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GENERALIZED VEGETATION MAP OF NORTH MERRITT ISLAND BASED ON A SIMPLIFIED MULTISPECTRAL ANALYSIS

(and other topics)

By
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By
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ABSTRACT

A simplified system for classification of multispectral data has been used for making a generalized map of ground features of North Merritt Island. Because of frequent invasion of one vegetation type by another there exists a certain degree of latitude in the choice of the exact position of generalized boundaries is possible with an acceptable degree of accuracy. Subclassification of vegetation within the broad categories has given promising results which should lead to a completely automatic method and to the production of satisfactory detailed maps. A comparison of the generalized map and an earlier IMAGE-100 output of the area with a more recent IMAGE-100 output indicates some environmental change in a area North of Happy Hammocks. This change is evidently related to water relations of the soil and is not associated with the last winter freeze-damage which affected mainly the mangrove species which are however likely to re-establish themselves by natural processes. A supplementary investigation involving reflectance studies in the laboratory has shown that the reflectance by detached citrus leaves, of wave lengths lying between 400μ and 700μ, showed some variation over a period of seven days during which the leaves were kept in a laboratory atmosphere.

INTRODUCTION

The direction which the project under review has been following recently is the development of a simplified system for a completely automatic classification of multispectral data and map construction so as to show not only the broad outlines of all ground features but also the pertinent details within the broad divisions. The reason for the high level of accuracy which the system in its present form achieves in the mapping of broad categories, is that the broad categories are synthesizable from their component parts by operators who have examined a sample area. The procedure is easy because broad categories such as Salal Forest versus Typha-Spartina are systematically related to each other by topography and direction. Within the broad categories however, although the same factors permit differentiation of sub-categories, the details are just slightly too excessive to permit systematization visually. To categorize empirically on a purely mathematical basis would of course be worse, as is evident from a study of current work. What is required is of course further numerical analysis of sub-categories and stage by stage mapping, in order to investigate the existence of systematic relationship between the computer-produced sub-categories. This has been attempted with zeric and mesic hardwoods with promising results and it appears that a basis will emerge for complete automation of the simplified classification system without loss of accuracy.

Concurrently with the above line of investigation, imagery generated by the IMAGE-100 System and Color Infrared Photos of North Merritt Island are studied and compared with each other and with the maps which result from the Simplified Classification System referred to above. The purpose is to compare the relative merits of the various systems for remote observation and to monitor the surface of North Merritt Island for spatial and temporal change in the environment, both aquatic and terrestrial.

The report shows the methods employed, the results and the next logical steps to be pursued.

AIMS

The aims of this project during the past recent period have been: -

1. To construct a generalized map of North Merritt Island by remote observation.
2. To make the Simplified M.S.S. data Analysis and Mapping system completely automatic.
3. To compare results of various Image-Generating Systems as methods of monitoring the environment of North Merritt Island.
4. To initiate reflectance studies with small units of vegetation on a laboratory scale.
5. To observe the results of freeze damage with a view to devising means of regeneration.

MATERIALS AND METHODS

The generalized map of North Merritt Island was developed on a remote terminal from LANDSAT Multispectral data using a Simplified Software. The Multispectral data was classified into more than 40 discrete classes from which six principal ground features were synthesized.

Because two of the broad categories are appreciably heterogenous and consequently are difficult to map into sub-categories which also poses a problem for automation, those two classes have been analyzed in greater detail. The procedure is designed to search for a systematic relationship between sub-categories so as to permit mapping over appropriate ground features within broad categories.

Imagery was provided by two other methods beside the remote terminal which in effect produced a character map that was subsequently colored appropriately. One of the methods was Infrared Color Photography carried out by low-flying NASA aircraft. The other was Imagery generation by the IMAGE-100 System using the same LANDSAT-acquired Multispectral data as that used on the remote terminal for character map production.

In order to study more critically the behaviour of reflected light of various wave-lengths a laboratory study was initiated using a Spectronic 20 with a Bosch and Lomb attachment. The light studied lay in the wave-length range 420 μ - 700 μ .

Field observations were made on species which are most susceptible to freeze-damage in Central Florida and the results will be compared with observations made by remote methods.

RESULTS

Generalized Map of North Merritt Island.

The categories of ground features shown on the attached map are: -

1. Areas under water
2. Mangrove
3. Typha-Spartina
4. Sabal Palm Forest
5. Mesic Hardwoods
6. Zeric Hardwoods containing other groups

The map presented as Figure I was made by graduating the boundaries of a colored character map which was presented on an earlier occasion.

The details presented in the earlier map can probably undergo some improvement after further analysis but the broad outlines represented in the map are not likely to change significantly.

The data on which the map was based was classified on the basis of mean values of classes. Table I shows the same data classified on the basis of variances of classes. Although there is some measure of accentuation of class differences, the procedure does not result in an appreciably better differentiation, neither for broad categories nor sub-categories.

Thus for better differentiation of the sub-categories at least, other techniques must be adopted.

The generalized map shown in Figure I was compared with Field features in order to estimate the accuracy of the boundaries. An estimate of field error is given in Table II where it is seen that the mean error of 11 meters is not statistically significant. This is probably not true of all areas which are referred to as sub-categories.

It is interesting at this stage to point out that in addition to the value of the character map for production of a generalized map by graduation, it has also served the purpose of being a basis for evaluating the relative proportions of various types of ground features. A summary of the area under various categories is given in Table III. This table refers to the year 1974. Similar Tables can be made at various intervals for comparison with the bases year in monitoring environmental change temporally and spatially.

Images produced by IMAGE-100 system

Figures II and III show images produced on the IMAGE-100 System from MSS tapes recorded in 1974 and 1976. It is clear that the broad distribution of ground features is similar in the two cases. This means that the System is

satisfactory for broad classification. The broad categories are not however identical in their locations. This does not necessarily indicate that change has occurred in the environment as a whole because sampling with the cursor causes a variation in imagery. However in both cases general patterns agree with field distribution and the computer-generated character map. It is deserving of mention that a comparison of the two IMAGE-100 outputs indicates an appreciable difference in the Palm Hammock area North of Happy Hammocks. Field examination shows that the water level of the soil in that area may have increased sufficiently to affect the vegetation favorably. If this is a trend it should accentuate itself in time and be recordable remotely.

Color Infrared Photos

The most recent of these photos have not indicated any major catastrophic change in the environment. It is believed that the next series would show the areas where freeze-damage was appreciable. It is believed that Color Infrared Photos are probably not capable of very reliably showing the probable change which is occurring in the North of Happy Hammocks.

Analysis of ERTS Multispectral Data for December 1976 by Remote Terminal

The classification of data for this period shown in Table IV refers to the features around the Orbiter Landing Facility. It is clear that the table that the total number of sub-classes correspond well with the number shown in Table I. Thus it appears likely that it will be found that major environmental changes will be revealed by this system of classification particularly if a table such as Table III can be derived from the complete classification of the 1976 data. During the approaching quarter, it is expected that the rest of the data will be analyzed and tabulated for comparison with Table III.

Sub-classification of zeric hardwoods.

As explained previously, it is not only necessary to accurately map the sub-categories of features within the main categories, but also to modify the Simplified Classification System into one which is completely automatic. Both these results can be achieved by finding what relationships exists between the sub-categories. A number of classes result from the analysis of the zeric hardwoods into its sub-categories. It is clear from Figure IV that the sub-classes arrange themselves in the field into six distinct features. It would be difficult or nearly impossible to group these sub-categories equally effectively by most if not any existing method. After further computer runs are made and the effectiveness of the procedure is confirmed, the results will be used to make the classification system completely automatic.

Laboratory Studies on Reflectance from individual leaves

It is usually valuable to conduct laboratory studies in order to evaluate effects due to single or a few factors more critically than is possible in the Field.

The results shown in Figure V indicate that there is some variation in reflectance between leaves of different species, and between leaves of the same species having different water levels due to detachment from the plant over a range of seven days. The wave lengths used in these experiments varied between 420 μ and 700 μ . The results may not be extrapolated for the ultraviolet or infra-red ranges. The infra-red ranges will be used in the next stage.

Study of freeze damage.

The list of species most subject to freeze damage is given in Table VI. A field examination shows that the most important of these occupy the mangrove

areas. Perhaps the first series of Color Infrared Photos made subsequent to the freeze damage may give a fairly accurate distribution of the effect. Laboratory results must be compared with the results of Color Infrared Photos.

It is interesting to observe that a high proportion of frozen mangrove species have produced fresh spouts and that these species are capable of re-establishment by transplantation as shown in Figure V.

CONCLUSIONS

1. Reliable generalized maps can be produced by a simple analysis of multi-spectral data as shown for North Merritt Island.
2. Analysis of main categories shown on the generalized maps, into sub-categories, produces reliable field mapping of the sub-categories and holds good promise for enabling complete automation of the Simplified Classification System.
3. The Simplified Classification System yields data on proportions of vegetation types which may be compared with corresponding proportions at any subsequent date in order to monitor environmental change.
4. Remote observation methods have revealed what appears to be a trend in the environment of an area North of Happy Hammocks. IMAGE-100 outputs have proven valuable in this connection.
5. Laboratory reflectance studies reveal that reflectance of monochromatic light within the range 420μ to 700μ cannot detect differences in vegetation type or condition.
6. It would appear that Laguncularia and Avicennia two important species damaged by the last freeze are capable of recovery by sprouting again, and by transplantation of seedlings.

ACKNOWLEDGEMENTS

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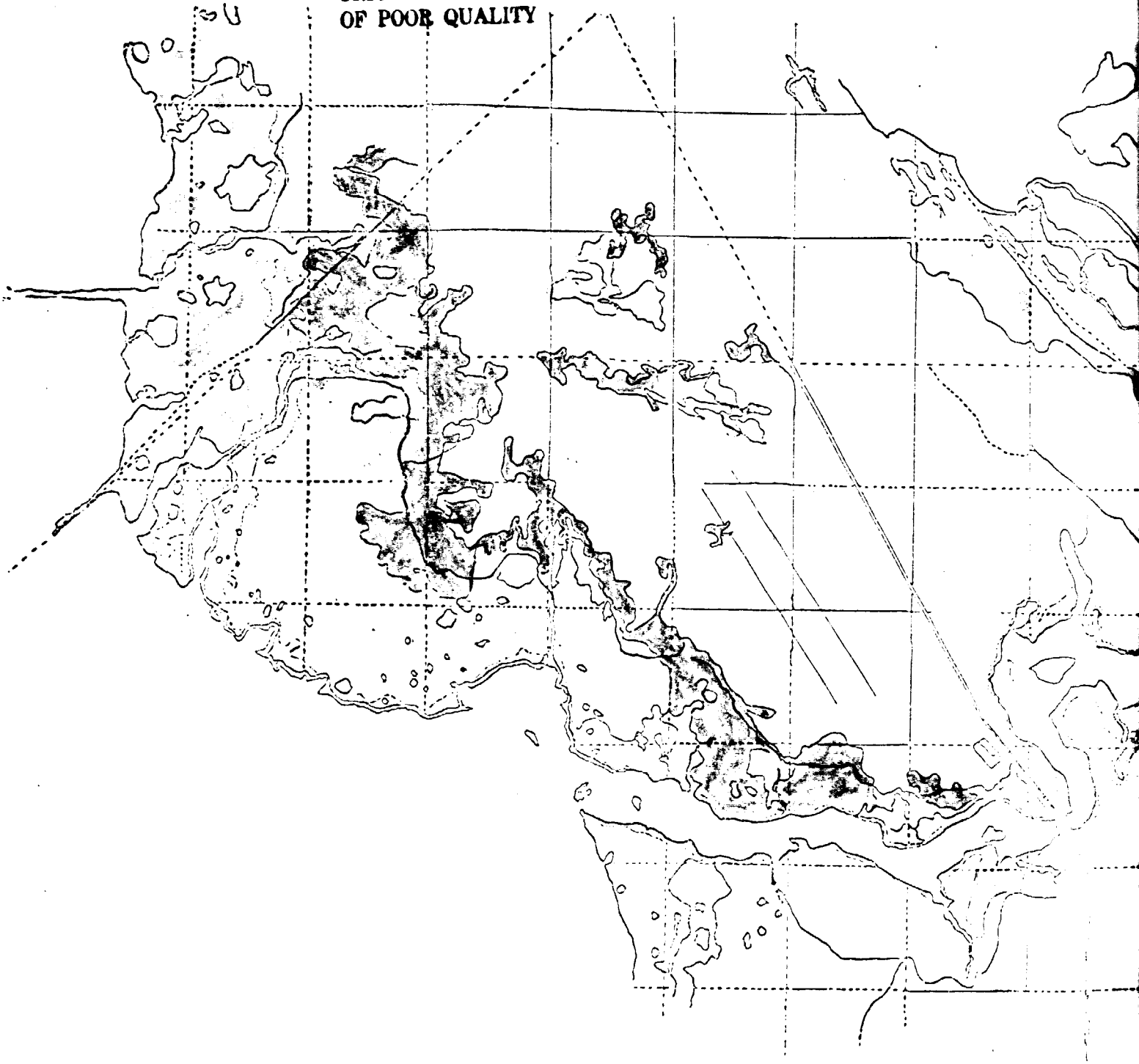
FOLDOUT FRAME

FIGURE I. GENERALIZED MAP OF NORTH MERRITT ISLAND
BASED ON SIMPLIFIED MULTISPECTRAL ANALYSIS



GENERALIZED MAP OF NORTH MERRITT ISLAND
N SIMPLIFIED MULTISPECTRAL ANALYSIS

FOLDOUT FRAME 2

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OF POOR QUALITY

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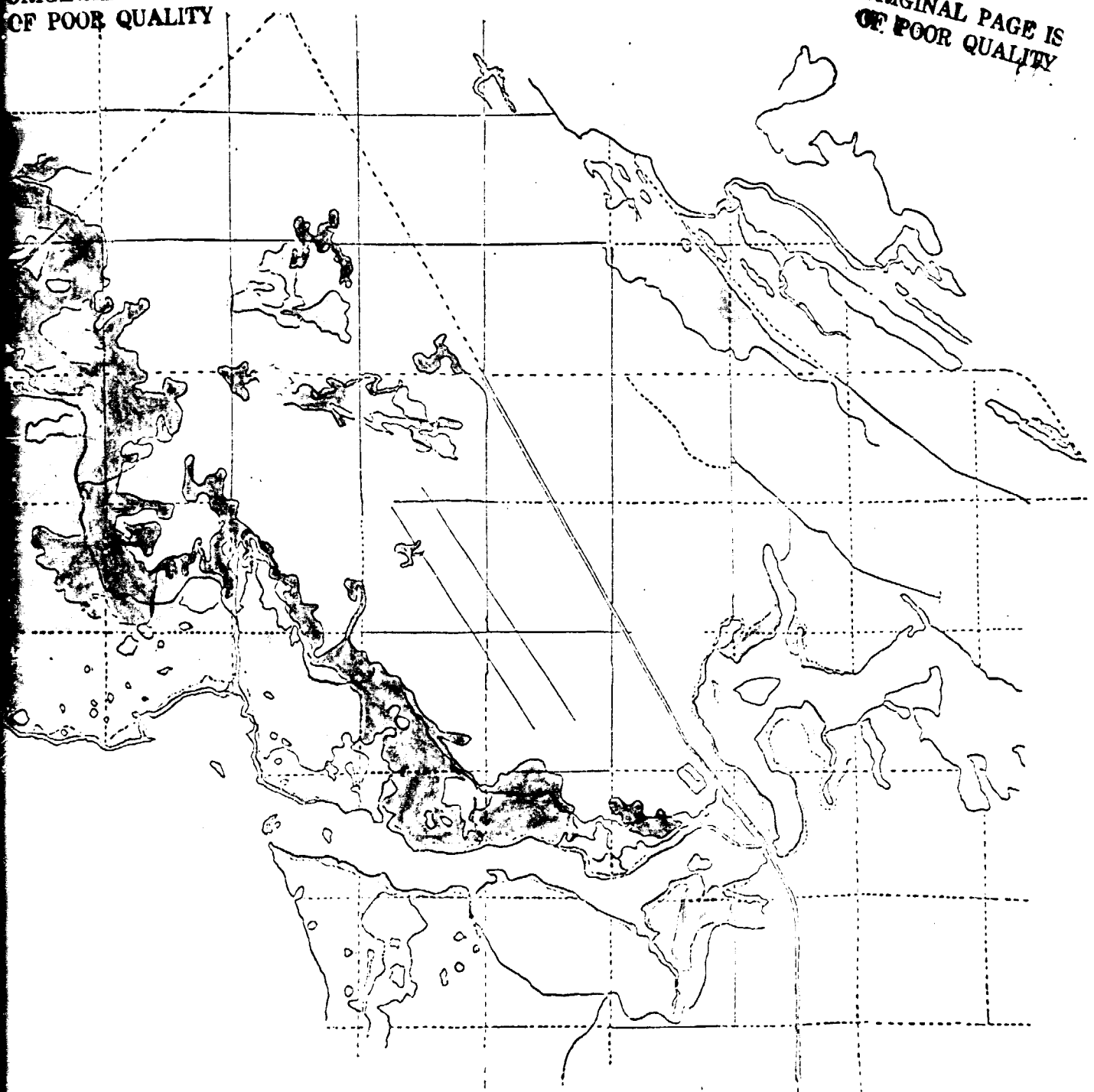


FIGURE II. IMAGE-100 MAP PRODUCED FROM MULTISPECTRAL DATA RECORDED IN 1976

FIGURE III. IMAGE-100 MAP PRODUCED FROM MULTISPECTRAL DATA RECORDED IN 1974

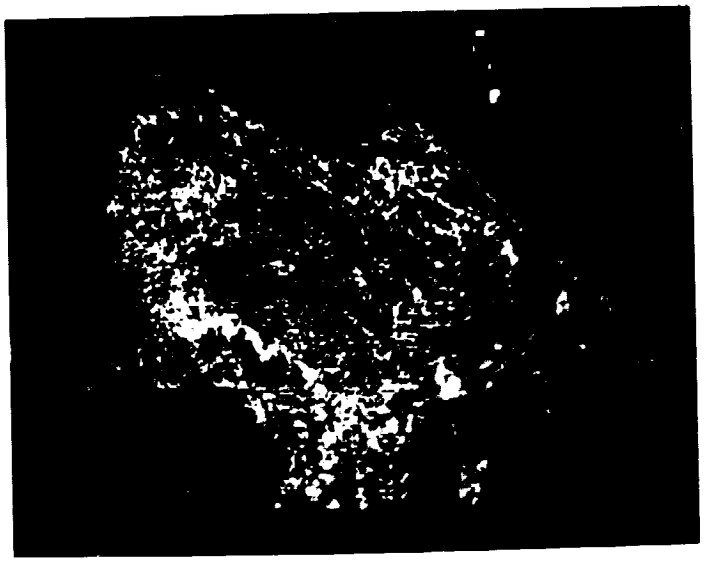
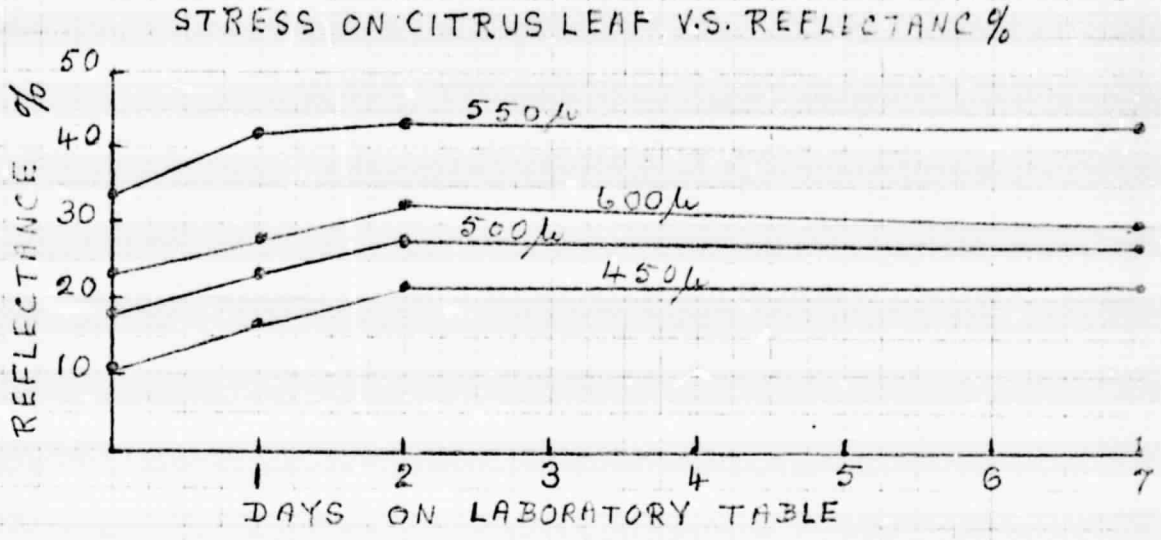


FIGURE IV. VARIATION IN REFLECTANCE OF VARIOUS WAVELENGTHS BY CITRUS LEAF STANDING IN A LABORATORY DURING 7 DAYS



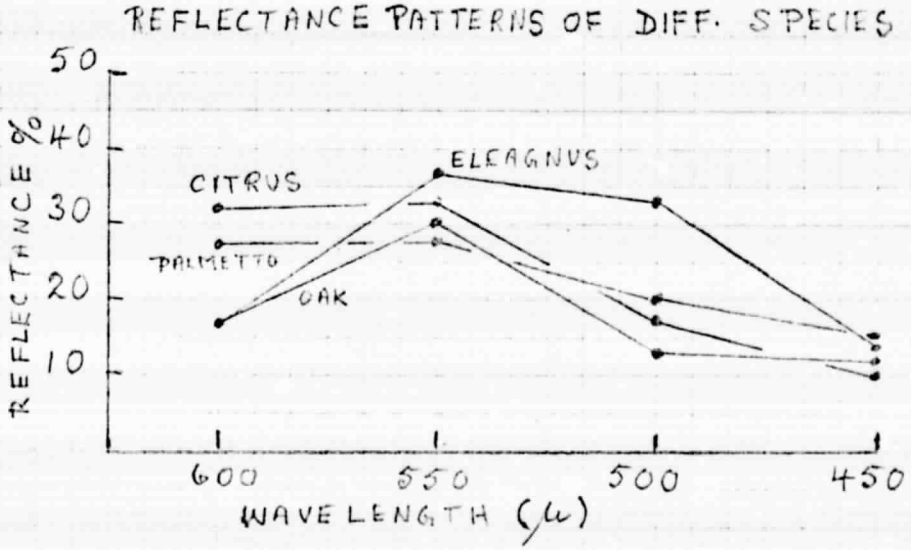


FIGURE V. REGENERATION OF MANGROVE BY TRANSPLANTING, RESPROUTING AND SEED

TABLE I. CLASSIFICATION OF MULTISPECTRAL DATA ON THE BASIS OF VARIANCES

f(x)	Variances of x1	x2	x3	x4	Mean Variance
-2	7.0756	11.6964	15.6025	5.0176	9.8480
-1	6.9696	10.6929	15.3664	4.3681	9.3492
0	6.6564	9.4249	13.2496	4.4521	8.4457
1	6.7081	10.240	14.2884	4.5369	8.9433
2	7.7284	11.9716	16.6464	4.7961	10.2856
3	5.0176	8.3521	10.0489	4.2025	6.9052
4	5.4289	8.9401	11.0889	4.4944	7.4880
5	9.4249	16.000	20.1601	7.1824	13.1918
6	9.0000	14.440	18.5761	6.4516	12.1169
7	10.3041	16.4836	21.9024	6.7600	13.8625
8	12.1801	19.0096	25.6036	7.8400	16.1583
9	12.6736	21.3444	27.8784	8.9401	17.7091
10	26.2144	49.9849	63.5209	17.9776	39.4244
11	19.9809	33.0625	47.6100	11.2896	27.9857
12	27.8784	46.9225	65.2864	16.5649	39.1630
13	43.4281	85.1929	102.8196	32.3624	65.9257
14	51.9841	87.4225	116.6400	31.5844	71.9077
15	34.3396	68.7241	83.7225	25.4016	53.0469
16	42.7716	33.9889	98.4064	29.4849	51.1629
17	57.6081	101.4049	130.1881	39.1876	82.0971
18	61.6225	112.3600	145.6849	41.0881	90.1889
19	52.5625	93.7024	123.4321	33.9889	75.9214
20	58.5225	108.1600	141.3721	37.5769	77.013
21	28.0900	52.2729	67.8976	18.4900	41.6876
22	28.3024	52.5625	70.2244	17.7241	42.2033

Table I Cont'd.

f(x)	Variances of x1	x2	x3	x4	Mean Variance
23	31.9225	56.1001	75.3424	19.8025	45.7918
24	41.3449	77.0884	101.8081	26.2144	61.6139
25	69.3896	132.0201	171.8721	45.4276	104.8023
26	82.0836	166.1521	216.6784	52.2729	129.2967
27	93.8961	172.6596	230.7361	58.5225	138.4535
28	91.5849	169.7809	224.7001	57.9121	135.9945
29	145.9264	284.9344	372.4900	93.3156	224.1666
30	137.1241	280.5625	355.3225	91.5849	216.1485
31	188.7876	328.3344	460.9609	107.5369	271.4049
32	135.9556	252.1744	326.5249	90.4401	201.2737
33	67.7329	147.6225	175.2976	52.7076	110.8401
34	50.2681	68.7241	99.6004	28.7296	61.8305
35	144.4804	287.9809	312.5582	127.9161	218.2336
36	8.0089	32.0356	32.0356	8.0089	20.0222

TABLE II. SHOWING THE DEGREE OF ACCURACY OF VEGETATIONAL BOUNDARIES ON THE GENERALIZED MAP

DIFFERENCES BETWEEN FIELD AND MAP DISTANCES (METERS)	
	110
	- 75
	- 125
	- 85
	+ 68
	+ 87
	+ 75
	+ 34
TOTAL =	+ 89
MEAN =	+ 11

STANDARD ERROR OF MEAN =

$\therefore$ the mean is not significantly different from zero

TABLE III. PROPORTIONS OF VEGETATION TYPES BASED UPON MULTI-SPECTRAL ANALYSIS OF NORTH MERRITT ISLAND

VEGETATION TYPE	AREA%
MANGROVE	12
SPARTINA-TYPHA	34
PALM FOREST	19
ZERIC HARDWOOD	22
MESIC HARDWOODS	13

TABLE IV. DEGREE OF FREEZE DAMAGE SUFFERED BY VARIOUS SPECIES OF PLANTS ON NORTH MERRITT ISLAND

SPECIES	DEGREE OF DAMAGE
White mangrove	
Laguncularia racemose	3-4
Black mangrove	
Avicennia nitida	5
Brazilian pepper	
Schinus terebinthfolius	4
Briar	
Smilex auriculata	2
Palmetto	
Serenoa repens	1
Oak	
Quercus spp.	1
Wax myrtle	
Myrica cerifera	1
Seagrafe	
Coccoloba uvifera	4
Myrsine guianexsis	5

1 = no damage
2 = very slight damage
3 = some leaf scorch
4 = severe leaf scorch
5 = very severe damage