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INTERDISCIPLINARY RESEARCH ON THE APPLICATION OF ERTS-1 DATA TO THE REGIONAL LAND USE PLANNING PROCESS

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ABSTRACT

Although the degree to which ERTS-1 imagery can satisfy regional land use planning data needs is not yet known, it appears to offer means by which the data acquisition process can be immeasurably improved. This paper documents the initial experiences of an interdisciplinary group attempting to formulate ways of analyzing the effectiveness of ERTS-1 imagery as a base for environmental monitoring and the resolution of regional land allocation problems.

The investigation and documentation of the application of ERTS-1 imagery to the regional planning process consists of utilizing representative geographical regions within the state of Wisconsin. These locations represent: 1) a variety of natural and cultural resource data, 2) different regional planning problems facing Wisconsin, and 3) varying scales of data. Because of the need to describe and depict regional resource complexity in an interrelatable state, certain resources within the geographical regions have been inventoried and stored in a two-dimensional computer-based map form. Computer oriented processes were developed to provide for the economical storage, analysis and spatial display of natural and cultural data for regional land use planning purposes. Statistical programs have been developed that correlate interpreted data with stored data, both spatially and numerically.

The authors are optimistic that ERTS-1 and its following systems will assist in providing relevant data for land use decision making at regional levels.

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Original photography may be purchased from:
EROS Data Center
10th and Dakota Avenue
Sioux Falls, SD 57198

1. REGIONAL OBJECTIVES: THE NEED FOR REGIONAL PLANNING DATA

As a result of continual interaction with the land use planning process through teaching, research and professional experience, the authors have encountered a lack of spatial physical resource data. Previous decades of environmental alteration and mismanagement coupled with a change in perception of what constitutes life quality, have led to requirements that physical planners document environmental impact before plan implementation. Physical planners are being asked to predict environmental consequences in quantified terms prior to construction. In addition, the generation and quantification of alternatives is being required and, therefore, environmental alterations (e.g., highways, urban expansion, energy transmission systems, etc.) must be located and quantified in terms of environmental impact.

The requirement to provide location alternatives and quantify impact requires that physical resource data be available in a form which provides for manipulation, both spatially and quantitatively.

In addition to experience gained from long-term interaction with land planning procedures, the authors last year participated in a university-wide faculty land use seminar which was charged with assisting the Governor of the state of Wisconsin in determining land use planning policy and legislation. As would be suspected, the faculty seminar concluded, after examination of twenty-seven individual land use planning problem areas (e.g., urban sprawl, wetland loss, flooding, transportation planning, etc.), that lack of sound, spatially-based physical resource data was a principle cause of inadequate land use planning and plan implementation (1). This lack affected every level of management and planning effort for private lands, public lands and public facilities. The lack of physical resource data and a means of data manipulation has prevented the formulation of sound overall policies, the examination of planning and management concepts, and the evaluation of individual projects. States and regions endowed with extensive physical resources which desire to plan for the purpose of assuring environmental quality, must quantify, monitor and assess their physical environment. To meet this need, various forms of remote sensing must be considered, evaluated, and utilized when appropriate. Therefore, the potential use of ERTS-1 data to assist in supplying information required for regional land use planning is being explored.

2. BACKGROUND

Involvement in the ERTS-1 investigation was based upon experience in other forms of remote sensing research including the use of remote sensing for water quality monitoring and resource data acquisition for input into geo-information systems. (In the context of this paper geo-information systems are automated spatial resource data systems which were or are being utilized for regional or large area planning purposes.) In this investigation geo-information systems are serving as both the basis for ground truth comparisons with ERTS-1 imagery and as the structure for determining relevant land use planning resource data and variables. The investigation is being pursued by a diversity of disciplines including the planning professions and the remote sensing disciplines. Close review of the effort is being accomplished through an advisory council consisting of representatives of concerned governmental and private agencies. The application of ERTS-1 imagery to immediate resource data needs is being supported by the Wisconsin Department of Administration which is responsible for state-wide data gathering coordination. Because of the past experience in quantifying physical resources for the development of geo-information systems for regional planning, the thrust of this interdisciplinary research will be the evaluation of ERTS-1 data as compared with present data stored within four geo-information systems. Figure 1 indicates the location of these four geo-information data banks and also shows flight lines of RB-57 supporting imagery.

The REMAP (Regional Environmental Mapping and Analysis Process) geo-information system was developed to assist the Wisconsin Division of Highways in locating and assessing environmental impact from proposed Interstate 57 between Milwaukee and Green Bay, Wisconsin (2). The location and assessment procedure was dependent upon the storage and manipulation of spatial resources. Figure 2, Composite Transportation Location Model, diagrams the procedure utilized and shows five basic sub-systems. Sub-system 3.0, Data Bank, is dependent upon spatial resource data and therefore remote sensing input. Figure 3, Data Bank Development Model, is an

elaboration of sub-system 3.0. This figure illustrates the structuring of data types required, their means of collection, and the organization of a spatial geo-information system. Automated spatial storage of data provides the opportunity for a variety of manipulation techniques. Figure 4, Least Disruption to the Ecological System, is graphic output of a model minimizing ecologic impact. The most appropriate areas for highway location are the darker areas, in which a highway would cause the least ecological disruption. The actual location of the most appropriate interstate corridor is accomplished with an optimization routine. The REMAP geo-information system consists of approximately 10,000 one-kilometer cells each containing potentially 137 physical resource data. Table I, A Comparison of Significant Impact on Natural Resources, is an example of the environmental impact analysis presented at the public hearings on the interstate highway route selection. The table indicates that corridor alternative 3, in comparison with the other corridors recommended by the Division of Highways and other groups, has less resource impact in terms of the physical resources systems. REMAP provides a basis for the evaluation of the usefulness of ERTS-1 imagery for transportation planning at the corridor level. Table II, REMAP I Data Listing, is the list of data stored within the REMAP system.

A second geo-information system which is being employed is the LUSE (Land Use Suitability Evaluation) System, which was developed using the "Pheasant Branch Data Bank" as a demonstration area. Table III lists the variables stored in this data bank and also the computer evaluations that have been made using this system. Figure 1 shows the general location of this data bank. The LUSE System is being used to evaluate the physical characteristics of land in order to rate the capability of land to support various land uses, including the capability to support urban growth. Figure 5, Capability for Urban Development, shows the results of a capability analysis applied to a 60 km^2 portion of the Pheasant Branch Data Bank. In this analysis, the darker cells, each one hectare in size, have the greater capability to support urban growth, based on the topographic slope, soil, depth to bedrock, soil drainage, and flooding characteristics of the terrain.

A third geo-information system is the EDAP (Environmental Decision Alignment Process) procedure which was developed to assist the Wisconsin Power and Light Company and the Madison Gas and Electric Company to minimize environmental impact from 345 Kv electrical energy transmission systems. Figure 6, Naturalists Viewpoint, is a graphic representation of one of the models. This particular model minimizes impact to natural resource systems. In this case each symbol represents 1/4 kilometer with the lightest symbol showing areas that are the most appropriate for the location of the transmission system. The actual transmission corridor route is optimized and selected by a similar procedure as in the interstate investigation. Table IV, The EDAP Storage System, describes the cultural and natural resource data types in this data bank which are available for comparison with the ERTS-1 imagery. Also listed are the variables, components (higher level of variable aggregation), determinants, and policy models which were developed, modeled and mapped within the geo-information system data area for the location of transmission systems.

A fourth available geo-information system is the EMAP (Environmental Monitoring and Analysis Process) system. Table V is a list of EMAP data types. Sample computer output from the EMAP process is shown as Figure 7, which illustrates detected levels of environmental alteration in a rural watershed.

As previously stated, these four existing geo-information systems are being utilized as an initial basis for establishing relevant data for regional planning and will be used to varying extents as "ground truth" for comparisons with data interpreted from ERTS-1 imagery.

3. PROCEDURE

3.1. SCOPE OF RESEARCH

Although the degree to which ERTS-1 imagery can satisfy regional land use planning needs is not yet known, it appears to offer the means by which present techniques can be improved. Efforts are being made to determine the efficiency of ERTS-1 data (of both natural and cultural resources) in comparison with resource inventories conducted by conventional methods. Objectives of the research are:

1. Compare ERTS-1 imagery to specific types of natural and cultural data at varying scales and during different dates of the year.

2. Determine the usefulness of ERTS-1 data for regional land use planning and allocation decisions.

3. Assist the total community of government and private groups involved with aspects of regional planning by making recommendations as to the usefulness of satellite imagery to the types of land allocation decisions that must be made.

To achieve the general objectives of this project, the specific research objectives are to compare the ERTS-1 imagery with the described geo-information systems to determine to what extent: 1) specific data can be imaged and interpreted, 2) the data acquisition is affected by scale, 3) the data acquisition is affected by temporal effects, and 4) spectral ranges affect data discernibility.

3.2. RESEARCH PHASES

Phase one (1) consists of organizational arrangements and an initial meeting with an Advisory Council to discuss objectives and various land use interests.

Phase two (2) will consist of the comparison of the ERTS-1 interpreted data with the existing data bases. In the case of the geographic areas with geo-information systems, this comparison will be almost instantaneous. With other geographic areas in Wisconsin, which do not have computer-stored data bases, a longer time period will be required.

Phase three (3) will begin after some representative amount of ERTS-1 data is available. The effects of scale and temporal change will be investigated by continual comparisons with the original data.

Phase four (4) will be the documentation of the evaluation process and results.

Phase five (5) will consist of recommendations to various government and private groups as to the potential usefulness of ERTS-1 imagery for regional land use planning.

The quality and usefulness of the evaluations and recommendations to a great extent depends on the organization of the project. The project operations have been organized into five areas, as shown in Figure 8, ERTS Project Organization Concept, and Figure 9, ERTS Project Organization. A significant part of the project organization is the formation of an Advisory Council.

3.3. ADVISORY COUNCIL

The purpose of the advisory council is to bring various land use interests in the state of Wisconsin into interaction with the principal investigators of the project. Individuals have agreed to serve who represent:

Agriculture
Conservation and Preservation
County Planning
Forestry (Public & Private Sectors)
Recreation (Public & Private Sectors)
Regional Planning
State Department of Natural Resources
State Environmental Affairs
State Planning
State Transportation Planning
University Extension
Utilities Planning

It is the intent of the principal investigators to meet with these individuals often during the life of ERTS. At these meetings discussions will be directed to how ERTS-1 can aid the regional planning process from the viewpoint of each individual land use interest. As noted in Figure 9 this information will be fed back into the project direction. It is felt that this advisory council can be quite effective in formulating data requirement policy.

3.4. DATA/VARIABLE IDENTIFICATION

Three types of data will be generated by the ERTS project:

1. Data that are similar to those presently stored in existing data banks.

2. Data that are generated from interaction with the Advisory Council.

3. Data that ERTS provides which are important to regional planning but cannot be acquired by conventional means.

Data types that are stored in the data banks have been presented earlier in this paper. Data stored in these data banks vary in classification and specificity. The data were reviewed and divided into four groups. (1) The first group contains variables directly identifiable on the imagery without supplementary verification from other data sources. (2) The second group contains variables discernible, but identifiable only with the aid of supplementary data sources such as maps. Precise adherence to the data bank definitions and levels of specificity make direct identification of these variables impossible. (3) Several data in group two, however, can be grouped into broader categories which then are directly interpretable; these comprise the third group. (4) The fourth group contains data not detectable on the ERTS-1 images.

As was noted earlier it is the hope of the principal investigators that the Advisory Council can aid the investigation by defining their needs in terms of types of data ERTS can provide. Specifically, this should enable the investigators to not only make correlations to existing data but generate new data of real use to regional decision makers.

It is assumed that this investigation will also generate a third type of data of great importance to regional planning concerns. It has long been the conviction of the authors that remote sensing is most effective when it is used to provide data that cannot be efficiently acquired by conventional means. ERTS data, because of its repetitiveness, promises to fulfill this need. Such data is critical to the decision maker since it better represents the complexities of man's environment. Leith (1970) noted several types of data important to phenology studies. The following data types are the kinds of data which could be extracted to interact with existing stored data:

Duration of growth of vegetation periods

Quantitative data on growth and development

Migration patterns

Relations of population growth to food resources

Correlations with macroclimatic variables

Environmental influences between climatic and edaphic characteristics

Relations between phenological events and environmental conditions

It is hoped that by bringing these various types of data together, a better understanding of the applications of ERTS data to the regional land use planning process can be achieved. An important aspect of bringing the data together is the process of data interpretation and capture.

3.5. INTERPRETATION AND DATA CAPTURE

The ERTS-1 and RB-57 imagery will be interpreted by experts based upon their knowledge of the area of investigation and their professional background. For example, land use planners with remote sensing experience will interpret land use data. Geologists and soil scientists with remote sensing experience will interpret geologic and landform data.

ERTS-1 imagery of the primary test sites (the REMAP, EDAP, LUSE, and EMAP data bank areas) has not yet been received. However, comparison and evaluation of RB-57 photography has begun. To initiate and test comparison procedures, a group of variables was interpreted from RB-57 color-infrared photographs taken on 29 September 1971, from a flight height of 60,000 feet, yielding a photo scale of 1:120,000. One kilometer grids were established on the film using 1:62,500 U.S.G.S. topographic maps as a geo-reference source. An area 10 km by 10 km was selected for initial interpretation and comparison of all "group one" variables (as defined in Section 3.4.). With 1 km cells located on the imagery each variable was interpreted and its percent of occurrence (0-99%) in the cell recorded on a portable

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cassette tape recorder. The tape was then played back, the values recorded on a gridded control sheet, and the values then key punched for computer input. An alternate computer input procedure could also be followed where the values are recorded from the control sheet on OCR cards and read by an Optical Character Reader.

Figure 10 is a black and white reproduction of a color infrared aerial photograph (1:120,000 original scale) with a 20 by 20 km grid superimposed. The 10 by 10 km area in the upper left-hand corner is the comparison area which is located within the REMAP I geo-information area. Figure 11 is a U.S.G.S. topographic map of the 10 by 10 km area. The grid cell size for both Figures 10 and 11 is one km^2. For comparison, Figure 12 is an ERTS-1 image of the southwest part of Lake Superior (1:1,000,000 original scale) with a one km^2 grid superimposed.

3.6. INTERPRETATION AND GROUND TRUTH COMPARISON

3.6.1. PROCEDURE. The interpretation results can be displayed and compared with data bank values by means of computer-printed maps, such as shown in Figures 13 through 16, or by means of statistical analyses. Statistical analyses can involve simple frequency tables of data, calculation of means and standard deviations of frequency counts, cross-tabulation of two data items, regression analysis for various models, etc. The University of Wisconsin computing center has statistical analysis packages available which enable rapid statistical computations to be performed. The principle analysis done, to date, has been the cross-tabulation of data obtained from interpretation of the RB-57 color infrared photographs and data from the REMAP I data bank. This procedure is similar to the way in which data interpreted from ERTS-1 imagery, when available, will be compared with the existing data banks.

Some CROSSTAB results, derived from statistical analysis of data in the 10 by 10 km (100 cell) area shown at the upper left-hand part of Figure 10, are shown as Tables VI through IX. Computer printouts showing the entire REMAP-I data area, and also the 100 cell area, are shown as Figures 13 through 16.

The CROSSTAB analysis comparing the percent of agricultural land use in each of the 100 cells, as interpreted from RB-57 imagery versus that contained in the REMAP-I data bank, is shown as Table VI. The column headings and totals refer to REMAP-I data. A comparison of column and row totals shows the amount of agreement between the two data sources. These totals can be re-tabulated as follows:

Percent of each cell in agricultural land use	No. of cells in this range REMAP-I data	No. of cells in this range RB-57 Interp.
0-9	0	1
10-19	3	1
20-29	3	3
30-39	3	6
40-49	7	5
50-59	7	6
60-69	17	9
70-79	17	10
80-89	27	22
90-99	16	37
100	maximum coded in data bank is 99%	

Ideally, if there is complete correlation between the two data being analyzed, the numbers shown in the body of the table should lie on a diagonal from upper left to lower right. The extent to which numbers deviate from this diagonal determines the degree of correlation between data. To give an example: According to the interpretation of RB-57 photographs, there are 10 cells in the 100-cell study area that have 70-79 percent agricultural land. These 10 cells were coded in the REMAP-I data bank as follows: 60-69 percent, 3 cells; 70-79 percent 5 cells; and 80-89 percent, 2 cells. Looking at the table another way, according to the REMAP-I data bank, there are 17 cells in the 100-cell study area that have 70-79 percent agricultural land. These 17 cells were interpreted from RB-57 photographs as follows: 30-39 percent, 1 cell; 60-69 percent, 1 cell; 70-79 percent, 5 cells, 80-89 percent, 6 cells; and 90-99 percent, 4 cells.

In addition to using the statistical analysis just described, the data from the RB-57 interpretation and the REMAP-I data bank can also be compared spatially. The percent of each cell in the data bank devoted to agricultural land use is shown in Figure 13. Percents of cell are shown in 10 levels, each with a different computer printout symbol. The lighter symbols represent the lesser percent agricultural use and the darker symbols represent the greater percent agricultural use. The principal printout shows the REMAP-I data area, with the 100-cell study area outlined. At the right, at a larger size, is the printout of the 100-cell study area, as interpreted from RB-57 photographs. Visual comparisons of such computer printout allow for spatial comparison of data patterns.

3.6.2. RESULTS. An inspection of Table VI shows that there is good agreement between the RB-57 interpretations and the 100-cell portion of the REMAP-I data bank. In 85 percent of the cells, the percent of land in agricultural use as determined by RB-57 interpretation is within 10 percent of the percent contained in the REMAP-I data bank. There is also a good correlation between the patterns seen in Figure 13 for RB-57 and REMAP-I. Table VI shows numerical differences in data and Figure 13 shows the spatial location of these differences.

Another example of the comparison procedure is the use of RB-57 photography to capture vegetational data. State-wide vegetational data are critically missing in Wisconsin and have not been accounted for since 1930. Table VII and Figure 14 show the results of data comparison for the vegetation type "upland forest" and Table VIII and Figure 15 show the results for "lowland forest". An analysis of CROSSTAB results shows good agreement for both forest types, with the better agreement for lowland ofrest. The percent of cells in agreement within 10 percent (RB-57 versus REMAP-I) is 86 percent for the upland forest analysis and 92 percent for the lowland forest analysis.

As can be seen in Table IX and Figure 16, there is complete agreement between RB-57 and REMAP-I in the case of suburban residential land use. There is, of course, only one cell in which the percent of suburban land use exceeds 10 percent. It is noteworthy, however, that this specific cell was identified on the RB-57 photographs.

For data interpretation and analysis using the ERTS-1 satellite imagery, it may be necessary, at times, to aggregate some of the data presently stored in REMAP-I and the other data banks. For example, it may not be possible to distinguish between lowland forest and upland forest on the ERTS-1 imagery. It may, however, be possible to identify "forest", as compared with other types of land cover. In this case, "lowland forest" and "upland forest" could be aggregated to form a new REMAP-I data called "forest". Such aggregation will probably be required for many of the variables listed in Tables II-V.

4. CONCLUSIONS

Definitive conclusions are not possible at this time. There are many unanswered questions about the usefulness of ERTS-1 and other high altitude remote sensing platforms. There is little question, however, that data are critical to the land use planning process and that traditional means have not and cannot cope with all data needs. Even at this stage, the authors are optimistic that ERTS-1 and its following systems will assist in providing relevant data for land use decision making at regional levels.

5. ACKNOWLEDGEMENT

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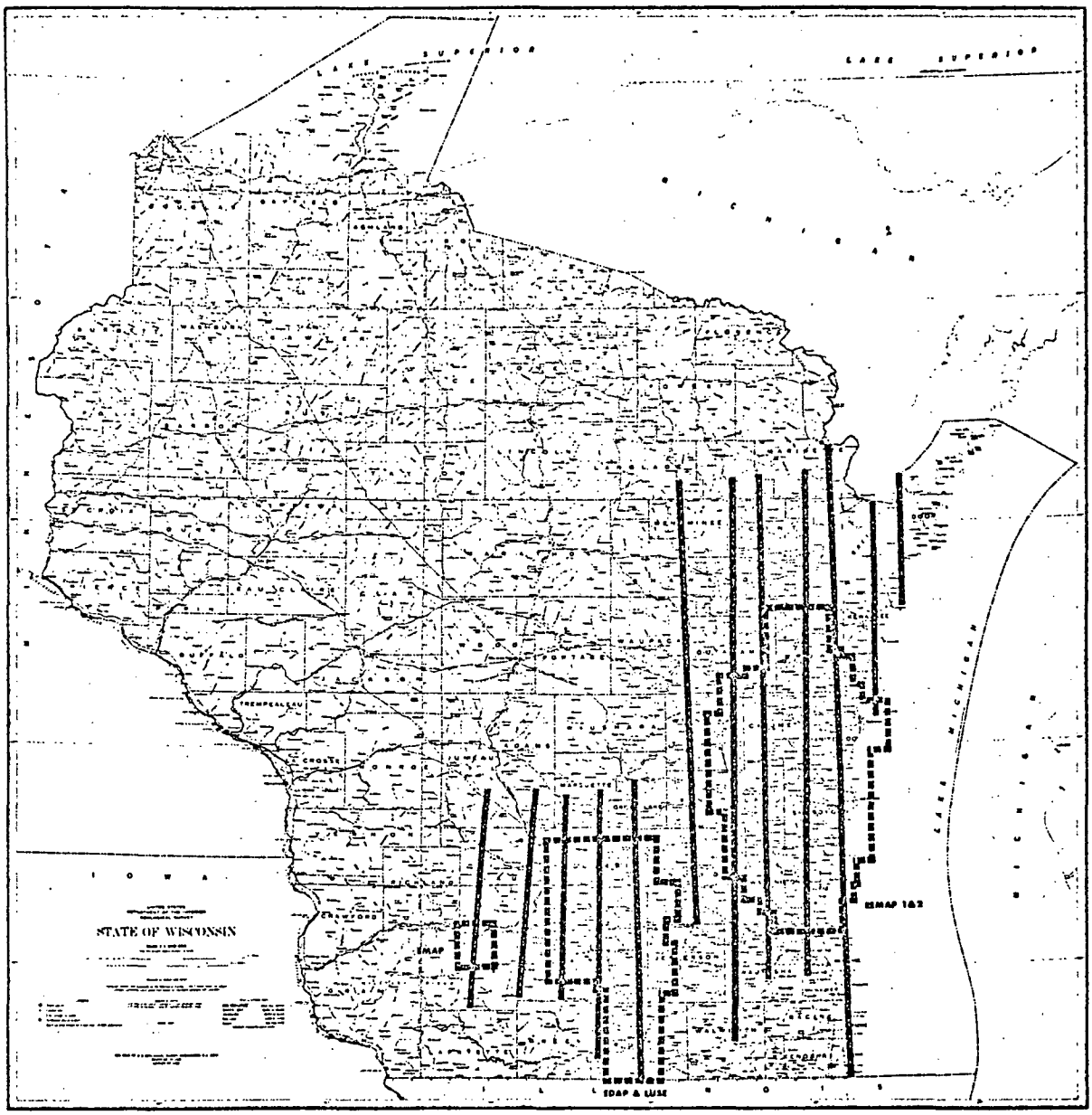

FIGURE 1. LOCATIONS OF DATA BANKS.

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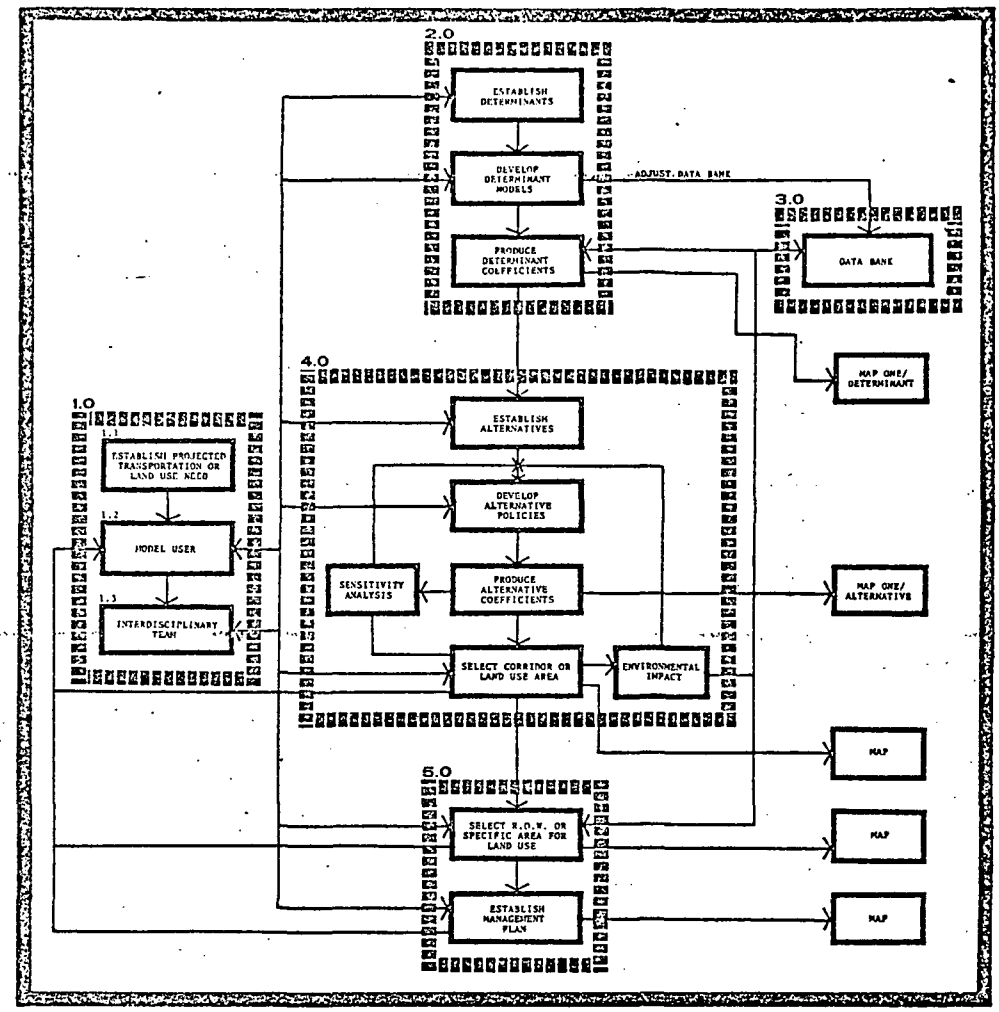

1.0 DECISION AND POLICY DEVELOPMENT
2.0 DETERMINANT DEVELOPMENT MODEL
3.0 DATA INTERPRETATION, CAPTURE, AND BANK DEVELOPMENT MODEL
4.0 POLICY SELECTION MODEL
5.0 RIGHT-OF-WAY AND MANAGEMENT MODEL

FIGURE 2. COMPOSITE TRANSPORTATION LOCATION MODEL.

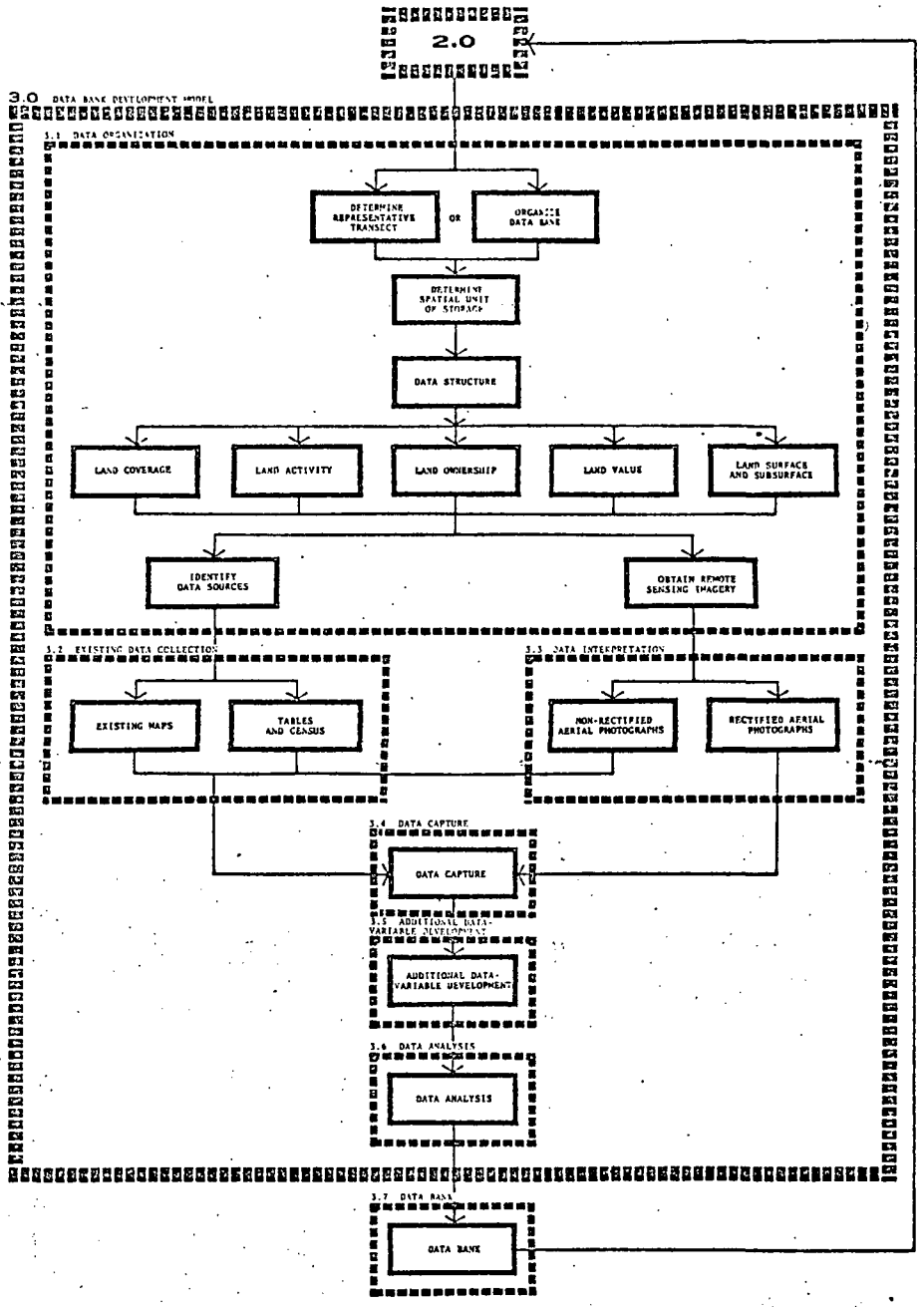

FIGURE 3. DATA BANK DEVELOPMENT MODEL.

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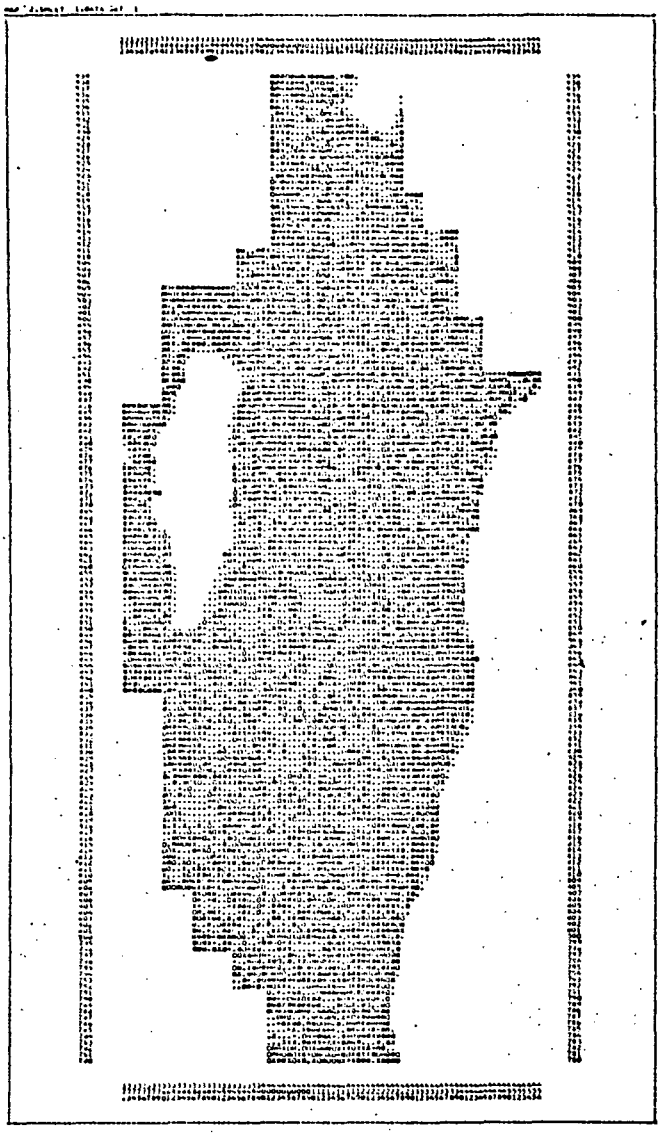

FIGURE 4. LEAST DISRUPTION TO THE ECOLOGICAL SYSTEM.

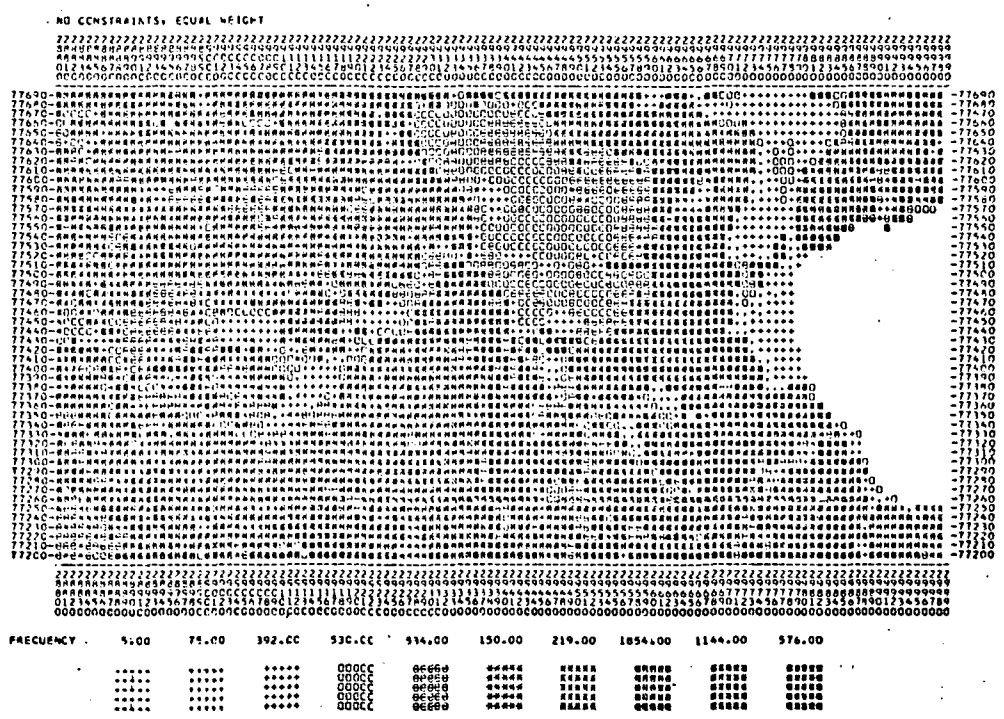

FIGURE 5. CAPABILITY FOR URBAN DEVELOPMENT.

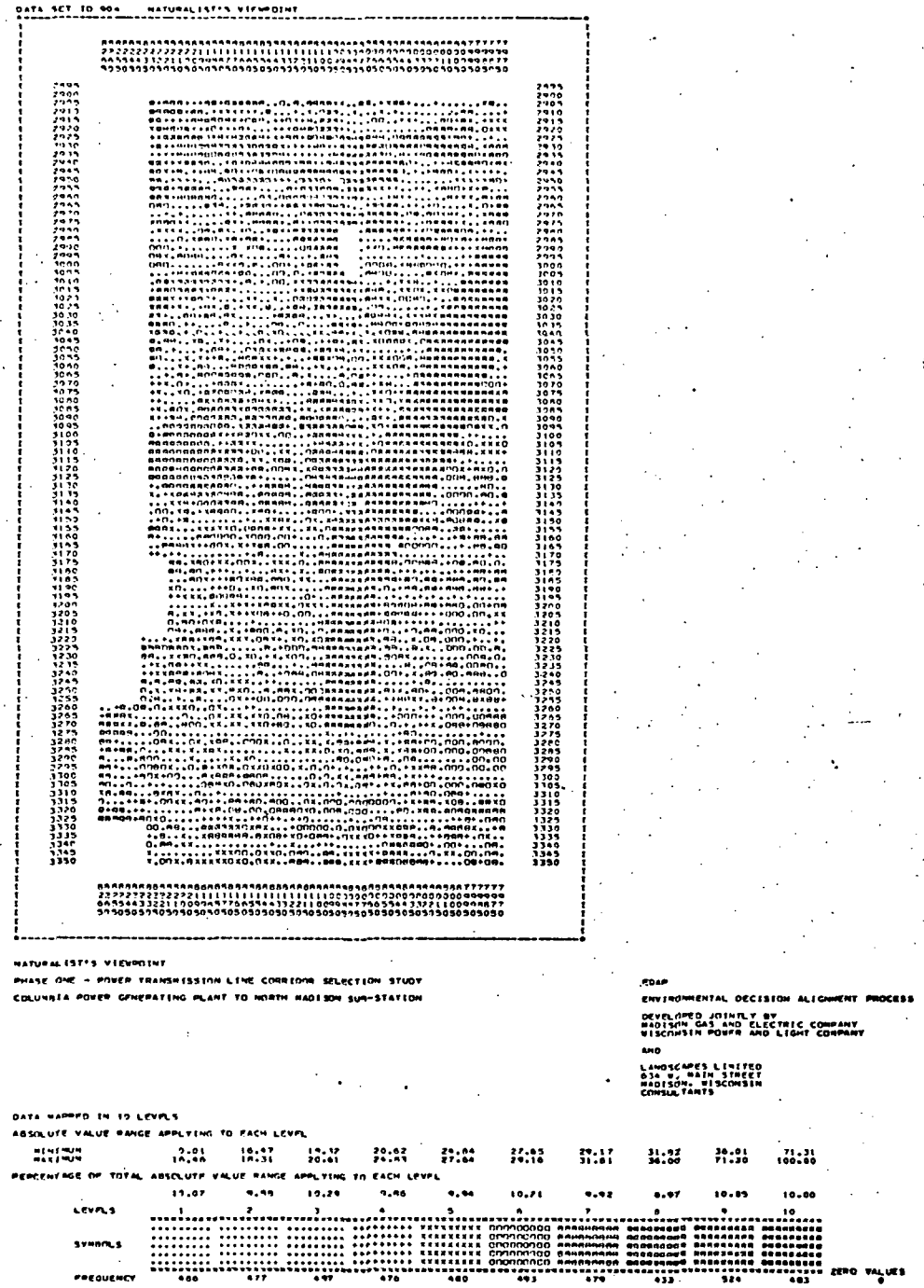

FIGURE 6. NATURALIST'S VIEWPOINT.

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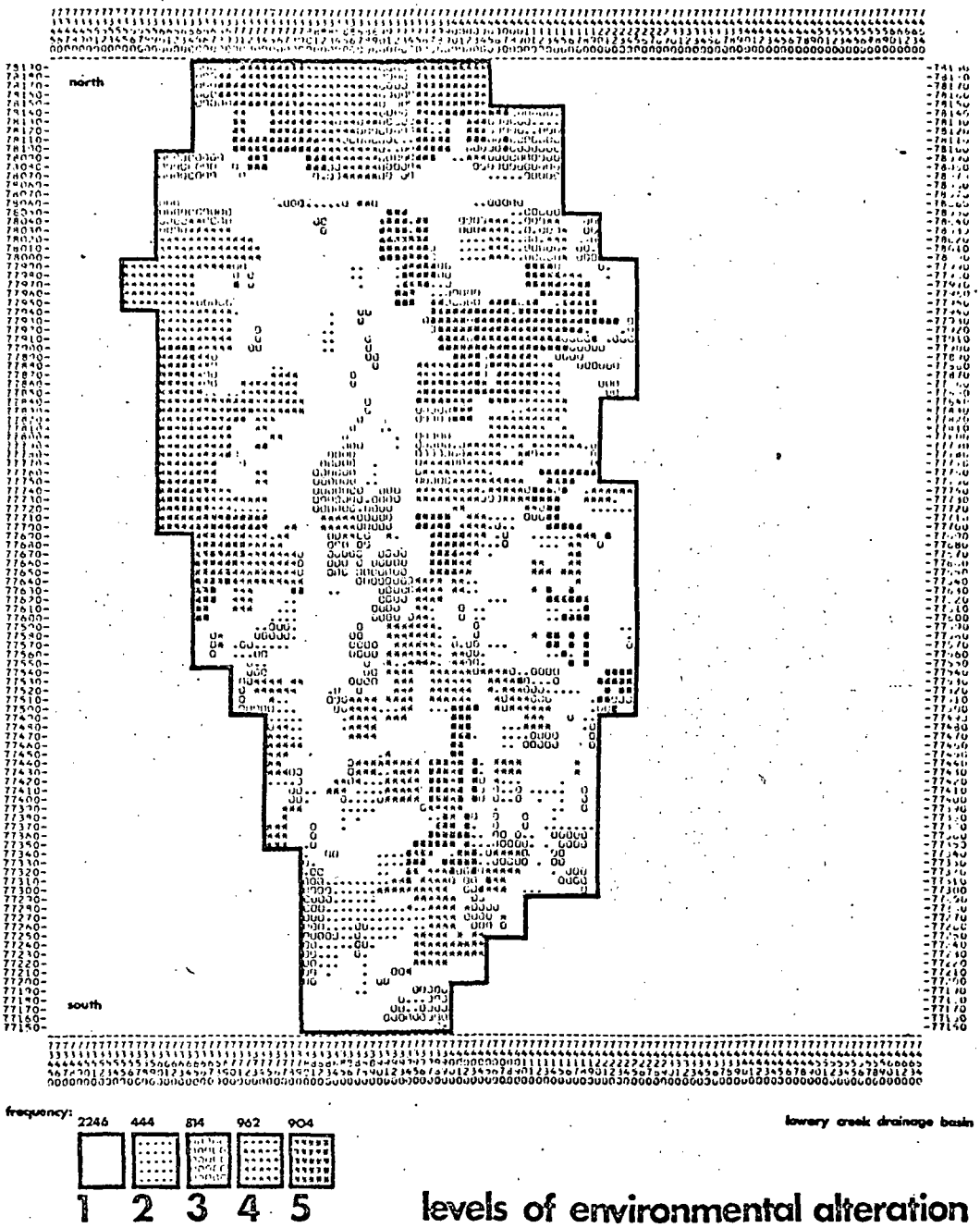

FIGURE 7. LEVELS OF ENVIRONMENTAL ALTERATION IN A RURAL WATERSHED.

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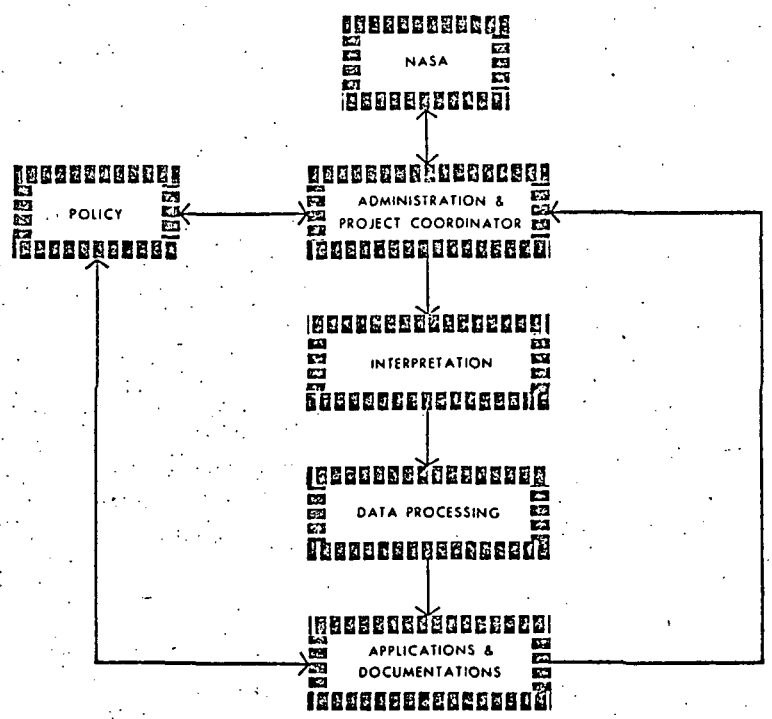

FIGURE 8. ERTS PROJECT ORGANIZATION CONCEPT.

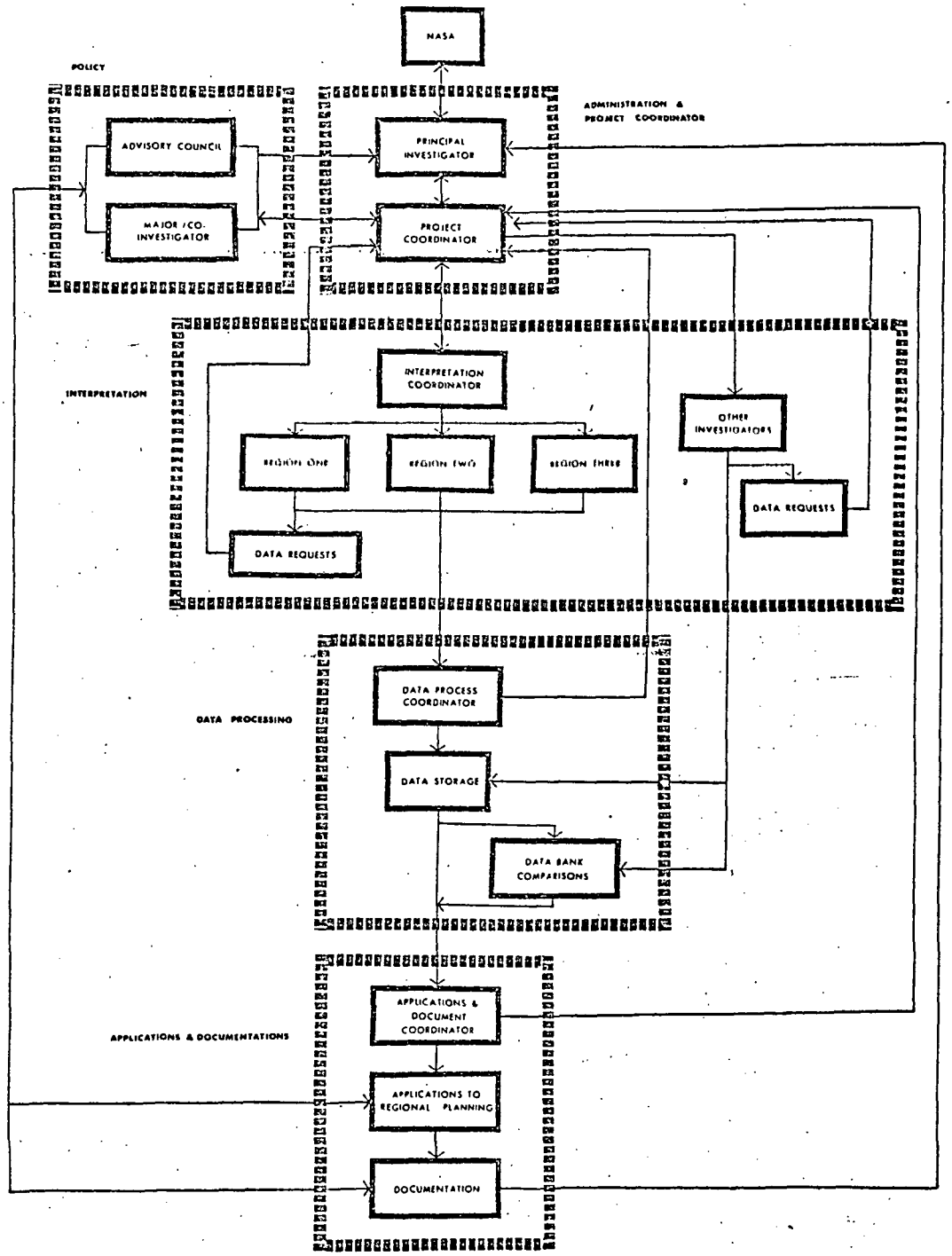

FIGURE 9. ERTS PROJECT ORGANIZATION.

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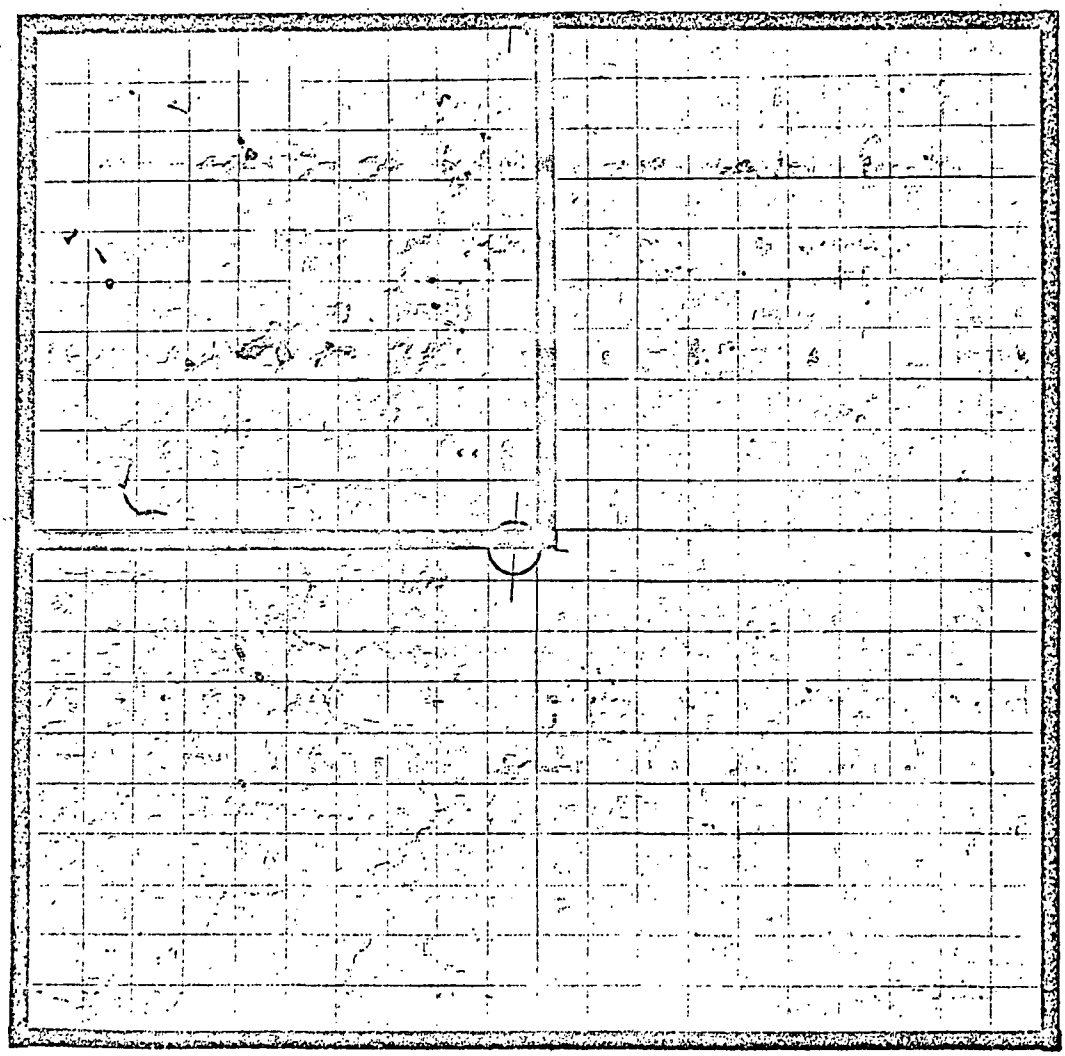

FIGURE 10.
RB-57 IMAGE

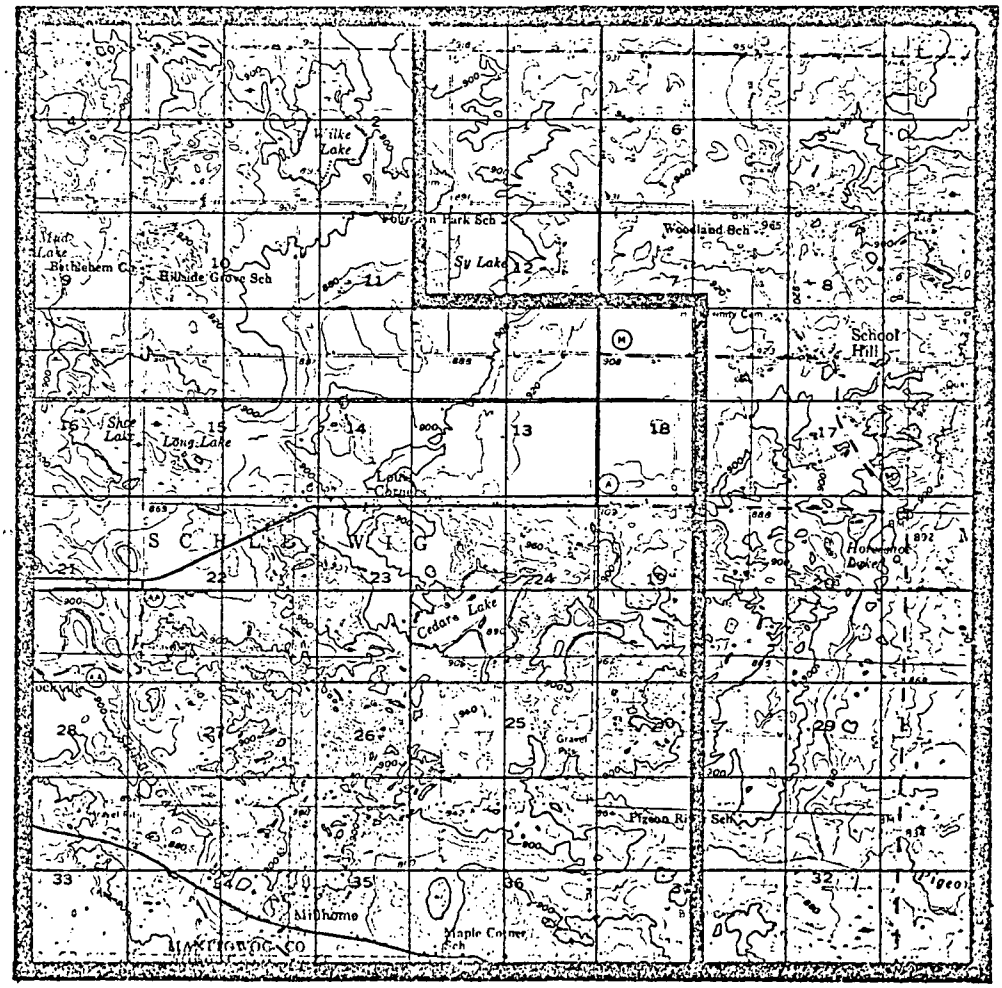

FIGURE 11.
U.S.G.S. TOPOGRAPHIC MAP

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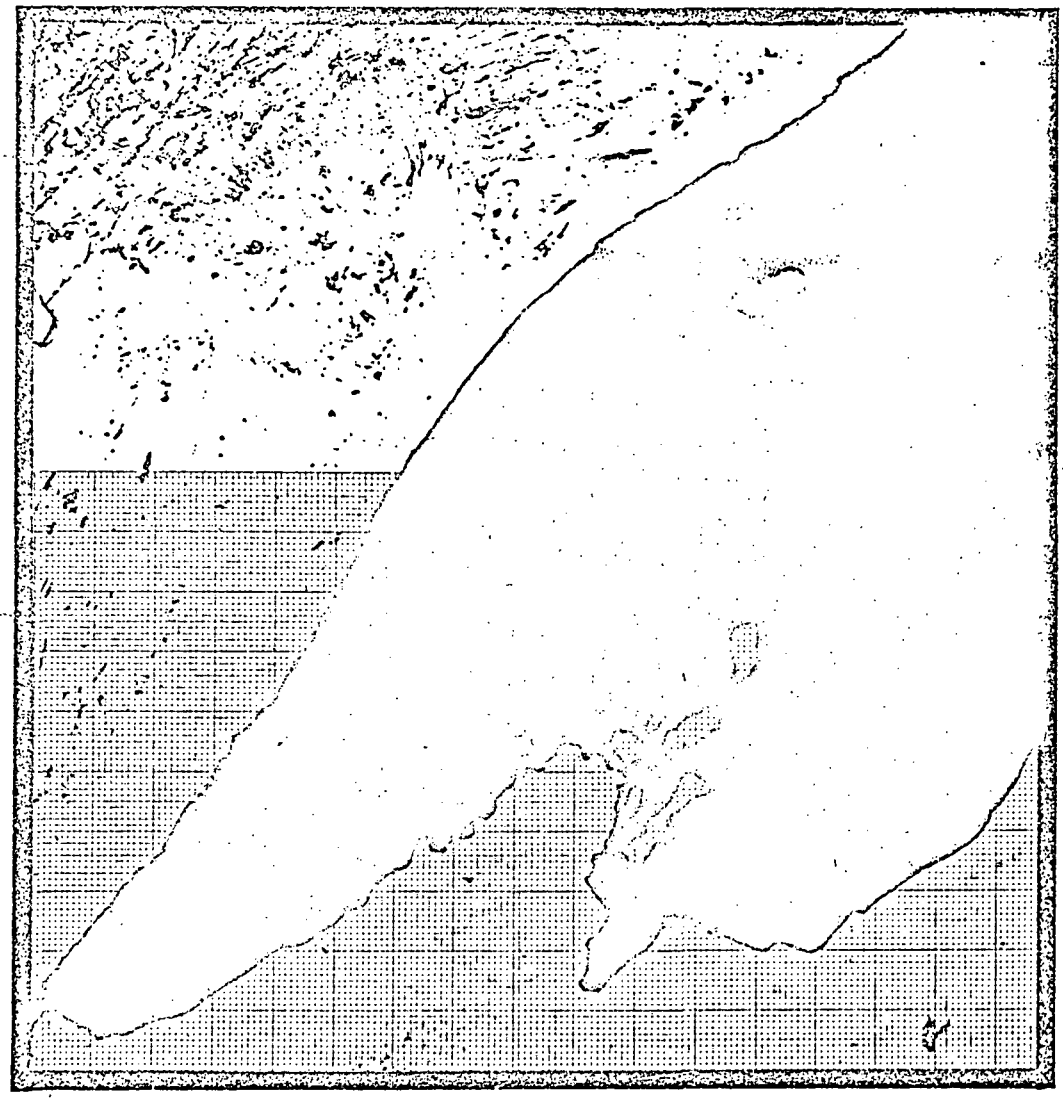

FIGURE 12.
ERTS-1 IMAGE

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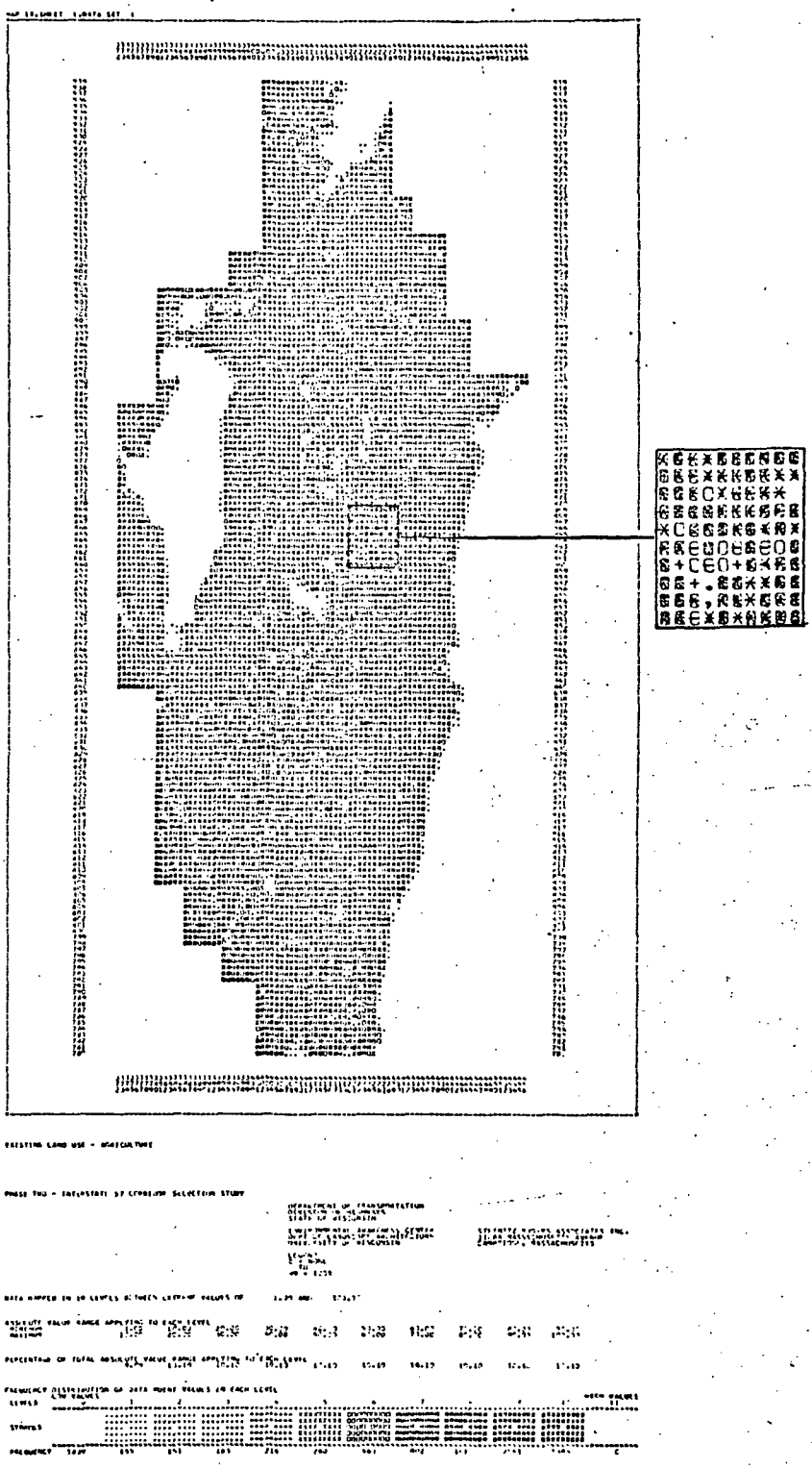

FIGURE 13. SPATIAL COMPARISON - AGRICULTURE.

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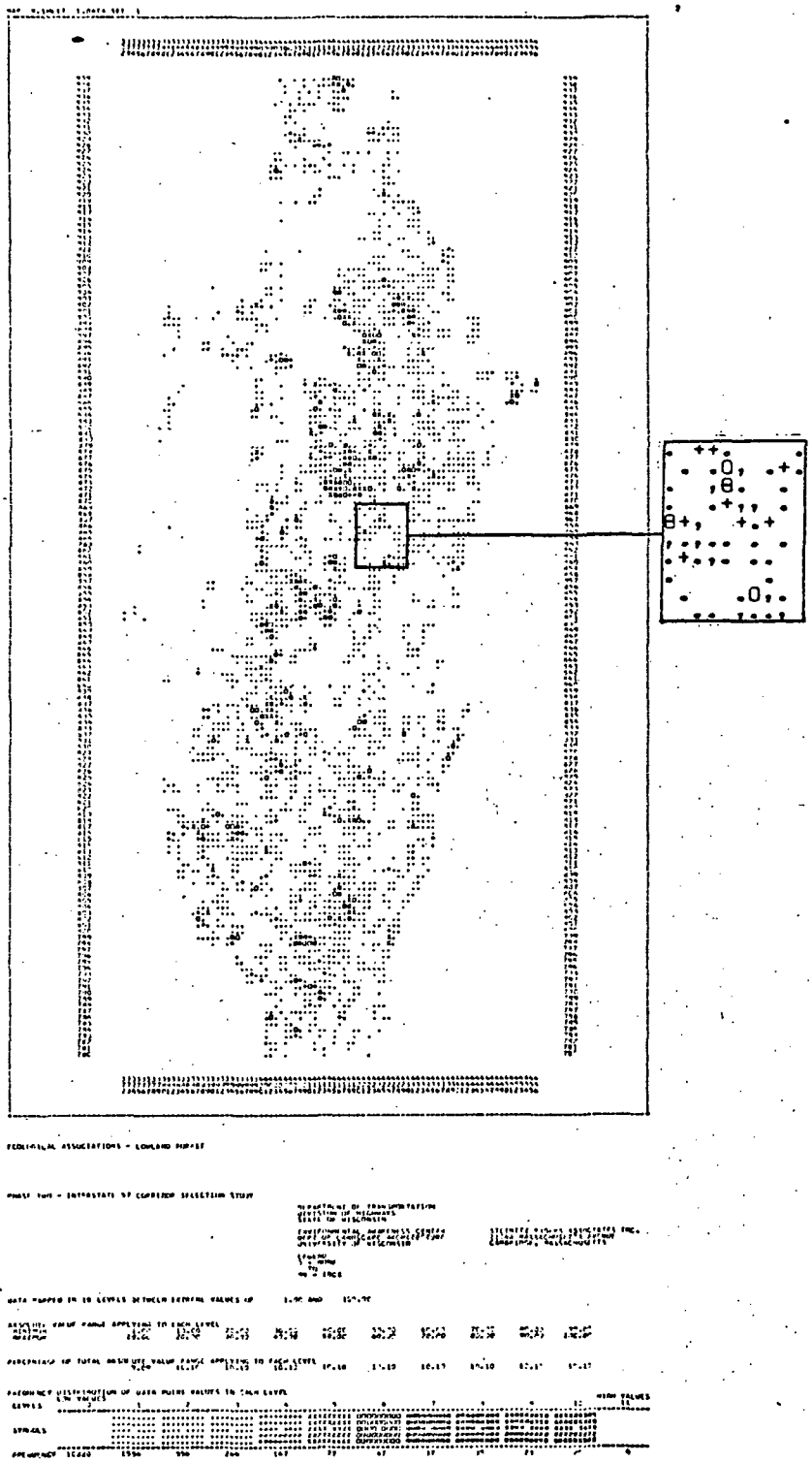

FIGURE 14. SPATIAL COMPARISON - LOWLAND FOREST.

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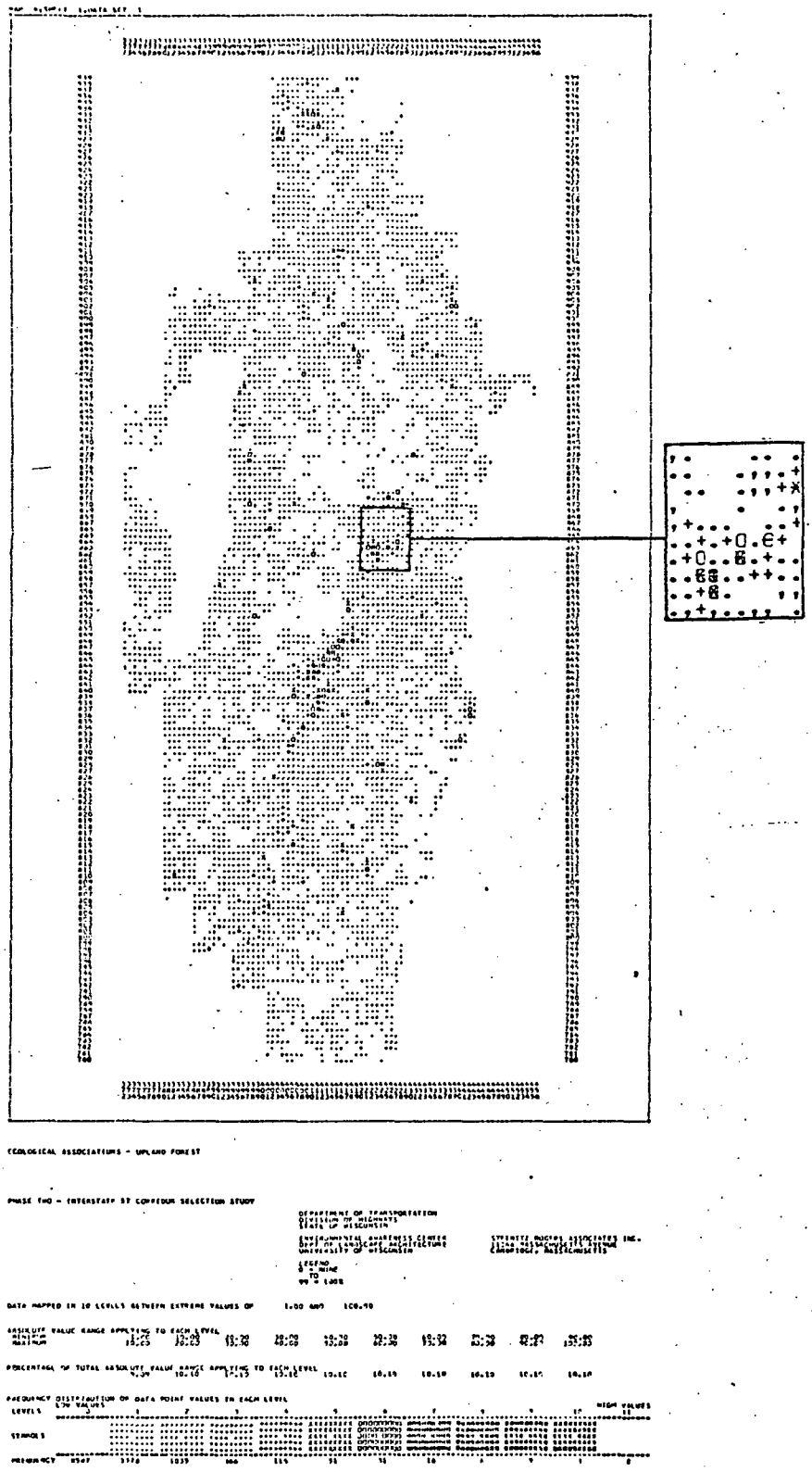

FIGURE 15. SPATIAL COMPARISON - UPLAND FOREST.

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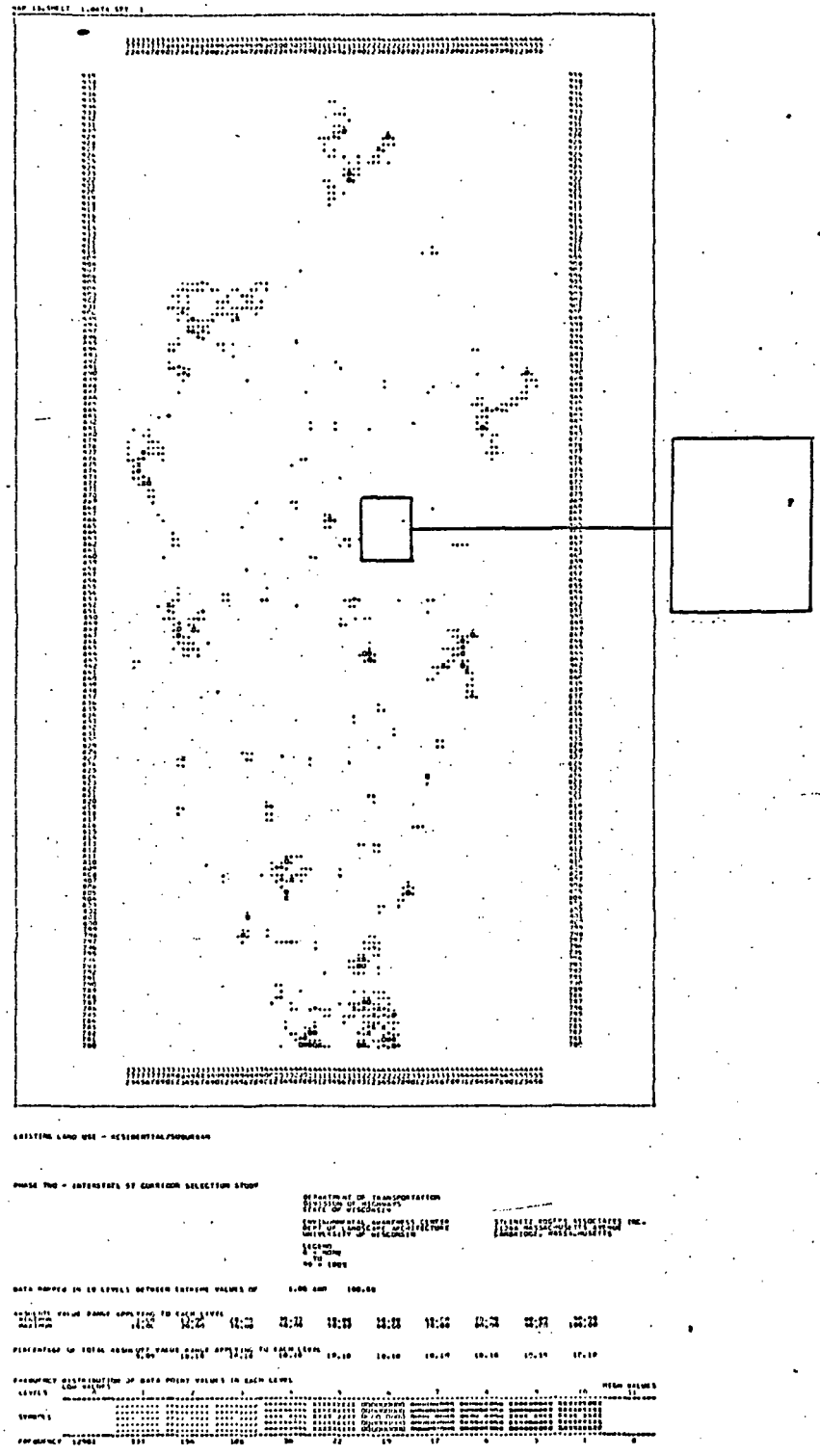

FIGURE 16. SPATIAL COMPARISON - RESIDENTIAL/SUBURBAN.

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IMPACT WIDTH 1km
QUANTITY IN ACRES

RESOURCE	CORRIDOR ALTERNATIVES 1	2	3	4	5
Intermittent Streams	128.86	141.85	85.35	100.31	172.84
Streams	45.77	44.34	9.28	52.79	83.09
Minor River	94.70	89.08	10.52	14.85	20.93
Major River	29.98	4.95	.00	.00	.00
Pond or Lake Less than 50 acres	58.81	51.36	12.57	49.50	7.32
Lake	19.80	7.42	.00	.00	.00
Upland Forest	1962.54	2441.23	836.52	1307.04	1315.40
Lowland Forest	1526.56	2173.31	556.32	686.81	639.39
Open Swamp	235.23	294.17	64.23	135.49	81.06
21% +	530.75	1076.67	184.10	374.27	540.95
Recreational/ Conservational	1174.95	1089.89	5.98	3.71	127.21
TOTAL	5807.95	7414.27	1764.87	2724.27	2988.19
Per Cent Increase	229.1%	320.2%	%	45.4%	69%

TABLE I. IMPACT OF CORRIDOR ALTERNATIVES ON NATURAL RESOURCES.

Bottom of Typing Area

I. NATURAL CHARACTERISTICS:

A. Hydrological Systems

- Intermittent Stream
- Stream
- Minor River
- Major River
- Lake or Pond less than 50 acres
- Lake, greater than 50 acres
- Lake Michigan

B. Ecological System

- Barren Land
- Upland Forest
- Lowland Forest
- Open Swamp

C. Physiographic System

Topographic Orientation:

- Degree of Orientation
- Single Direction
- Two Directional
- Three Directional

Topographic Slope:

- 0-2%
- 2-6%
- 7-12%
- 13-20%
- 21% and over

Topographic Elevation:

- Highest Elevation in Cell
- Lowest Elevation in Cell
- Centroid Elevation

Landforms - Predominant Type:

- Outwash Plain
- Beach Ridge
- Terraces (Alluvium)
- Ground Moraine/Ground Moraine over Outwash
- Ground Moraine over Glacial Lakebed/Glacial Lake
- Sand Dunes
- Drumlins
- Eskers
- End Moraine
- Escarpment

D. Pedological Systems

- Surface Soils (7 classes)
- Subsurface Soils (10 classes)
- Substratum Soils (9 classes)

E. Natural Landscape Units

- Watersheds

II. CULTURAL CHARACTERISTICS:

A. Existing Land Use Systems

- Residential - Rural
- Residential - Vacation
- Residential - Suburban
- Residential - Urban
- Commercial
- Industrial

Recreation:

- River or Lake Zoning
- Wildlife Preserve
- State/Local Forest
- State/Local Park
- Scientific Areas
- Scenic Highways
- Environmental Corridors
- Intrinsic Resources/Wildlife
- Intrinsic Resources/Vegetation
- Intrinsic Resources/Physiographic
- Intrinsic Resources/Wetland
- Intrinsic Resources/Water
- Extrinsic Resources/Topographic Associated Structures
- Extrinsic Resources/Camps
- Extrinsic Resources/Trails and Accommodations
- Extrinsic Resources/Water Associated Sports and Facilities
- Extrinsic Resources/Winter Sports Facilities
- Extrinsic Resources/Publically or Privately owned lands and associated clubs
- Extrinsic Resources/Water associated projects
- Extrinsic Resources/Wildlife and Conservation
- Extrinsic Resources/Historic Structures
- Extrinsic Resources/Historic Feature
- Extrinsic Resources/Cultural Structure
- Extrinsic Resources/Cultural Feature

Institutional

- Institutional - Military
- Institutional - Reservation

Agricultural

B. Projected Land Use Systems

- Residential
- Commercial
- Industrial
- Recreational/Conservational
- Institutional

C. Population Distribution Systems

- Urban Centers (9 classes by population)
- Rural Land Ownership

TABLE II. REMAP I DATA LIST.

II. CULTURAL CHARACTERISTICS (Cont'd):

D. Communication Systems

Roadways/Town - Unpaved
Roadways/Town - Paved
Roadways/County Road
Roadways/State Highway
Roadways/Federal Highway
Roadways/Limited Access Highway
Roadways/Interchange
Trip Ends - Projected 1990 -- All trips
Trip Ends - Projected 1990 -- Greater than 50 miles
Utilities - Telephone Cable
Utilities - Gas Lines 3"-14"
Utilities - Gas Lines 16"-24"
Utilities - High Pressure Oil Lines
Utilities - Power Transmission Lines
Utilities - Railway Lines

E. Cultural Landscape Units

Counties (total of 13)
State Senatorial Districts (total of 8)
State Assembly Representation - Number per district (13 districts, 35 representatives)
Congressional Districts (total of 4)
Cooperative Educational Service Agency Districts (4 CESA districts, 62 school districts)
Regional Planning Commission - Name (total of 5)

TABLE II. REMAP I DATA LIST.

Bottom of Typing Area

NATURAL AND CULTURAL VARIABLES

1) topographic slope
2) USDA-USCS soil type
3) USCS soil class of surface soil
4) USCS soil class of subsoil
5) USCS soil class of substratum
6) soil permeability
7) soil frost hazard
9) geologic landform
10) depth to bedrock
11) bedrock type
12) soil drainage class
13) depth to ground water table
14) flood hazard
15) tree cover
16) existing land use
17) linear transportation systems
18) zoning

LAND USE CAPABILITY/SUITABILITY EVALUATIONS

1) low density residential with septic tanks
2) low to medium density residential with public sewer
3) high rise apartments
4) sanitary landfill
5) commercial - community centers
6) commercial - regional centers
7) light industrial
8) heavy industrial
9) highways
10) roads and streets
11) airports
12) railroads
13) pipelines and conduits
14) agricultural
15) parks and picnic areas
16) playgrounds and playfields
17) campsites
18) nature trails
19) golf courses
20) wildlife habitat
21) sand and gravel pits
22) quarries
23) cemeteries

TABLE III. LUSE DATA LIST.

Bureau of Typing Area

Top of Typing Area

000 - 099 LANDSCAPE UNITS

000 - 049 CULTURAL UNITS

001 Study Area
010 County
011 Township
020 Corporate Limit
021 Extra Territorial Limit
040 Land Owned by Wisconsin Power and Light
041 Generating Plant Pool
042 Generating Plant Facility

050 - 099 NATURAL UNITS

051 Watershed
060 Landscape Type

100 - 299 CULTURAL CHARACTERISTICS

100 - 149 EXISTING LAND USES

100 Urban Land
110 Rural Residential - Suburban
111 Rural Residential - Rural
113 Rural Residential - Agricultural
114 Rural Commercial
115 Rural Industrial
116 Rural Extractive
117 Rural Institutional
120 Agricultural - Row Crop
121 Agricultural - Row Crop - Irrigated/Dusted
122 Agricultural - Specialized Crop
123 Agricultural - Livestock
124 Agricultural - Fur, Game, Poultry
125 Agricultural - Plantation
126 Agricultural - Strip Cropping
127 Agricultural - Research Farm
130 Recreation - State Park
131 Recreation - County Park
132 Recreation - Local Park
133 Recreation - Local Forest
134 Recreation - Wildlife Preserve
135 Recreation - Scientific Area
136 Recreation - Organized Public/Private
137 Recreation - Public Hunting Areas
138 Recreation - Public Fishing Area
139 Recreation - Private Hunting Area
140 Recreation - Private Fishing Area
141 Recreation - Wayside
142 Recreation - John Muir's View
143 Recreation - Historic Site
144 Recreation - Poynette Game Farm
149 No Discernible Land Use

150 - 169 PROPOSED LAND USES

150 Proposed Residential (701)
151 Proposed Commercial (701)
152 Proposed Industrial (701)
153 Proposed Institutional (701)
154 Proposed Recreational
155 Proposed Scientific Areas

170 - 179 ZONED LAND USES

171 Zoned Residential
172 Zoned Commercial
173 Zoned Industrial
174 Zoned Recreational
175 Zoned Agricultural
176 Zoned Flood Plain
177 Zoned Shore Line

200 - 249 EXISTING COMMUNICATION SYSTEMS

202 Communication - Interstate Highway
203 Communication - Federal Highway
204 Communication - State Highway
205 Communication - County Highway
206 Communication - Local Roadway
210 Communication - Rural Airfield
220 Communication - Power Transmission Substation
250* Communication - Railway
240 Communication - Power Transmission Line (69 Kv)
241 Communication - Power Transmission Line (138 Kv)
242 Communication - Power Transmission Line (345 Kv)
243 Communication - High Pressure Oil Line
244 Communication - Gas Line
245 Communication - Telephone Cable
246 Communication - Radio and TV Transmission Towers

250 - 299 PROPOSED COMMUNICATION SYSTEMS

230* Proposed Principal Arterial
251 Proposed Primary Arterial
252 Proposed Standard Arterial
253 Proposed Minor Arterial
254 Proposed High Collector
255 Proposed Low Collector
260 Proposed Rural Airfield
270 Proposed Railway
280 Proposed Transmission Line (69 Kv)
281 Proposed Transmission Line (138 Kv)
282 Proposed Transmission Line (345 Kv)

TABLE IV. EDAP DATA LIST.

Bottom of Typing Area

Top of Typing Area

283 Proposed High Pressure Oil Line
284 Proposed Gas Line
285 Proposed Telephone Cable

300 - 499 NATURAL CHARACTERISTICS

300 - 349 HYDROLOGIC

300 Intermittent Stream
301 Stream
302 Stream - Trout
303 Stream - Small Mouth Bass
304 Stream - Panfish
305 Stream - Other Game Fish
310 River
311 River - Small Mouth Bass
312 River - Panfish
313 River - Complex
314 River - Other Game Fish
320 Pond
321 Pond - Seasonal
330 Lake
331 Lake - Trout
332 Lake - Small Mouth Bass
333 Lake - Panfish
334 Lake - Complex
335 Lake - Other Game Fish

350 - 399 PHYSIOGRAPHIC

350 Centroid Elevation
351 Center E Elevation
352 Center S Elevation
353 Center W Elevation
354 Center N Elevation
360 0-2% Slope
361 3-6% Slope
362 7-12% Slope
363 13-20% Slope
364 12% and Greater

400 - 424 PEDOLOGIC

410 Soil Association
420 Muck - Mucky Peat
421 Marsh
422 Rocky and Stony Land
424 Rock Outcropping

425 - 499 VEGETATIONAL

425 Upland Hardwoods Closed
426 Upland Hardwoods Medium
427 Upland Hardwoods Open
428 Hardwood with Conifers Closed
429 Hardwood with Conifers Medium
430 Hardwood with Conifers Open
431 White Pine Closed
432 White Pine Medium
433 White Pine Open
434 Popple with White Birch Closed
435 Popple with White Birch Medium
436 Popple with White Birch Open
437 Oak Hickory Closed
438 Oak Hickory Medium
439 Oak Hickory Open
440 Jack Pine Closed
441 Jack Pine Medium
442 Jack Pine Open
443 Pin Cherry Closed
444 Pin Cherry Medium
445 Pin Cherry Open
450 Swamp Hardwoods Closed
451 Swamp Hardwoods Medium
452 Swamp Hardwoods Open
453 White Cedar Closed
454 White Cedar Medium
455 White Cedar Open
456 Tamarack Closed
457 Tamarack Medium
458 Tamarack Open
470 Tagalder, Willow, Dogwood Closed
471 Tagalder, Willow, Dogwood Medium
472 Tagalder, Willow, Dogwood Open
473 Marsh

500 - 599 GENERATED DATA

510 Existing or Proposed Airfield
524 Zoned Agriculture
540 Upland Hardwoods
541 Hardwoods with Conifers
542 Oak Hickory
543 Pin Cherry
544 White Pine
545 Popple with White Birch
546 Jack Pine
547 Swamp Hardwoods
548 White Cedar
549 Tamarack
550 Tagalder, Willow, Dogwood
551 Hydric Soil Continuum
552 Elevation Variability
554 Vegetation Closed
555 Vegetation Medium
556 Vegetation Open
557 Non-Vegetated

600 - 699 VARIABLES

600 Slopes - Row Crops
601 Soil Associations - Row Crops
602 Slopes - Aerial Dusting
603 Slopes - Livestock
604 Soil Association - Livestock
605 Potential Capability for Row Crops
606 Aerial Dusting
607 Potential Capability of Livestock Areas
610 Relative Capability of Row Crops

TABLE IV. EDAP DATA LIST.

Bottom of Typing Area

611 Relative Capability of Row Crops with Potential for Aerial Dusting
612 Relative Capability of Livestock Areas
630 Existing Lands Designated for Recreational and Conservational Use
631 Existing Non-Designated Lands being Utilized for Recreational Purposes
640 Impact to Hydric - Xeric State
641 Vegetation - Hydric - Xeric State
642 Xeric Forest - Hydric - Xeric State
643 Mesic Forest - Hydric - Xeric State
644 Hydric Forest - Hydric - Xeric State
645 Soil Associations - Hydric - Continuum
646 Soil Anomalies - Hydric - Xeric State
647 Impact to Successional State
648 Impact to Vegetational Density
649 Erodability of Soils
650 Slopes
651 Tolerance of Water Systems
652 Upland Forest - Wildlife
653 Lowland Forest - Wildlife
654 Swamp Land - Wildlife
655 Existing Utility Rights-of-Way
656 Existing Highway Rights-of-Way
657 Proposed Utility Rights-of-Way
658 Proposed Highway Rights-of-Way
661 Potential Exposure from Rural Land Use
662 Potential Exposure from Recreational and Conservational Land Use
663 Potential Exposure from Water Systems Being Utilized for Recreational Activities
664 Unique Views
665 Vegetation Height
666 Vegetation Density
670 Soil Suitability - Construction
671 Least Right-of-Way Clearing
672 Topographic Variability
673 Availability of Right-of-Way Access
674 Relative Value of Existing Urbanized Land
675 Relative Value of Agricultural Land
676 Relative Value of Recreational Land
677 Relative Value of Land with No Discernible Use
678 Relative Value of Highway Rights-of-Way
679 Relative Value of Utility Rights-of-Way
680 Relative Value of Proposed Land Use
681 Least Rights-of-Way Maintenance
682 Steepness of Slope

700 - 799 COMPONENTS

700 Greatest Compatibility with Existing Land Uses
701 Greatest Compatibility with Existing Communication Systems
702 Greatest Compatibility with Proposed Land Uses
703 Greatest Compatibility with Zoned Land Uses
704 Greatest Compatibility with Proposed Communication Systems
707 Least Disruption to Existing Agricultural Land Uses
708 Least Disruption to Zoned Agricultural Uses
711 Least Disruption to Existing Recreational Land Uses
712 Least Disruption to Proposed Recreational Land Uses
715 Physical Tolerance to Vegetational Impact
716 Tolerance to Impact to Water System
717 Potential Impact to Wildlife
720 Functional Compatibility with Existing Right-of-Way
721 Functional Compatibility with Proposed Right-of-Way
724 Extent of Potential Visual Exposure
725 Potential Visual Access to Facility
726 Potential Visual Screen
729 Minimization of Construction Cost
730 Minimization of Right-of-Way Procurement or Lease Hold
731 Minimization of Recurring Maintenance Cost

800 - 899 DETERMINANTS

801 Maximization of Compatibility with Urbanized Land Use Practices
802 Minimization of Disruption to Agricultural Land Use Practices

TABLE IV. EDAP DATA LIST.

803 Minimization of Disruption to Recreational Land Use Practices
804 Minimization of Disruption to the Natural System
805 Maximization of Potential for Functional Right-of-Way Sharing
806 Maximization of Compatibility with Potential Visual Exposure
807 Minimization of Financial Investment

900 - 999 ALTERNATIVES

901 Equal Importance
904 Naturalist Policy
906 Naturalist Policy with All Others
907 Farmers' Policy
910 Politicians' Policy
915 Tourist Policy
916 Naturalist Policy with Cost

TABLE IV. EDAP DATA LIST.

ABIOTIC FACTORS

EDAPHIC FACTORS
- SOIL CHARACTERISTICS
  - AVAILABLE WATER
  - BEARING VALUE
  - BEDROCK DEPTH
  - CATION EXCHANGE CLASS
  - CORRISION POTENTIAL
  - COLOR
  - CROPPING POTENTIAL
  - DRAINAGE CLASS
  - EROSION HAZARD
  - FLOOD HAZARD
  - FROST HAZARD
  - ORGANIC MATTER
  - PERMEABILITY
  - REACTION
  - SHRINK-SWELL POTENTIAL
  - SOIL MINERALOGY CLASS

GEOMORPHIC FACTORS
- EXPOSED & SURFACE BEDROCK
  - BEDROCK EXPOSED (ABOVE SURFACE)
  - BEDROCK UNDER SURFACE - 0-12"
- FORM CONFIGURATION*
  - PLAN VIEW FORM - CONVEX
    - " " " - CONCAVE
    - " " " - STRAIGHT
    - " " " - PLANE
  - CROSS SECTION FORM - CONVEX
    - " " " - CONCAVE
    - " " " - STRAIGHT
    - " " " - PLANE
- ORIENTATION
  - NORTH ORIENTATION
  - NORTHEAST ORIENTATION
  - EAST ORIENTATION
  - SOUTHEAST ORIENTATION
  - SOUTH ORIENTATION
  - SOUTHWEST ORIENTATION
  - WEST ORIENTATION
  - NORTHWEST ORIENTATION

HYDROMORPHIC FACTORS
- DRAINAGE BASIN MAGNITUDE
- STREAM ORDER

BIOTIC FACTORS

BOTANIC FACTORS
- COMMUNITY FORM TYPES
  - AQUATIC COMMUNITIES
  - GRASSLAND, MEADOW & SHRUB COMMUNITY
  - SAVANNA COMMUNITY
  - FOREST COMMUNITY
  - PRESETTLEMENT VEGETATION
- COMPLEXITY OF TRANSITIONAL ZONES
  - FOREST - SAVANNA
  - FOREST - AQUATIC
  - FOREST - CROPLAND
  - FOREST - LINKAGES
  - SAVANNA - AQUATIC
  - SAVANNA - CROPLAND
  - SAVANNA - LINKAGES
  - AQUATIC - CROPLAND
  - AQUATIC - LINKAGES
  - CROPLAND - LINKAGES
  - INTER - CROP
  - INTRA - FOREST
- DISTURBANCE RESPONSE
  - REPLACEMENT
  - REGRESSION
  - RETARDATION
  - RELEASE
- DISTURBANCE STATE
  - UNDISTURBED
  - DISTURBED
- DOMINANT PLANT FORM TYPE
  - HERBS DOMINANT
  - HARDWOODS DOMINANT - TREES
  - HARDWOODS DOMINANT - SHRUBS
  - CONIFERS DOMINANT - TREES
  - CONIFERS DOMINANT - SHRUBS (TALL)
  - CONIFERS DOMINANT - SHRUBS (SMALL)
- ENVIRONMENTAL CONDITIONS - MOISTURE
  - DRY
  - DRY-MESIC
  - MESIC
  - WET-MESIC
  - WET
- PER CENT OF CANOPY LAYER - 1970
  - 0-20% DENSITY
  - 20-40% "
  - 40-60% "
  - 60-80% "
  - 80-100% "
- PER CENT OF CANOPY LAYER - 1940
  - 0-20% DENSITY
  - 20-40% "
  - 40-60% "
  - 60-80% "
  - 80-100% "
- PER CENT OF GROUND LAYER COMPOSITION
  - 0-20% NATIVE PLANTS
  - 20-40% " "
  - 40-60% " "
  - 60-80% " "
  - 80-100% " "
- VEGETATIVE MASSES
  - MATURE TREES NOT PRESENT
  - MATURE TREES PRESENT

TABLE V. EMAP DATA LIST.

Bottom of Typing Area

TABULATION NUMBER 7 RB-57 VS I-57 FOR AGRICULTURAL

PERCENT OF TOTAL TABLE

LOWER BOUNDS OF INTERVALS OF VARIABLE 18 (REMAP I)	RB-57 LOWER BOUNDS OF INTERVALS OF VARIABLE 7: 0	10	20	30	40	50	60	70	80	90	100	TOTALS
0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
10	1.0	1.0	1.0	.0	.0	.0	.0	.0	.0	.0	.0	3.0
20	.0	.0	1.0	2.0	.0	.0	.0	.0	.0	.0	.0	3.0
30	.0	.0	.0	1.0	2.0	.0	.0	.0	.0	.0	.0	3.0
40	.0	.0	1.0	1.0	2.0	3.0	.0	.0	.0	.0	.0	7.0
50	.0	.0	.0	1.0	1.0	1.0	3.0	.0	1.0	.0	.0	7.0
60	.0	.0	.0	.0	.0	2.0	5.0	3.0	3.0	4.0	.0	17.0
70	.0	.0	.0	1.0	.0	.0	1.0	5.0	6.0	4.0	.0	17.0
80	.0	.0	.0	.0	.0	.0	.0	2.0	11.0	14.0	.0	27.0
90	.0	.0	.0	.0	.0	.0	.0	.0	1.0	15.0	.0	16.0
100	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
TOTALS	1.0	1.0	3.0	6.0	5.0	6.0	9.0	10.0	22.0	37.0	.0	100.0

TABLE VI. CORRELATIONS: AGRICULTURE.

TABULATION NUMBER 3 RB-57 VS I-57 FOR UPLAND FOREST

PERCENT OF TOTAL TABLE

LOWER BOUNDS OF INTERVALS OF VARIABLE 14 (REMAP I)	RB-57 LOWER BOUNDS OF INTERVALS OF VARIABLE 3: 0	10	20	30	40	50	60	70	80	90	100	TOTALS
0	44.0	4.0	1.0	.0	.0	.0	.0	.0	.0	.0	.0	49.0
10	15.0	5.0	1.0	.0	.0	.0	.0	.0	.0	.0	.0	21.0
20	4.0	3.0	3.0	.0	.0	.0	.0	.0	.0	.0	.0	10.0
30	3.0	.0	4.0	1.0	.0	.0	.0	.0	.0	.0	.0	8.0
40	.0	.0	3.0	.0	.0	1.0	.0	.0	.0	.0	.0	4.0
50	1.0	.0	1.0	.0	1.0	.0	.0	.0	.0	.0	.0	3.0
60	.0	.0	.0	1.0	.0	.0	.0	.0	.0	.0	.0	1.0
70	.0	.0	.0	.0	.0	.0	.0	2.0	.0	.0	.0	2.0
80	.0	.0	.0	.0	.0	.0	.0	1.0	.0	1.0	.0	2.0
90	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
100	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
TOTALS	67.0	12.0	13.0	2.0	1.0	1.0	.0	3.0	.0	1.0	.0	100.0

TABLE VII. CORRELATION: UPLAND FOREST.

Bottom of Typing Area

TABULATION NUMBER 4 RB-57 VS I-57 FOR LOWLAND FOREST

PERCENT OF TOTAL TABLE

LOWER BOUNDS OF INTERVALS OF VARIABLE 15 (REMAP I)	RB-57 LOWER BOUNDS OF INTERVALS OF VARIABLE 4: 0	10	20	30	40	50	60	70	80	90	100	TOTALS
0	73.0	3.0	3.0	1.0	1.0	.0	.0	.0	.0	.0	.0	81.0
10	3.0	4.0	3.0	.0	.0	.0	.0	.0	.0	.0	.0	10.0
20	1.0	3.0	1.0	.0	.0	.0	.0	.0	.0	.0	.0	5.0
30	.0	.0	.0	1.0	.0	.0	.0	.0	.0	.0	.0	1.0
40	.0	1.0	1.0	.0	1.0	.0	.0	.0	.0	.0	.0	3.0
50	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
60	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
70	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
80	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
90	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
100	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
TOTALS	77.0	11.0	8.0	2.0	2.0	.0	.0	.0	.0	.0	.0	100.0

TABLE VIII. CORRELATION: LOWLAND FOREST.

TABULATION NUMBER 6 RB-57 VS I-57 FOR RESIDENTIAL / SUBURBAN

PERCENT OF TOTAL TABLE

LOWER BOUNDS OF INTERVALS OF VARIABLE 17 (REMAP I)	RB-57 LOWER BOUNDS OF INTERVALS OF VARIABLE 6: 0	10	20	30	40	50	60	70	80	90	100	TOTALS
0	99.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	99.0
10	.0	1.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	1.0
20	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
30	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
40	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
50	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
60	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
70	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
80	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
90	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
100	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
TOTALS	99.0	1.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	100.0

TABLE IX. CORRELATION: RESIDENTIAL/SUBURBAN.

Bottom of Typing Area

Top of Typing Area

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Bottom of Typing Area

JAN 1973
RECEIVED
NASA STI FACILITY
INPUT BRANCH