Paper L 8

THE APPLICATION OF ERTS-1 DATA TO THE LAND USE PLANNING PROCESS

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ABSTRACT

The need for the development and implementation of methods for the detection, inventory and monitoring of land resource variables is reflected in present and pending federal and state legislation. ERTS can provide an operational data source for many of the significant land use variables at the policy level.

Land resource data has been extracted on a percent of cell basis from ERTS imagery, RB-57 color infrared imagery and best available conventional sources for a 10,000 square kilometer test area in eastern Wisconsin.

First, the data from the three sources is compared on a spatial basis for a 300 square kilometer portion of the test area. For those land resource variables associated with cover, ERTS derived resource data compared favorably with both the RB-57 and conventional data. In the case of those variables which change with respect to time and are not regularly monitored by conventional means, the ERTS derived data is superior to conventional data.

Second, the effect of the data source on land use decisions is examined. Three interstate highway corridors are located through the same region based upon data extracted from each of the three sources. A policy of preserving natural environmental systems was used as a basis for the corridors selection in each case. The resulting three corridors compare favorably.

INTRODUCTION

The urban population growth, the demands of population centers for recreational resources, the growing need and concern for environmental resource planning, all dictate the need for better data in the land use planning process. This need for a relevant and environmentally responsive regional planning and management data base is crucial to the economic future for an assuring quality of life. At present, the regional decision maker typically lacks relatable basic information on the use, the composition, character, and the temporal change of the region. The most basic forms of these data, such as the extent of vegetation cover, wetlands distribution, urban growth and the ecological well-being of the landscape are examples of data that have been traditionally unavailable in formats directly useable in the regional planning process. The results of this study, while clearly demonstrating that ERTS-generated information will not be a panacea for all regional planning data needs, does offer a technique by which the data acquisition process can be significantly improved.

METHOD OF INVESTIGATION

The investigation was conducted in three basic phases. The first phase consisted of the determination of which land use variables could be extracted from ERTS and RB-57 images. The second phase consisted of the quantitative and spatial comparison of land resource variables extracted from ERTS, RB-57 and available conventional data sources. The third phase, which is still under investigation, compares the spatial effects of the data sources on land use planning decisions.

Test Site

The principal test site employed in the investigation, called REMAP-I, consists of a 10,000 square kilometer area between Milwaukee and Green Bay, Wisconsin, shown in Figure 1. A smaller portion of the area, the 10 x 30 kilometer Sheboygan Test Site, was employed in some of the analyses. A computer-based data bank had been developed for REMAP-I area by the Environmental Awareness Center of the University of Wisconsin from conventional data sources to assist the Wisconsin Department of Transportation in the location of a corridor for Interstate 57. Thirty-eight land resource variables, made up of 132 data items, are stored for each 1 km cell in REMAP-I on a percent-of-cell basis. The cells are spatially organized on a UTM base. Any combination of variables, which can be individually weighted, can be developed as a spatial density printout for comparisons with ERTS and RB-57 derived information. Figure 2 shows a sample printout for the variable "Existing Agricultural Land Use." Figure 3 illustrates the use of the REMAP-I data base to generate a spatial density printout of the study area employing a particular policy. The policy illustrated in Figure 3 is environmental impact. All variables which relate to environmental considerations are weighted high. The resulting lighter areas should be protected under this policy. The policy can be modified by changing the weights assigned to the variables.

In the construction of the REMAP-I data bank significant difficulties were encountered. These centered on the non-availability of compatible data sources. The "best available" sources of appropriate data varied in format, scale, accuracy, vintage, controlling agency and spatial reference. The cost of data extraction from these varied sources was estimated at $10 per cell or $100,000 for the entire 10,000 cell REMAP-I area.

Interpretation Technique

Conventional air photo interpretation techniques were employed to extract data from the ERTS and RB-57 images. Nine-inch transparencies were used for both ERTS and RB-57 sources as the basic image format. Data extraction on a percent-of-cell basis was made using a zoom stereoscope. A 1 km cell grid was superimposed on the imagery by navigation with respect to identifiable features on the imagery. Extracted data were keypunched and input to the computer data bank. This procedure was followed for each variable identifiable. An ERTS-1 Interpretation Matrix was prepared which lists the REMAP-I variables, data and coverage interpreted, the band employed, a classification of identification by difficulty, and the image format and date most appropriate for each variable identification. This matrix is viewed as incomplete at this time due to inadequate spring and fall ERTS coverage caused by poor weather conditions.

SPATIAL COMPARISONS OF VARIABLES

Figures 4, 5 and 6 illustrate the spatial comparison of three of the land resource variables for the Sheboygan Test Site, a 10 x 30 kilometer portion of the REMAP-I data bank. The figures are computer-generated spatial-referenced quantitative information as derived from (1) ERTS-1 multispectral imagery, (2) RB-57 high altitude color-infrared photography, and (3) the REMAP data bank constructed from conventional sources. Each cell is one square kilometer in size, spatially referenced to the UTM system. The density of the symbol printed in each cell indicates the percentage of that cell occupied by the resource in question. Beneath the spatially represented areas are given the total area occupied by each resource as determined from each data source. Numbers of occurrence and areas for each of the three data sources are presented for each level of occurrence.

Figure 4, the printout for the variable "Agriculture," shows the spatial/statistical comparison for the amount of land in the Sheboygan Test Site devoted to agricultural land use (land used directly or indirectly for the growth of food products, including crop, animal and poultry farming; includes both crop land and grazing land). There is excellent agreement among all three data sources and ERTS imagery is useful for the determination of lands devoted to agricultural use. Because of the continuing change in the use of agricultural lands, there is a real need for monitoring this variable on a regular basis.

Figure 5, the variable "Forest," shows spatial/statistical comparisons for the land covered with forests (those land areas with at least 50% tree canopy cover). "Upland Forest and Lowland

Forest" were treated as separate variables in the original REMAP-I and RB-57 data extractions, but are combined into the one category "Forest" in the case of ERTS. There is reasonable agreement among all three data sources, but it should be emphasized that the ERTS interpretation contains less discrete information than RB-57 and REMAP-I. It is possible that the ERTS derived data could be refined by (1) coverage over an entire season, and (2) more sophisticated methods of data extraction.

Figure 6, the variable "Open Water and Wetlands," shows the spatial/statistical comparisons for land covered with open water and wetlands. Four resource variables, "rivers," "lakes," "lakes smaller than 50 acres," and "open wetlands," were individually analyzed for ERTS, RB-57 and REMAP. For the purposes of this comparison they were combined to yield that component of the land covered by open water (rivers and lakes) and wetlands (principally areas occupied by such biotic communities as those dominated by grasses, sedges, emergent aquatics, dogwoods, shrubwillows, and alders). There is reasonable agreement between ERTS and RB-57 in identifying the major open water and wetland areas in the test site. However, in many cases where only a small percentage of each cell is occupied by open water and/or wetland, detection was not made on the ERTS imagery, as shown by the number of occurrences.

It can be seen that there is not a good agreement between the REMAP areas and the RB-57 and ERTS areas for open water and wetlands. In order to investigate the possible reasons for this discrepancy, a field check was undertaken. It showed that many areas classified as "open wetlands" in the REMAP data bank are now covered by "lowland forest" tree species. Such areas are, therefore, shown as "forest" on the ERTS and RB-57 printouts and as "open wetlands" on the REMAP printout. When printouts for "lowland forest" and "open wetlands" were compared for RB-57 and REMAP, it indicated that the total areas of "lowland forest" plus "open wetlands" are quite close for these two data sources.

WETLANDS VERIFICATION

Variable	Total Km^2 as derived from		
	ERTS	RB-57	REMAP
Open Wetlands	10.8	9.2	20.8
Lowland Forest		31.9	18.9
TOTAL		41.1	39.7

This example points clearly illustrates that (1) land cover changes with time and 40-year-old data are probably inadequate, (2) field checks are an essential part of remote sensing data extraction studies, and (3) resource definitions must be carefully drawn.

EFFECT OF DATA SOURCE ON LAND USE DECISIONS

A spatial comparison of data derived from the three sources, although valuable, does not approach the more fundamental question of how the source of the data affects the decisions based upon the data.

In order to approach this question, Policy Models were established for the Sheboygan Test Site for each of the three data sources. This was accomplished by resource disciplines assigning weights to each variable according to its significance with respect to that policy. Figure 7 shows the printout for the Policy Minimum Environmental Impact for each of the data sources. The more dense cells represent those areas which have a high sensitivity to impact and should be avoided under this Policy. Note that if there are differing opinions or changes in perception over variable weights to be assigned to a policy, the spatial effect of a change of weights or policy can be quickly examined.

The ERTS model is based upon five variables, the RB-57 model upon eight variables, and the REMAP-I model upon all 38 variables. This reflects the varying degree of discreteness of the respective data sources and the greater dependence upon varying sources required for REMAP I.

In order to examine the effect of the three data sources on land use decisions, a computer optimization program was developed which selects an interstate highway corridor through the test site based upon minimum environmental impact as established by the policy. These corridors are shown in Figure 7 as the dark lines.

Although this portion of the investigation is only preliminary, an examination of Figure 7 reveals some interesting features. First, all three sources produce corridors which are quite similar. Second, as the data become more discrete, the corridors become less direct. A significant amount of investigation remains to be done on this question, particularly on the optimization of the data base using each source for those variables for which that source is most appropriate.

STATE LAND INFORMATION SYSTEM

In order to meet the data needs of the land use planning process it is necessary that four key elements be represented. These are shown diagramatically in Figure 8. First, there must be a hierarchy of data sources, including earth resources satellites. Second, the data needs and definitions must be established by the user groups. Third, the legislative support must be provided. Fourth, an information system must be designed to be responsive to all these elements. These components must be dynamic and responsive to social and technological change.

PRELIMINARY CONCLUSIONS

1. Land resource data/information, regardless of source, must be spatially referenced to be of maximum value for planning.

2. It is essential to establish precise definitions of critical land resources and the parameters which determine them in terms of measurement techniques economically available.

3. It is essential to establish precise criteria and data required for the establishment and measuring of the relative quality of critical resources.

4. ERTS derived data/information is potentially superior to conventional land use data for those items (1) which change rapidly with time, and (2) for which conventional data is not available.

5. For broad land cover assessments, data derived from ERTS by non-sophisticated methods is sufficient for initial resource assessments at the state or regional policy level.

6. More specific land resource information is available from ERTS if machine-based analysis techniques are employed.

7. Machine-based data extraction systems should be interactive, employing the man to identify and the machine to analyze and measure.

8. A state or regional data/information system must encompass a hierarchy of data sources including satellites, high-altitude aircraft, low-altitude aircraft, and ground-based surveys.

9. ERTS has provided a focus from which the regional land use planning data/information problem can be approached.

10. Any effort directed toward the implementation of a data/information system for regional land use planning must be multidisciplinary.

11. It is essential to integrate development funds from multiple sources in order to develop and implement a comprehensive data/information system for state and regional planning.

12. The effective implementation of a state or regional data/information system requires the assignment of responsibility, authority and funds to a single agency.

13. The successful implementation of a state or regional data/information system requires interagency cooperation and may require interagency reorganization.

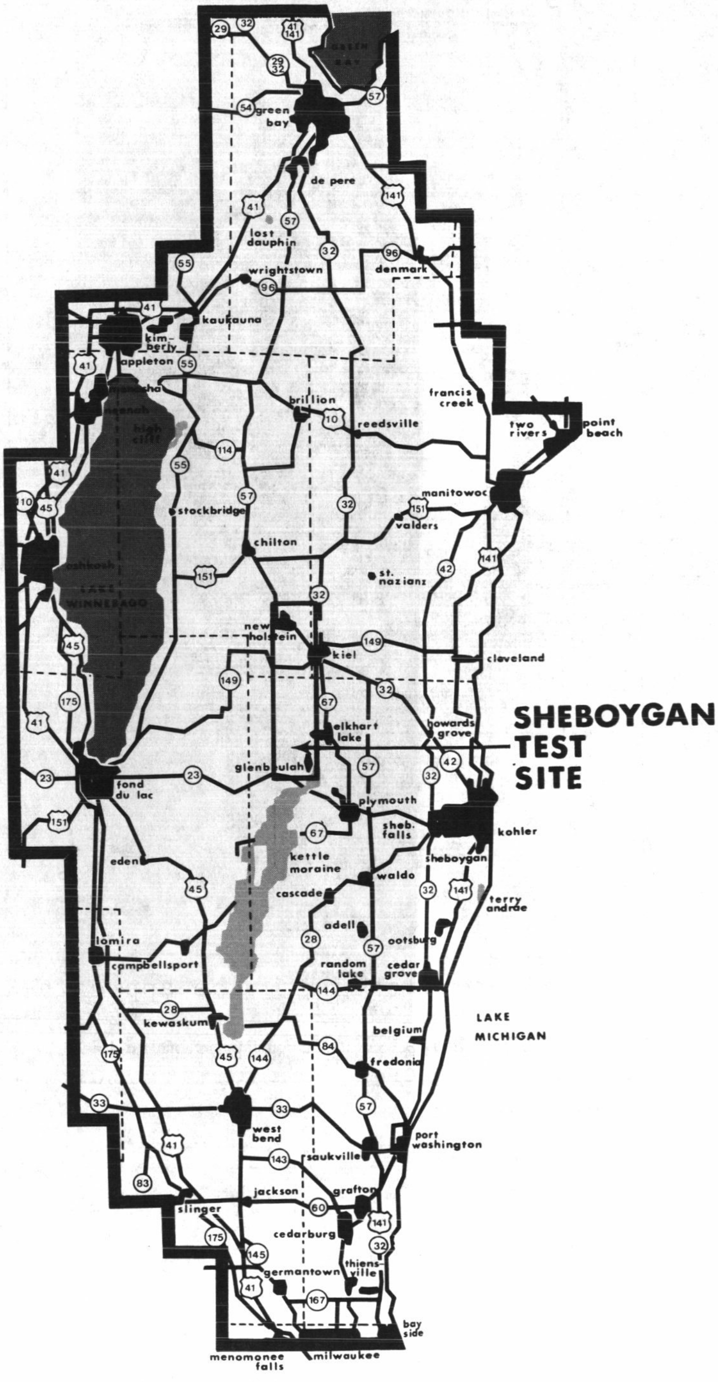

FIGURE 1. REMAP-I TEST SITE.

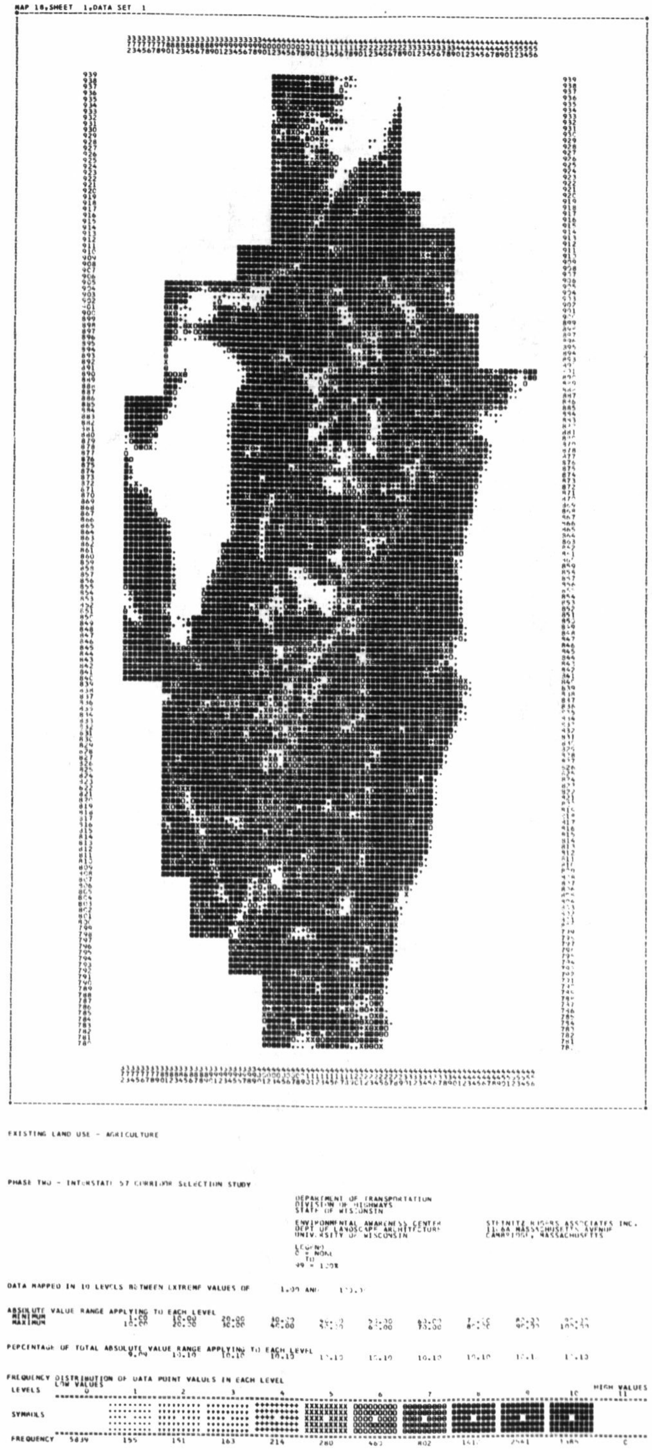

FIGURE 2. REMAP-I DATA BANK
EXISTING AGRICULTURAL USE

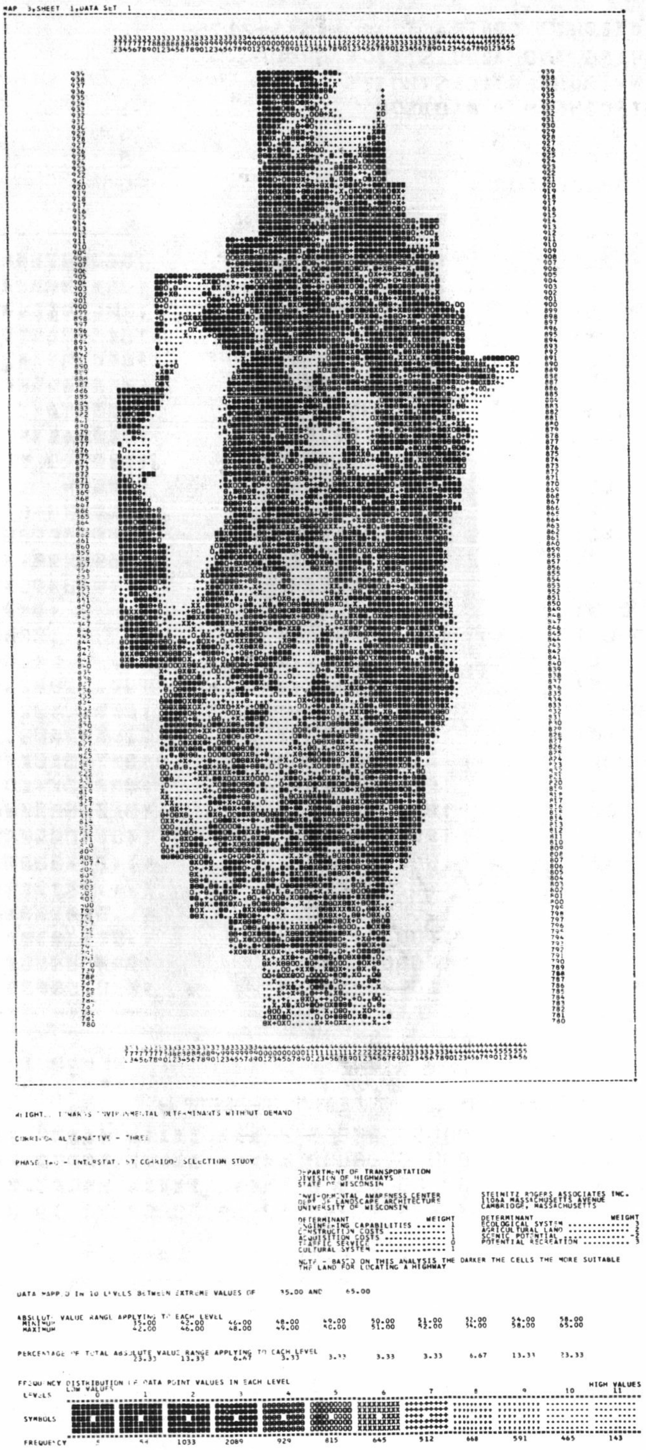

FIGURE 3. POLICY MODEL -
WEIGHTED TOWARDS ENVIRONMENTAL CONSIDERATIONS

ERTS-1 INVESTIGATION: CONTRACT # NAS 5-21754
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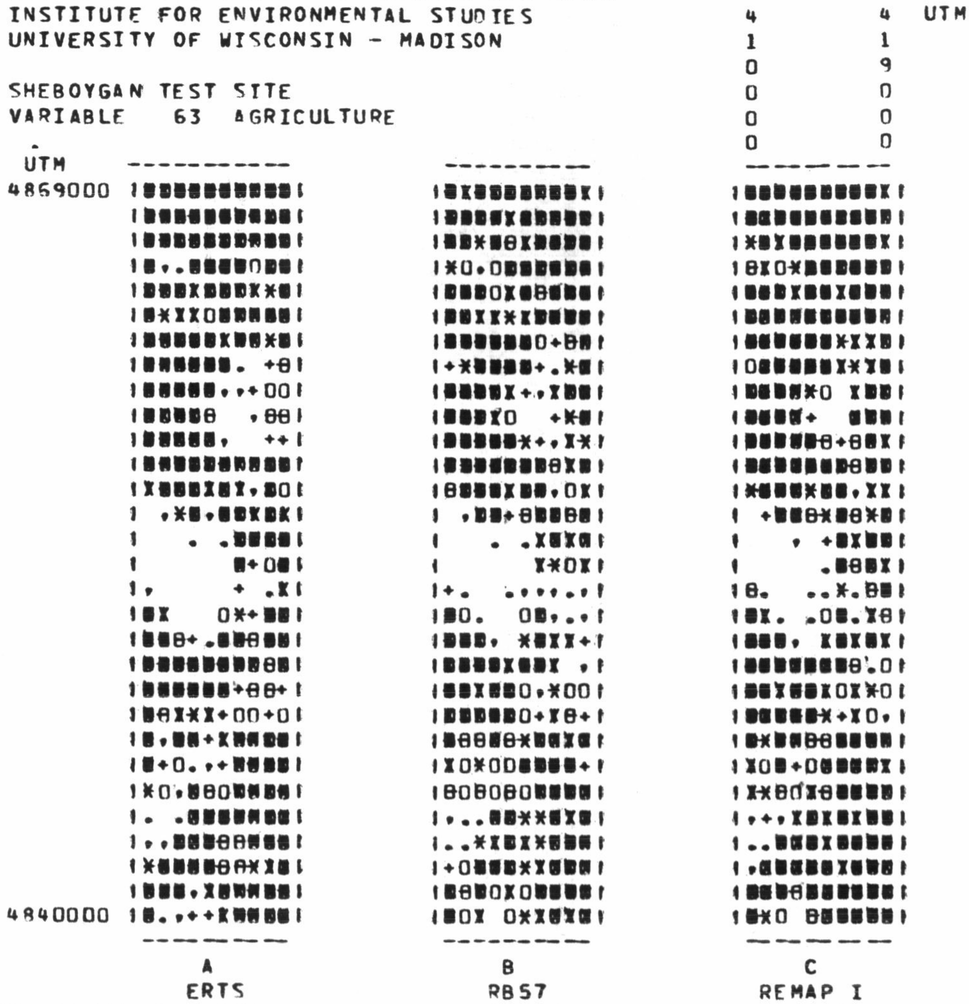
SHEBOYGAN TEST SITE
VARIABLE 63 AGRICULTURE



	A	B	C
TOT. SQ.KM	183.630	181.600	198.110

LEVELS		1	2	3	4	5	6	7	8	9	10
SYMBOLS		.....	,,,,,	+++++	00000	88888	XXXXX	IIIII	■■■■■	■■■■■	■■■■■
RANGE (%)		1-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99
OCCUR	A	10	16	17	13	15	9	18	39	49	88
	B	12	15	13	24	15	19	35	33	51	63
	C	11	7	7	12	17	15	34	42	66	71
SQ.KM	A	.47	1.97	3.70	4.05	6.12	4.70	11.35	28.60	40.33	82.34
	B	.68	2.20	3.12	8.34	6.43	10.44	22.55	24.81	43.46	59.57
	C	.63	1.08	1.65	3.99	7.50	8.24	21.74	31.28	55.97	66.03

ERTS BAND 5 14.SEPTEMBER.1972 1053-16093-5

FIGURE 4. AGRICULTURAL LAND USE
ERTS and RB-57 INTERPRETATIONS <u>vs</u>
REMAP-I DATA BANK

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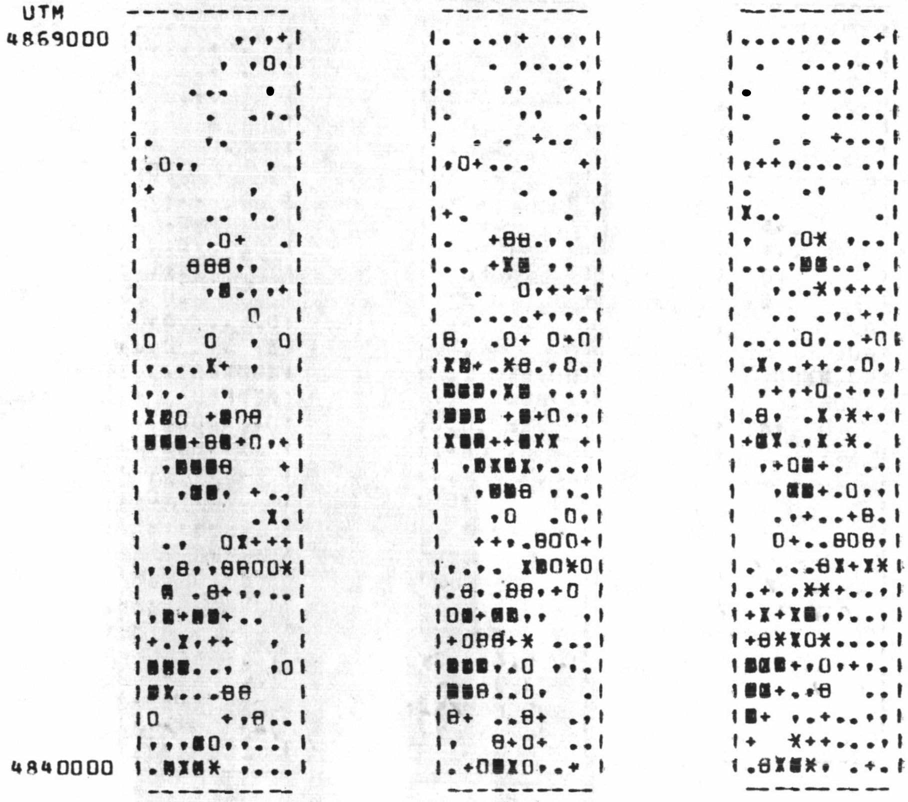
SHEBOYGAN TEST SITE
VARIABLE 24+25 FOREST



TOT. SQ.KM	48.830 (A)			59.470 (B)				51.990 (C)		
LEVELS	1	2	3	4	5	6	7	8	9	10
SYMBOLS	.....	,,,,,	+++++	00000	θθθθθ	*****	XXXXX	■■■■■	■■■■■	■■■■■
RANGE (%)	1-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99
OCCUR A	43	48	21	16	13	2	7	7	9	7
OCCUR B	62	48	32	21	15	3	10	9	8	10
OCCUR C	100	52	37	11	8	11	11	3	9	2
SQ.KM A	2.36	6.38	4.73	5.30	5.42	1.10	4.48	5.13	7.43	6.50
SQ.KM B	2.84	5.96	7.39	6.79	6.35	1.58	6.27	6.40	6.55	9.34
SQ.KM C	4.33	7.10	8.92	3.62	3.39	5.85	7.09	2.16	7.62	1.91

ERTS BAND 5 14.SEPTEMBER.1972 1053-16093-5

FIGURE 5. FOREST LAND COVER

ERTS and RB-57 INTERPRETATIONS
vs REMAP-I DATA BANK

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SHEBOYGAN TEST SITE
VARIABLE 20+21+26+147 OPEN WATER AND WETLANDS

		1	2	3	4	5	6	7	8	9	10
TOT. SQ.KM		14.070 (A)			16.740 (B)				29.460 (C)		
LEVELS		1	2	3	4	5	6	7	8	9	10
SYMBOLS		.....	,,,,,	+++++	00000	88888	*****	XXXXX	■■■■■	■■■■■	■■■■■
RANGE (%)		1-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99
OCCUR	A	13	8	2	8	4	1	1	4	3	1
	B	32	11	4	9	6	2	0	2	1	4
	C	61	23	9	10	5	1	3	6	2	8
SQ.KM	A	.80	.97	.41	2.69	1.78	.52	.68	2.90	2.42	.90
	B	1.05	1.39	.95	3.09	2.57	1.05	.00	1.40	.80	4.44
	C	2.23	3.00	1.95	3.58	2.21	.53	1.35	4.56	1.71	7.84

ERTS BAND 7 14.SEPTEMBER.1972 1053-16093-7

FIGURE 6. OPEN WATER AND WETLANDS
ERTS and RB-57 INTERPRETATIONS
vs REMAP-I DATA BANK

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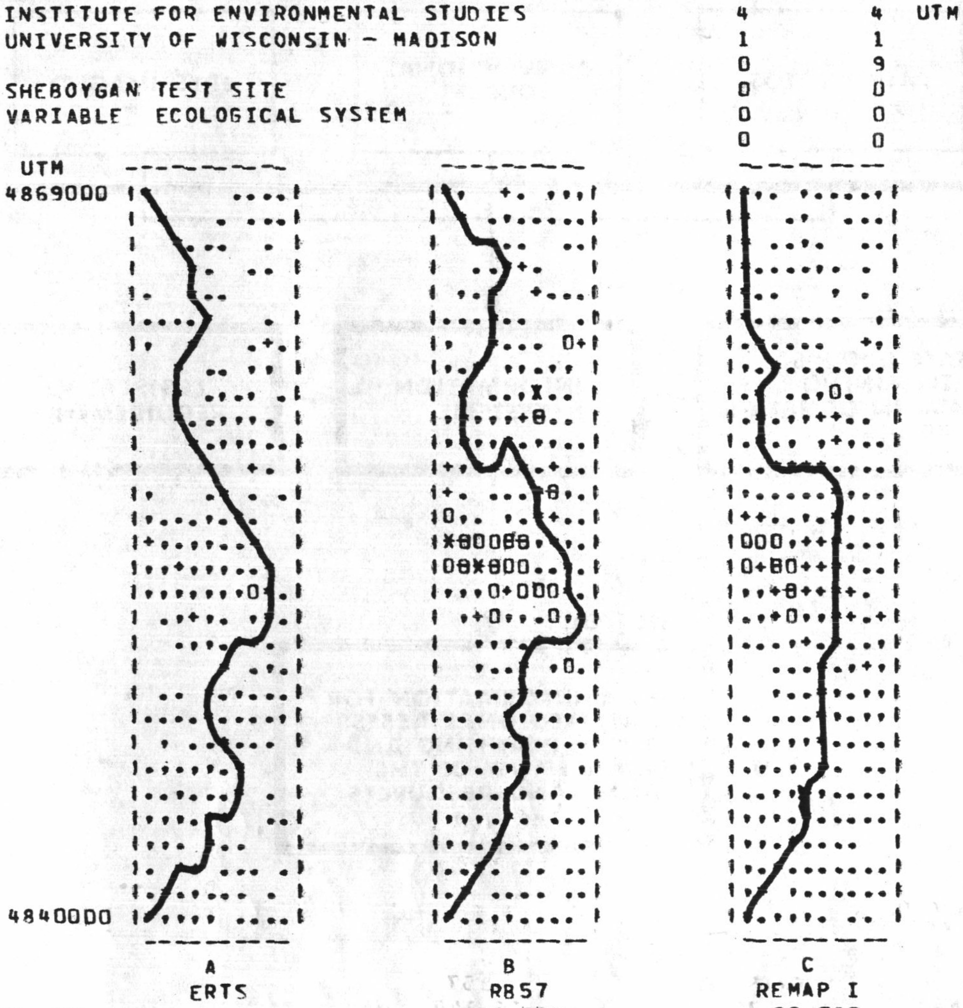
SHEBOYGAN TEST SITE
VARIABLE ECOLOGICAL SYSTEM



		1	2	3	4	5	6	7	8	9	10
TOT. SQ.KM		13.250 (A ERTS)			26.260 (B RB57)			22.780 (C REMAP I)			
SYMBOLS		.....	,,,,,	+++++	00000	88888	XXXXX	IIIII	■■■■■	■■■■■	■■■■■
RANGE (%)		1-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80-89	90-99
OCCUR	A	108	52	5	1	0	0	0	0	0	0
	B	115	63	11	14	7	2	1	0	0	0
	C	142	60	20	7	2	0	0	0	0	0
SQ.KM	A	3.93	7.73	1.21	.38	.00	.00	.00	.00	.00	.00
	B	4.74	9.08	2.64	4.95	3.14	1.03	.68	.00	.00	.00
	C	6.36	8.23	5.04	2.34	.81	.00	.00	.00	.00	.00

FIGURE 7. LAND USE DECISION MODEL
"LINE FINDER" HIGHWAY ALIGNMENT.
WEIGHTED TOWARDS ENVIRONMENTAL
CONSIDERATIONS

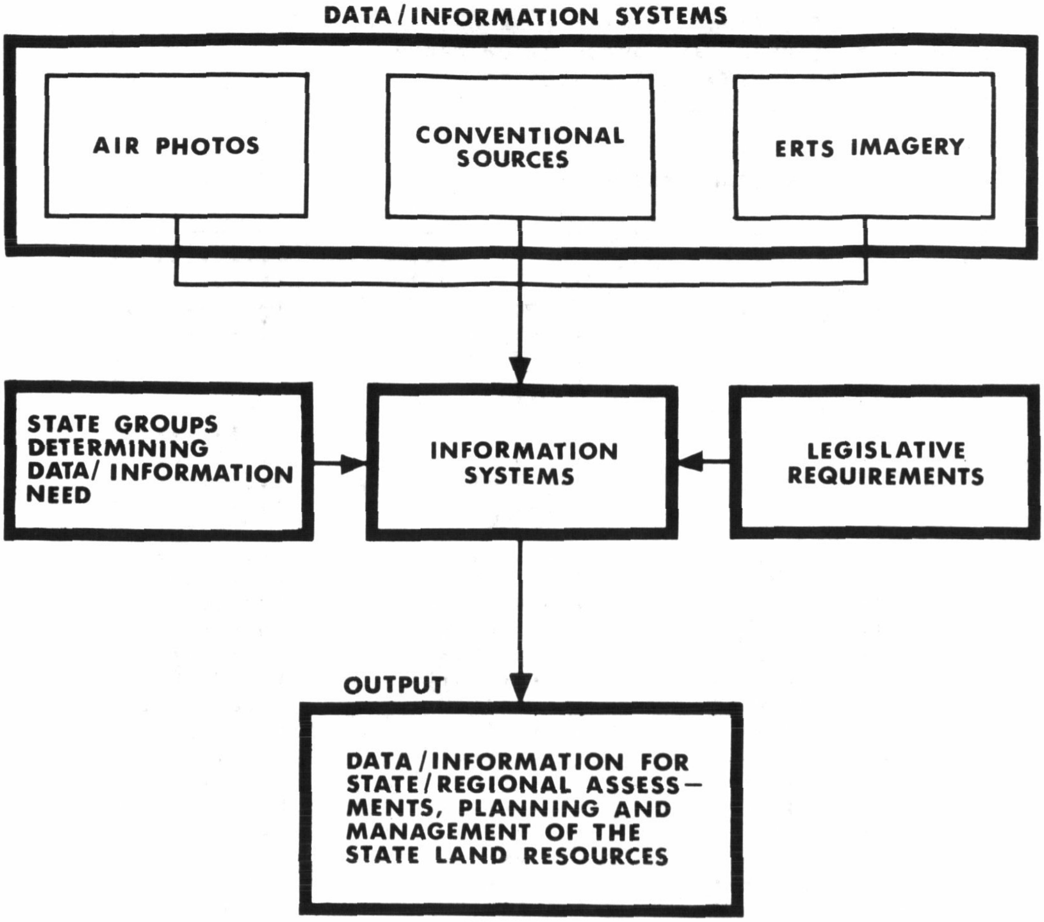


FIGURE 8. DATA/INFORMATION AND LEGISLATIVE REQUIREMENTS FOR STATE INFORMATION SYSTEMS