Robert J. Reimold*
John L. Gallagher
Donald E. Thompson

Remote Sensing of Tidal Marsh

These techniques and production measurements are of value to those planning industrial and recreational development of the coastal zone by providing information on the spatial distribution of species and primary production in the marsh.

Introduction

One of the objectives of contemporary ecology is to describe the flow of energy and materials within various ecosystems. In many estuaries, primary production in the tidal marshes is the major source of fixed carbon. This carbon enters the estuarine food web primarily as detritus washed from the marsh surface by the ebbing tide (Odum and de la Cruz, 1967). Estimates of tidal marsh primary production have been made by Smalley, 1959; Morgan, 1961; Odum, 1961; Teal, 1962; Wass and Wright, 1969; Udell *et al.*, 1969; Stroud and Cooper, 1969; and Williams and Murdoch, 1972. A review of these data indicates that primary production varies between 150 and 3300 grams of dry matter per square meter per year. Because of the difficulties of working in the soft soils of the marshes, the limitations imposed by tidal fluxes and inaccessibility, most of the production figures are based on studies of relatively small areas and few samples. Local zonational variation in marsh production combined with small sample sizes has resulted in production estimates which may not be representative of the larger region. Reliable primary production values on large areas are necessary components in developing an understanding of estuarine energetics and nutrient cycling.

Abstract: *Remote sensing is considered to provide quantitative data on primary production in tidal marsh ecosystems. Emphasis focuses on: (1) differentiation of vegetative types (species), and (2) assessment of primary production between each vegetative type (species) and within the dominant species,* Spartina alterniflora. *Remote sensing methodology utilized single-image photographs with Aerochrome Infrared 2443 at various altitudes. Thermal imagery was used to examine various bands of reflected and emitted radiation. Image parameters and plant characteristics were quantified by visual interpretation and color densitometry. Ground-truth data was used to calibrate remote sensing imagery. Ground-truth measurement included plant biomass by standard harvest methodology, stem density, plant height, size class distribution, and plant pigment concentration. The agronomic production on a 46-hectare area of* Spartina *marsh was 571 g m^{-2} year^{-1}, and 698 g m^{-2} year-1 on a 16-hectare site of* Juncus, Distichlis *and* Spartina. *The average production for the 1142-hectare Duplin Estuary marsh is 591 g m^{-2} year^{-1}.*

Remote sensing techniques, coupled with reliable ground-truth data, provide a rational approach for assessment of primary production on large land areas. The technical and physical aspects of imaging with photographic sensors was reviewed by Heller (1970). Among the advantages of photographic sensors he enumerates are: (1) high resolution capabilities, (2) good spatial orientation with precision cameras, and (3) the relative ease of identifying vegetation and making measurements. Anson (1966) com-

* Study supported in part by National Science Foundation Grant GA 29446 to the University of Georgia. Messers Reimold and Gallagher are with the University of Georgia Marine Institute, Sapelo Island, Ga. 31327. Mr. Thompson is with MAPCOtech Inc., Daytona Beach, Fla. 32015.

pared panchromatic, color and color-infrared films for effectiveness in mapping drainage, vegetation and soils types. With the exception of soils mapping, color and color-infrared were considered to be the most effective films.

Olson (1964) was able to recognize general types of marsh vegetation from panchromatic or color aerial photographs. Stroud and Cooper (1969) used Kodak Ektachrome Infrared Aero film, type 8443, to differentiate vegetative types in marshes of North Carolina. Randomly selected portions of the marsh photographs were interpreted and the acreage of each community type in the whole marsh was based on these selected areas. Color and color-infrared transparencies were used by Eyre (1971) to determine the decrease in wetlands (in Florida) due to drainage for agricultural and industrial use. Egan and Hair (1971) and Anderson and Wobber (1972) used color and color-infrared film to delimit the boundaries of wetlands in Maryland and New Jersey respectively.

Among the disadvantages of photographic sensors are the need for clear weather and lack of sensitivity (of these sensors) to portions of the electromagnetic spectrum beyond the 0.90 nm (nanometers) range (see Figure 1). Gates (1970) emphasized the importance of leaf geometry, morphology, physiological state and chemistry, as well as soil and climate, on the spectral quality and intensity of reflected and emitted energy. Reflectance and emissivity patterns of various plants can be useful in selecting bands within the electromagnetic spectrum where differences are maximized. Colwell and Olson (1966) have separated ten vegetation and terrain types in the Mud Lake Bog area of Michigan using a series of six spectral band tone signatures on concert.

METHODS

Three remote sensing flights with concurrent ground truth acquisitions were conducted. Figure 2 shows the location of Sapelo Island along the coast of Georgia and indicates the location of the Duplin Estuary marsh study sites along the west side of the island.

Stereo coverage of the two study sites on east-west flight lines was acquired at scales of 1:2,500 and 1:5,000 using Kodak Aerochrome Infrared type 2443 film and a Zeiss RMK A 15/23 camera. The Duplin River estuary-marsh complex (hereafter termed the *Duplin*) was photographed with stereo coverage on north-south flight lines at scales of 1:5,000 and 1:10,000 (Plate 1). During the third mission, the *Duplin* was also photographed at scales of 1:20,000 and 1:40,00. The first photographs were taken near solar zenith and low tide. Because of solar reflection from the wet soils, the second and third flights were timed to coincide with an approximately 50° sun angle at low tide. The first photographic mission was conducted 22 June 1971; the second mission, 18 August 1971; and the third mission, 14 September 1971. These dates were chosen to be equally spaced during the theoretical maximum primary productivity period of the marsh plants.

The other remote sensing technique used was interpretation of thermal imagery with a Bendix Thermal Mapper Model LN-3. Flight lines for the first, second and third missions included an east-west flight line over the two study sites and a north-south flight line over

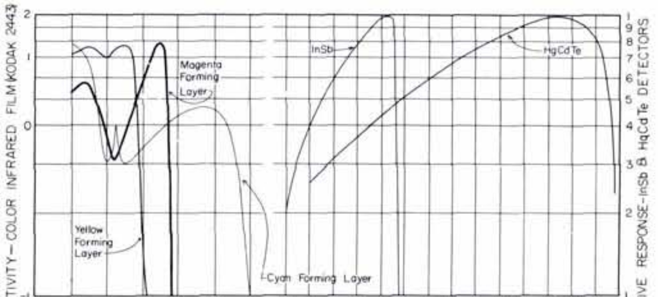


FIG. 1. Spectral sensitivity of the sensors. (1 micron = 1 micrometer (μm)).

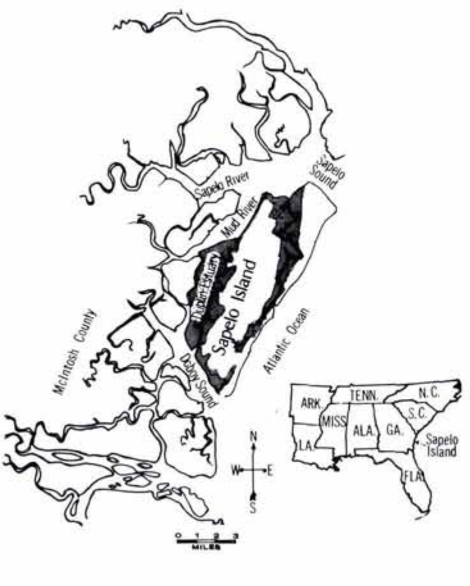


FIG. 2. Location of the Duplin Study Area on the west side of Sapelo Island, Georgia.

the entire *Duplin*. All flight lines were flown during the daylight hours. The first mission using thermal imagery was flown with a mercury-cadmium-telluride detector crystal in the thermal mapper filtered to receive the 8.0- to 12.5-micrometer (μm) wavelength band. In addition, the second mission included band widths of 2.0 to 3.5, 2.0 to 13.0 and 3.7 to 5.5 μm. On the third mission, an indium-antimonide detector, filtered to detect the 2.0 to 3.5 μm wavelength band, was used in addition to the detector-filter combinations used during the second mission. A summary of the remote sensing data acquired is shown in Table 1.

The north study site is located approximately four miles north of the mouth and on the east side of the Duplin Estuary. It was chosen because it contains a large variety of habitats. *Spartina alterniflora* grows in dense tall stands along the streams and in thin stands in other areas; large sections are composed of pure stands of *Juncus roemerianus;* and mixed stands of *Spartina alterniflora, Distichlis spicata* and *Salicornia* sp. form a band along the bare sands bordering the woods. In contrast, the south study site, located approximately two miles north and on the east side of the mouth of the Duplin Estuary, consists of a pure stand of *Spartina alterniflora.*

Prior to the photography and ground truth collection, the study sites were divided into 250 meter square grids and each point marked with a one meter, white circular plywood disk. These disks formed a collar around the posts and were free to float with the rising and falling water. They provided identi-

TABLE 1. SUMMARY OF REMOTE SENSING DATA ACQUIRED

	Data	*Mission*		
		1	2	3 °
Color	*Scale*			
Infrared	1: 2,500	x	x	x
Photography	1: 5,000	x	x	x
	1:10,000	x	x	x
	1:20,000			x
	1:40,000			x
Thermal	*Mercury-Cadmium-*			
Imagery	*telluride*			†
	2.0 – 3.5 μm		x	x
	3.5 – 5.5 μm		x	x
	8.0 – 12.5 μm	x	x	x
	2.0 – 13.0 μm		x	x
	Indium antimonide			
	2.0 – 3.5 μm			x
Date		22 June 1971	18 August 1971	14 September° 7 October † 1971
Sun angle		90°	45–50°	45–50°
Tide stage		Low	Low	Low

fiable points on both the photographs and the ground.

Ground-truth data for the first mission were obtained by harvesting all living and dead material at the soil line in a 1.0-m^2 plot at 25-meter intervals along a line extending east and west through the middle of both the north and the south study sites. Thirty square meters were cut along the transect in the south study site and 20 square meters along the north. Each species in each plot was sorted into living and dead plants and into one-half meter height classes.

Data from the 50 square meters were organized into groups depending on the photographic color of the area where they were cut. Studies of the initial photographs indicated that perhaps six production categories could be seen.

Sampling sites for the second mission were selected from the vegetative patterns portrayed on the first mission photography. Variability within species and areal coverage were used as the bases for determining the number of replicates to be taken. Five samples were collected in the *Juncus* and *Distichlis* areas and 20 in the *Spartina* where four categories were established. Square white markers, similar to those used for the grid system, were placed on the plots following harvest and the photographs subsequently taken. Samples of plants from each of these areas for pigment analysis were returned to the lab and frozen. Pigments were extracted in acetone and chlorophyll *A* determined by the method of Odum *et al.* (1958).

For the third mission the sampling stations were once again selected by predicting areas of similar production based on the six color categories noted on previous photographs. Areas for sampling were selected to fall within the limits of each of the six colors rather than trying to select all of exactly the same hue.

Results and Discussion

The ground truth from the third mission is shown in Table 2, Dry weight of living matter varied from 1665 g m^{-2} for stream bank *Spartina* to 246 g m^{-2} for the *Distichlis* stand. These values represent the maximum standing crop and were used to compute the study site and watershed values. Chlorophyll *A* was assessed only in the leaves of this collection because the leaves appear to be the major contributors to the spectral reflectance or spectral response of the plants (Table 2). Within *Spartina*, chlorophyll *A* differences are clear at the extremes (red and blue), but between the intermediate groups (light red and blue-red) variations within each group preclude statistical separation. The spectral reflectance of *Juncus* and tall and short *Spartina* as measured in the laboratory with a Beckman DK-2A spectrophotometer are shown in Figure 3 (courtesy Dr. Harold Gausman, Rio Grande Soil and Water Research Center, Weslaco, Texas). The characteristic color of *Juncus* compared to *Spartina* on the color-infrared film was used to determine the proportion of these two major angiosperms in the *Duplin*. *Juncus* covers 67

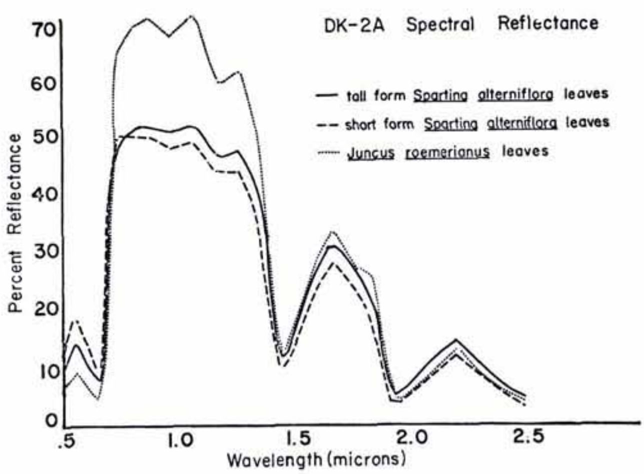


FIG. 3. Reflectance spectra for leaves of *Juncus roemerianus* and two forms of *Spartina alterniflora*. (1 micron = 1 micrometer (μm)).

TABE 2. GROUND-TRUTH DATA FROM THE THIRD MISSION (14 SEPTEMBER 1971) ON THE DUPLIN ESTUARY MARSH

	PRODUCTION CLASSIFICATION											
	Juncus		*Distichlis stand*		*Spartina*							
					Red		*Light red*		*Blue-red*		*Blue*	
Data	$Y^{n=5}$	*CV*	$Y^{n=5}$	*CV*	$Y^{n=5}$	*CV*	$Y^{n=5}$	*CV*	$Y^{n=5}$	*CV*	$Y^{n=5}$	*CV*
DENSITY												
Stems m^{-2}	786	20.5			98	19.2	167	25.7	142	26.2	206	38.9
Height Class (Percent abundance)												
0.01 – 0.50 m	15.5				28.2		35.7		51.0		78.8	
0.51 – 1.00 m	42.0				16.0		64.3		47.1		17.1	
1.01 – 1.50 m	42.5				23.5				1.9		2.9	
> 1.51 m					32.4						1.3	
LIVING MATTER												
Dry Weight ($g\ m^{-2}$)	912.7	28.3	246.0	11.4	1664.9	41.3	629.5	41.9	499.1	24.7	331.3	34.2
Dry Weight (Percent)	47.5		42.8		27.6		35.7		34.5		35.7	
DEAD MATTER												
Dry Weight ($g\ m^{-2}$)	624.6	30.3	357.3	30.8	301.1	71.2	169.4	25.0	225.8	35.2	57.1	46.2
Dry Weight (Percent)	63.2		62.0		32.3		40.6		32.5		34.9	
CHLOROPHYLL "A" (mg g^{-1} of fresh weight of leaf)	0.730		1.690		1.216		0.714		0.636		0.571	

** *Y*, mean; *CV*, coefficient of variation; *n*, sample number.

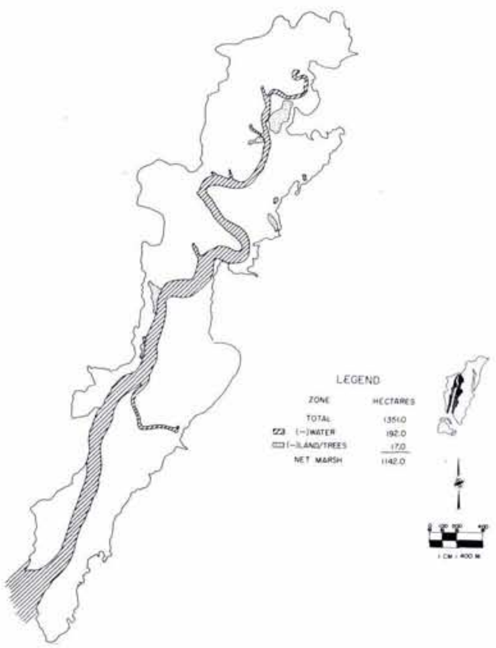


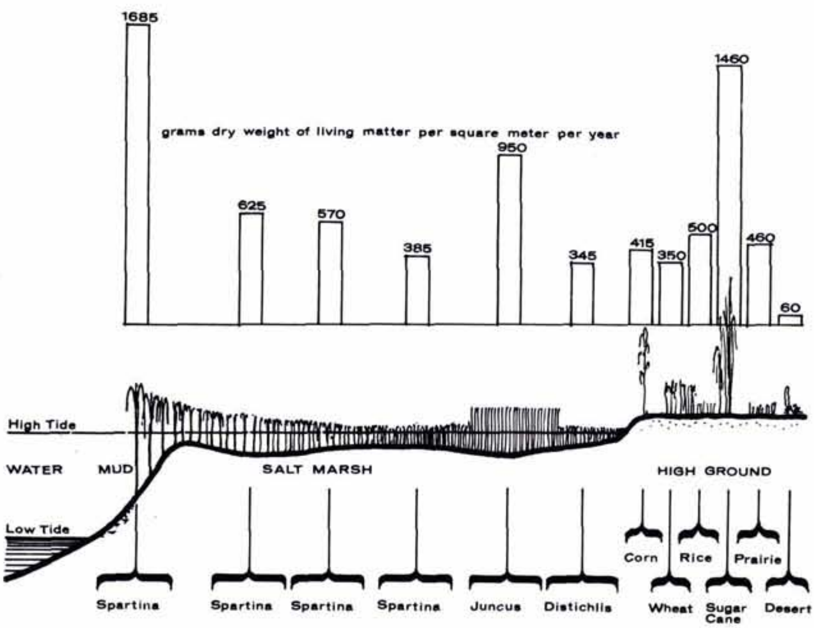
FIG. 4. Visual interpretation of marsh area in Duplin Watershed from color-infrared photographs, scale 1:40,000, 14 Sept. 1971.

hectares and *Spartina* covers 1075 hectares. The *Duplin* consists of 192 hectares of water and 1142 hectares of marsh as outlined in Figure 4.

Three distinct colors corresponding to *Juncus*, *Spartina* and a mixed stand composed primarily of *Distichlis* and *Salicornia* can be seen in the marsh areas of the photographs. Within the *Spartina* areas four fairly distinct colors are discernible: (1) bright red, tall robust plants; (2) light red, medium height robust plants; (3) blue-red, medium height-medium density plants; and (4) blue, low density short or medium height plants. (A typical area depicting these variations appears on the cover of this journal.)

The net reflectance from the various marsh areas depends on a number of factors including plant density, geometry, morphology, and the reflectance of the soil. The color produced if color-infrared film is exposed (with the proper filter) is due to the combined effects of all incoming energy with wavelengths between 0.5 and 0.9 μm. The colors produced (although their basis of formation is not completely documented) are useful in distinguishing various categories of marsh vegetation.

Because healthy, verdurous plants generally have a high reflectance in the near-infrared (see Figure 3), exposure of the color-infrared film layers should result in a bright red or magenta color. Differences in chlorophyll and carotenoid concentrations caused by factors such as mineral limitations, disease, genetic differences, physical edaphic condi-



tions and salt stress dominate the reflectance patterns at the lower end of the film's spectral sensitivity. In the short-infrared range, the reflectance differences of the plants are associated with differences in moisture in the mesophyll and differences in leaf anatomy (Gates, 1970). Based on the relationship where dry weight divided by wet weight multiplied by 100 equals the percent dry weight, the lower percent dry weight figures (as summarized from Table 2 and depicted in Figure 5) for the stream bank *Spartina* (red on color-infrared film) as opposed to that in the high marsh (blue) may indicate differences in the proportion of various cell types, cell size and intercellular spaces. Stream bank *Spartina* averaged 27.6 percent dry weight whereas the high marsh was 35.7 percent (significantly different at the 0.001 level).

The areas of each color class in the north and in the south study sites were interpreted on a Kern PG-2 stereo plotter and their areal extent determined with H. Dell Foster quantifying accessories. The maps produced are shown in Figures 6 and 7. Using the September living plant biomass figures as an indicator of agronomic production, the mean values for the south study site were 571 g m^{-2} $year^{-1}$ and for the north 698 g m^{-2} $year^{-1}$. The average production for the 1142 hectare Duplin Estuary marsh is 591 g m^{-2} $year^{-1}$.

All of the film used for the three missions flown was purchased at one time and only the amount needed for a single mission was unfrozen and removed from the roll at a given time. Because of variations that may occur from one batch of film to the next and the cost of film, it is desirable to cover as much area as possible with a single 9×9-inch photograph. In the third mission, photographs were taken at 1:20,000 and 1:40,000 scale. A comparison of the interpretation of the north and south study sites was made on enlargements of the 1:40,000 scale photographs. Figures 8 and 9 show these 1:40,000 scale interpretations. The comparisons of the interpretations at the two scales is shown in Table 3. Total species areas are distinguished with equal ease on either scale photograph. Within the *Spartina* there is a tendency to interpret a larger portion of the area as blue-red on the 1:40,000 scale photograph than on the 1:5,000.

Figure 10 shows images of the north study site formed using the four bands with the mercury-cadmium-telluride detector plus the one with indium-antimonide dectector. Ther-

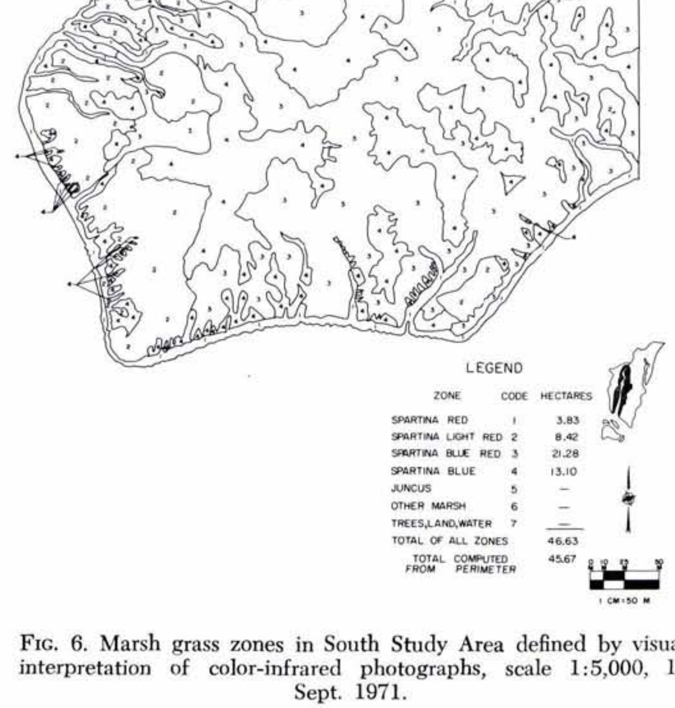
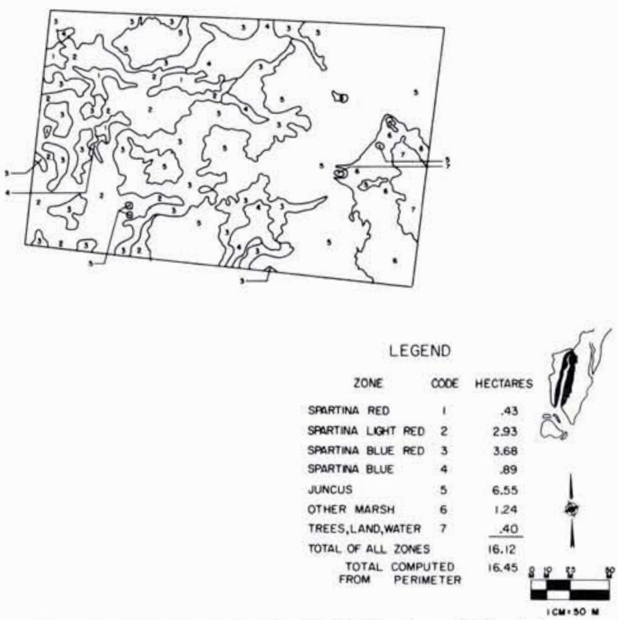


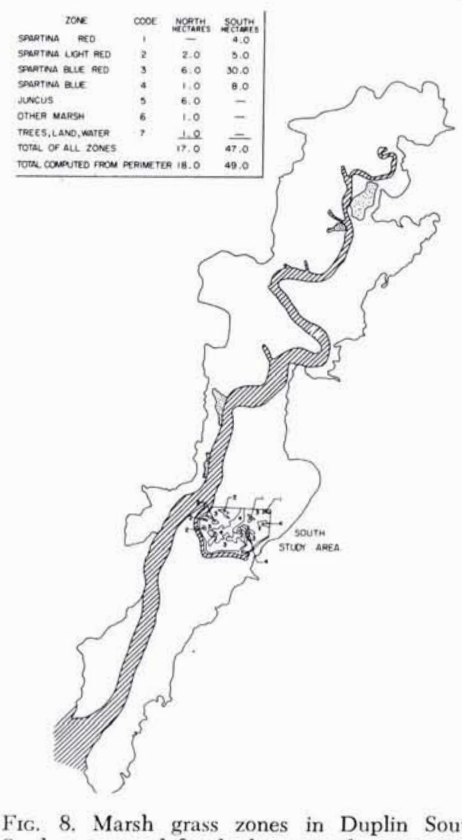
FIG. 6. Marsh grass zones in South Study Area defined by visual interpretation of color-infrared photographs, scale 1:5,000, 14 Sept. 1971.



LEGEND

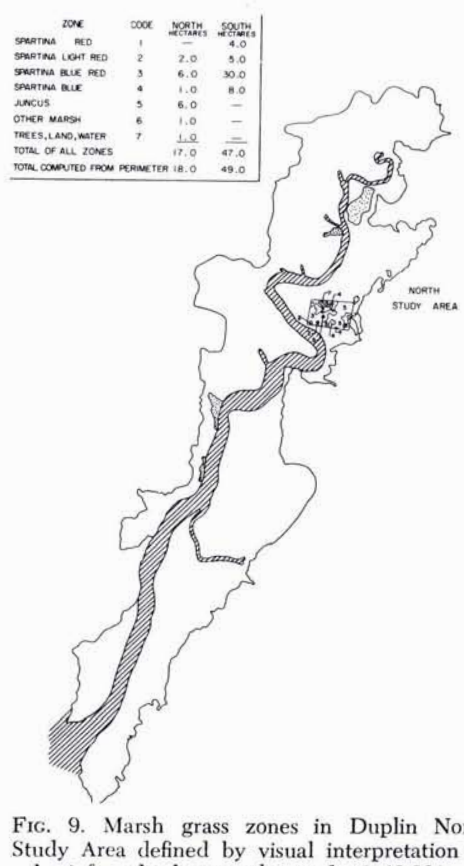
ZONE	CODE	HECTARES
SPARTINA RED	1	.43
SPARTINA LIGHT RED	2	2.93
SPARTINA BLUE RED	3	3.68
SPARTINA BLUE	4	.89
JUNCUS	5	6.55
OTHER MARSH	6	1.24
TREES, LAND, WATER	7	.40
TOTAL OF ALL ZONES		16.12
TOTAL COMPUTED FROM PERIMETER		16.45

FIG. 7. Marsh grass zones in North Study Area defined by visual interpretation of color-infrared photographs, scale 1:5,000, 14 Sept. 1971.



ZONE	CODE	NORTH HECTARES	SOUTH HECTARES
SPARTINA RED	1	—	4.0
SPARTINA LIGHT RED	2	2.0	5.0
SPARTINA BLUE RED	3	6.0	30.0
SPARTINA BLUE	4	1.0	8.0
JUNCUS	5	6.0	—
OTHER MARSH	6	1.0	—
TREES, LAND, WATER	7	1.0	—
TOTAL OF ALL ZONES		17.0	47.0
TOTAL COMPUTED FROM PERIMETER		18.0	49.0

FIG. 8. Marsh grass zones in Duplin South Study Area defined by visual interpretation of color-infrared photographs, scale 1:40,000, 14 Sept. 1971.



ZONE	CODE	NORTH HECTARES	SOUTH HECTARES
SPARTINA RED	1	—	4.0
SPARTINA LIGHT RED	2	2.0	5.0
SPARTINA BLUE RED	3	6.0	30.0
SPARTINA BLUE	4	1.0	8.0
JUNCUS	5	6.0	—
OTHER MARSH	6	1.0	—
TREES, LAND, WATER	7	1.0	—
TOTAL OF ALL ZONES		17.0	47.0
TOTAL COMPUTED FROM PERIMETER		18.0	49.0

FIG. 9. Marsh grass zones in Duplin North Study Area defined by visual interpretation of color-infrared photographs, scale 1:40,000, 14 Sept. 1971.

Plate 1. A characteristic color-infrared photograph of an area north of the Duplin North Study Area. The original scale was 1:5,000; here it is approx. 1:6,400. 14 Sept. 1971.

TABLE 3. COMPARISON OF VISUAL INTERPRETATION OF THE 1:5,000- AND 1:40,000-SCALE COLOR-INFRARED PHOTOGRAPHS OF THE TWO STUDY SITES

Production Categories	*Study Sites*			
	North		*South*	
	1:5,000	1:40,000	1:5,000	1:40,000
	Hectares			
Juncus	6.5	6.0	–	–
Distichlis stand	1.2	1.0	–	–
Spartina				
red	0.4	0	3.8	4.0
light red	2.9	2.0	8.4	5.0
blue-red	3.7	6.0	21.3	30.0
blue	0.9	1.0	13.1	8.0

mal imagery with the 2.0- to 3.5-μm bands and either the mercury-cadmium-telluride or indium-antimonide detector gives clear distinction of *Juncus* and *Spartina* vegetative zones.

A possible use of the thermal imagery, not anticipated at the outset of the study but discovered while working with the Datacolor System Color Densitometer, is the capability to discriminate the tidal flooding pattern of the marsh by color enhancement of the thermal imagery taken at low water. Preliminary examination of successive black-and-white infrared photographs taken over a flooding tidal period verify this new method.

SIGNIFICANCE OF RESEARCH

It is evidently possible to increase the accuracy of primary production estimates of large marsh areas by employing remote-sensing techniques. The interpretations of physiographic features seen in the photographic and nonphotographic images, the creation of vegetation maps and the measurement of primary production over large areas of the tidal marsh are already proving to be useful to ecologists and other scientists (U.S. Army Corps of Engineers, Georgia State Highway Department, and other state and federal agencies). These remote-sensing techniques and production measurements are also of value to those planning industrial and recreational development of the coastal zone by providing information on the spatial distribution of species and primary production in the marsh.

Primary production estimates for large areas obtained by coupling ground-truth

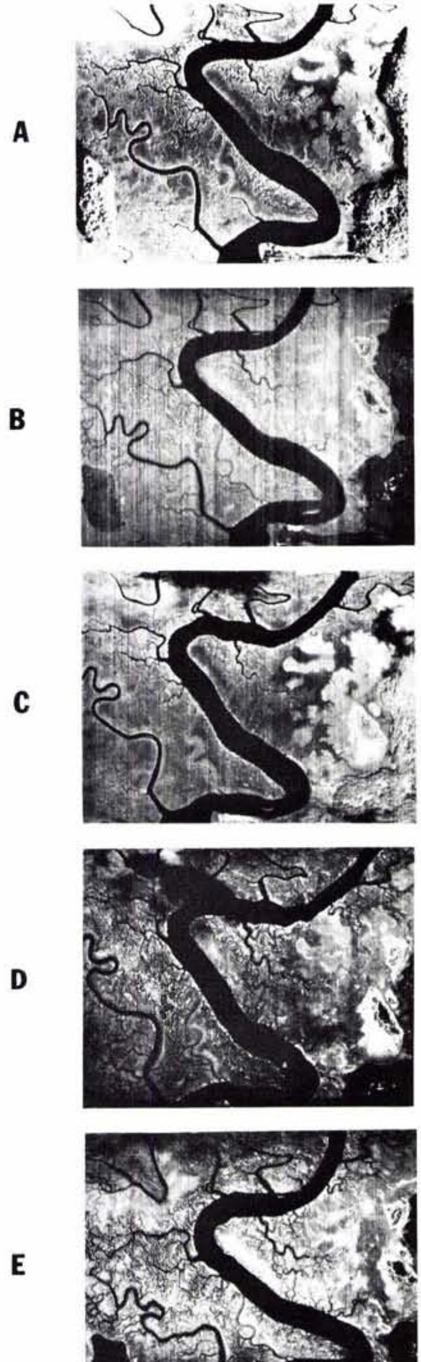


FIG. 10. Imagery of the North Study Area acquired with a Bendix LN-3 thermal mapper. *A*–Indium-antimonide detector, 2.0-3.5 μm. *B*–Mercury-cadmium-telluride detector, 3.7-5.5 μm. *C*–Mercury-cadmium-telluride detector, 2.0-3.5 μm. *D*–Mercury-cadmium-telluride detector, 2.0-13.0 μm. *E*–Mercury-cadmium-telluride detector, 8.0-12.5 μm.

measurements and photographic and non-photographic images provide essential basic information for mathematical modeling of the salt marsh ecosystem. Information on species spatial relations and primary production category distribution has proven useful for selecting sampling sites for other studies. As other ecosystem processes are associated with species and production distribution, the information obtained in this study is additionally useful in evaluating the contribution of particular areas to numerous aspects of the biological activity of the ecosystem.

Literature Cited

ANDERSON, R. R. and F. J. WOBBER, 1972. "Wetlands Mapping in New Jersey." p. 530 to 536. *In* Kosco, W. J., Chairman. *Proceedings* of the 38th annual meeting, American Society of Photogrammetry, Falls Church, Virginia. 636 p.

ANSON, A. 1966. "Color photo comparisons." *Photogrammetric Engineering.* 32:286–297.

COLWELL, R. N. and D. L. OLSON. 1966. "Thermal infrared imagery and its use in vegetation analysis by remote aerial reconnaissance." p. 77 to 91. *Selected Papers on Remote Sensing of Environment,* American Society of Photogrammetry, Falls Church, Virginia. 291 p.

EGAN, W. C. and M. E. HAIR. 1971. "Automated delineation of wetlands in photographic remote sensing." p. 199 to 200 *Summaries Seventh International Symposium of Remote Sensing of Environment.* University of Michigan, Ann Arbor, Michigan. 218 p.

EYRE, L. A. 1971. "High-altitude color photos." *Photogrammetric Engineering.* 37:1149–1153.

GATES, D. W. 1970. "Physical and physiological properties of plants." p. 224 to 252. *Remote Sensing with Special Reference to Agriculture and Forestry.* National Academy of Sciences, Washington, D.C. 424 p.

HELLER, R. C. 1971. "Imaging with photographic sensors." p. 35 to 72. *Remote Sensing with Special Reference to Agriculture and Forestry.* National Academy of Sciences. Washington, D.C. 424 p.

MORGAN, MARCIA H. 1961. *Annual angiosperm production on a salt marsh.* M.Sc. Thesis. Univ. of Delaware. 34 p.

ODUM, E. P. 1961. *The role of tidal marshes in estuarine production.* N.Y. State Conserv. 35:12–15.

ODUM, E. P. and A. A. DE LA CRUZ. 1967. "Particulate organic detritus in a Georgia salt marsh-estuarine ecosystem." p. 383 to 388. *In* Lauff, G. H. (ed.) *Estuaries,* American Association for the Advancement of Science. Washington, D.C. 757 p.

ODUM, H. T., W. MCCONNELL and W. ABBOTT. 1958. "The chlorophyll "A" of communities." *Publ. of the Inst. of Mar. Sci.* 5:66–96.

OLSON, D. P. 1964. "The Use of Aerial Photographs in Studies of Marsh Vegetation." *Marine Agr. Expt. Sta. Bull.* 13. 62 p.

STROUD, LINDA M. and A. W. COOPER. 1969. "Color-infrared Aerial Photographic Interpretation and Net Productivity of a Regularly Flooded North Carolina Salt Marsh." Water Resources Research Institute of the Univ. of N.C. *Report No.* 14. 86 p.

SMALLEY, A. E. 1959. "The role of two invertebrate populations, *Littorina irrorata* and *Orchelimum fidicinium,* in the energy flow of a salt marsh ecosystem." Ph.D. Thesis. Univ. of Georgia. 126 p.

TEAL, J. M. 1962. "Energy flow in the salt marsh ecosystem of Georgia." *Ecology* 43:614–624.

UDELL, A. F., *et al.* 1969. "Productivity and nutrient values of plants growing in salt marshes of the town of Hempstead, Long Island." *Bull. Torrey Bot. Club* 96:42–51.

WASS, M. S. and T. D. WRIGHT. 1969. "Coastal Wetlands of Virginia. Interim Report to the Governor and General Assembly." Va. Inst. of Mar. Sci. *Spec. Rept. in Applied Mar. Sci. and Ocean Eng.* No. 10. 154 p.

WILLIAMS, R. B. and MARIANNE B. MURDOCH. 1972. "Compartmental analysis of the production of *Juncus roemerianus* in a North Carolina salt marsh." *Chesapeake Sci.* 13:69–79.

Articles for Next Month

Y. I. Abdel-Aziz, Lens distortion at close range.
W. Faig and H. Moniwa, Convergent photos for close range.
J. J. Fisher and *E. Z. Steever,* 35-mm quadricamera.
S. *E. Masry* and *J. G. Gibbons,* Distortion and rectification of IR.
C. I. Miller, Stereo models for measuring the space scene.
D. E. Ross, Simple multispectral photos and color viewing.
F. F. Sabins, Aerial camera mount for 70-mm stereo.
G. H. Schut, Similarity transformation and least squares.
J. E. Wasielewski, et al., Holography, radar data and P.I. performance.
F. J. Wobber and *R. R. Anderson,* ERTS data for coastal management.
K. W. Wong, et al., Analysis of RBV television system.