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Coastal Zone Classification from Satellite Imagery

Coastal zone land use and vegetation were investigated using ERTS and SKYLAB imagery.

ERTS-1 AND SKYLAB/EREP DATA ANALYZED

IMAGERY AND DIGITAL tapes from nine ERTS-1 passes and one successful Skylab pass over the Delaware Bay test site (Figure 1) were analyzed. (NASA-ERTS-1 I.D. Nos. 1024-15073, 1079-15133, 1133-15141, 1186-15081, 1187-15140, 1205-15141, 1294-15083, 1349-15134, 1385-15131, 1403-15125 and SKYLAB/EREP pass of September 12, 1973, respectively). The ERTS-1 imagery used was produced by the four-channel multispectral scanner (MSS) having the bands shown in Table 1. From an altitude of 920 km, each frame covering an area of 185 km by 198 km. In addition to the 9-track 800 bpi magnetic tapes, reconstructed negative and positive transparencies in 70 millimeter format and 9-inch prints were obtained from NASA. No Return-Beam Vidicon Camera data were used.

The SKYLAB Earth Resources Experiment Package (EREP) was activated during the following three SKYLAB passes over the Delaware Bay region: August 5, 1973 (Track 61, Revolution 1197), September 12, 1973 (Track 43, Rev. 1747), and September 17, 1973 (Track 43, Rev. 1818). However, of the three SKYLAB/EREP attempts, only the pass on September 12, 1973 produced imagery free of major cloud cover.

The SKYLAB/EREP data products evaluated include magnetic tapes from the multispectral scanner (S192), containing 13 spectral bands ranging from 0.4 microns to 12.5 microns; a 5-inch format color transparency from the S190B Earth Terrain Camera; and six sets of 70 millimeter positive transparencies from the S190A Multispectral Photographic Facility, including color, color infrared, and four additional bands in approximately the same wavelength bands as the four ERTS-1 MSS

ABSTRACT: *Digital* ERTS-1 MSS *scanner data and* SKYLAB-EREP *photographs have been used in an attempt to inventory and monitor significant natural and man-made cover types in Delaware's coastal zone. Automatic classification of* ERTS *data yielded classification accuracies of over 80 per cent for all categories tested. Visual interpretation of* EREP *Earth Terrain photographs distinguished a minimum of 10 categories with classification accuracies ranging from 75 per cent to 99 per cent. Noise problems prevented analysis of* EREP-S192 *scanner data. Most noise sources have been identified and filtered S192 tapes should soon be available, allowing application of automated classification techniques used on* ERTS *data. The spectral and spatial resolution of the* SKYLAB-EREP *S192 scanner should allow more detailed mapping of land cover while the repetitive coverage of* ERTS *is important for change detection.*

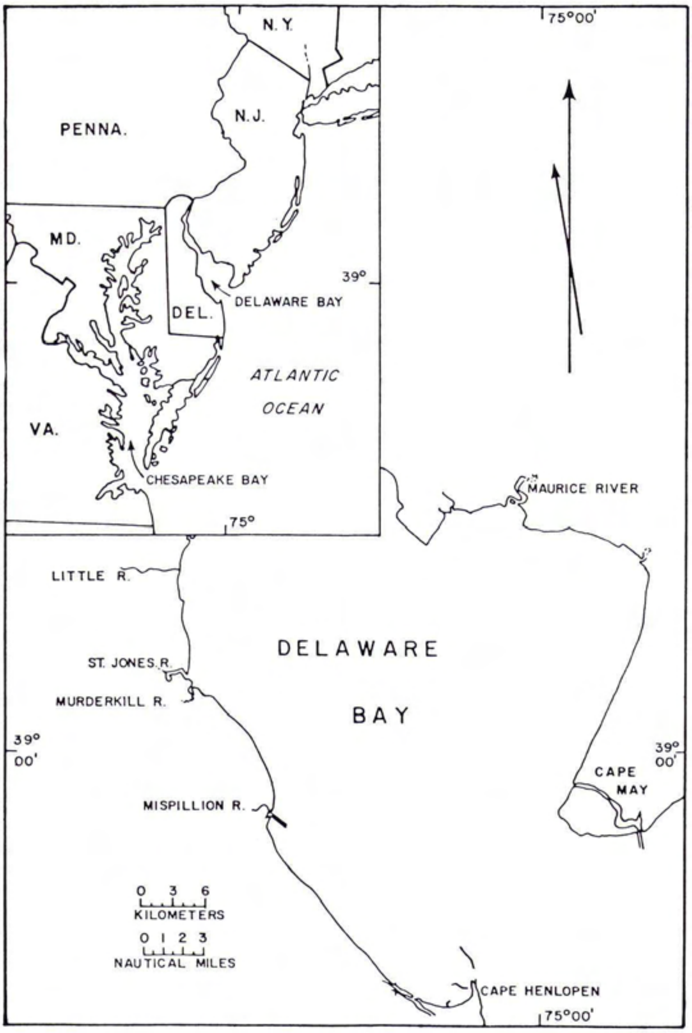

FIG. 1. Delaware Bay test site for ERTS-1 and SKYLAB/EREP investigations.

TABLE 1. EREP S192, S190A AND ERTS MSS BANDS.

EREP S192		ERTS MSS		EREP S190A	
Band No.	Band (Microns)	Band (Microns)	Band No.	Camera No.	Band (Microns)
1	0.41 – 0.46				
2	0.46 — 0.51				
3	0.52 — 0.56			4	0.4 – 0.7
4	0.56 — 0.61	0.5 – 0.6	4	6	0.5 – 0.6
5	0.62 – 0.67	0.6 – 0.7	5	5	0.5 – 0.7
6	0.68 – 0.76			3	0.5 – 0.88
7	0.78 – 0.88	0.7 – 0.8	6	1	0.7 – 0.8
8	0.98 – 1.08				
9	1.09 – 1.19	0.8 – 1.1	7	2	0.8 – 0.9
10	1.20 – 1.30				
11	1.55 – 1.75				
12	2.10 – 2.35				
13	10.2 –12.5				

bands (Table 1). From an altitude of 435 km, each S190A camera frame was imaging an area of 150 × 150 km.

The most notable difference between the SKYLAB S192 and ERTS MSS sensor characteristics is the larger number of S192 bands, 13 as compared to four in MSS, and the S192's swath width (72.3 km.) which covers approximately half of the distance covered by ERTS (185 km.). A scene of Delaware and Delaware Bay acquired by the S192 scanner on September 12, 1973, is shown in Figure 2. Table 1 provides S192 band locations and notes corresponding ERTS bands.

In the data processing area, a difference is the format in which the data are provided from NASA. The S192's data are recorded on a high density digital tape (HDDT) having 10,000 bpi whereas the ERTS data is recorded on a standard 9-track 800 bpi tape. NASA, however, plans to distribute future S192 tapes in the standard CCT format. Another significant characteristic is the conical-line scan pattern used by the S192. Single band imagery produced directly from the HDDT distorts the conical pattern, making ready identification of small targets (based on spatial features) extremely difficult. However, ERTS CCTS generated from NASA bulk processing also contain some geometric distortions, the most obvious one being due to effects of the earth's rotation. Nevertheless targets still are recognized easily in imagery produced directly from these CCTS, even though their exact earth coordinates are difficult to determine. Computer analyzed ERTS data are geometrically corrected for effects of earth rotation.

The S192 HDDT data must be preprocessed before any usable data products can be generated. These steps include: (1) transferring raw data from HDDT to standard 9-track CCT, and (2) using this tape to generate another CCT whose data are 'linearized' (i.e., as if scan were normal to direction of spacecraft motion). These data, although linearized, still have distortions due to earth rotation.

The various noise patterns observable in many of the S192 bands are another notable feature. Noise characteristics observed in the unfiltered S192 imagery are:

- Detector noise, a slow variation in scanner gain and offset most noticeable in thermal band 13 caused by changes in the calibration signals.
- Cooler piston noise, a regular, mechanically caused noise which could be removed by simulating a notch filter.
- Power inverter noise, another noise source having a regular frequency which could be removed by digitally simulating a notch filter.
- Sync, drop-outs caused by a poor signal to noise ratio on the sync signal resulting in the major banding observed in bands 3 and 4.

Linearized S192 data are available (Figure 2); however, noise problems prevented more than a cursory examination of this imagery. NASA and other organizations are intensively studying noise problems and noise-filtered tapes are expected to become available in the near future.

RESULTS OF AUTOMATED ANALYSIS OF ERTS-1 DATA

Ten vegetation and land-use categories were chosen (see Table 2) as offering the most useful information while being readily identifiable in high altitude imagery. Emphasis was given to inventorying the distribution of three vegetation communities of the tidal wetlands (categories 2, 3 and 4). Tidal wetlands have been identified as an ecological unit of prime interest in Delaware because of their extent (10 per cent of the total area of the State), importance as a fish and wildlife habitat, and pressure from developers resulting in the destruction of large areas of wetlands during the last 20 years. In addition, the limited accessibility and large, homogeneous vegetative communities of tidal marshes make them ideal subjects for remote sensing inventory and analysis.

Automated analysis of ERTS-1 CCT data was performed at the Bendix Earth Resources Data Center. Training areas, chosen from ground truth and low altitude aerial imagery, were edited from the CCT's and a set of "canonical coefficients" derived for each cover category being sought. These coefficients are used by the computer to form a linear combination of the ERTS measurements to produce a "canonical variable" whose amplitude is associated with the probability of an ERTS measurement being from the target sought. The probability of an ERTS measurement aris-

TABLE 2. VEGETATION AND LAND-USE CATEGORIES

1. Forest land
2. *Phragmites communis* (Reed grass)
3. *Spartina patens* and *Distichlis spicata* (Salt marsh hay and spike grass)
4. *Spartina alterniflora* (Salt marsh cord grass)
5. Cropland
6. Plowed cropland
7. Sand and bare sandy soil
8. Mud and asphalt
9. Deep saline water
10. Sediment laden and shallow saline water

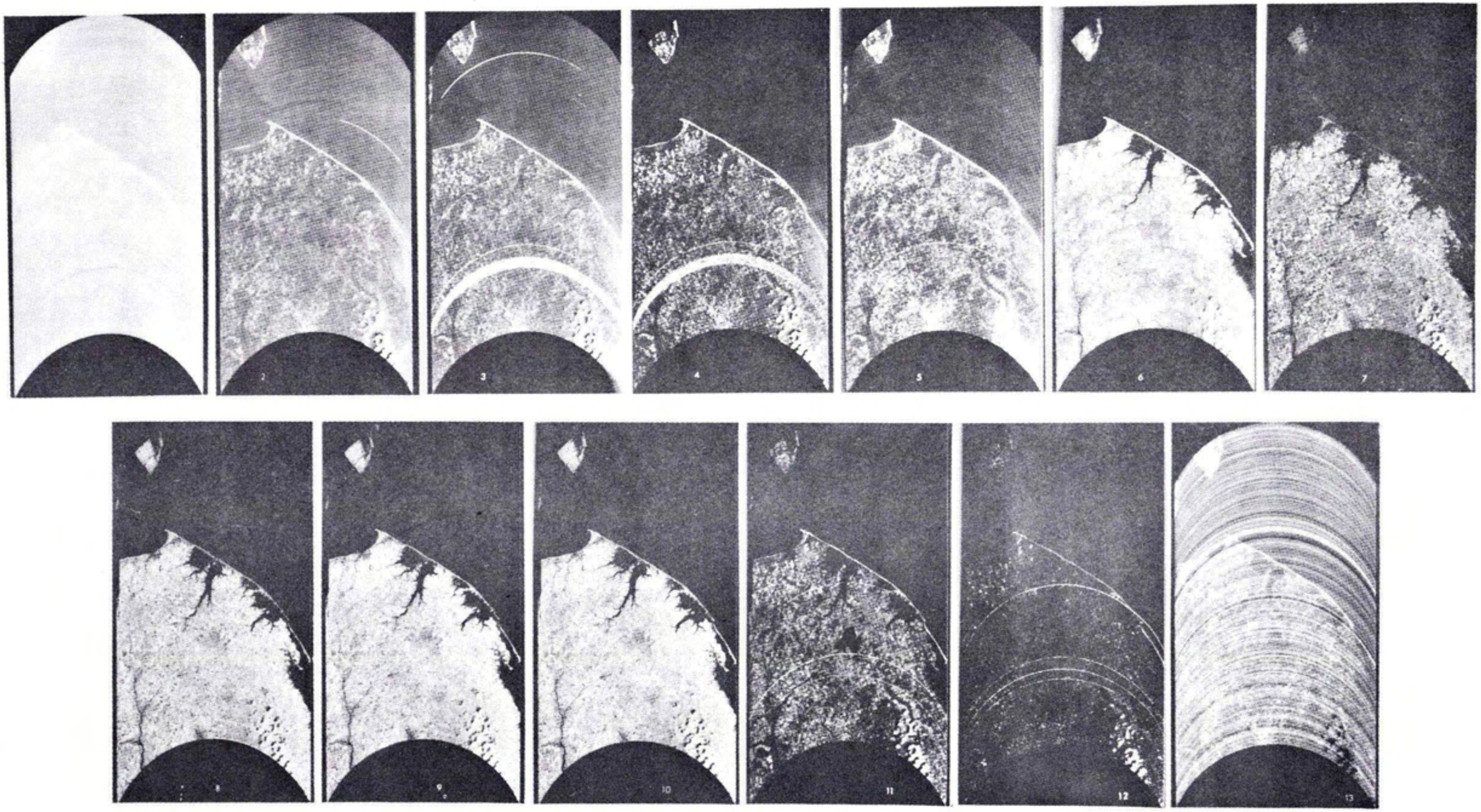

FIG. 2. Delaware Bay region as viewed by 13 spectral channels of the SKYLAB/EREP S192 multispectral scanner with its conical line scan pattern.

Table 3. Classification Accuracy 25-Jan-74 12:21:26.

Rejection Level = 0.100000 Percent

TNG SET	PERCENT CLASSIFIED AS GROUP 0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	0.000	83.333	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	12.667	16.667	0.000	0.000	0.000
2	0.000	0.000	97.500	2.500	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
3	0.000	0.000	0.000	100.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
4	0.000	0.000	0.000	0.000	100.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
5	0.000	0.000	0.000	0.000	0.000	84.906	11.321	0.000	0.000	0.000	0.000	0.000	0.000	3.774	0.000	0.000
6	0.000	0.000	0.000	0.000	0.000	14.000	86.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
7	0.000	0.000	0.000	0.000	0.000	0.00	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
88	0.000	0.000	0.000	2.667	0.000	0.000	0.000	0.000	97.333	0.000	0.000	0.000	0.000	0.000	0.000	0.000
9	1.471	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	98.529	0.000	0.000	0.000	0.000	0.000	0.000
10	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	100.000	0.000	0.000	0.000	0.000	0.000
11	2.564	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	97.436	0.000	0.000	0.000	0.000
12	0.000	14.286	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	85.714	0.000	0.000	0.000
13	0.000	0.000	0.000	0.000	0.000	1.282	2.564	0.000	0.000	0.000	0.000	0.000	0.000	94.872	0.000	1.282
14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	98.649	1.351
15	0.000	0.000	0.000	0.000	0.000	3.704	5.556	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	90.741

Program Run Time = 00:01:13

Training Set	Category	Training Set	Category
1	----------- Forest Land	9	----------- Plowed Cropland
2	----------- *Spartina alterniflora*	10	----------- Cropland
3	----------- Bare Mud	11	----------- Sand and Bare Sandy Soil
4	----------- Impounded Fresh Water	12	----------- Industrial (Deleted)
5	----------- *Spartina patens*	13	----------- *Phragmites communis*
6	----------- Cropland	14	----------- Cropland
7	----------- Deep Saline Water	15	----------- Cropland
8	----------- Bare Mud		

ing from each one of the different land-use categories of interest is computed for each ERTS spatial resolution element, and a decision is reached based on these computations. If all probabilities are below a threshold level specified by the operator, the computer is permitted to decide that the target viewed is unknown (a category undefined).

A test of the canonical coefficients is to proceed to use them in decision processing but to limit the data processed to that which is well known, i.e., the training data previously edited and stored on the disk file. Processing this data and keeping an accurate record of decisions permits the computer print-out shown in Table 3 to be developed.

The table provides the investigator with a quantitative measure of the classification accuracy achieved by the canonical coefficients in decision processing. For example, training set two, *Spartina alterniflora*, is classified correctly as *Spartina alteriflora* 97.5 per cent of the time and is mistaken for bare mud 2.5 per cent of the time. Such confusion is to be expected because *S. alterniflora* is a wetlands plant and patches of bare mud would be associated with wetlands, including the area in which the training data set was located.

When the classification accuracies predicted by canonical analysis of known sites are acceptable, decision processing is initiated, producing color coded, geometrically corrected maps of the type shown in Plate 1.

Results of Visual Analysis of Skylab/EREP Imagery

SKYLAB/EREP photos were visually analyzed using the Bausch and Lomb "Zoom Transfer Scope." The 5-inch, S190B, color photograph (see Plate 2) was used, primarily because it offered the best spatial resolution. Enlargements of the 70 mm, S190A, color infrared photo (see Plate 3) were used to supplement the analysis, particularly where more detailed definition of water boundaries and vegetation species was required. Ten land-use and vegetation categories were identified and mapped at a scale of 1:125,000 (see Figure 3).

Table 4. Vegetation and Land-Use Categories

1. Forest land
2. *Spartina alterniflora*
3. Cropland
4. Plowed cropland
5. Sand and bare sandy soil
6. Deep saline water
7. Sediment-laden and shallow saline water
8. Built-up land
9. Tended grass (including golf courses, etc.)
10. Dunes and beach grass

Of these, one through seven correspond to categories identified using ERTS-1 data. The spatial resolution of the S190B photo allowed more detailed differentiation of these categories particularly in the separation of individual fields (see Figure 3). Several subcategories of cropland could be seen but were not mapped in this initial attempt. Automated color-slicing techniques will be applied in the future and it is hoped that this will allow more detailed and accurate spectral discrimination than could be obtained visually. Cartographic quality appeared to be very good visually as no anamorphic corrections were required in the scale matching and map overlay procedure performed with the "Zoom Transfer Scope." Resolution of the S190B image (10-20 m.) appears compatible with map accuracy standards for maps at scales of 1:100,000 or smaller, although at this stage no attempt has been made to conform to those standards in thematic mapping.

Categories eight to ten on the EREP map are not included in the ERTS-1 thematic maps. The spatial and spectral resolution of ERTS data was not sufficient to show these categories in Delaware. The small towns of Lewes and Rehoboth, for instance, are shown on the EREP-generated maps but are too small to provide adequate training areas for automated discrimination from ERTS data. A similar situation exists for the "tended grass" and "dune" categories identified in the EREP photo.

Categories mapped from ERTS data but not shown on the EREP-derived map were omitted, not because they were not identifiable in the SKYLAB photos, but because they simply were not to be found in the small area mapped thus far (Figure 3). Examination has shown, however, that *Phragmites communis*, *Spartina patens* and *Distichlis spicata*, impounded fresh water, and mud and asphalt can be identified in the EREP imagery.

Observed Ground Resolution

The definition of resolution is based on the photographic criterion of image quality as related to the observable minimum spacing of bar targets of specified design. However, it is well known that one can detect bright or long, narrow objects having widths well below the resolution limit of the sensor if they contrast strongly against their background.[1] This explains our ability to discern our ground truth boat, roads, and the piers near Cape Henlopen (see Figure 3), all having widths well

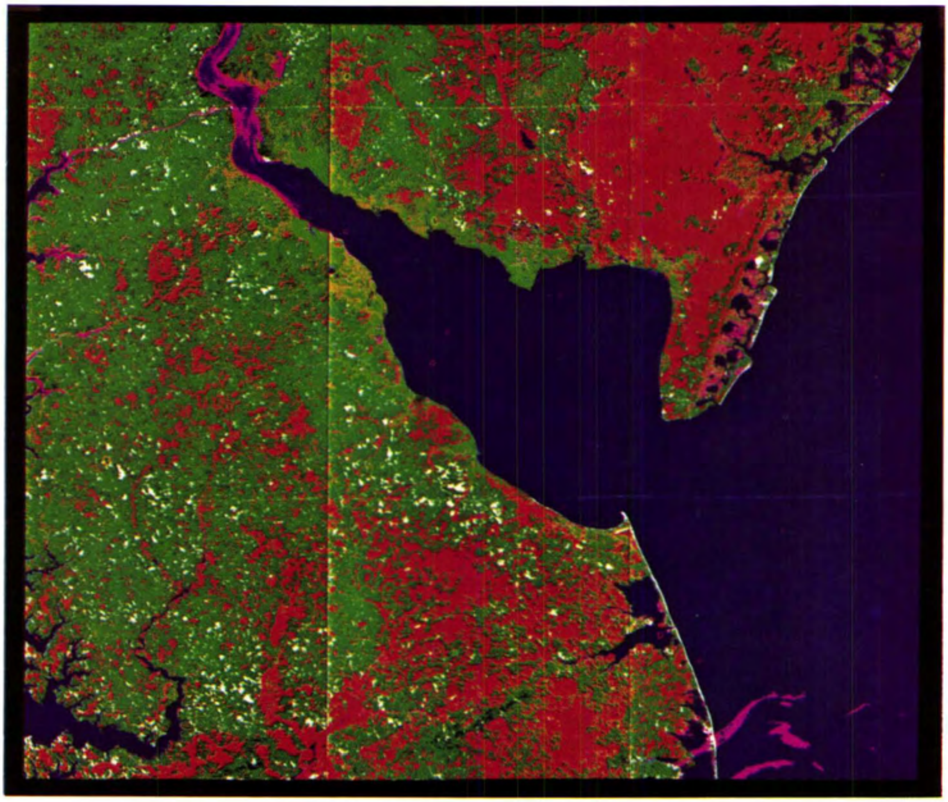

PLATE 1. Land use map produced from ERTS-1 MSS digital tapes of the July 7, 1973, ERTS-1 pass over Delaware Bay.

PLATE 2. SKYLAB/EREP photograph of the Delaware Bay region obtained with the S 190B earth terrain camera on September 12, 1973.

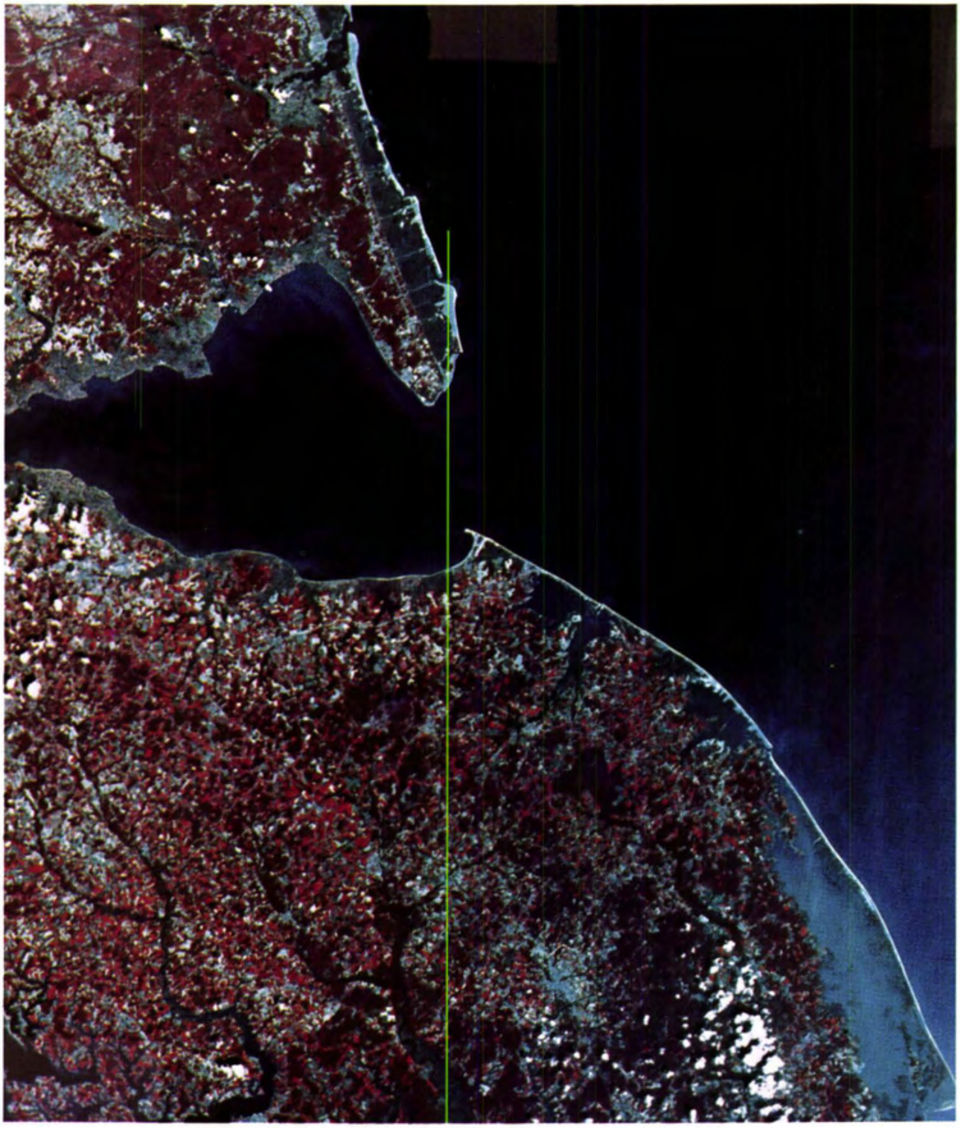

PLATE 3. SKYLAB/EREP color infrared photograph of the Delaware Bay region obtained with the S190A multispectral photographic facility on September 12, 1973.

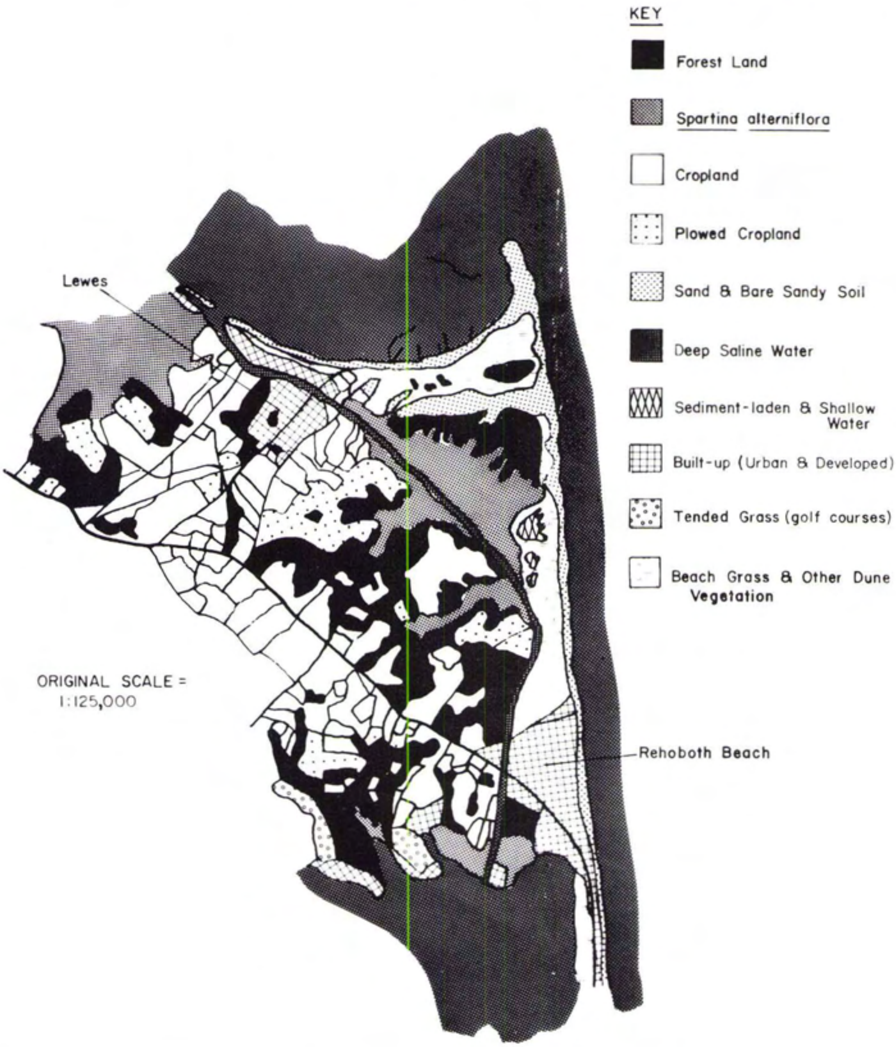

FIG. 3. Land use map derived from SKYLAB/EREP image in Plate 1 by visual photointerpretation.

below predicted SKYLAB and ERTS-1 resolution limits. Based on the analysis of high contrast pier structures and urban street line patterns, it appears that the ERTS-1 multispectral scanner has a resolution of about 70 to 100 meters, the S190A Multispectral Photographic Facility about 20 to 40 meters, and the S190B Earth Terrain Camera about 10 to 20 meters. These values do not differ significantly from predicted resolution figures based on the sensor characteristics.[1,2,3]

SKYLAB's multispectral scanner (S192) will be included in this comparison once the noise has been filtered out. The predicted resolution for the S192 scanner is approximately 80 meters.

Discussion and Evaluation of Data Products

Data obtained through analysis of ERTS CCT's has been compared with information from a variety of other sources in an attempt to evaluate the accuracy and reliability of the man-assisted, automatic classification system used.

The classification accuracy table (Table 3) predicts good accuracy in classification of most categories: accuracies of greater than 90 per cent for *Spartina alterniflora* (Salt marsh cord grass), *Phragmites communis* (Reed grass), bare sand, cropland (the four subcategories of cropland are combined and accuracies averaged), plowed cropland, bare mud and all water categories. *Spartina patens* (Salt marsh hay) shows a classification accuracy of 85 per cent. Forest land shows an accuracy of 83 per cent with all confusion occurring with the industrial category which was deleted in the final analysis for lack of an adequate training area. Thus, one would expect higher accuracy values for Forest Land and there is evidence of this shown later.

The accuracies calculated and shown in Table 3 become much more meaningful when the ERTS results are actually compared with known sites on the ground. The Classification Accuracy table, after all, is based only on the computer's knowledge of the scene. It is conceivable that a training area could be completely mislabeled, but the computer analysis would show good classification accuracy if that training set were spectrally distinct enough not to be confused with other training sets. Furthermore, the computer accuracy calculation is based only on the training areas and does not necessarily indicate the accuracy of classification in other areas. For these reasons, a quantitative comparison of ERTS classification results with two other sources of data, at two different scales, was performed. The two sources were the USGS — CARETS land-use map at a scale of 1:133,000 (reduced from a scale of 1:100,000) and a 1:60,000 NASA-RB57 aerial photograph. The CARETS map was compiled from photos taken in 1970 and the RB57 photo was taken in 1970. Because of the time separating these data from the ERTS overpass, the ephemeral, tide-dependent category of Bare Mud was eliminated from the comparison. Also, plowed cropland and cropland were combined into a single Agricultural category for purposes of comparison, as were the two water categories. Previous work indicated that significant changes in the other categories would not occur in the intervening time. *Phragmites communis* and Bare Sand were not included because neither were present in the areas used for comparison. In addition, the *Spartina alterniflora* and *Spartina patens* categories were combined for comparison with the CARETS map since these maps have a Wetlands category with no species differentiation. In both cases grids were used to quantify the comparison with the grid size chosen as the finest usable pattern compatible with each scale. Thus, a grid size of 0.25 cm (each grid representing approximately 22,500 m^2 on the ground) was used on the 1:60,000 photo while a finer grid size of 0.1 cm (each grid representing 17,690 m^2 on the ground) was used on the 1:133,000 CARETS map. These compare with an area on the ground of approximately 10,000 m^2 for an ERTS pixel.

At 1:60,000, 1811 points were compared covering an area of 40.75 km^2 while at 1:133,000, 8130 points were compared, covering an area of 145 km^2. In both cases, the areas compared were chosen not to include areas used as training sets.

The results of comparison are shown in Tables 5 and 6, presented in the same format as Table 3. At 1:133,000 the accuracy for Agriculture is quite good and similar to that predicted by averaging the cropland values in Table 3, indicating that the training sets selected were representative of the category desired. The Wetlands classification accuracy is greater than that predicted by Table 3,

TABLE 5

CLASSIFICATION ACCURACY TABLE DERIVED BY COMPARISON OF ERTS THEMATIC DATA WITH USGS-CARETS LAND USE MAPS.

Scale = 1:133,000

CATEGORY	Forest	Wetlands	Water	Agriculture	Urban (CARETS ONLY)
Forest	81.5%	00.0%	00.0%	18.5%	00.0%
Wetlands	00.0	97.8	00.0	2.2	00.0
Water	00.0	00.0	87.9	00.0	12.1
Agriculture	.8	00.0	00.0	90.2	9.0

TABLE 6

CLASSIFICATION ACCURACY TABLE DERIVED BY COMPARISON OF ERTS THEMATIC DATA WITH NASA-RB-57 PHOTOGRAPHY.

Scale = 1:60,000

CATEGORY	Forest	S. alt.	S. pat.	Water	Agriculture
Forest	89.9%	00.0%	4.5%	00.0%	5.6%
S. alt.	00.0	93.7	5.7	.6	00.0
S. pat.	00.0	7.7	87.0	2.2	3.0
Water	00.0	2.6	3.9	93.5	00.0
Agriculture	3.5	.3	2.1	00.0	94.1

probably due to the combining of the two wetlands species, differentiated by ERTS, into one category. Forest accuracy is 81.5 per cent with all confusion occurring with Agriculture, a condition which, it was observed by comparing CARETS maps with photos, is partially caused by the classification on the CARETS maps of small patches of trees within an agricultural area as Agriculture. Thus the true accuracy of Forest classification is probably closer to that shown in Table 5 (89.9 per cent). The low accuracy of the water classification due to confusion with urban areas is puzzling but might be caused by registration problems between the ERTS image and the map. Evidence for this lies in the fact that accuracy values for water are also depressed in Table 6 with confusion occurring with two more, very different, categories (*S. alterniflora* and *S. patens*).

Apparently, confusion is occurring randomly with whatever categories happen to be geographically adjacent to the water.

At 1:60,000 the accuracies are generally higher than at 1:133,000, due perhaps to the relatively larger grid size used and to the fact that original photos rather than maps were used for comparison. As was discussed earlier, even at larger scales, the automated ERTS mapping often makes finer distinctions than a human photo-interpreter is willing to make. Thus, areas which the CARETS interpreters considered too small to distinguish are actually picked up in the ERTS analysis. This was observed to be the case with the Forest Land and thus the higher value for that category (and perhaps some of the others) seen in Table 6. The confusion between *S. alterniflora* and *S. patens* is not predicted spectrally by the computer analysis and so, while it is tempting to assert that mixed stands of the two included in training sets are responsible for the confusion (in fact such mixed stands rarely occur over a large area), it is more likely that registration errors between these usually adjacent plant communities are the problem. Further, as predicted in Table 3, there is confusion between *S. patens* and Agriculture. This almost certainly reflects a natural situation of signature overlap between *S. patens* (commonly called salt marsh hay) and hay and fallow fields classified as Agriculture.

In general, the accuracy of classification of ERTS data appears quite good. Those categories compared in Tables 5 and 6 show good correlation and there is no reason to believe that bad results are being obtained in any other categories, particularly such spectrally distinct categories as Bare Sand and Mud. Visual comparison of classified imagery with known sites definitely tends to conform to the feeling that accuracies obtained for those categories not included in the quantitative study are not significantly different from those predicted on the basis of signature comparison in Table 3.

One significant obstacle to more accurate classification which appears to have a technical solution is contained in the present use of training sets in training the computer. Problems with mixtures of several categories inadvertently included in a training area, or the inability to find a large enough homogenous area to serve as a good training set are responsible for many classification errors. The alternative is to use absolute reflectances of the desired targets, a procedure which would not only enhance classification accuracy but would also greatly increase the automated component, and thus the speed, of the classification procedure. In order to use absolute reflectances, a means must be found to correct the ERTS measurements for atmospheric and sun angle effects. One such means has been developed by Bendix[4] and is currently in the early stages of testing in the Delaware Bay.

Accuracy analysis, similar to that performed on ERTS data products, was applied to the EREP-derived thematic map (Figure 3). A grid size of 1 mm^2 was used corresponding (at a scale of 1:25,000) to an area on the ground of 15,625 m^2 5,600 grid squares were checked—a total area of 87.3 km^2. The resulting classification accuracy table (Table 7) is comparable to Tables 5 and 6 in its first four (starred) categories. As might be expected, the increased resolution of the S190A photograph, combined with visual photo-interpretation produced equal or greater accuracies in the Forest (88 per cent), Water (98 per cent) and Agriculture (99 per cent) categories. The accuracy for *Spartina alterniflora* (78 per cent), however, is much lower than that obtained from ERTS data. Most of the commission errors in the classification of S. *alterniflora* (17 per cent) occurred through confusion with another wetlands plant community that was not spectrally resolved by the color S190A photograph. The *spatial* resolution of the S190B color-infrared photograph used to supplement the S190A was apparently not sufficient to discriminate the two communities. Due primarily to differences in coverage of ERTS and EREP spacecraft, the accuracy analysis was not performed on the same area of both data sources at this stage. This factor certainly effects the discrepancy between the accuracy values.

The confusion between the Dune Vegetation and Urban categories is puzzling but appears to be caused by a reversible error in interpreter judgment. Even so, these categories are not identifiable at all in ERTS imagery, indicating a potential for finer classification of EREP imagery than is possible with ERTS data.

Conclusions

ERTS multispectral data has been used to map and inventory ten land cover categories in Delaware Bay's coastal areas. The man-assisted, automated approach used, correctly classified all categories tested more than 80 per cent of the time and shows potential as an efficient, cost effective method of extracting useful information from ERTS digital data. In

TABLE 7

CLASSIFICATION ACCURACY TABLE DERIVED BY COMPARISON OF EREP-INTERPRETED, THEMATIC MAP (FIGURE 3)

Scale = 1:125,000, with NASA-RB-57 photography

Category	Forest	S. alt.	Water	Agric.	Sand	Dune	Urban	Other
*Forest	88%			11%				1%
*S. alt.	5%	78%						1%
*Water			98%		2%			
*Agric.	1%			99%				
Sand			11%		87%			2%
Dune						75%	25%	
Urban							93%	7%

addition, the continual, frequent coverage of ERTS promises fruitful results from operational monitoring and change detection, particularly if semi-automated or automated techniques are employed.

SKYLAB-EREP has the disadvantage of limited coverage in space and time. However, superior spectral and spatial resolution indicate that more detailed analysis of EREP data is possible, particularly when noise problems of S192 scanner data are resolved.

Whereas accuracy analysis suffers from a lack of a good alternative land-use and resource data base, results do indicate that both ERTS and SKYLAB can be used to inventory significant cover types on a regional basis.

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