phragmites communis* (Solid black)
- 90-99% *Spartina alterniflora* (Diagonal lines /)
- 80-89% *Spartina patens* and *Spartina cynosuroides* (Diagonal lines \)
- 70-79% *Spartina patens* (tall form) and *Spartina patens* (short form) (Horizontal lines)
- 60-69% *Spartina alterniflora* (tall form) (Vertical lines)
- 50-59% *Muhlenbergia floridana* (Stippled)
- 40-49% *Fragaria virginiana* (Dotted)
- 30-39% *Zizania aquatica* (Cross-hatched)
- 20-29% *Najas* (Wavy lines)
- 10-19% *Fragaria virginiana* (Dotted)
- 0-9% *Muhlenbergia floridana* (Stippled)

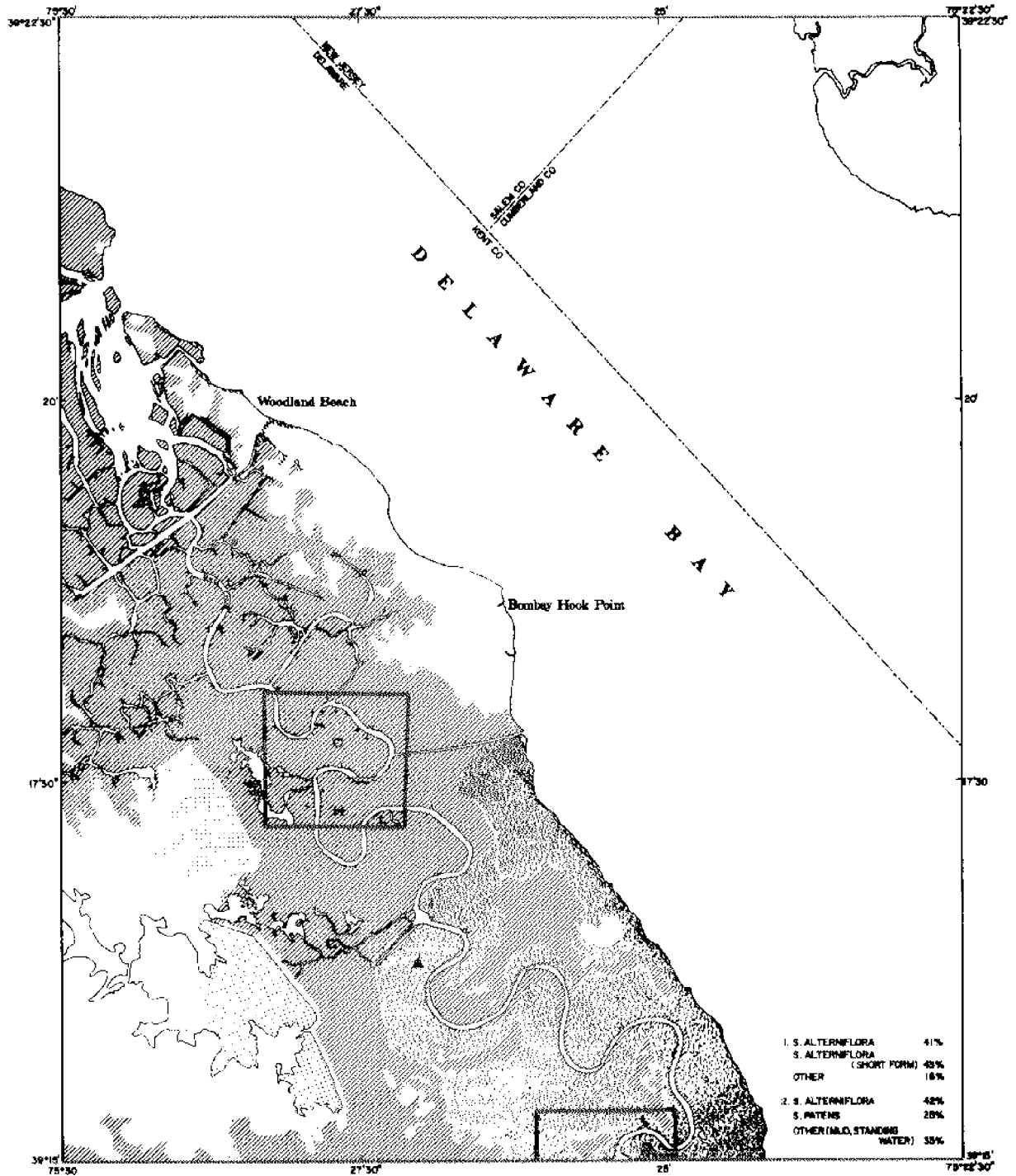


SMYRNA, DEL.



VEGETATION MAP SERIES I

Map No. 1. U.S. Department of Interior, Geological Survey, Series 1927, Technical Publication. Vegetation Map and Publication for the State of Delaware, University of Delaware, Newark, Delaware, 1971.



LETTERS IN BRACKETING INDICATE SECONDARY SPECIES

- P. *Phragmites australis*
- A. *Spartina alterniflora*
- C. *Spartina patens*
- H. Salt Hay, *Spartina patens* and *Distichlis spicata*
- S. *Spartina* spp. (*Spartina patens* and *Spartina alterniflora*)
- S. *Spartina* spp.
- M. *Muhlenbergia*
- Z. *Zostera aquatica*
- A. *Avicennia*
- F. *Fragaria virginiana* (*Fragaria virginiana* - *Fragaria virginiana*)

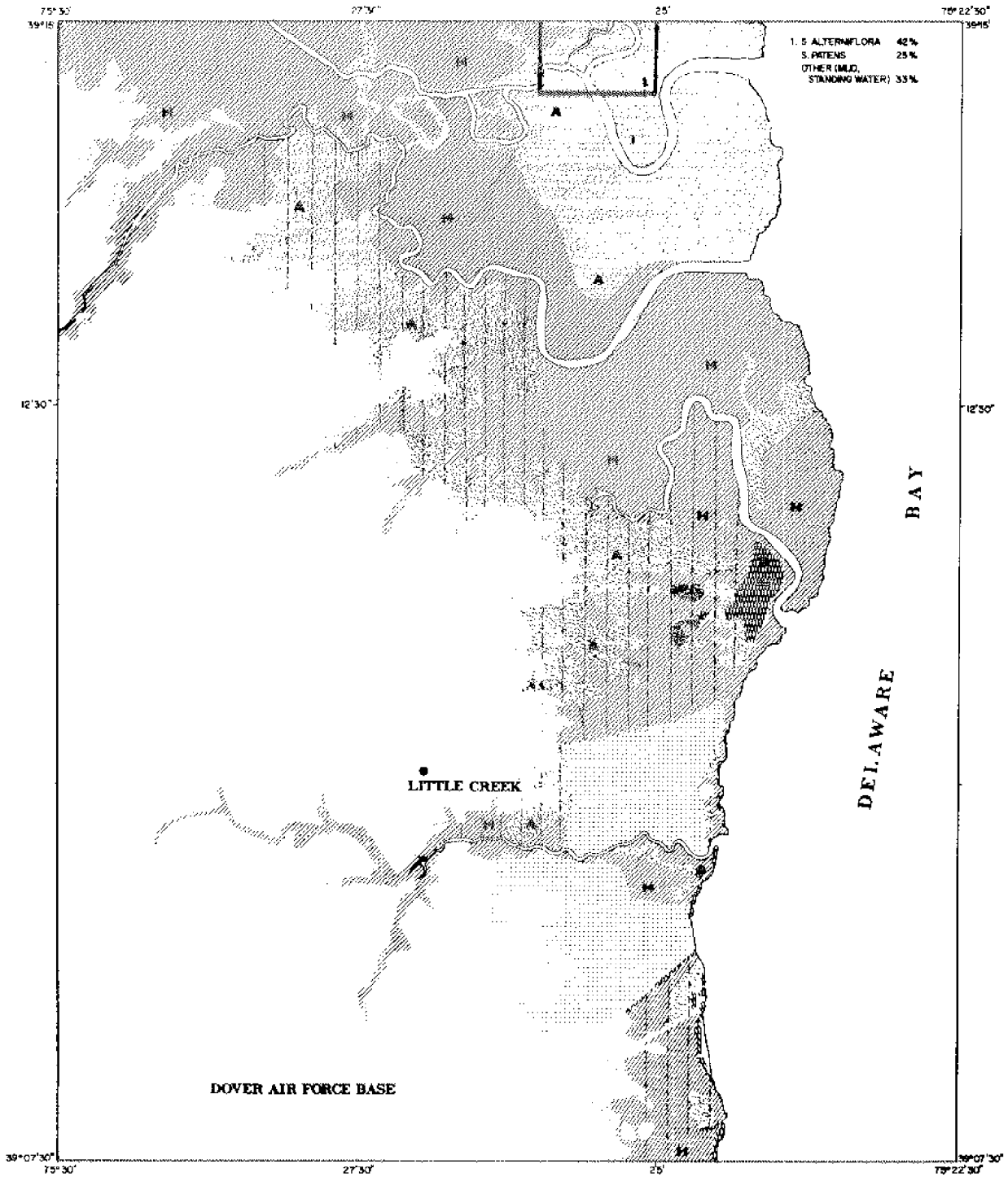
GRAPHIC KEY OF DOMINANT SPECIES SYM

- Phragmites australis* (Marsh Grass)
- Spartina alterniflora* (Salt Marsh Cord Grass)
- Spartina patens* and *Distichlis spicata* (Salt Hay)
- Spartina* spp. and *Spartina patens* and *Spartina alterniflora* (Marsh Spartina)
- Spartina* spp.
- Spartina* spp.
- Spartina* spp.
- Spartina* spp.
- Spartina* spp.

BOMBAY HOOK, DEL.

VEGETATION MAP SERIES I

Map No. 1000-1, Department of State, Division of Geology, Dover, Delaware, 1990. Prepared by the Department of State, Division of Geology, Dover, Delaware, 1990.



1. S. ALTERNIFLORA 42%
 S. PRITENS 25%
 OTHER (MUD, STANDING WATER) 33%

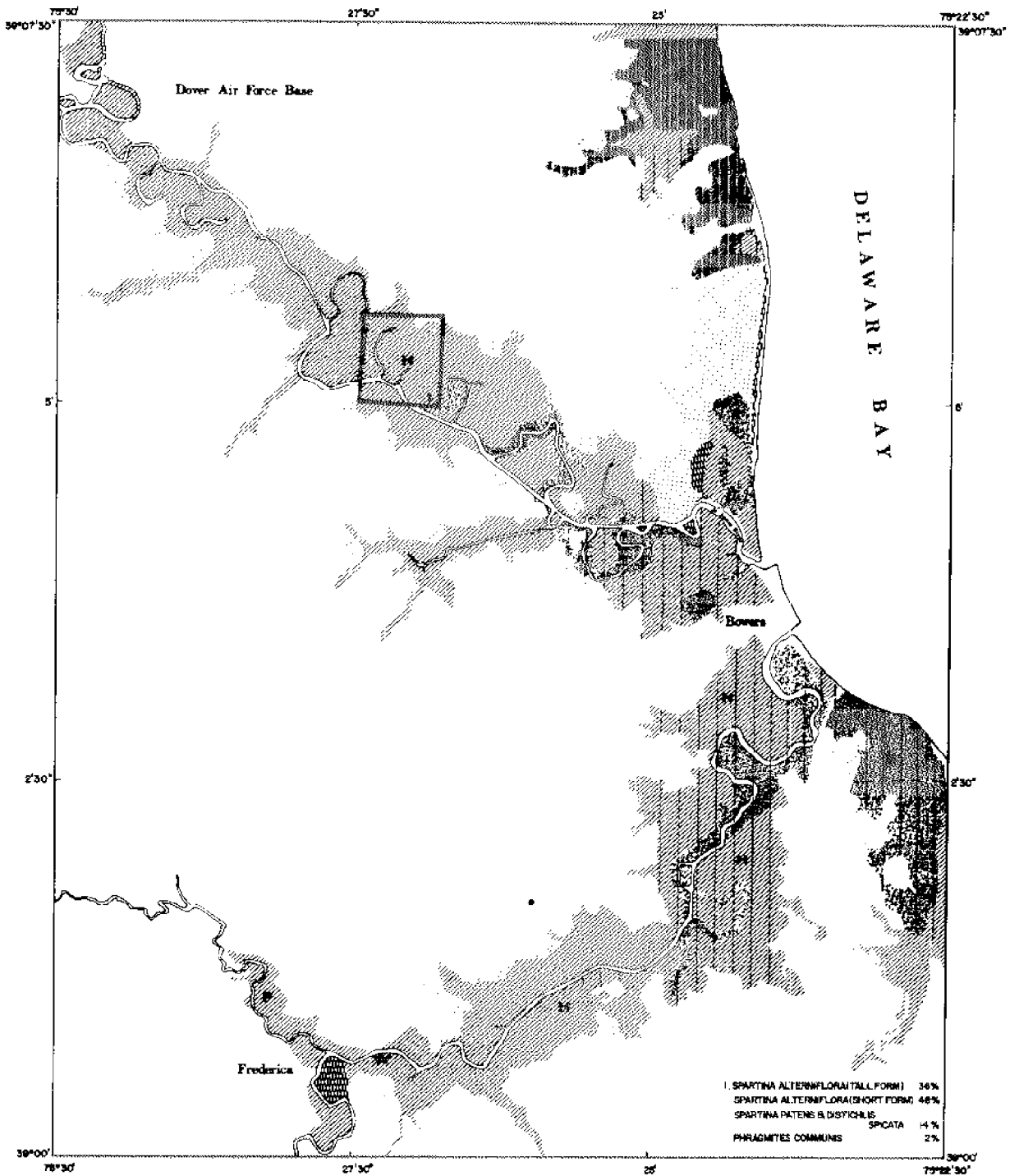
- LETTER KEY FOR AIDING SECONDARY SPECIES
- P. Phragmites communis
 - A. Spartina alterniflora
 - L. Spartina patens
 - H. Spartina patens and S. alterniflora
 - S. Spartina patens and S. alterniflora
 - S. Spartina patens
 - M. Spartina patens
 - Z. Spartina patens
 - W. Spartina patens
 - F. Spartina patens

- GRAPHIC KEY OF DOMINANT SPECIES (SHEETS)
- Spartina alterniflora (Salt Marsh Cordgrass)
 - Spartina patens and S. alterniflora (Salt Marsh)
 - Spartina patens and S. alterniflora (Salt Marsh)
 - Spartina patens
 - Spartina patens
 - Spartina patens
 - Spartina patens
 - Spartina patens

LITTLE CREEK, DEL.

VEGETATION MAP SERIES I

For more information, contact the National Wetlands Inventory, Department of the Interior, Bureau of Land Management, Washington, D.C. 20250.



Dover Air Force Base

DELAWARE BAY

Bowers

Frederica

PERCENTAGE OF DOMINANT SPECIES (EST.)

Spartina alterniflora (TALL FORM)	34%
Spartina alterniflora (SHORT FORM)	46%
Spartina patens BIDISTICHLIS	4%
Spartina SPICATA	4%
PHRAGMITES COMMUNIS	2%

LETTER KEY INDICATING SECONDARY SPECIES:

- A Phragmites communis
- B Spartina alterniflora
- C Spartina cynosuroides
- D Spartina patens patens and Spartina spicata
- E Spartina patens bidistichilis and Spartina spicata
- F Spartina spicata
- G Spartina patens
- H Spartina patens
- I Spartina patens
- J Spartina patens
- K Spartina patens
- L Spartina patens
- M Spartina patens
- N Spartina patens
- O Spartina patens
- P Spartina patens
- Q Spartina patens
- R Spartina patens
- S Spartina patens
- T Spartina patens
- U Spartina patens
- V Spartina patens
- W Spartina patens
- X Spartina patens
- Y Spartina patens
- Z Spartina patens

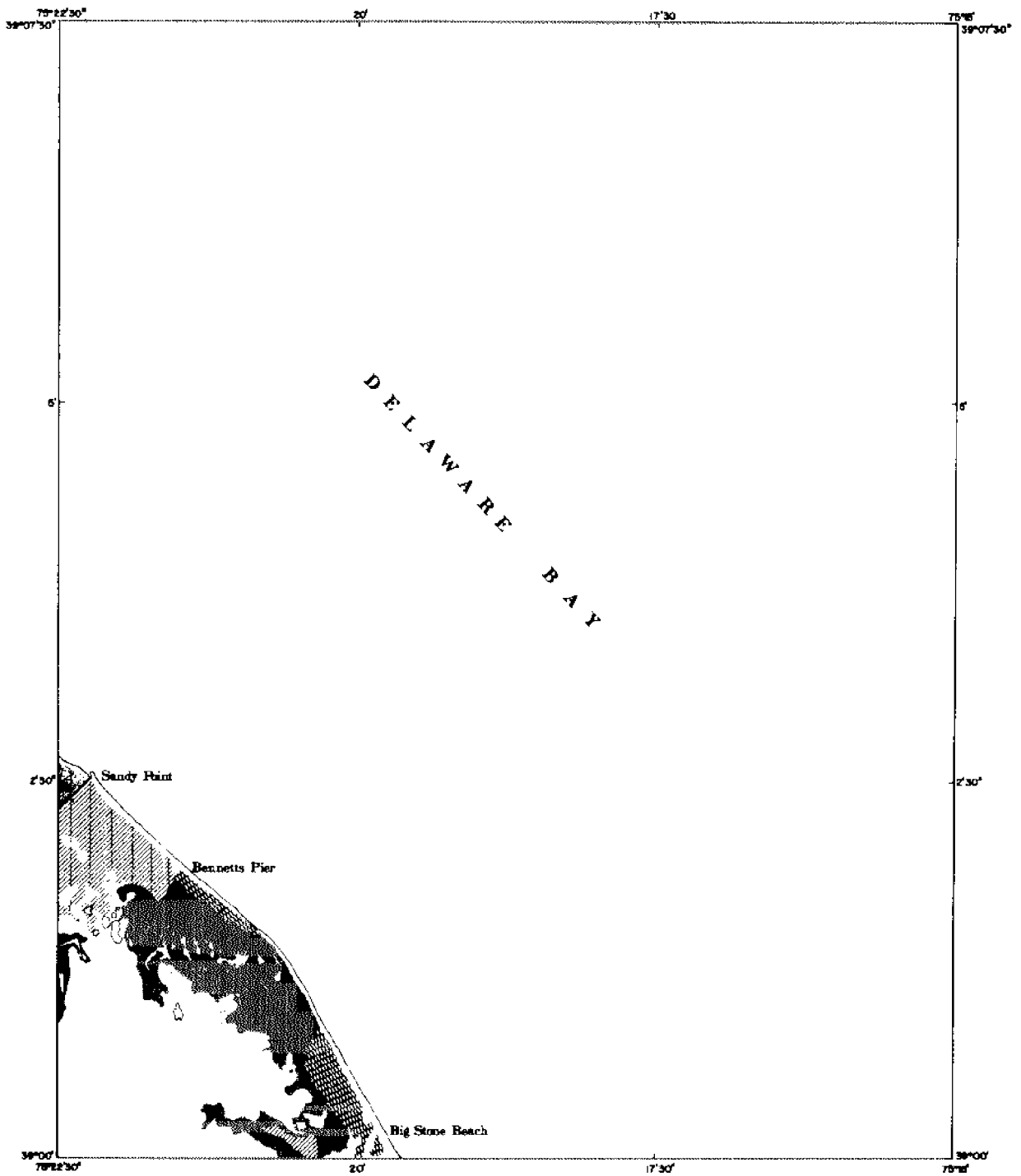
GRAPHIC KEY OF DOMINANT SPECIES (EST.)

- Phragmites communis (Tall Grass)
- Spartina alterniflora (Short Form)
- Spartina patens and Spartina spicata (Salt flat)
- Spartina patens bidistichilis and Spartina spicata (High Marsh)
- Spartina spicata
- Impounded Fresh Water
- Mud flat in development and or algae upon 100% salt mangrove vegetation
- Mudflat (Coastal Ditching)

FREDERICA, DEL.

VEGETATION MAP SERIES I

Map No. 100-1, U.S. Department of Interior, Geologic Survey, States and Possessions, Vegetation Survey, Frederica, Delaware, December 1965



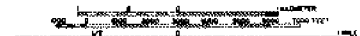
LETTER KEY INDICATING SECONDARY SPECIES

- A. *Phragmites communis*
- B. *Spartina patens*
- C. *Spartina alterniflora*
- D. *Spartina patens* and *Spartina alterniflora*
- E. *Spartina patens*
- F. *Spartina patens*
- G. *Spartina patens*
- H. *Spartina patens*
- I. *Spartina patens*
- J. *Spartina patens*
- K. *Spartina patens*
- L. *Spartina patens*
- M. *Spartina patens*
- N. *Spartina patens*
- O. *Spartina patens*
- P. *Spartina patens*
- Q. *Spartina patens*
- R. *Spartina patens*
- S. *Spartina patens*
- T. *Spartina patens*
- U. *Spartina patens*
- V. *Spartina patens*
- W. *Spartina patens*
- X. *Spartina patens*
- Y. *Spartina patens*
- Z. *Spartina patens*

GRAPHIC KEY INDICATING SPECIES COVER

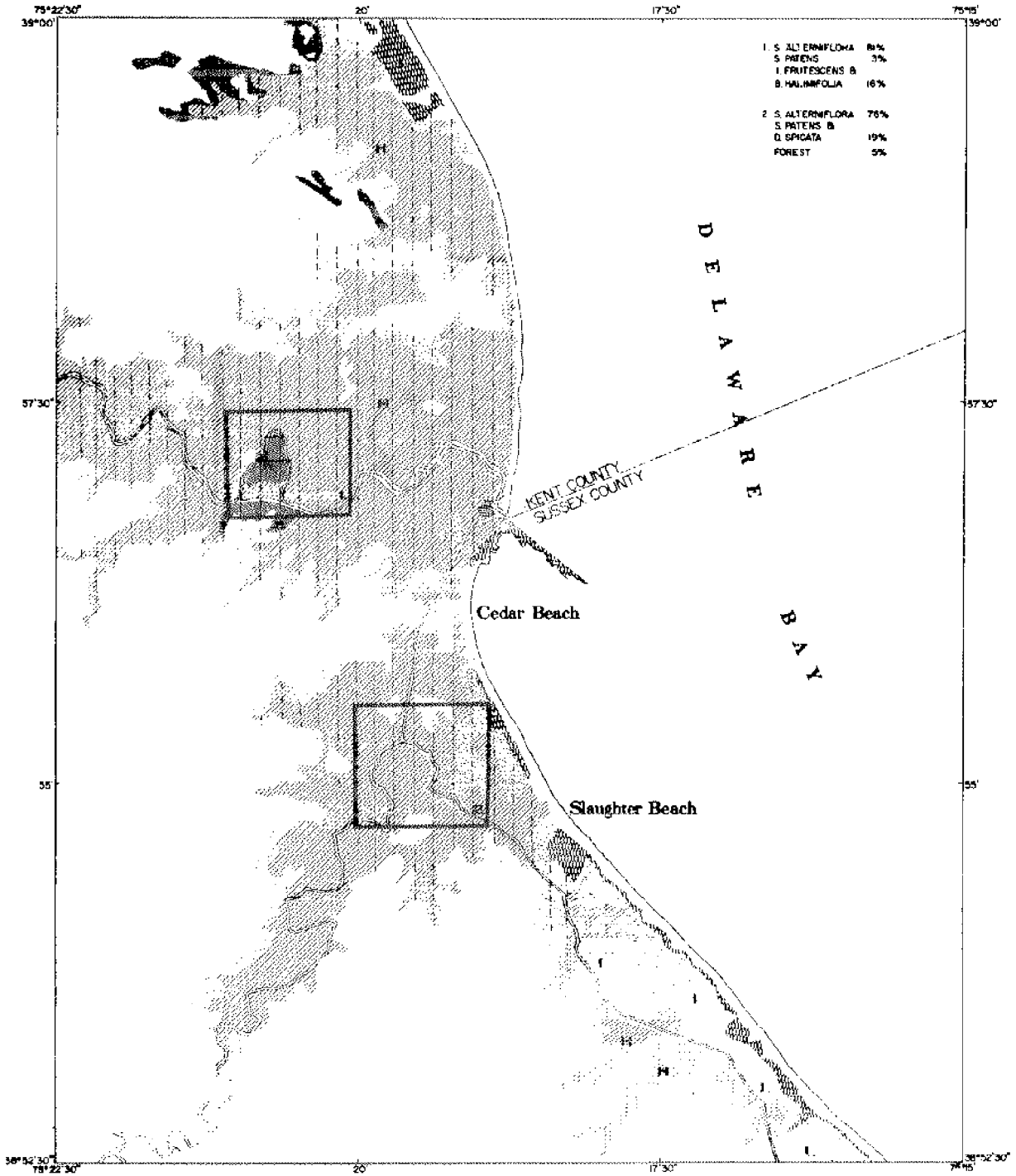
- 1. *Phragmites communis* (Black Grass)
- 2. *Spartina patens* (Salt Marsh Cord Grass)
- 3. *Spartina patens* and *Spartina alterniflora* (Salt Marsh)
- 4. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 5. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 6. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 7. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 8. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 9. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 10. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 11. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 12. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 13. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 14. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 15. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 16. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 17. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 18. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 19. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 20. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 21. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 22. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 23. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 24. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 25. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 26. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 27. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 28. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 29. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 30. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 31. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 32. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 33. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 34. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 35. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 36. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 37. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 38. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 39. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 40. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 41. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 42. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 43. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 44. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 45. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 46. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 47. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 48. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 49. *Spartina patens* and *Spartina alterniflora* (High Marsh)
- 50. *Spartina patens* and *Spartina alterniflora* (High Marsh)

BENNETTS PIER, DEL.



VEGETATION MAP SERIES I

MAP MADE FROM U.S. DEPARTMENT OF AGRICULTURE SURVEY DATA, JANUARY 1952. PART OF THE VEGETATION MAP SERIES I, COLLEGE OF MARINE STUDIES, DELAWARE COLLEGE OF MARINE STUDIES, DEPARTMENT OF DELAWARE, DECEMBER 1951.



SYMBOLS INDICATING VEGETATION

- P. *Prospicea* (Common)
- A. *Spartina alterniflora*
- C. *Scirpus americanus*
- H. *Spartina patens* and *Spartina alterniflora*
- I. *Spartina patens* and *Spartina alterniflora*
- S. *Spartina patens*
- M. *Marrubium*
- Z. *Zostera*
- W. *Wetland*
- F. *Fresh Water*



MISPILLION RIVER, DEL.

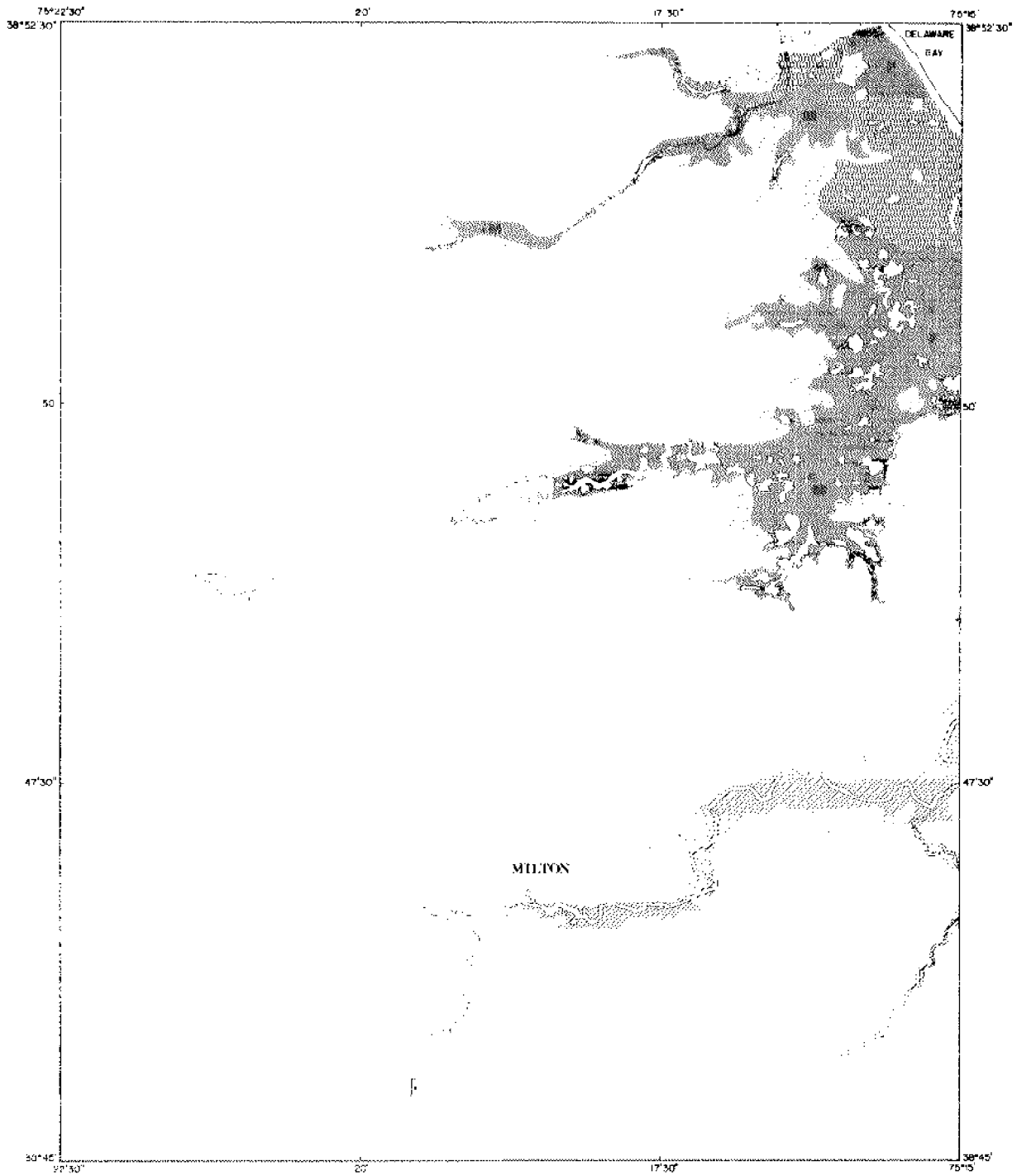


VEGETATION MAP SERIES I

Scale 1:50,000. A. Department of Natural Resources, Delaware. 1977. 1980. 1981. 1982. 1983. 1984. 1985. 1986. 1987. 1988. 1989. 1990. 1991. 1992. 1993. 1994. 1995. 1996. 1997. 1998. 1999. 2000. 2001. 2002. 2003. 2004. 2005. 2006. 2007. 2008. 2009. 2010. 2011. 2012. 2013. 2014. 2015. 2016. 2017. 2018. 2019. 2020.

SYMBOLS INDICATING SPECIES DISTRIBUTION

- Spartina alterniflora* (Common)
- Spartina patens* (Common)
- Spartina alterniflora* (Common)
- Spartina patens* (Common)
- Spartina alterniflora* (Common)
- Spartina patens* (Common)
- Spartina alterniflora* (Common)
- Spartina patens* (Common)
- Spartina alterniflora* (Common)
- Spartina patens* (Common)

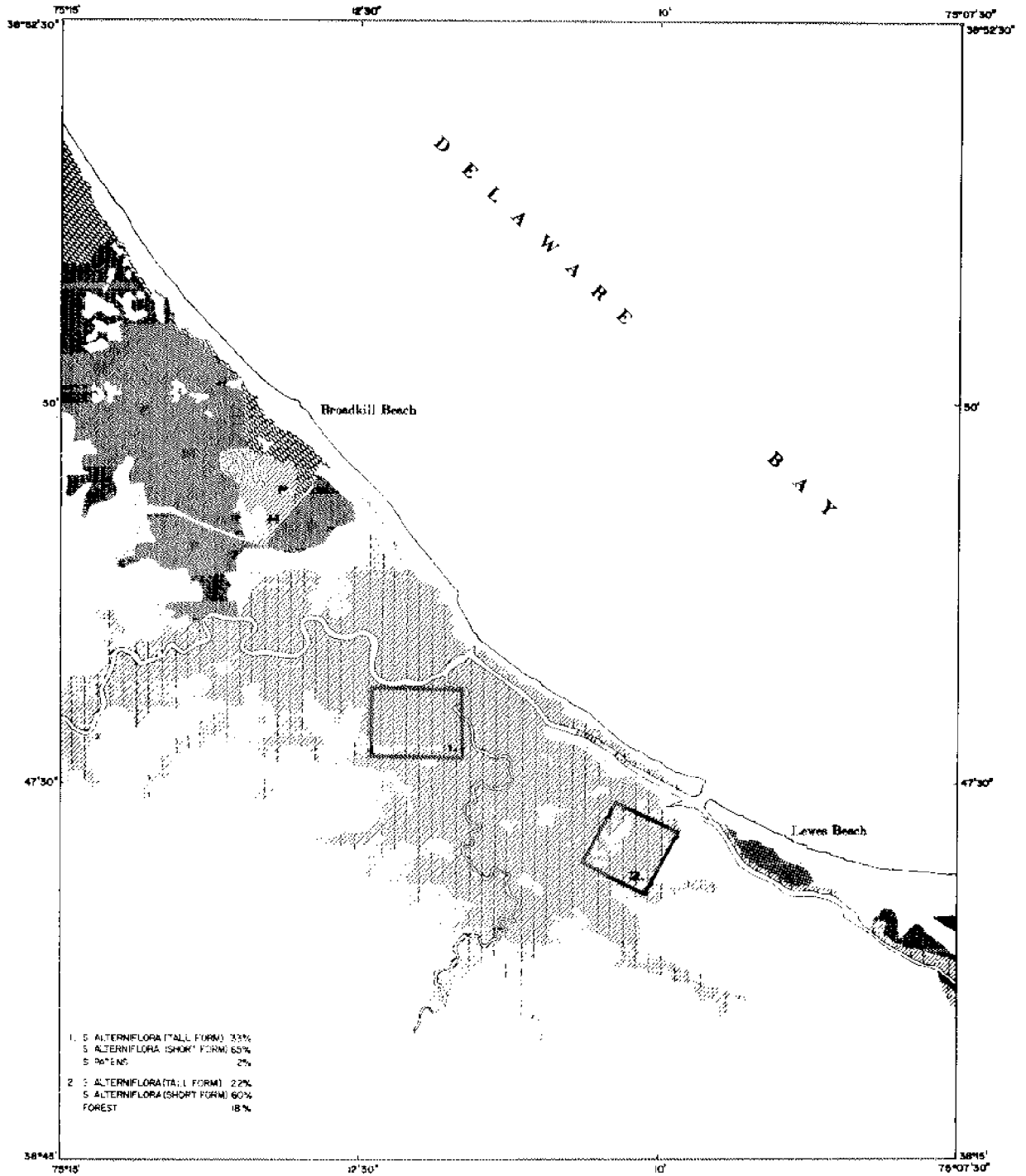


1. ...
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 3. ...
 4. ...
 5. ...
 6. ...
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 8. ...
 9. ...
 10. ...

MILTON, DEL.

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 10. ...

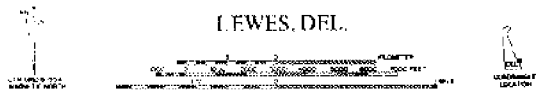
1. ...
 2. ...
 3. ...
 4. ...
 5. ...
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 7. ...
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 9. ...
 10. ...



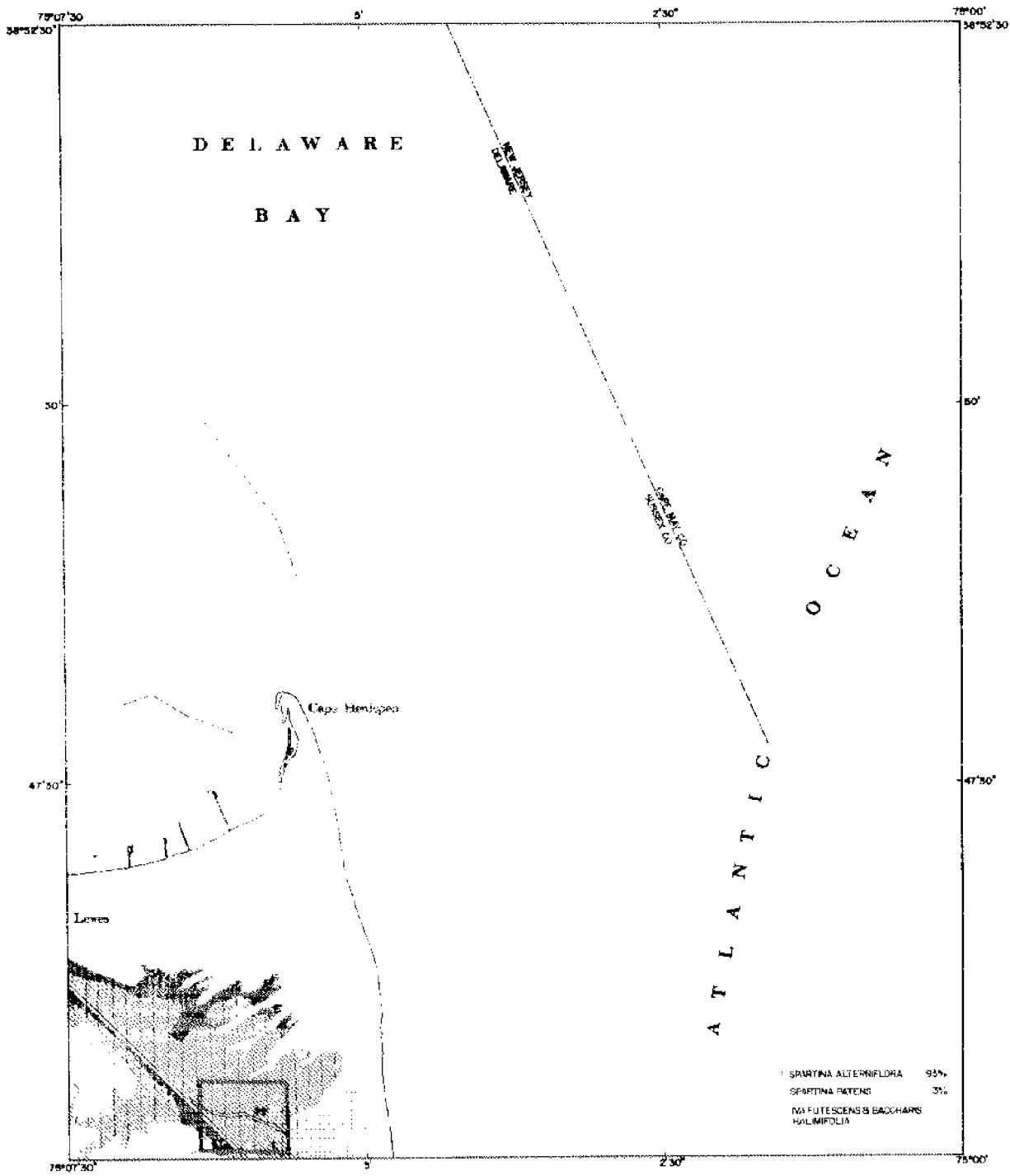
- 1: S. ALTERNIFLORA (TALL FORM) 33%
- S. ALTERNIFLORA (SHORT FORM) 63%
- S. PATENSIS 2%
- 2: S. ALTERNIFLORA (TALL FORM) 22%
- S. ALTERNIFLORA (SHORT FORM) 60%
- FOREST 18%

- VEGETATION MAP SERIES
1. 1985-1986
2. 1987-1988
3. 1989-1990
4. 1991-1992
5. 1993-1994
6. 1995-1996
7. 1997-1998
8. 1999-2000
9. 2001-2002
10. 2003-2004
11. 2005-2006
12. 2007-2008
13. 2009-2010
14. 2011-2012
15. 2013-2014
16. 2015-2016
17. 2017-2018
18. 2019-2020
19. 2021-2022
20. 2023-2024
21. 2025-2026
22. 2027-2028
23. 2029-2030
24. 2031-2032
25. 2033-2034
26. 2035-2036
27. 2037-2038
28. 2039-2040
29. 2041-2042
30. 2043-2044
31. 2045-2046
32. 2047-2048
33. 2049-2050

LEWES, DEL.



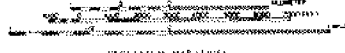
- LEGEND
1. 1985-1986
2. 1987-1988
3. 1989-1990
4. 1991-1992
5. 1993-1994
6. 1995-1996
7. 1997-1998
8. 1999-2000
9. 2001-2002
10. 2003-2004
11. 2005-2006
12. 2007-2008
13. 2009-2010
14. 2011-2012
15. 2013-2014
16. 2015-2016
17. 2017-2018
18. 2019-2020
19. 2021-2022
20. 2023-2024
21. 2025-2026
22. 2027-2028
23. 2029-2030
24. 2031-2032
25. 2033-2034
26. 2035-2036
27. 2037-2038
28. 2039-2040
29. 2041-2042
30. 2043-2044
31. 2045-2046
32. 2047-2048
33. 2049-2050
34. 2051-2052
35. 2053-2054
36. 2055-2056
37. 2057-2058
38. 2059-2060
39. 2061-2062
40. 2063-2064
41. 2065-2066
42. 2067-2068
43. 2069-2070
44. 2071-2072
45. 2073-2074
46. 2075-2076
47. 2077-2078
48. 2079-2080
49. 2081-2082
50. 2083-2084
51. 2085-2086
52. 2087-2088
53. 2089-2090
54. 2091-2092
55. 2093-2094
56. 2095-2096
57. 2097-2098
58. 2099-2100



- LETTER REFERENCE TO SECONDARY SYMBOLS
- P. *Phragmites communis*
 - A. *Spartina alterniflora*
 - G. *Spartina patens*
 - M. *Myrica aspera*
 - I. *Iva frutescens*
 - S. *Spartina patens*
 - M. *Myrica aspera*
 - J. *Juncus roemerianus*
 - W. *Widgeon*
 - F. *Fragaria virginiana*



CAPE HENLOPEN, DEL.

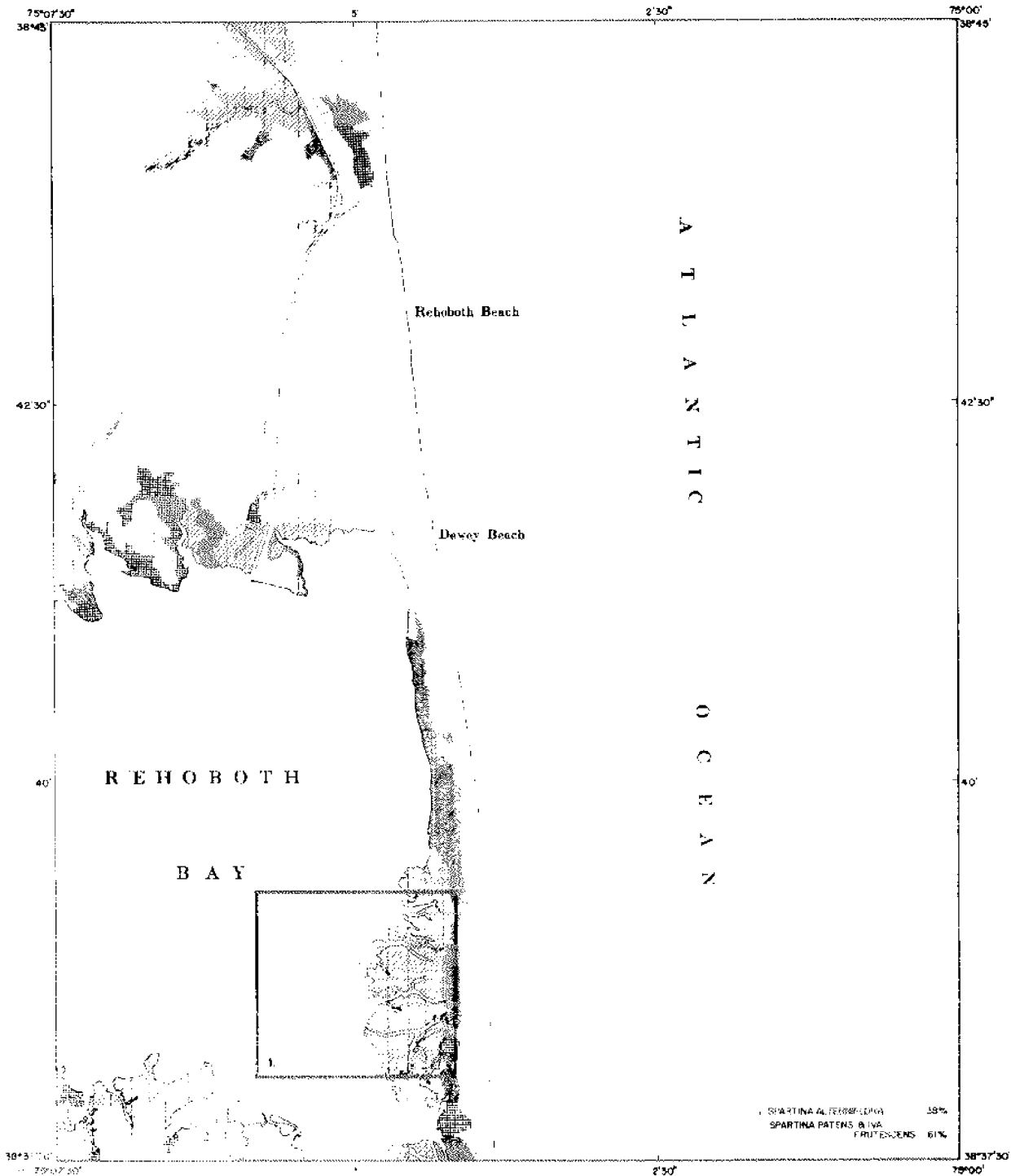


VEGETATION MAP SERIES

U.S. Department of Interior, Geological Survey, Office of Biological Services, Washington, D.C.

PERCENTAGE OF DOMINANT SPECIES

- Phragmites communis* 93%
- Spartina alterniflora* 3%
- Iva frutescens* & *Baccharis halimifolia*



SPARTINA ALTERNIFLORA 38%
 SPARTINA PATENS & SVA FRUTESCENS 61%

- LISTED KEY POINTS AND FEATURES SPECUL
- 1. 1990s NA projection
 - 2. 2007 NA datum
 - 3. 2007 NA datum
 - 4. 1:50,000 scale
 - 5. 2007 NA datum
 - 6. 2007 NA datum
 - 7. 2007 NA datum
 - 8. 2007 NA datum
 - 9. 2007 NA datum
 - 10. 2007 NA datum
 - 11. 2007 NA datum
 - 12. 2007 NA datum
 - 13. 2007 NA datum
 - 14. 2007 NA datum
 - 15. 2007 NA datum
 - 16. 2007 NA datum
 - 17. 2007 NA datum
 - 18. 2007 NA datum
 - 19. 2007 NA datum
 - 20. 2007 NA datum

REHOBOTH BEACH, DEL.

DEPARTMENT OF ENVIRONMENTAL CONTROL

PLANTATION MAP 050508 R

DATE: 05/05/08

SCALE: 1" = 100'

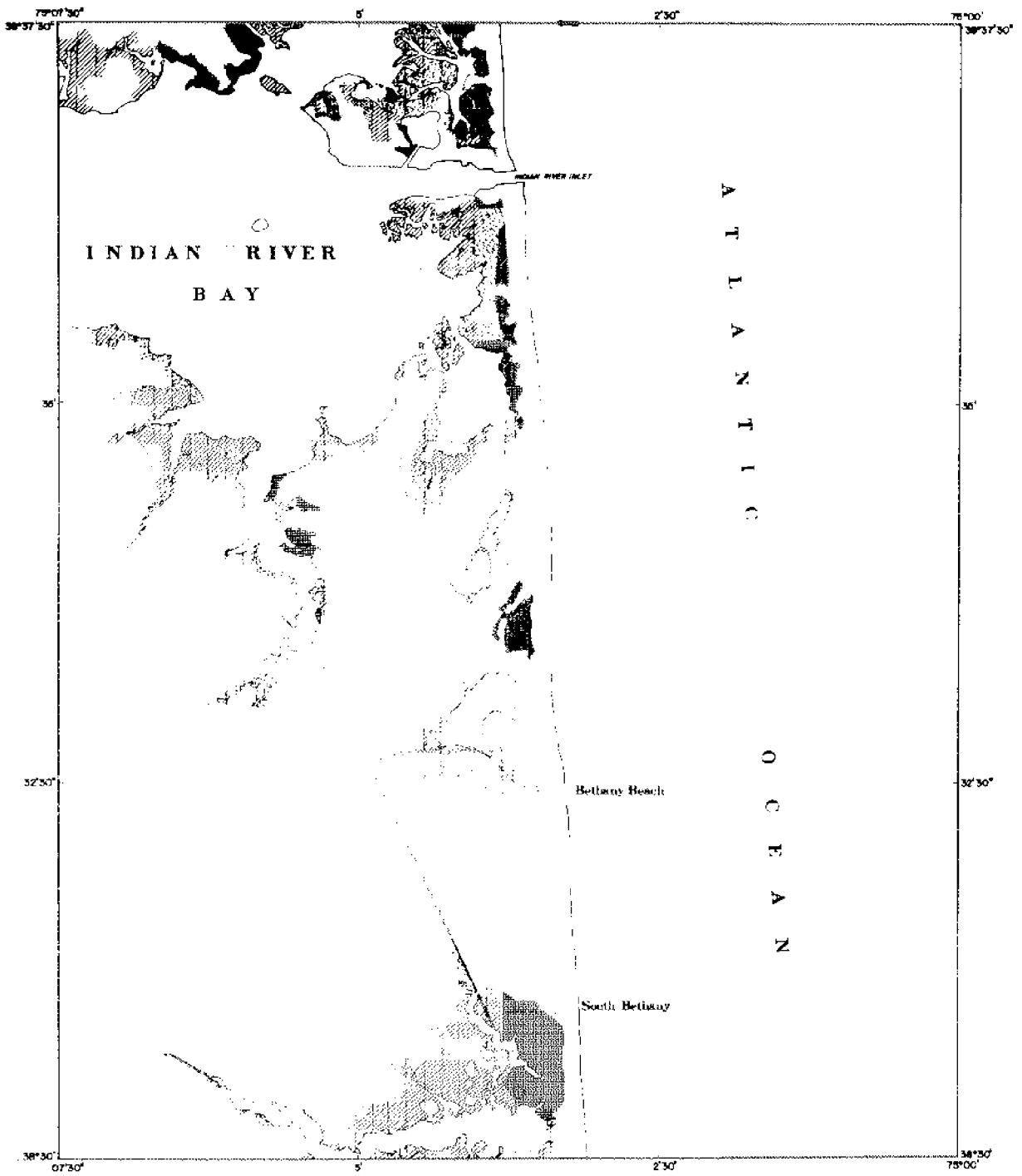
PROJECT: REHOBOTH BEACH PLANTATION MAP 050508 R

DRAWN BY: [Name]

CHECKED BY: [Name]

APPROVED BY: [Name]

- GRAPHIC KEY OF SYMBOLS SPECIFIED
- 1. 1990s NA projection
 - 2. 2007 NA datum
 - 3. 2007 NA datum
 - 4. 1:50,000 scale
 - 5. 2007 NA datum
 - 6. 2007 NA datum
 - 7. 2007 NA datum
 - 8. 2007 NA datum
 - 9. 2007 NA datum
 - 10. 2007 NA datum
 - 11. 2007 NA datum
 - 12. 2007 NA datum
 - 13. 2007 NA datum
 - 14. 2007 NA datum
 - 15. 2007 NA datum
 - 16. 2007 NA datum
 - 17. 2007 NA datum
 - 18. 2007 NA datum
 - 19. 2007 NA datum
 - 20. 2007 NA datum



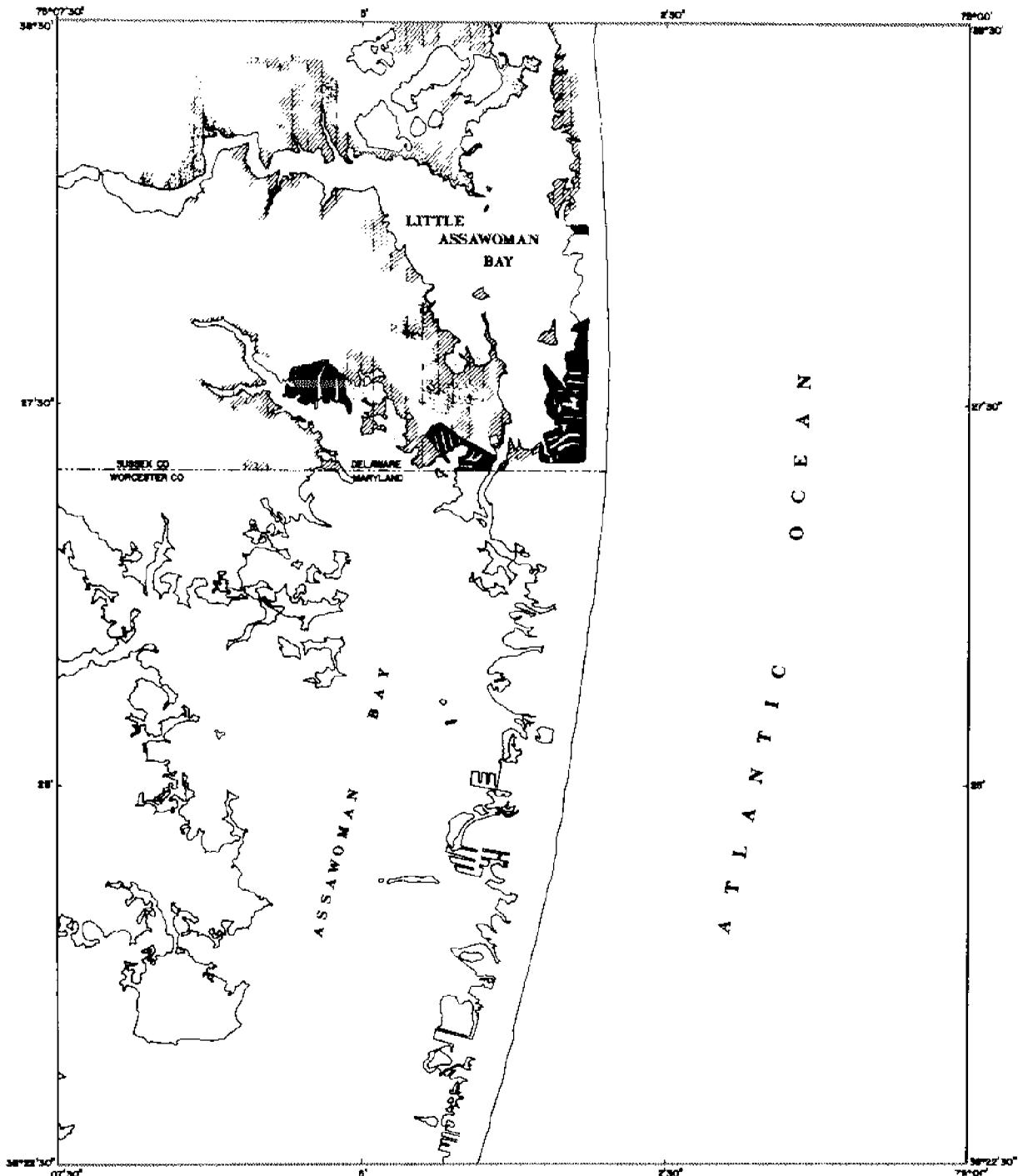
- OTHER VEGETATION INDICATING SECONDARY SPECIES
- 1. *Pinus strobus*
 - 2. *Quercus prinus*
 - 3. *Quercus alba*
 - 4. *Quercus sp.*
 - 5. *Pinus strobus*
 - 6. *Pinus strobus*
 - 7. *Pinus strobus*
 - 8. *Pinus strobus*
 - 9. *Pinus strobus*
 - 10. *Pinus strobus*



BETHANY BEACH, DEL.

U.S. GEOLOGICAL SURVEY
 WATER RESOURCES DIVISION
 BETHANY BEACH, DELAWARE
 VEGETATION MAP SERIES 7

- DOMINANT SPECIES
- 1. *Pinus strobus*
 - 2. *Quercus prinus*
 - 3. *Quercus alba*
 - 4. *Quercus sp.*
 - 5. *Pinus strobus*
 - 6. *Pinus strobus*
 - 7. *Pinus strobus*
 - 8. *Pinus strobus*
 - 9. *Pinus strobus*
 - 10. *Pinus strobus*

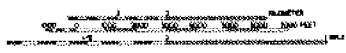


LETTERS IN THE MARGINS IDENTIFY SPECIES

1. *Pinus strobus*
2. *Quercus alba*
3. *Liquidambar styraciflua*
4. *Thuja occidentalis*
5. *Juniperus horizontalis*
6. *Thuja occidentalis*
7. *Juniperus horizontalis*
8. *Thuja occidentalis*
9. *Juniperus horizontalis*
10. *Thuja occidentalis*
11. *Juniperus horizontalis*

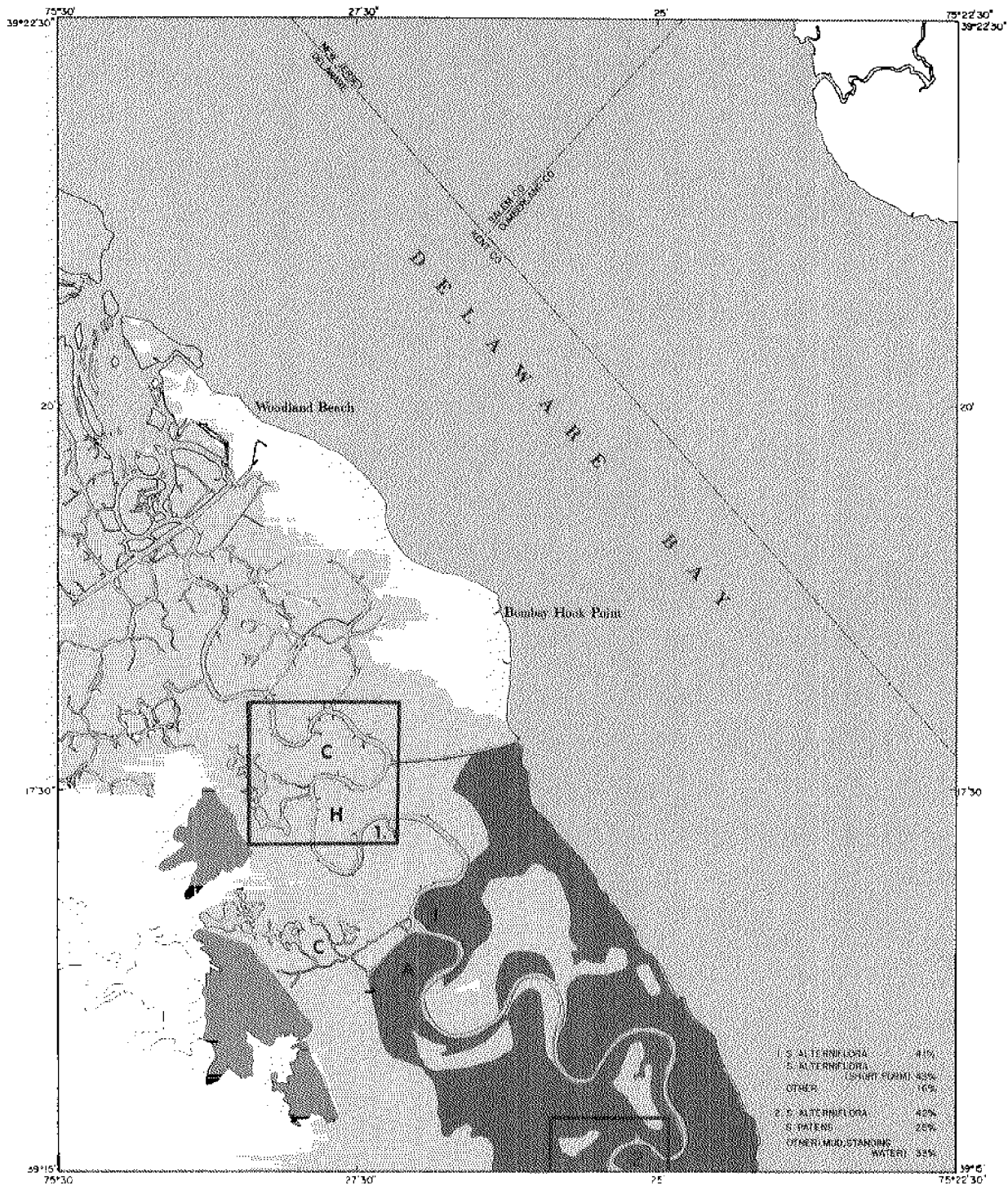


ASSAWOMAN BAY, DEL.



VEGETATION MAP SURVEY I
 By Mr. H. C. ... Department of Biology, College of Arts and Sciences, University of Delaware, Newark, Delaware 19711

- LEGEND FOR SHADING SYSTEMS
- 1. *Pinus strobus* (Red 100%)
 - 2. *Quercus alba* (Blue 100%)
 - 3. *Liquidambar styraciflua* (Green 100%)
 - 4. *Thuja occidentalis* (Black 100%)
 - 5. *Juniperus horizontalis* (White 100%)
 - 6. *Thuja occidentalis* (Black 50%)
 - 7. *Juniperus horizontalis* (White 50%)
 - 8. *Thuja occidentalis* (Black 25%)
 - 9. *Juniperus horizontalis* (White 25%)
 - 10. *Thuja occidentalis* (Black 10%)
 - 11. *Juniperus horizontalis* (White 10%)

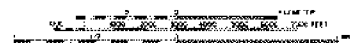


LETTER KEY TO BOMBAY HOOK SPECIES

- A. *Alpheidae*
- B. *Alpheidae*
- C. *Alpheidae*
- D. *Alpheidae*
- E. *Alpheidae*
- F. *Alpheidae*
- G. *Alpheidae*
- H. *Alpheidae*
- I. *Alpheidae*
- J. *Alpheidae*
- K. *Alpheidae*
- L. *Alpheidae*
- M. *Alpheidae*
- N. *Alpheidae*
- O. *Alpheidae*
- P. *Alpheidae*
- Q. *Alpheidae*
- R. *Alpheidae*
- S. *Alpheidae*
- T. *Alpheidae*
- U. *Alpheidae*
- V. *Alpheidae*
- W. *Alpheidae*
- X. *Alpheidae*
- Y. *Alpheidae*
- Z. *Alpheidae*



BOMBAY HOOK, DEL.

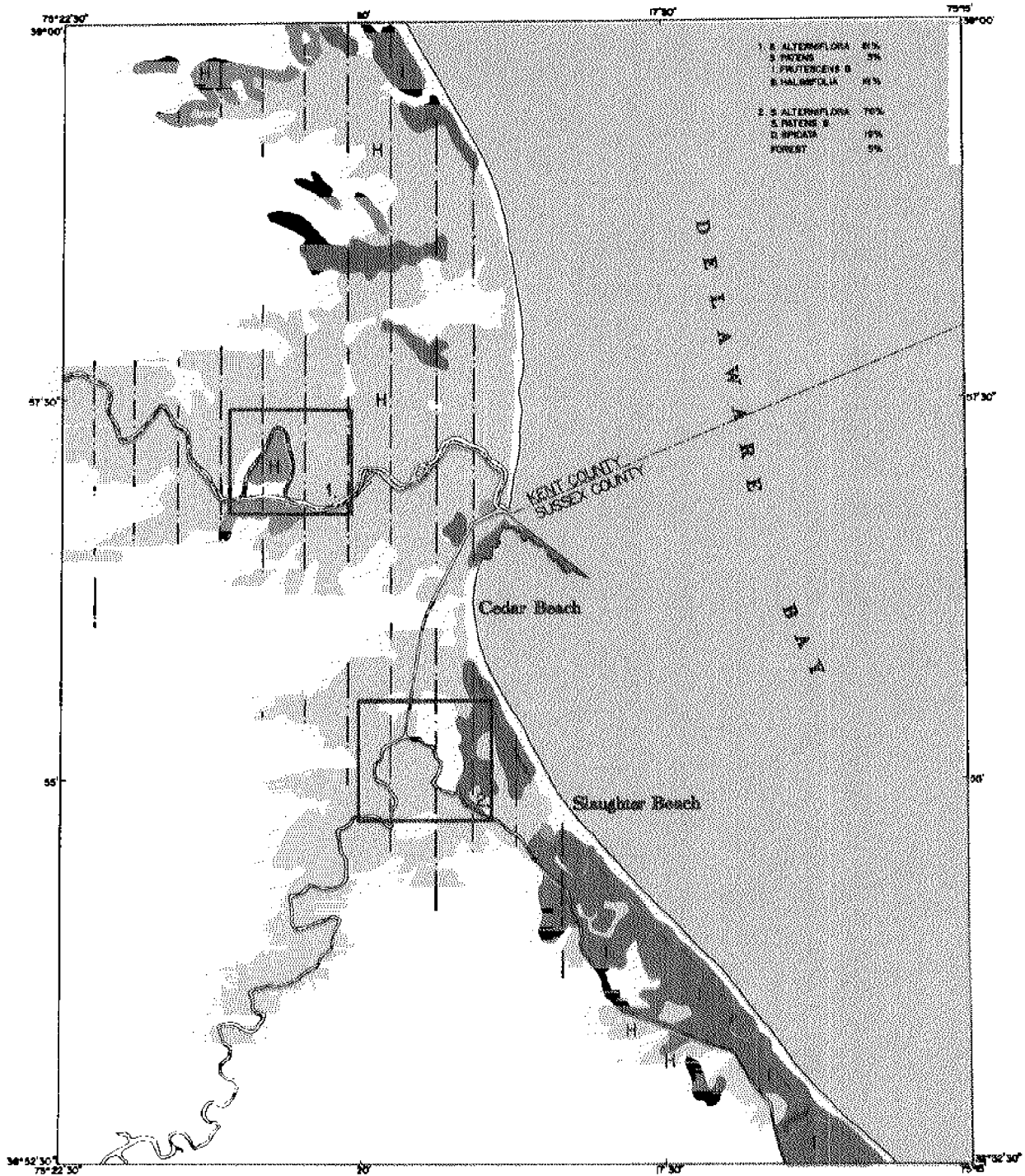


1:25,000 SCALE MAP SERIES 1

Map prepared by the Delaware Department of Natural Resources and Environmental Control, 1998. Original map prepared by the Delaware Department of Natural Resources and Environmental Control, 1998.

GRAPHIC KEY TO BOMBAY HOOK SPECIES

- 1. *Alpheidae*
- 2. *Alpheidae*
- 3. *Alpheidae*
- 4. *Alpheidae*
- 5. *Alpheidae*
- 6. *Alpheidae*
- 7. *Alpheidae*
- 8. *Alpheidae*
- 9. *Alpheidae*
- 10. *Alpheidae*
- 11. *Alpheidae*
- 12. *Alpheidae*
- 13. *Alpheidae*
- 14. *Alpheidae*
- 15. *Alpheidae*
- 16. *Alpheidae*
- 17. *Alpheidae*
- 18. *Alpheidae*
- 19. *Alpheidae*
- 20. *Alpheidae*
- 21. *Alpheidae*
- 22. *Alpheidae*
- 23. *Alpheidae*
- 24. *Alpheidae*
- 25. *Alpheidae*
- 26. *Alpheidae*
- 27. *Alpheidae*
- 28. *Alpheidae*
- 29. *Alpheidae*
- 30. *Alpheidae*
- 31. *Alpheidae*
- 32. *Alpheidae*
- 33. *Alpheidae*
- 34. *Alpheidae*
- 35. *Alpheidae*
- 36. *Alpheidae*
- 37. *Alpheidae*
- 38. *Alpheidae*
- 39. *Alpheidae*
- 40. *Alpheidae*
- 41. *Alpheidae*
- 42. *Alpheidae*
- 43. *Alpheidae*
- 44. *Alpheidae*
- 45. *Alpheidae*
- 46. *Alpheidae*
- 47. *Alpheidae*
- 48. *Alpheidae*
- 49. *Alpheidae*
- 50. *Alpheidae*

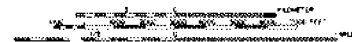


1. S. ALTERNIFLORA	81%
2. PATENSIS	9%
1. PRUTERENSIS	8
2. HALIMIFOLIA	3%
2. S. ALTERNIFLORA	78%
2. PATENSIS	17%
FOREST	5%

FLORA KEY (DETERMINED DOMINANT SPECIES)

- F. *Spartina alterniflora*
- A. *Spartina patens*
- S. *Spartina alterniflora*
- H. *Halimolobos*
- P. *Prunella*
- N. *Nyssa*
- Z. *Zostera*
- A. *Alnus*
- F. *Fragaria*

MISPILLION RIVER, DEL.



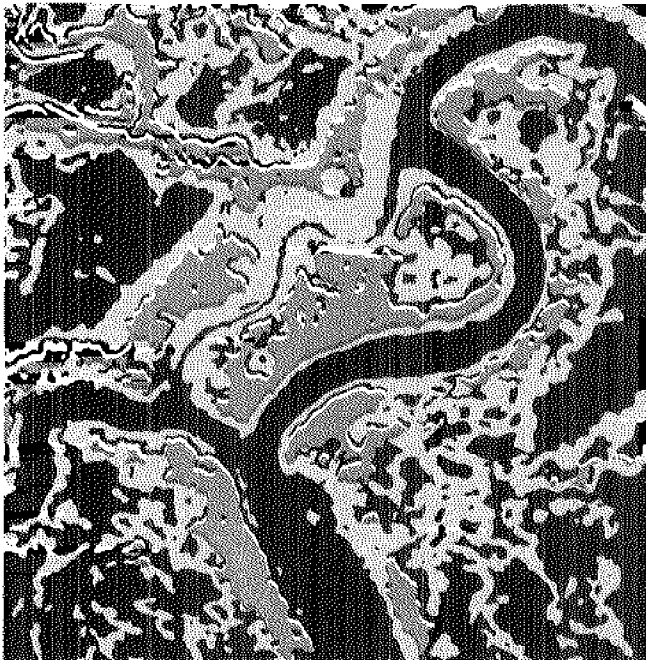
VEGETATION NEAR SITES 1



GRAPHIC KEY TO DOMINANT SPECIES

- Spartina alterniflora*
- Spartina patens*
- Halimolobos*
- Prunella*
- Nyssa*
- Zostera*
- Alnus*
- Fragaria*

FIGURE 4

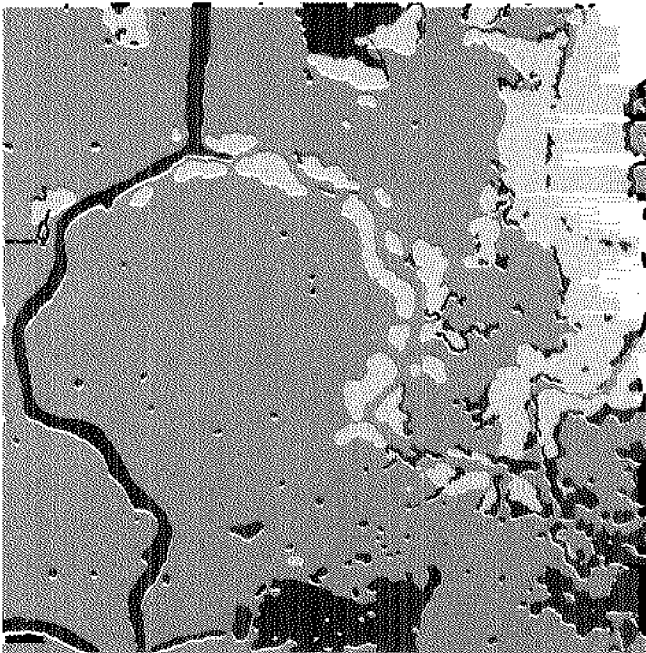


A)
Enhancement of area
in box #1, Little Creek
Quad.

Black - water and mud

Blue - *S. patens* and *D. spicata*

Yellow - *S. alterniflora*
and *S. cynosuroides*



B)
Enhancement of area
in box #2, Mispillion
R. Quad.

Black - water and forest

Blue - *S. alterniflora*

Yellow - *S. patens*

REFERENCES

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2. Garvin, L. E. and Wheller, R. H., "Coastal Wetlands Inventory in Maryland" in Coastal Mapping Symposium, Am. Soc. of Photogrammetry, 1972.
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4. Delaware Natural Resources Inventory, Delaware State Planning Office, 1970.
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6. "General Electric Multispectral Data Processing System -- System Description" -- General Electric Space Center, Valley Forge, Pennsylvania.
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