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ENVIRONMENTAL MONITORING OF

NORTH MERRITT ISLAND

By
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1. ABSTRACT

The environmental impact of the space shuttle operation on North Merritt Island is being studied mainly by means of color infra red photos and field visits, with satisfactory results. An attempt is also being made to generate character maps of the Island using LANDSAT data with a view to decreasing the cost of monitoring and making the process more flexible in terms of rapid estimation of the extent of selected ground features. It seems possible that the IMAGE-100 output can be improved by using it in conjunction with certain of the software systems which are now being used for generating character maps. All the methods for generating maps show six main plant associations on North Merritt Island. It has now been shown that the six associations are related by ecological succession, merge into their neighbors in terms of component species and are capable of being observed for changes in terms of component species.

2. INTRODUCTION

The plant associations of North Merritt Island are being studied on a continuing basis in order to determine any environmental impact that the Space Shuttle Runway operation may have upon them. This report discusses the methods which were used during the November, 1974-October, 1975 project year, the results obtained so far and plans for the 1975-76 period. In addition to the civic and scientific value of the project, it provides an opportunity for participation of the students of Bethune-Cookman College in meaningful Under-graduate Research and personal development. The site which is being studied is shown in Figure 1.

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3. AIMS

The general aim of the program is to evaluate changes in the environment on North Merritt Island by comparing the condition of plant associations from time to time with their original condition during the year 1972-1973 and with the condition of similar associations in other parts of Merritt Island. The condition of the vegetation shall be expressed in terms of the species composition of the associations.

The project has two further aims. One of these is to assess the effectiveness of various methods of remote monitoring of the environment, namely, the use of LANDSAT Multispectral Data on the IMAGE-100 System, the use of LANDSAT Data on other image-generating computers and the use of color infra red photography.

The other of the two additional aims is to provide undergraduate students with the opportunity to participate in research.

4. MATERIALS AND METHODS

4.1 Materials

The data used in this work consist of multispectral observations acquired by LANDSAT, percentage composition of the various plant associations in terms of the species which occur in them obtained by field study, and field measurements of the principal ground features. Other source material used in the study consists of color infra red photographs acquired by NASA aircraft at approximately 6 month intervals on scales of 1:6000 and 1:24000.

Analysis by IMAGE-100 System

One of the methods of analysis of multispectral data acquired by LANDSAT over North Merritt Island is by use of the IMAGE-100 System, an interactive multispectral image analysis computer (2) which produces imagery which indicate the location of borders of broad classes of vegetation and ground features usually with a fair measure of accuracy namely a non-significant mean error of about 24 meters (1). The plant associations which it attempts to distinguish are: Submerged species, Mangrove, Typha-spartina, Sabal Hammocks, Woodlands and Oak-Palmetto scrub. It must be mentioned that it has been found that the borders between Woodlands and Oak-Palmetto are often indistinguishable on the IMAGE-100 output.

Preparation of character maps by means of the Signature Development Program

A software system developed at the Earth Resources Division of the Kennedy Space Center, known as the Signature Development Program is used as another method for generating character maps. The degree of differentiation of ground features can be made to vary in accordance with the strictness of the criteria used for merging the mathematically generated classes of pixels, until a representative number of classes is found which correspond with the ground features. The features referred to here are mainly the plant associations mentioned in the previous sub-section headed "Analysis by IMAGE-100 System".

Preparation of character maps on a time-sharing terminal

A third method for generating imagery corresponding with ground features was developed at Bethune-Cookman College and is known as a natural classification system. The method is to be used for classifying multispectral picture elements (pixels) acquired by LANDSAT on February 15, 1975 for North Merritt Island. The area to be studied will be the same as that for which a character map was developed by the use of the Signature Development Program. One of the advantages

of the Natural Classification System is its simplicity and hence its negligible processing cost. Another important advantage is the low standard deviation of pixel values within categories and hence its effectiveness as a classifier.

Use of Color Infra Red Photographs

Fourthly, the method of color infra red photography carried out by low-flying NASA aircraft results in transparencies and pictures which permit the identification of borders of ground features with negligible error. The scales of the color infra red photos used are approximately 1:6000 and 1:20000. The smaller scale is used for most of the area of North Merritt Island and the larger scale is used for strips adjacent to the space shuttle runway. The color infra red photos indicate satisfactorily, the distribution of the six principal plant associations mentioned under "Analysis by IMAGE-100 System", above. It is expected that changes in the extent and composition of the six plant associations will be reflected in corresponding changes on color infra red photos.

The method of field observation

Fifthly and finally, the method of field observation is employed for studying the composition and distribution of plant associations and for any changes which may occur from time to time. The observations on the distribution of plant associations are compared principally with features of color infra red photos which are made twice per year. Comparisons of field observations are also made with character maps developed by the Signature Development Program and in due course with maps to be developed by the Natural Classification System. Such comparisons are commonly referred to as ground truthing.

Comparison of ground features with color infra red photos is done by comparing field measurements with measurements made on the photos as shown in Table 1.

Comparison of ground features with computer generated character maps is done by comparing measurements made on color infra red photos with measurements made on character maps.

Changes in the environment are measured in two ways, firstly, by comparison of measurements on color infra red maps made in 1973 with measurements made subsequently as shown in Table 2, and secondly, by observing changes wherever those may occur, as indicated in Table 2.

5. RESULTS

In the results which follow, an attempt is made to evaluate various methods for determining environmental change which may occur on North Merritt Island as a result of the impact of the space shuttle runway operation. The methods which are being compared have been discussed in Section 4.

Results with IMAGE-100 System

Imagery produced with data acquired by LANDSAT multispectral scanners in 1973 and 1975 show six vegetation types in each case, namely, submerged flora, mangrove, typha-spartina swamp, sabal hammock, woodlands and oak-palmetto scrub.

On both occasions, the types which are best defined by the imagery are submerged vegetation, mangrove, typha-spartina and sabal hammocks. The differentiation between woodlands and oak-palmetto scrub is somewhat less accurate on the IMAGE-100 vegetation maps. The degree of accuracy with which IMAGE-100 themes identify the borders of vegetation types was found to be about 24 meters in 1973 but much higher in using LANDSAT data acquired in February of 1975. The general positions of vegetation types are however indicated clearly.

It is possible to use external software systems in conjunction with the IMAGE-100 system and thus improve its flexibility of performance. For example, pixel categories generated by the Natural Classification System may be displayed as themes on the C.R.T. of the IMAGE-100 and, if necessary, modified until satisfactory themes are produced. In the first attempt to use the results of the Natural Classification System for producing themes on the IMAGE-100, it was found that the themes representing various ground features were generated in the

appropriate areas but the number of pixels alarmed were less than expected. An attempt will be made to overcome this anomaly.

Results obtained with the Signature Development Program

The new software system referred to as the Signature Development Program has proven to be capable of classifying multispectral data for North Merritt Island with an error exceeding 72 meters in an unsupervised classification but perhaps much less in a semi-supervised classification. The processing of the data and production of character maps were done by Mr. Royce Hall at the Kennedy Space Center using LANDSAT tapes of February 15, 1975. It is believed that with increased supervision in processing of the data, a higher degree of discrimination can be achieved with this software system.

Results expected with a Natural Classification System

A Natural Classification System based upon natural relationships between reflectance values in four spectral bands, is being used to classify multispectral data and make character maps of North Merritt Island with promise of good results. The data to be used for this application will be the same as those used in the previous experiment discussed above. Processing of the data and preparation of character maps will be carried out on a remote terminal of a Time Sharing System, located at Bethune-Cookman College. The cost of processing the data and producing a character map after the data have been placed on file is estimated to be less than $100 per 25 square miles.

The categories of pixels generated by the Natural Classification System have been shown by the IMAGE-100 to constitute definite classes of ground features. It is therefore expected that satisfactory character maps will be produced on a remote terminal.

Results obtained with color infra red photography

Color infra red photos made on a scale of 1:6000 give positions of borders of plant associations with a degree of accuracy indicated in Table 1. The

twenty-five pairs of measurements shown there refer to widths of ground features measured in two ways namely, on color infra red photos and in the field. The mean difference between the two sets of values is so small that it may be ignored. It is less than its standard error (3).

Because color infra red photos show the size of ground features with a high degree of accuracy and also show changes in the condition of the vegetation, it has been possible to obtain results shown in Table 2 where the differences between the same ground features are indicated over a period of about 2 years namely 1973-1975. The features which show changes in vegetation occur on sites near to drainage canals or ditches and thus underwent a period of water scarcity during the early stages of the runway construction. Since those sites carry sensitive species such as Saggitaria lancifolia and Typha angustifolia it would be expected that under the stress of water scarcity they would undergo some change. Since the restoration of the water level, there are some appreciable signs of recovery.

Results of field studies

Field studies are carried out in connection with the maps produced by the IMAGE-100 System, the Signature Development Program, the Natural Classification System and infra red photography. A discussion of the correspondence between the maps and field features appears under each of the four methods above and will not be repeated here.

A note will however be added about the vegetation types and their distribution. The main relationships are shown in Figure 2.

Although the vegetation of North Merritt Island has been classified into six associations, it must be considered as a single coastal complex the parts of which are related to each other by ecological succession. In the tables and discussions of the six associations, they are usually placed in order of ecological

succession in terms of decreasing water content of the environment. Thus the wettest is the submerged association and the driest is the oak-palmetto scrub.

Wherever on North Merritt Island there occurs a suitable change in water level extending over a reasonable distance, the six associations are likely to exist. The change in water levels is often so abrupt in numerous depressions that some members of the series of successions are severely abbreviated or non-existent.

The relationship between the six plant associations whereby they can be placed in series in order of ecological succession permits a prediction of species composition on any given site depending on water level, which is the factor which determines the species in each succession shown in Figure 2.

Thus a basis exists for observing ecological change in each association in terms of major species composition shown in Figure 2. Where the environment is not subjected to any appreciable stress, the expected species composition should continue to prevail. This is to be considered a basic principle for monitoring environmental impact.

The major species of the six plant associations encountered in North Merritt Island and the overlapping of some of those species into naighboring associations are shown in Figure 2.

6. CONCLUSIONS

1. The IMAGE-100 System has proven to be a fairly good tool for analysis of LANDSAT multispectral data but sometimes fails to discriminate between closely related ground features. It promises to give good results in conjunction with certain other software system.

2. The Signature Development Program produces fair character maps and will probably give best results in semi-automatic applications.

3. A Natural Classification System has been developed which promises to generate fair character maps at a cost of less than $100 per 25 square miles once the data have been placed on disc storage.

4. Color infra red photographs define plant association borders with considerable accuracy and has so far been capable of indicating vegetation changes resulting from excessive drainage on a few limited sites, satisfactorily. It has also indicated that with a rise of the water table, the affected areas have started to recover.

5. Field studies show that the six plant associations of North Merritt Island are members of a series which are related to each other by ecological succession and by overlapping of certain species. Ecological change within any association may be expressed in terms of species composition.

7. AIMS FOR 1975-76 PROJECT YEAR

1. Monitoring of North Merritt Island for environmental impact will continue mainly by means of field work and color infra red photographs.

2. An outline vegetation map will be produced for North Merritt Island.

3. The Signature Development Program and a Natural Classification System will be examined as tools for generating low cost character maps of North Merritt Island.

4. An attempt will be made to use the Natural Classification System for improving the IMAGE-100 output for North Merritt Island.

8. ACKNOWLEDGEMENTS

The work embodied in this report was made possible as a result of a grant made by the National Aeronautics and Space Administration to Bethune-Cookman College. The cooperation of Mr. Thomas A. Hammond NASA Technical Officer for the grant, is gratefully acknowledged. Mr. Joe Bartozek and the Administration of the Data Analysis Facility of the Kennedy Space Center kindly made available the use of the IMAGE-100 System. Mr. Royce Hall continued to assist as consultant in data processing and in certain field operations. Faculty personnel involved in the project were Dr. P. Poonai, Principal Investigator, Mr. W. J. Floyd, and Mr. J. L. Fisher. Student participants were Messrs. D. Wilchcombe, P. A. Lambert, M. Stephens, R. Paige, Willie Reed, J. Dotson and Misses E. Martin, F. Mussa, T. Floyd, and S. Barkley. The classes of Botany and Ecology also participated. Secretarial help was provided by Mrs. Helen Wymes.

9. REFERENCES

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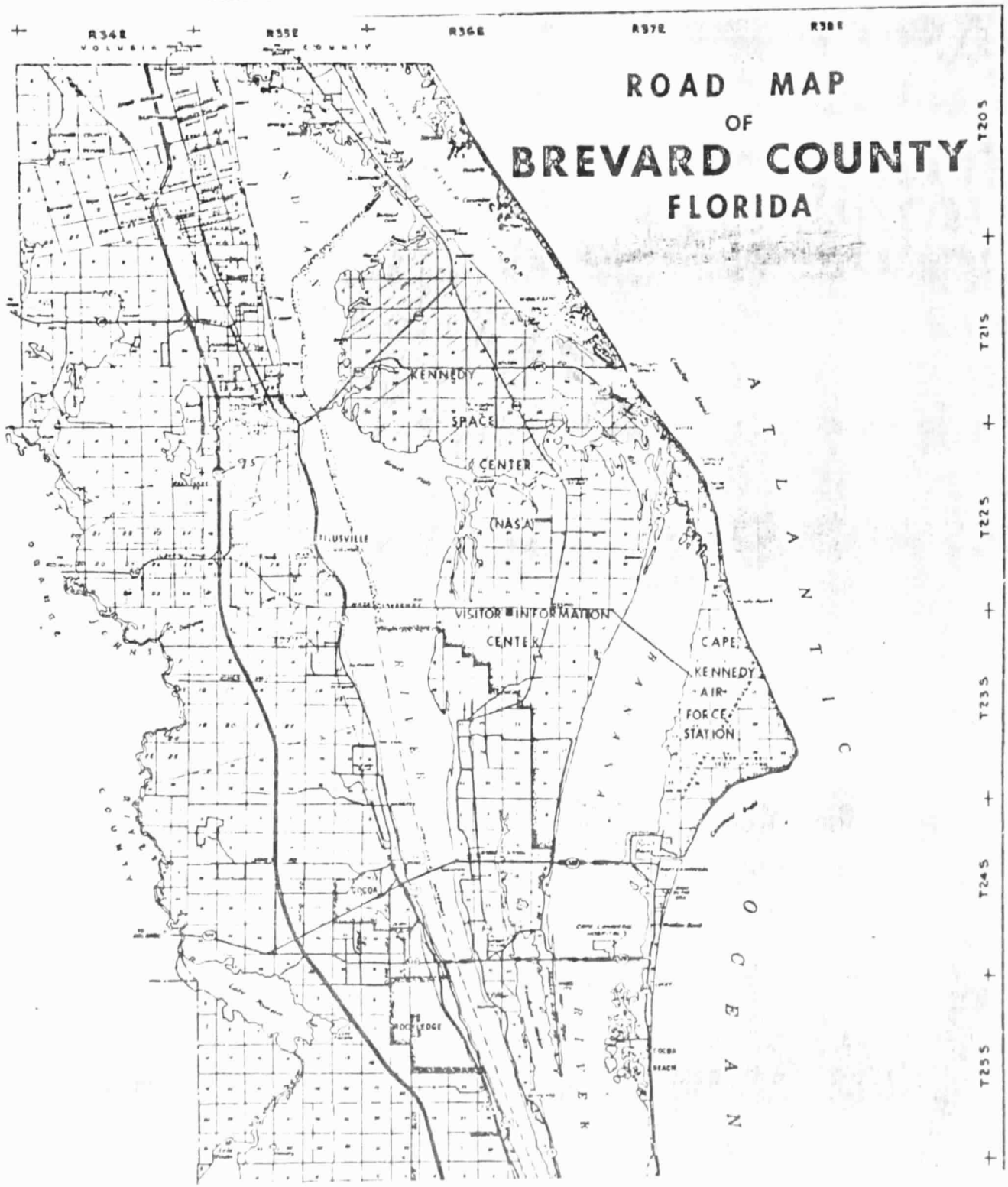
(2) IMAGE-100 Users' Manual. Ground Systems Department, General Electric Space Division. 1974

(3) Yule, G. U. and Kendall, M. G. An Introduction to the Theory of Statistics. Charles Griffin and Company Ltd. London. 1950.

FIGURE 1

SHOWING THE SITE OF THE EXPERIMENTAL AREA



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OF POOR QUALITY

FIGURE 2

A REPRESENTATION OF ASSOCIATIONS SHOWING
ECOLOGICAL SUCCESSION ON NORTH MERRITT ISLAND

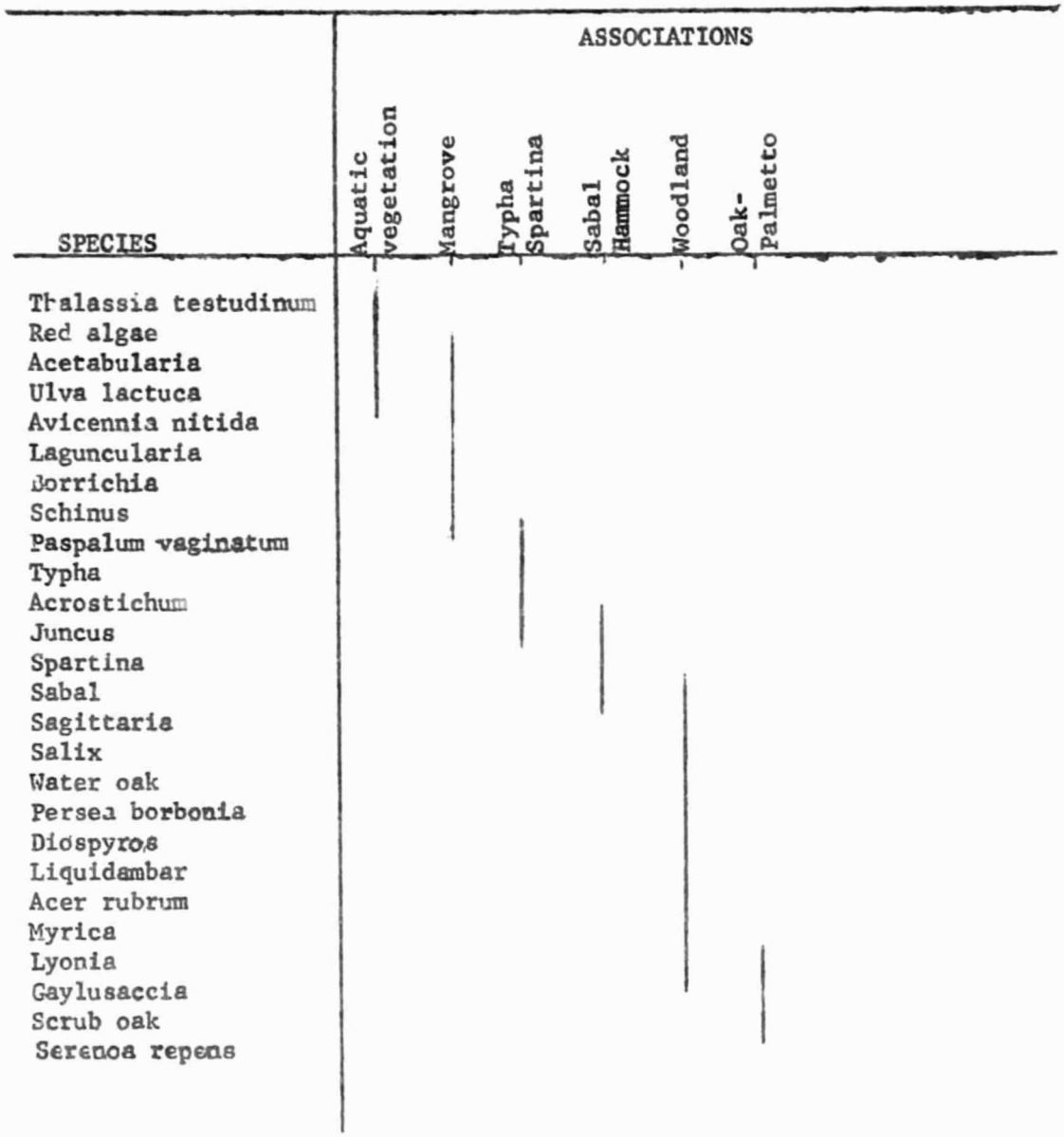

TABLE I

COMPARISON OF FIELD MEASUREMENTS AND MEASUREMENTS ON C.I.R. PHOTOS MADE ON A SCALE OF 1:6000

	Field Measurements (m)	Photo Measurements (m)	Difference
	74.063	71.320	+2.743
	64.005	64.919	-0.914
	92.959	106.979	-14.020
	103.332	110.027	-6.705
	309.052	307.833	+1.219
	141.725	160.622	-18.897
	127.400	125.267	+2.133
	208.778	196.282	+12.496
	275.221	279.183	-3.962
	207.559	204.816	+2.743
	285.584	273.392	+12.192
	188.357	193.234	-4.877
	129.229	145.687	-16.458
	169.156	154.526	+14.630
	46.632	47.546	-0.914
	69.796	65.529	+4.267
	181.957	169.461	+12.496
	198.110	195.977	+2.133
	413.593	406.888	+6.705
	71.320	68.272	+3.048
	200.244	195.977	+4.267
	93.569	88.997	+4.572
	76.196	83.206	-7.010
	109.723	103.932	+5.791
	256.629	273.392	-16.763
Total	4094.179	4093.264	+0.9150
Mean	163.767	163.731	+.0366

Standard error of mean difference = $\pm$ .195

$\therefore$ mean difference of .0366 is not significant (3)

TABLE 2

DIFFERENCE IN SIZE BETWEEN FEATURES ON
C.I.R. PHOTOS MADE ON 9th NOV. 1973
AND 29th APRIL 1975 (cm)

	9th NOV., 1973 (cm)	29th APRIL, 1975 (cm)	DIFF.	ANY OBSERVABLE VEGETATION CHANGES
	0.40	0.40	0.00	YES
	0.62	0.58	0.04	YES
	1.53	1.55	-0.02	—
	0.38	0.37	0.01	—
	0.39	0.37	0.02	—
	0.60	0.56	0.04	—
	1.60	1.58	0.02	YES
	1.40	1.38	0.02	YES
	1.25	1.23	0.02	YES
	0.58	0.70	-0.12	YES
	0.90	0.84	0.06	—
	1.38	1.35	0.03	—
	0.50	0.55	-0.05	YES
	0.52	0.44	0.08	YES
	0.50	0.53	-0.03	YES
	1.03	1.08	-0.05	YES
	1.05	1.10	-0.05	—
	0.45	0.45	0.00	
Total	15.08	15.06	0.02	
Mean	0.837	0.836	0.001	

Standard error of mean difference = .1128

$\therefore$ mean difference is not significant (3)