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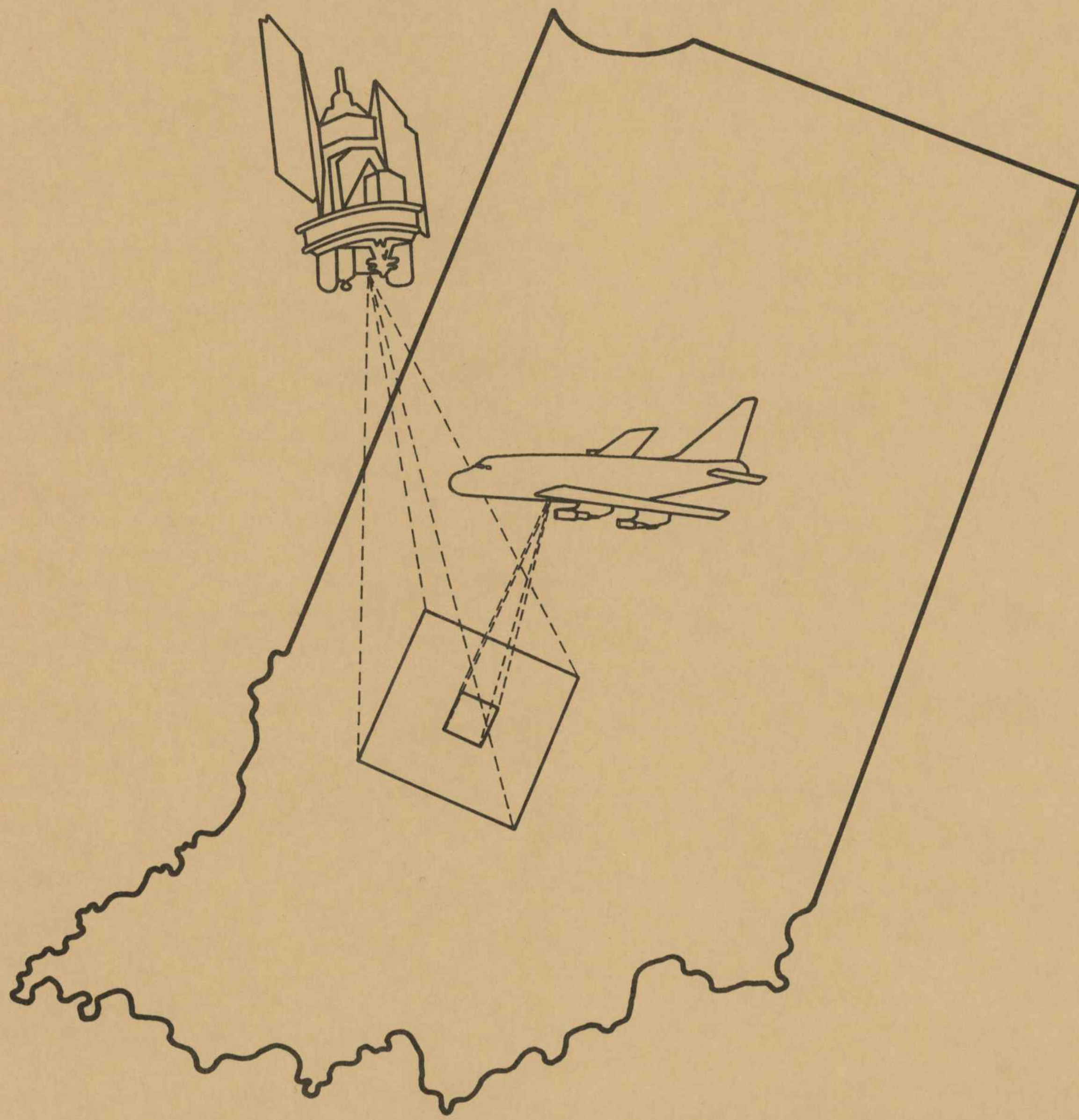
Semi-Annual Status Report

Application of Remote Sensing Technology to the Solution of Problems in the Management of Resources in Indiana



Laboratory for Applications of Remote Sensing
Purdue University W. Lafayette, Indiana

December 1, 1976 - May 31, 1977 NGL 15-005-186

SEMI-ANNUAL REPORT

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Title of Investigation:

The Application of Remote Sensing Technology to the Solution of Problems in the Management of Resources in Indiana

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INTRODUCTION

This semi-annual status report covers the period from December 1, 1976 to May 31, 1977 and contains a review of the research and applications, completed or in progress, as funded by the Office of University Affairs, NASA and conducted by Purdue University, Laboratory for Applications of Remote Sensing.

This reporting period marks the second half of the fourth year of funding for a proposal entitled "The Applications of Remote Sensing Technology to the Solution of Problems in the Management of Resources in Indiana." As indicated in this title, the purpose of this work is to introduce remote sensing into the user community within the state of Indiana. The user community includes those local, regional and state agencies involved in the decision monitoring and/or managing processes of the state's resources.

In order to carry out this work it is not only necessary to initiate projects with these agencies but also it is necessary to meet with and provide information to as many people and groups as well as agencies as possible. During the past six months numerous meetings were held with many different groups.

Among the groups that were contacted and received information about this program were:

Area Planning Commission, Boone County
Indiana Heartland Coordinating Commission
Indiana Geological Survey
U. S. Forest Service
Tipton County Commissioners and Engineers
Indiana Department of Natural Resources
  a) Division of Reclamation
  b) Division of Forestry
  c) Division of Properties, Fish and Wildlife
  d) Soil and Water Conservation Committee
Soil Conservation Service
St. Joseph County Area Plan Commission
Michiana Council of Governments.

Listed below are the projects that are reported in this document:

Coordination with the Indiana Department of Natural Resources
Surface Geology and Natural Resources Inventory
Soils Inventory
Forestry Demonstration Project
Coastal Zone Management.

COORDINATION WITH INDIANA DEPARTMENT OF NATURAL RESOURCES

INTRODUCTION

Since January of 1977, LARS has stepped-up its efforts to develop a close relationship within the Indiana State Government. The Indiana Department of Natural Resources was a logical candidate to work with since LARS has had contact with individuals in IDNR's various Divisions.

A series of meetings were arranged with the Associate Director of the Bureau of Land, Forest, and Wildlife Resources. Each meeting was held in Indianapolis at the State Office Building. Meeting dates were arranged to coincide with Division Head Staff meetings, so that the maximum number of Division Heads could attend.

The Divisions within the Bureau that were included in the meeting were:

- Forestry
- Fish and Wildlife
- Parks
- Museum and Memorials
- Engineering Planning
- Reclamation
- Nature Preserves
- Entomology
- Reservoir Management
- Outdoor Recreation

There were a total of four meetings. Each meeting lasted between one and one and a half hours. The topics discussed included:

- An Overview of Remote Sensing
- Sensor Systems and Characteristics
- Applications in User Areas
- Future Potentials

The meetings were of an informative or tutorial nature with open discussions between participants. LARS' ultimate objective was to excite IDNR staff sufficiently in remote sensing in order to develop a long term relationship with the Department. We are hopeful that the Bureau will appoint an ad hoc committee to investigate IDNR's future use of remote sensing technology. Eventually, we would like to see this activity expand beyond the IDNR into other State agencies.

Our next planned activity will be a meeting with Bureau personnel to look into the long term future of remote sensing in IDNR. To entice comment from the Division Chiefs, a document (attachment 1) has been prepared for IDNR review.

INTRODUCTION

Remote sensing technologies offer to resource management tools which can help in the collection of baseline management information. Indeed, aerial photographs have been useful to various federal government agencies over the past three decades. With current capabilities we are able to collect data over a broader range of the spectrum than is possible with aerial photography. Satellites, such as Landsat, provide repetitive cover of the Earth's surface at a spatial resolution of approximately one acre. Other instruments, mounted in light aircraft, are capable of collecting a broad range of data which could be useful to various state agencies. Additionally, the sophisticated data analysis and reduction techniques are currently available to handle a wide gamut of data that can be collected. Furthermore, the future of this technology is bright with additional capabilities developed well into the decade of the 80's.

Since February 1977 various LARS staff have made periodic presentations to IDNR Division Chiefs. LARS' intent in entering into this activity was twofold:

1. To present IDNR an overview of remote sensing capabilities, and
2. To initiate discussions relative to the use of application of remote sensing technology within the Department.

The purpose of this document is to entice comment from IDNR staff on item 2 above - Applications of Remote Sensing within IDNR. For the specific purpose of discussion we have outlined what we imagine could be applications within the various Divisions. Our viewpoint is one of an outsider looking in, and our knowledge of the intricate working of State agencies should be considered by the reader.

To be most meaningful to us, we would like the opportunity to discuss these "potential applications" with the Division Chiefs as a group. We hope that the ideas presented herein could be used to kick-off such a discussion.

POTENTIAL APPLICATIONS OF REMOTE SENSING

Forestry

Landsat could provide the base for a current forest resource inventory for the state.

Successive analysis could be used to monitor change in forest condition.

Landsat combined with other information in a data base might provide a system for basing resource allocations.

Fish and Wildlife

Landsat or photographic data could be used to obtain habitat cover maps.

Landsat could be used as a base to map the State's wetlands and natural lakes.

Reclamation

Air photos could be used to monitor the progress of strip mine revegetation.

Entomology

Color infrared photography would be a useful way to monitor the spread of insect infestation.

Outdoor Recreation

Air photos could be useful in site planning especially if combined in a data base with other information inputs.

Thermal imaging devices combined with other data sources could be used to map scenic rivers.

Reservoir Management

Various techniques could be used to monitor water quality.

Air photos could be helpful in mapping vegetative conditions in reservoir watersheds.

Museum and Memorials

Photos would provide an historic record of sites.

Large scale photos may be useful in site resurrection.

Parks

Air photos could be useful for site planning, especially if used in conjunction with a data base.

Air photos could also be used to monitor vegetative conditions.

Nature Preserves

Air photos could assist in site inventory work.

SURFACE GEOLOGY AND NATURAL RESOURCES INVENTORY PROJECT

INTRODUCTION

Presented in the following discussion is a report on the computer-assisted classification of Landsat MSS imagery of St. Joseph County, Indiana. The purpose of the study was to obtain a Level II (USGS, Circular 671) land use or cover type classification of the county in order that needed information for a new zoning ordinance and attendant zoning maps could be supplied.

The study was initiated at the request of the Director of the St. Joseph County Area Plan Commission, Mr. Richard Johnson. This county has long been recognized as a progressive leader in their planning decisions for housing development and area zoning. The St. Joseph Plan Commission has jurisdiction over both the city of South Bend and the surrounding county. This yields a combination of an urbanized area with surrounding agricultural lands which is well suited to Landsat study. They have incorporated agricultural soils information for some years into their planning decisions, which is a practice that has only recently become widespread. Mr. Johnson and his staff indicated a desire for stronger physical base information (surface materials, including vegetative cover) for a new zoning ordinance and were encouraged that this type of analysis could accomplish their needs.

OBJECTIVES OF ANALYSIS

The objectives of the analysis were: 1) to use computer-assisted techniques to obtain, from the Landsat data, a land use and cover type classification of the northern portion of the county and 2) to present the output in a form most useful to the user, e.g., in 7½ topographic map size.

DESCRIPTION OF STUDY AREA

St. Joseph County is located in north central Indiana in the high population section of the state along the northern tier of counties adjacent to Chicago, Illinois and directly south of Michigan. The county contains a contrasting variety of glacial landforms including till plains, outwash plains, lake deposits and a vast quantity of organic materials. Urbanization to date has developed in accordance with these geologic conditions (some deposits yield significant foundation problems for houses and other buildings) and with the general location of adjacent population centers, (Mishawaka, Elkhart, and Goshen, Indiana; Niles, Michigan). The Area Plan Commission would like to direct this development in the county in accordance with zoning based on these physical and political factors.

Principal land uses in the county are agricultural and urban with the city of South Bend occupying the central portion of the county. The soils tend to reflect the drainage conditions and texturally they range from fine sands to organic deposits.

ANALYSIS PROCEDURE

A study of the Lydick, South Bend West, South Bend East and Osceola Quadrangles in the northern portion of the county was accomplished using June 8, 1975 data. This imagery is cloud-free and contains no abnormalities. The data was geometrically corrected to allow for overlay onto a 7½ topographic map.

A number of areas were selected which contained representative samples of each cover type within a given quadrangle. The areas were clustered resulting in ten classes of material. Ratioing of the spectral responses in the visible versus the reflective infrared wavelength regions was performed on all the classes to aid in delineating what each class represented. Definable areas on the cluster maps were matched to aerial photographs of 1976, and the classes delineated by spectral response through the clustering algorithm were defined. Statistics on each subsection were calculated and stored in binary form on punch cards. Classes not spectrally different in a significant way were combined and their statistics merged through the MERGESTATISTICS function of the LARS software system. Subsequently, the statistics were passed through the SEPARABILITY program which determines how separable the newly merged classes actually are. Similar classes were again combined and their statistics merged, resulting in a single set of statistics which was used in the classification process.

RESULTS

The Lydick, South Bend West, South Bend East and Osceola Quadrangles were successfully classified into twenty-six cover types with a high degree of accuracy. The classes were as follows: 1) new, suburban development, 2) medium density tree stands with grass, 3) mixed healthy vegetation with few trees, 4) light industry and business, 5) older, established neighborhoods with large lots and much vegetation, 6) scattered trees with grass, 7) bright, base soil A, 8) bright, base soil B, 9) light soil with some vegetation, 10) muck 1, 11) muck 2, 12) muck 3, 13) medium base soil, 14) bright base soil C, 15) scattered trees with grass 2, 16) dark base soil, 17) mixed healthy vegetation with few trees 2, 18) water and floating vegetation, 19) water, 20) water and muck, 21) bright concrete buildings, 22) light industry, shopping center, 23) roads with some vegetative cover, 24) base soil with a sparse vegetative cover, 25) heavy industry, and 26) bright base soils. Figures 1 through 4 are photo reductions of the line printer classifications of each quadrangle.

The ability of this computer-assisted classification system to delineate various stages of urban development, from heavy industry to new suburban development, was of particular interest to the planning commission. The classification of the aforementioned quadrangles demonstrates that this type of technology can be used with confidence in performing such a task. Also of importance to the commission, because of their desire for soils information to be used in their new zoning plan, was the success with which soil types were indicated.

The classification is clearly more beneficial than the existing agricultural soils and topographic maps because it shows the current ground cover conditions all on one map. It shows how the area is developing along with the specific type and location of new development. The classification also shows at a glance whether development is taking place in an area suitable for development or if growth is taking place in prime agricultural land, areas of poor foundation material or other places where development is not desirable. It is a combination of the necessary detail of cover type, the useful scale of the output and the current nature of the classification which has made this work so valuable to the planning commission.

DISCUSSION

When this study was initiated, the Level II classification in USGS Circular 671 was to have been used in the delineation of classes. As the study progressed, this idea was dropped because (1) in many cases greater detail could be achieved in classification than was called for by the 671 system and (2) some classes contained in the 671 system could not be distinguished spectrally.

The results obtained in St. Joseph Co. have demonstrated the applicability of remote sensing technology to local and regional governments. The St. Joseph County Area Planning Commission is quite impressed with the amount and quality of information which has been supplied to them thus far. They have indicated a continual commitment to the use of remote sensing technology in their planning activities.

In addition, the Michiana Council of Governments has been keeping abreast of this study in order to determine usefulness in relation to its own special needs. They are greatly encouraged by the results obtained in St. Joseph County. Their particular interest in the field is using remote sensing technology to update a data base of five northern Indiana counties which is now being established.

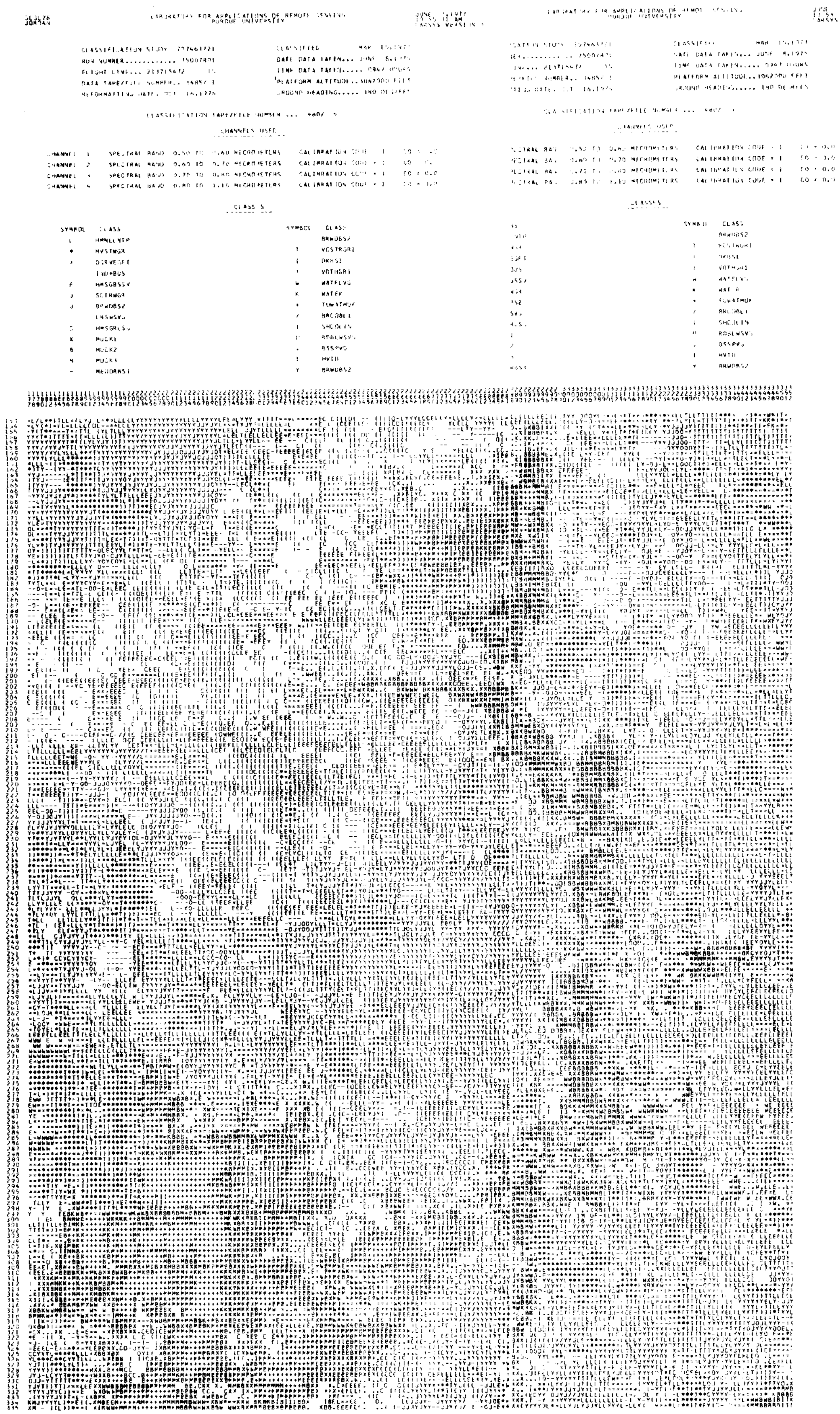

Figure 1. Classification results for the Lydick Quadrangle.

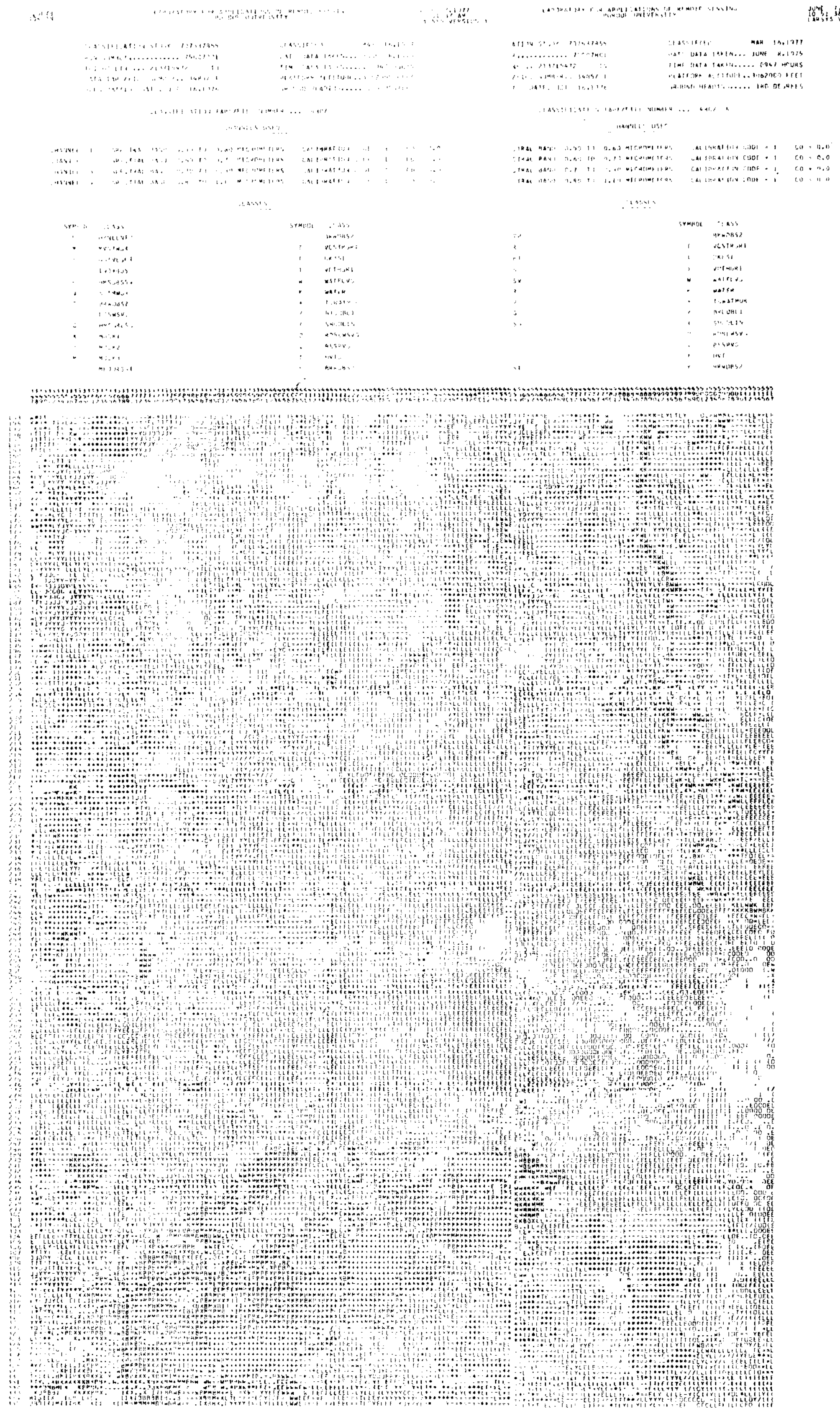

Figure 2. Classification results for the South Bend West Quadrangle.

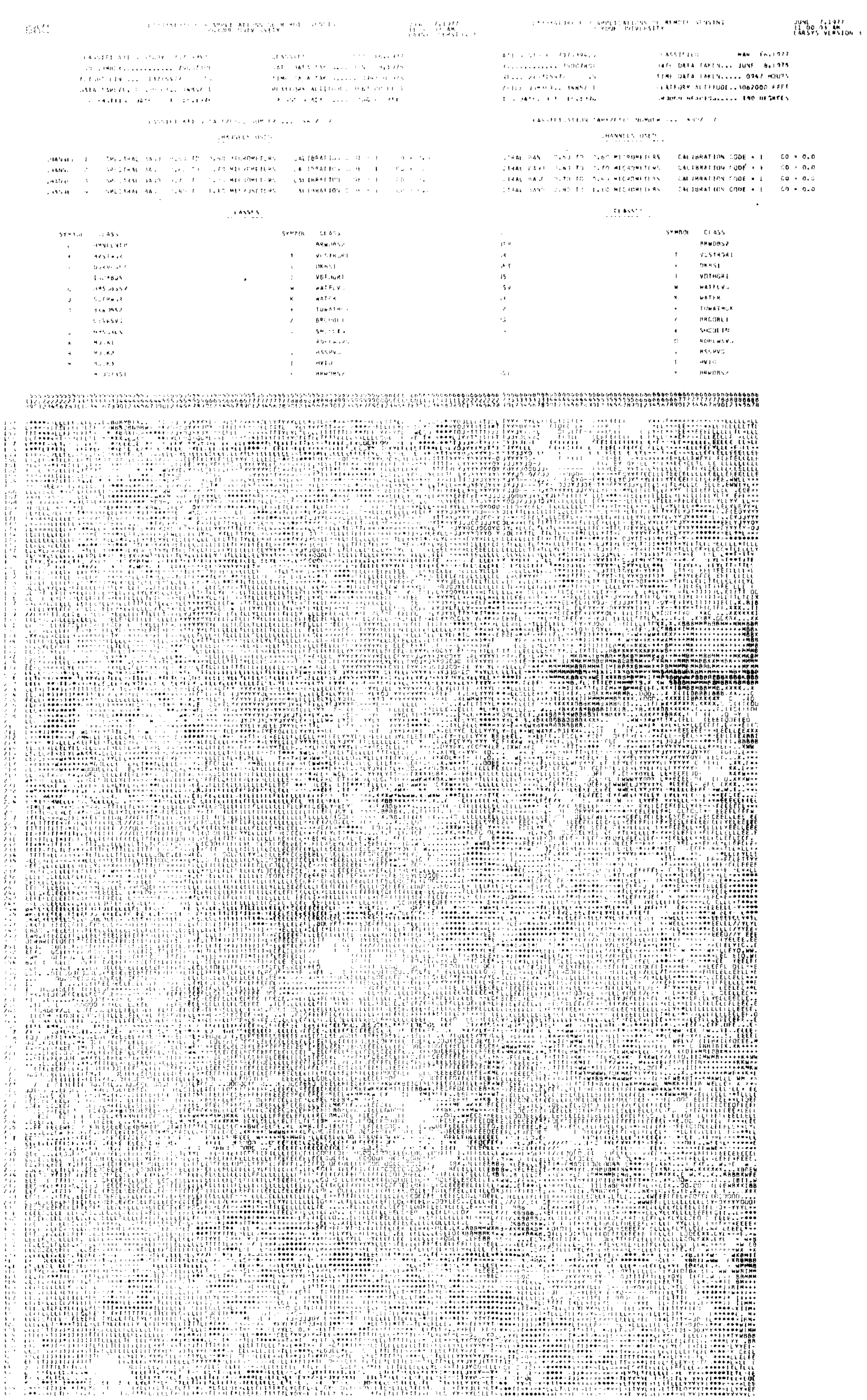

Figure 3. Classification results for the South Bend East Quadrangle.

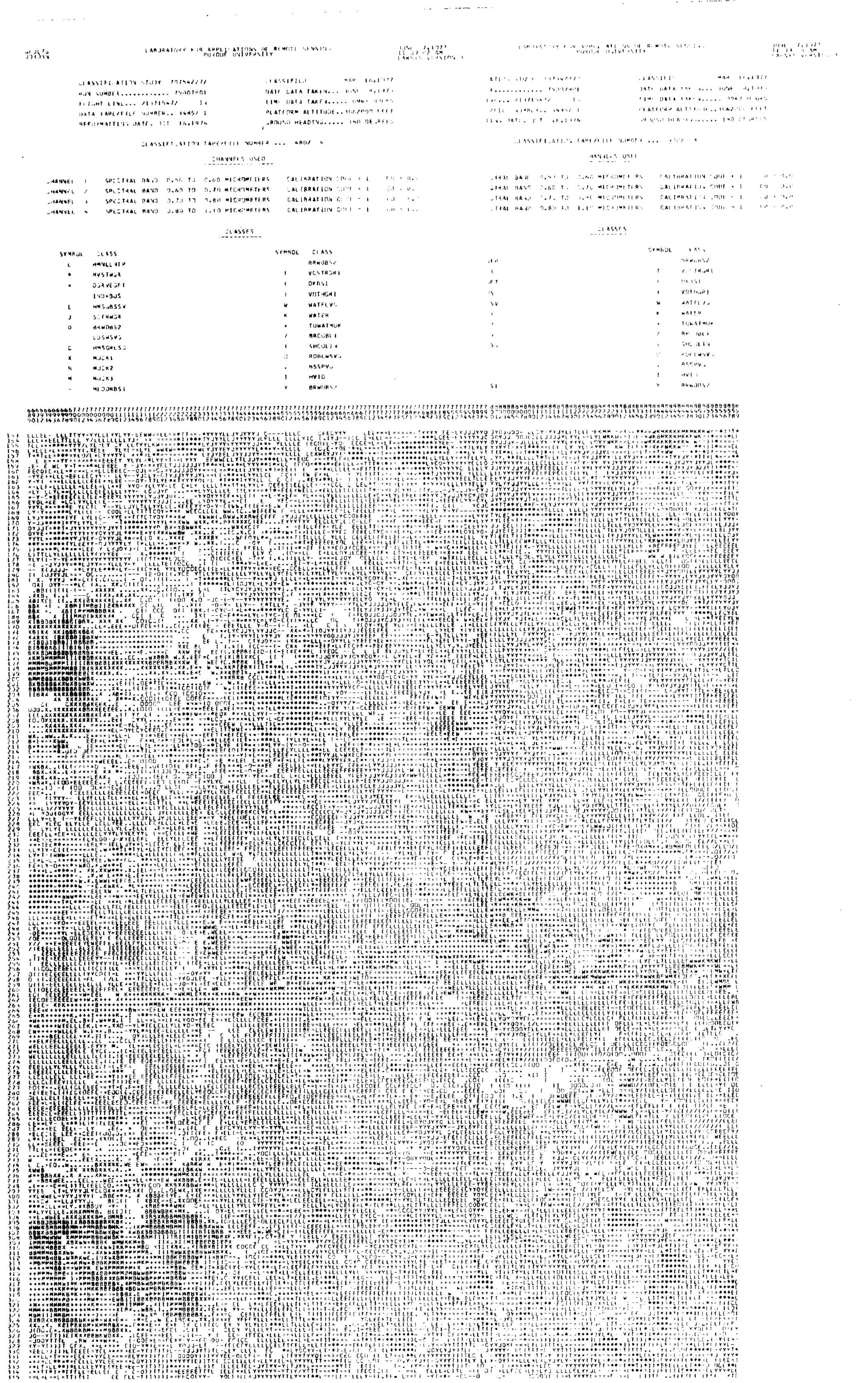

Figure 4. Classification results for the Osceola Quadrangle.

FORESTRY DEMONSTRATION PROJECT

INTRODUCTION

Since 1975 LARS staff have been involved in a mapping project of the Brownstown Ranger District of the Wayne-Hoosier National Forest. The primary object of this task has been the manipulation of a multitemporal Landsat data set to produce unit maps for the ranger district. Personnel at both the Forest Supervisor's office and the Regional office are showing increasing interest in the LARS activity.

Our principal accomplishments over this last reporting period have been the collecting of ancillary information. Ancillary information was necessary to improve the training data for the classification. The base source of this information has been Forest Survey permanent sample plots and aerial photography. The Forest Supervisors staff have cooperated in making this information available and it has been invaluable in the selection of representative training sites.

Also during this period we have met with the Forest and Regional Staffs in an effort to define the forests' information needs. LARS' principal concern for becoming involved in this demonstration is to identify the users' long term need for remote sensing data. We feel that scientists generally do not become involved enough in discussion of user needs and are, therefore, incapable of providing the appropriate information to the user. In order to overcome our own shortcomings in this area we are working with the Regional Foresters staff to help identify the forests' needs.

PLANNED ACTIVITY

Since the necessary ancillary information has been acquired, we have been working on reclassifying the Brownstown data set. When the data is reclassified, we will evaluate the results using sample forest compartment information. When this has been accomplished, we will make an assessment of the training material and classification and discuss these results with appropriate Forest Service personnel. The final stage of this task will be the production of a map atlas and statistics of forest land classes within the ranger district. The atlas will be presented on a township basis with statistics tallied by township and by the planning unit.

We are continuing discussions with the Regional Foresters staff in order to determine the ultimate application of remote sensing technology in the Eastern Region. One avenue that we have opened for discussion involves LARS making a classification tape of the Brownstown District available to the Regional office. This would involve formatting the tape so that it could be used on a Forest Service computer. If this were to occur, the Forest Supervisors staff would have access to the classification results, both map and tabular, through their on-line computer terminal at Bedford. We feel that this would enhance the utility of the information to the user. This activity is being given a high priority during the upcoming period.

COASTAL ZONE MANAGEMENT PROJECT

INTRODUCTION

Phase I of this project was completd when the State of Indiana published Technical Report No. 101, Natural Resources Inventory for the Coastal Zone Management Program. LARS' input to this publication has been discussed in previous semi-annual reports. The decision resulting from LARS Phase I activity was a continuation of the project in order to define the character of the woodland resources in the Coastal Zone Management Area.

APPROACH

The Landsat woodland classification, soils information based on woodland suitability rankings, and field sampling form the basis of the Phase II activity. The end product of this work will be a statement regarding the potential timber productivity in the Management Area and how this productivity is reflected in the available growing stock on the ground. The result of this information will be management plans for the proper use of the timber resources in the Coastal Zone Management Area.

The Landsat woodlands classification is used as the base map for encoding soil information from Soil Conservation Service published surveys. The soils information is keyed to its woodland suitability (the expected per annum increment of board foot productivity under ideal management) and soil capability (erodibility index) units. This data is collected on a section basis for each of the 15-townships within the management area. After the data base has been created a computer program totals the acres by potential productivity and capability units within each section. The section information is added for a township total and then a one percent random sample is selected for field sampling.

Since the project has just started, we have no preliminary results. However, we are confident that the approach which we are pursuing is valid and will yield satisfactory information for the development of the Phase II management plans.

FUTURE ACTIVITY

The summer will be spent encoding soils data and collecting field data. We hope that all the field data will have been collected by the start of Purdue's fall semester. Analysis of the field results should be completed by early fall, and development of management plans and recommendations should be completed by early winter.

SOIL INVENTORY PROJECT

INTRODUCTION

The acceleration of the National Soil Survey Program and the production of useful, high quality soil surveys in Indiana are among the prime goals of the USDA/Soil Conservation Service and the Indiana Department of Natural Resources Soil and Water Conservation Committee. The wide use of soil surveys for engineering and planning purposes in addition to agricultural uses has resulted in many specific questions concerning the physical nature of the different soil units depicted on soil maps. In order to provide the details necessary to understand the landscape composition and to provide interpretation of soil maps for specific uses, information of a quantitative nature is needed. To accomplish this task all avenues are being considered, including remote sensing technology which can provide quantitative measurements through computer analysis of Landsat multispectral scanner (MSS) data.

OBJECTIVE

The overall objective of this task is to determine the applicability of using computer analysis of Landsat multispectral scanner data in accelerating and improving the quality of the soil survey program in Indiana.

Early in 1976 field evaluation of computer-analyzed Landsat MSS data collected over Clinton and Jasper Counties indicated that remotely sensed data could be extremely useful in aiding the Indiana soil mapping program. To further evaluate the usefulness of the data the following specific studies were initiated:

1. Determine the feasibility of using spectral information to differentiate between alfisol and mollisol soils of the aquic suborder. These two soils have such a subtle difference in landscape and in surface color that it is impractical to separate them without extensive sampling.

2. Evaluate the usefulness of spectral soil maps produced from multispectral scanner data using pattern recognition techniques as a quality control in soil surveys and as a means to evaluate quantitatively the soil mapping unit composition.

3. Investigate the possibility of producing high quality general soil maps using false color Landsat imagery as the base map.

4. Develop a soil parent material map using multispectral resource data.

5. Determine the feasibility of producing a spectral soil map on a county-wide basis with its accompanying manuscript and evaluate the utility of this type of soil survey report to user groups.

6. Evaluate the usefulness of superimposing computer classification results upon aerial photobase maps in order to gain the benefit of the landscape perspective.

STATUS

The relationship between a computer-aided multispectral soil map based on selected training sites and a conventional soils map made by traversing the land and making soil borings is gradually being identified.

Previous attempts in evaluating soil maps made via digital analysis of multispectral data were based on the assumption that the spectral map had to compare very favorably to the conventional soils map, otherwise the digital map was considered to be in error.

Recent results at LARS indicates Landsat data is capable of providing much more detail than an individual can comprehend by investigating the landscape and interpreting aerial photographs. Therefore it is logical to expect quite contrasting differences when one compares conventionally made soil maps and those derived from the digital analysis of Landsat data.

The apparent key to designing a multispectral soils map, that is comparable with the conventional soil map, is in specifying the proper number of information classes so as to represent, as nearly as possible each distinct soil series in the landscape. Research has shown that natural soil drainage conditions definitely influence the relative magnitude of the reflectance. Therefore, in humid climates, soil drainage classes should be considered in developing a multispectral soil map.

JASPER COUNTY

Parent Material Map

To facilitate developing the overall soil map for Jasper County, a (soil) parent material map was produced by visual interpretation of false color imagery. The soil boundaries have been spot checked, in the field, and are being digitized onto the Landsat data. This will permit the development of a more refined classification and also make it possible to more accurately define the soil series mapped.

Mapping Training Sites

Twelve quarter sections were randomly selected in three different parent materials, namely outwash, lacustrine and glacial till. There, quarter section plots have been field mapped using a scale of 1:7920. At this scale, contrasting detail, down to one hectare in size has been delineated. These sites have been located on the Landsat data, and they will be used for "training sites" for gathering spectral statistics on soils of known parent material and drainage characteristics. If necessary, addition quarter section areas will be mapped to assure representation of all the soils in the county. The final product for Jasper County will consist of a digitized multispectral soil map produced at a scale of 1:15840 printed on clear mylar. This will underlay a matte halftone film positive of the aerial photo field sheet. In this manner the multispectral map will be used to guide the soil scientist in determining where to place soil boundaries for the various mapping units and to also point out specific locations, in the landscape, that are different and where additional investigative borings need to be made.

CLINTON COUNTY

The spectral soil map for Clinton County was completed and field checking was carried out to determine the adequacy of the classification. The original classification was carried out in three separate operations, namely the south half of the county, northeast portion and northwest portion. Statistics comprised of mean vectors and covariances for each spectral class were generated for each of the above areas of the county.

These three portions of the county were then merged into one and a single classification was generated. Field tests revealed serious discrepancies in the classification. As a result the three individual components were then evaluated. It was determined that the northwest section was responsible for the difficulties encountered. This area consisted of much rolling and steep topography along with severely eroded areas and localized sandy deposits. The other two areas consisted primarily of level and gently sloping ground moraine deposits having much more uniformity.

Currently, the northwest portion is being critically reviewed to determine what changes may be necessary and whether or not it is possible to include it as part of a single classification of Clinton County or whether it should be classified independently of the other two areas.

Other Activity

As a spin off of the Jasper County mapping, an investigation as to the spectral distinction of soil "natural" drainage classes is being conducted. This identification of drainage classes is valuable data for both soil mapping and subsequent agricultural or urban soil interpretation. Basically, the results of this investigation involves the magnitude of the spectral reflectance and the relative spectral separability of the internal soil drainage classes.

The necessity for output that can be readily comprehended by the layman has been responsible for the experimentation with the electrostatic plotter. Maps of soil classes represented by dot densities have been produced which represent classification results more easily understood by the layman as well as one that permits rapid comparison between various classes. Additional work will be carried out to further evaluate this procedure for representative soil mapping.