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SEMI-ANNUAL PROGRESS REPORT NO. 11

November 1, 1978 - April 30, 1979

APPLICATION OF REMOTE SENSING TO STATE AND REGIONAL PROBLEMS

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Submitted To

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Office of Space and Terrestrial Application
Technology Transfer Division
Washington, D. C.

Submitted By

W. Frank Miller*
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May 1, 1979

*Program Coordinator

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NASA Grant NGL-25-001-054

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APPLICATION OF REMOTE SENSING TO STATE AND REGIONAL PROBLEMS

I. INTRODUCTION

The major purpose of the Remote Sensing Applications Program is to interact with units of local, State, and federal government and to utilize Landsat data to develop methodology and provide data which will be used in a fashion such that a concrete, specific action will be taken by the cooperating agency. The attainment of this goal is dependent upon identification of agency problems which are immediate in nature, and subject to at least partial solution through the use of remotely sensed data.

Other subsidiary objectives include the development of a trained staff from the faculty of Mississippi State University who are capable of attacking the varied problems presented by the respective State agencies; the training of students in various University academic courses at both the undergraduate and graduate levels; the dissemination of information and knowledge through workshops, seminars, and short courses; and the development of a center of expertise and an operational laboratory for training and assistance to cooperating agencies.

II.A. GENERAL PROGRAM PROGRESS

1. Lowndes County

During this reporting period, the Lowndes County Project has received a great deal of attention by MSU Remote Sensing Applications Program personnel. The data base system is essentially complete, and for the past several months we have been generating models to suit the needs of various agencies within Lowndes County.

To date, three direct actions have resulted from the use of data from this project. Mr. Ray Gildea, Director, Lowndes County Civil Defense, has worked with Program personnel to develop various flood hazard models for the County. On April 11-13, 1979, heavy rains fell over Mississippi, and portions of Lowndes County were flooded. The following uses were made of models developed through the use of the Landsat-based information system:

1. Based upon an output map illustrating areas of high potential flood damage to agricultural crops, survey teams were dispatched to specific areas to assess damage and verify the extent and the impact of the floods - approximately $250,000 in damages to cropland were assessed for the County.

2. A periodic flood model was utilized during this same period to cross-check property damage data obtained from field estimates. The model information plus the field data were provided to the American Red Cross for use in dispatching teams to those portions of the County which were most severely damaged.

3. Prior to the flooding, Mr. Gildea requested assistance from the National River Forecast Center in Atlanta, Georgia, to establish a monitoring system in areas identified by a flood vulnerability model which are not

now being monitored. The Center's assistance is being requested to acquire the necessary instrumentation for monitoring, and to establish a cooperative effort for development of flash-flood, self-help schemes for use by County residents.

Mr. Della Valle has requested assistance in locating agricultural lands which have a specialized flood hazard potential in order that these lands might be considered for a lower market value for tax assessment purposes. Although Mr. Della Valle presenteded such a model to a recent meeting of the Lowndes County Board of Supervisors and received an encouraging response, it appears that no action will be taken on using the flood hazard model for tax assessment reevaluation until after County elections are held this fall.

Additionally, Program personnel have been busy illustrating the potential of the geo-information system to interested individuals, agencies, and groups. The individuals who have visited the Remote Sensing Applications Laboratory have been briefed on the operation of the data base for rational land use decision-making. A number of people have expressed a desire to utilize the geo-information system for general and specific applications within their areas of expertise. A list of people who have toured the Remote Sensing Applications Program facilities appears later in this report.

2. Strip Mine Project

During the first portion of this reporting period, major emphasis was placed on generating an initial product which the Geological

Survey of Alabama could use to monitor active and reclaimed surface coal mining activities within the State. The single purpose, decision-tree classifier that has been developed for the study (see Report #10, May 1 to October 31, 1978) was further refined to produce a software package that could easily be used by the GSA. Once a product had been obtained, members of the Remote Sensing Applications Program and the GSA met in Tuscaloosa, Alabama, in November 1978, to discuss the tree classifier package and its future use by the GSA to monitor strip mines in Alabama. This discussion produced mixed reactions towards the utility of Landsat data for monitoring surface mine activity in Alabama.

The GSA was complementary with respect to the accuracy and utility of the decision-tree classifier as a low cost, repetitive methodology for monitoring surface mining activity in Alabama. They found the initial results which were obtained from the tree classification of the study area in northwestern Alabama to be highly effective in discriminating several classes of active and reclaimed surface mining activities. The GSA was also impressed with the data obtained using the tree classifier to estimate the acreages of several mines sampled in the study area.

The GSA was not satisfied, however, with the hiatus between the date the imagery was sensed and the acquisition of the Landsat CCTs. At the time of our discussion with members of the GSA, turnaround time for obtaining Landsat digital products was approximately six months. This time-lag between sensing and acquisition was totally unacceptable to the GSA. For efficient monitoring of surface mining activity and reclamation efforts within the statutes established by the Alabama Surface Mining Act of 1975, the GSA needs Landsat data no later than six weeks after the imagery is sensed. Therefore, the GSA cannot effectively utilize the tree classifier software package until Landsat digital data can be acquired within a reasonable period of time. Efforts are now being made to acquire winter 1978-79 cloud-free data to test the utility of the classifier as a monitoring tool.

3. Beach Erosion Project

The purpose of this study was two-fold; first to develop and refine an aerial reconnaissance technique for the detection of aeolian erosion zones along coastal beaches, which is both economically feasible and technically simple enough to be used by private businesses as well as local, State, and federal agencies; and secondly, to recommend a functional and aesthetically pleasing system for the containment or controlling of these areas.

The most promising technique that would best satisfy the above criteria has proven to be Landsat analysis imagery on the I^2S signal slicer located at the EROS Users Assistance Facility, National Space Technology Laboratories, Bay St. Louis, Mississippi. These results were substantiated by a clustering analysis of the beach pixels by means of the LARSYS package implemented in the MSU UNIVAC 1180 computer. Three major zones of active wind erosion were identified by differences in spectral return between pixels representing different sand moisture content. A combination of vegetation and wooden post retainer walls was selected as the means of achieving control of the moving sand while enhancing aesthetic values and recreational potential of the beach. The only remaining task, and the most critical part of the project, is the implementation of the recommendations and adoption of the techniques by the cooperating agencies. A series of meetings with the Harrison County Board of Supervisors is being planned for the purpose of informing and educating the group. A final report is in manuscript form, and will be published in the near future.

4. White-Tailed Deer Habitat Evaluation

Four study areas representing different physiographic regions of Mississippi have been selected. These are the Choctaw, Tallahala, and Leaf River Game Management areas, and the Noxubee National Wildlife Refuge. The different physiographic regions are expected to have distinctly different productive potentials for white-tailed deer.

At each of these areas, aerial reconnaissance was utilized to select stands representative of different vegetation conditions. These stands will be characterized by ground truth procedures, and used in the computer-assisted analysis of Landsat multi-spectral scanner (MSS) data. Due to the unavailability of a radiometer, the development of a spectral signature "library" for each habitat class has been deleted from this project.

Ground truth procedures for all areas have begun, and are expected to continue into September 1979. At that time, computer-assisted analysis of Landsat MSS data to detect the vegetation component of white-tailed deer habits will be initiated.

5. Remote Sensing Data Analysis Support Systems

The major accomplishments in this area were in development of software for analysis of Landsat CCTs on the graphics/image processing minicomputer system, and development of an interactive capability for data base management and land use modeling. Both capabilities have been extensively utilized in demonstration and for a workshop. Except for the Varian Statos plotter, all hardware components are installed and accepted.

II.B. STATE-LEVEL REMOTE SENSING EFFORT

No appropriations were made by the 1979 Legislature for the purpose of establishing a remote sensing center. One of the major concerns during the session could, however, have a favorable influence on future efforts to obtain such appropriations. The State is under a court order to perform tax equalization by 1981, and methods to accomplish this task are being reviewed. The MSU Program Coordinator, and Mr. Roy Estes of NASA/ERL and Mr. Paul Tessar of the National and State Legislature were requested to make presentations to the House Ways and Means Committee and other interested legislators. The purpose of the session was to acquaint the legislators with Landsat and Landsat-based information system capabilities in general, and the capabilities of the MSU Remote Sensing Applications Program. As a result of this presentation, a very small demonstration project has been undertaken in cooperation with Mr. Guy Blankenship, Director of Equalization of the Mississippi Tax Commission. The purpose will be to demonstrate the utility of a computerized information system for tax parcel update, and land cover and productivity classification. Twenty sections of land, currently being mapped by standard methods, will be used as the study area. If successful, the technique could be adopted by the State Tax Commission as a basis for tax map updating.

III. PROJECT PROGRESS REPORTS

A. Remote Sensing Applications in Land Use Planning - Lowndes County

Objective

To develop a Landsat-based data management system that will provide variables and data which can be used by the County Tax Assessor, the Civil Defense Director, and the Lowndes County Board of Supervisors, and for employment in the land use planning function by the Golden Triangle Planning and Development District and the Mississippi Research and Development Center.

Accomplishments

At the present, the Lowndes County data base is essentially complete with 18 primary variables and 16 proximity variables encoded into the geo-information system (Appendix I). The data base is fully operational and we have used the system to generate suitability models based on the variables within the system. Suitability models that have been developed to date are listed in Appendix II, and other models will be developed upon demand to meet the needs of users. The data base itself is not a "closed" system; i.e., if other variables are needed by certain users, they can be input into the geo-information system for the county and used to create the appropriate suitability models.

With the completion of the data base has come the first examples of its real utility to rational land use planning. The Lowndes County

Civil Defense Director, Mr. Ray Gildea, has used the geo-information system to model flood-prone areas within the county. He is currently using the model in conjunction with the FIA (Flood Insurance Assistance program) and the Army Corps of Engineers to identify areas of residential flooding in the county. Mr. Gildea has also used this model to develop flash flood, self-help schemes for use by County residents; the plans, however, have not as yet been implemented (See Section IIA-1).

As mentioned previously, Mr. Bill Della Valle, the Lowndes County Data Processing Manager, has used the data base system to model agricultural lands that are susceptible to flood hazards. Unfortunately, any action on this model by the County Board of Supervisors has been delayed until after fall elections.

In addition to the actual operation of the data base system in hard-copy (i.e., computer print-out) format, we have also implemented the geo-information system in an interactive mode on the Program's interactive graphics display. The interactive operation of the data base has greatly enhanced the capabilities of the geo-information system for research and development and display activities (Figures 1-5). Software development for the interactive system is proceeding and significant progress has been made during this reporting period in actually displaying variables and models, creating algorithms for digital Landsat training site selection, and developing programs to enlarge scenes which are displayed on the CRT.

Aside from the more tangible accomplishments of the Lowndes County project, the value of the concept has been recognized in another

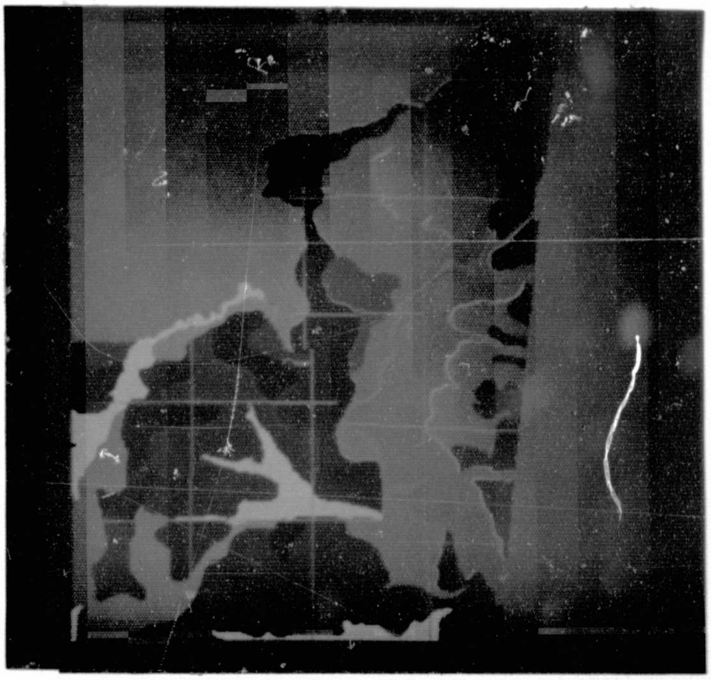


Figure 1. Lowndes County Soil Associations (Variable #5) Overlain with Township and Range Boundaries as Displayed on Color CRT.

Figure 2. LARSYS Landcover Display from Color CRT - East Central Lowndes County.

Brown/Dark Green = Forest

Tan = Pasture

Green = Agriculture Cropland

White = Inert

Blue = Water

Figure 3. Landcover Classification Display Overlain by Transportation Network and Incorporated Towns.

Figure 4. Waterway Industrial Suitability Model Overlain with Incorporated Towns, Transportation Network, and Township and Range System from Color CRT Display. Most Suitable Areas for Industrial Location with Close Proximity to Tennessee-Tombigbee Waterway are Shown in Pink.

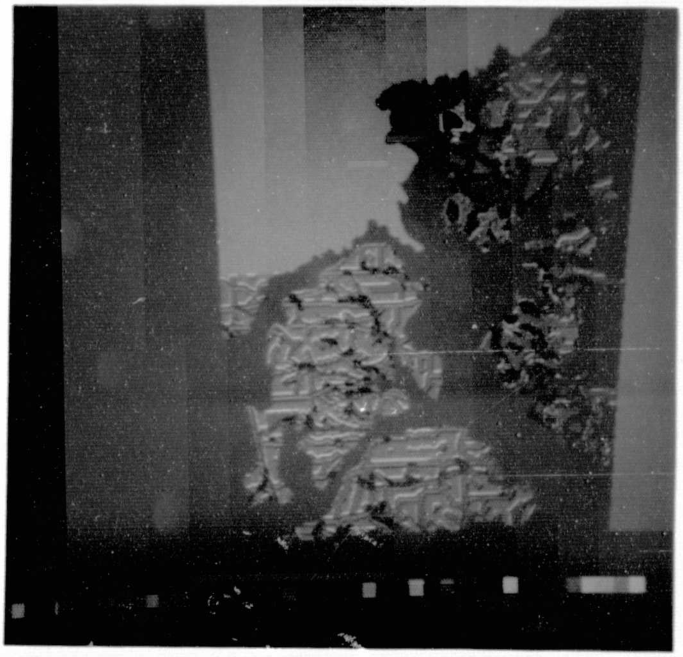


Figure 5. Sanitary Landfill Suitability Model from Color CRT Display. Most Suitable Areas for Sanitary Landfill Locations are Shown in Dark Green.

fashion; the Gildea Foundation, a non-profit organization, has offered to give $1500 per year for two years to maintain and update the data base. The money provided by the Foundation will be used to help defray the cost of maintaining the data base and to improve all facets of the geo-information system and its capabilities.

Future Plans

Priority will be given to software development for the interactive graphics system and the development of additional models which can be used in the decision-making process. We will also make a concerted effort to stimulate action by the appropriate County officials on the models already developed. Additionally, we intend to produce a demonstration display package illustrating the merits of the geo-information system for planning purposes, and intensify our efforts at attracting potential users to the data base system.

B. Applications of Landsat Data to Strip Mine Inventory and Reclamation

Objective

This project is intended to provide the Alabama Surface Mining Reclamation Commission and the Geological Survey of Alabama with the software and interpretative techniques for periodically monitoring strip mine occurrence and reclamation activities. The results of this project will also be provided to the Mississippi Geological, Economic, and Topographic Survey - the State agency which is responsible for administering the strip mining law in Mississippi.

Accomplishments

The single purpose, decision-tree classifier outlined in Semi-Annual Report #10 is now operational. Signatures for the thematic extraction of strip mines from Landsat digital data were obtained by employing both supervised and unsupervised procedures. The discrimination of different cover types was based on the reflectance values acquired from the 4 bands of Landsat MSS data plus 5 additional "normalized" signatures obtained from band ratioing. Using these signatures, a tri-level tree classifier has been developed which discriminates seven classes and subclasses of land cover:

1. Forest
2. Agricultural/Inert
3. Scrubland: Forest-pasture interface, and recently logged areas
4. Urban
5. Water
6. Shadow
7. Mining Activity
    a. rough spoil
    b. smoothed (less than 30% slope)
    c. smoothed and partially revegetated

In addition to the detection of mining activity, the accuracy of the tree classifier for measurement of mine area within a portion of the Warrior Coal Basin in northwestern Alabama was tested. Five mines ranging in size from 41 ac to 500 ac were selected for analysis. The GSA determined the individual mine areas by transferring detail from January 1976, 1/24,000, color infrared imagery overflight to U. S. Geological Survey 7½ minute quadrangle sheets by means of a Bausch and Lomb Zoom Transfer Scope; the amount of disturbed land for each mine was determined from the quadrangle sheets by a polar planimeter. A linear regression analysis was performed using these "true" planimetered values as the dependent variable and a pixel count of appropriate signatures as the independent variable (Table 1). The resulting prediction equation, $Y = -2.837 + 1.20\,X$, was highly significant ($r^2 = 0.9985$). The mean and standard error of estimate ($y \pm s_{\bar{y}}\ t_{05}$) was 268.8 ± 11.61 or an error of 4.3%.

TABLE 1

Pixel Count (X)(ac)	"True" Area (ac)	Predicted Area (Y)(ac)
39	41	43.9
148	175	174.7
238	297	282.7
288	331	342.7
419	500	499.9

The cost of classifying the entire study area using the tree classifier is approximately $0.009/ac, from tape acquisition to classification, compared with $0.17/ac for inventorying mines from the aircraft data. It is felt that with further refinement in the classifier software, computer costs can be reduced.

Our tests of the decision-tree classifier have indicated that it is a satisfactory methodology for discriminating surface mine activity in a portion of the Warrior Coal Basin in Alabama. The GSA also agrees that it is a useful, efficient software package for monitoring strip mines within the State. As stated earlier, however, the limiting factor in the acceptance of this methodology by the GSA is the turnaround time between data acquisition by the sensor and the availability of the CCTs to the user.

Future Plans

When a CCT of an area north of the present study site becomes available, we plan to test the spatial extension capabilities of the classifier in an area where the sandstone members of the Pottsville Formation are more dominant, resulting in less carbonaceous spoil material. We also plan to test the temporal extension attributes of the tree classifier; CCTs from a growing season and another leaf-off season will be acquired and analyzed once they become available.

The initial results of the decision-tree classifier outlined here were presented at the 45th Annual Meeting of the American Society of Photogrammetry/American Congress on Surveying and Mapping in Washington, D. C., during March 1979. The paper, authored by Mr. Miller, Dr. Solomon, and Mr. Quattrochi, was published in the Proceedings of the meeting, and a copy of the paper entitled "Development of a Tree Classifier for Discrimination of Surface Mine Activity from Landsat Digital Data" appears in Appendix III.

In addition to using the decision-tree classifier in a hard-copy format, we have also put the software package on magnetic tape for display on the Remote Sensing Application Program's interactive graphics minicomputer system. The decision-tree classifier as displayed on the Program's CONRAC CRT is illustrated in Figures 6-8. We are currently in the process of initiating the classifier software package in an interactive format on the graphics minicomputer system. Once established, the interactive capabilities of the decision tree will further our efforts in applying this methodology to similar problem areas in other portions of Alabama and Mississippi.

C. Beach Erosion Control - Pass Christian

Objectives

The overall project objective is to apply remote sensing technology to the delineation of zones of high erosion along the Pass Christian Beach.

Specific objectives are:

1) To refine and adapt remote sensing techniques to identify and define those beach areas along the Mississippi Gulf Coast at Pass Christian, Mississippi, which are sources of wind-blown sand.

2) To develop automated procedures calibrated with ground truth information and meteorological data for estimating zones of sand movement origin.

3) To design sand stabilization or turbulence obstruction features which, when appropriately located on the beach, will reduce

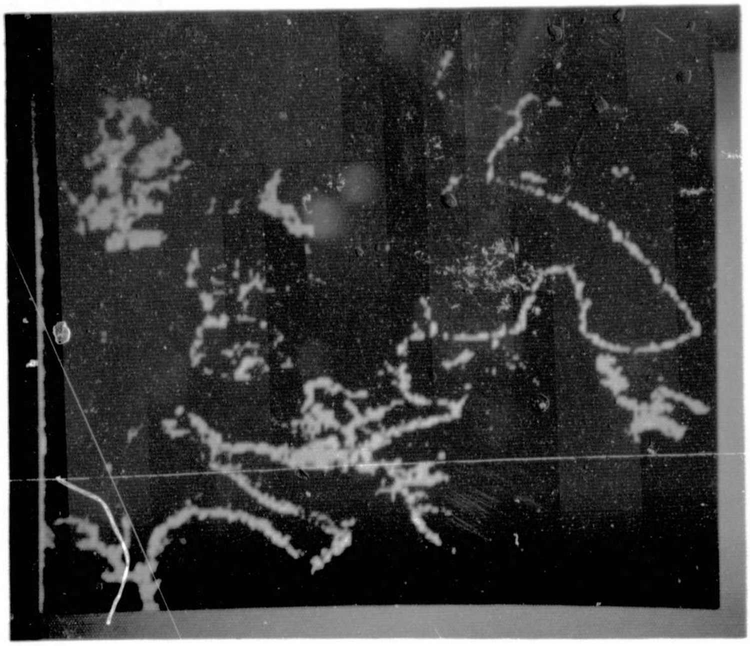


Figure 6. Decision-Tree Classifier as Displayed on Color CRT.

Light Blue = Water

Dark Blue = Shadow/Water

Light Green = Mine

Figure 7. Decision-Tree Classifier as Displayed on Color CRT.

Light Blue = Water

Dark Blue = Shadow/Water

Red = Mine

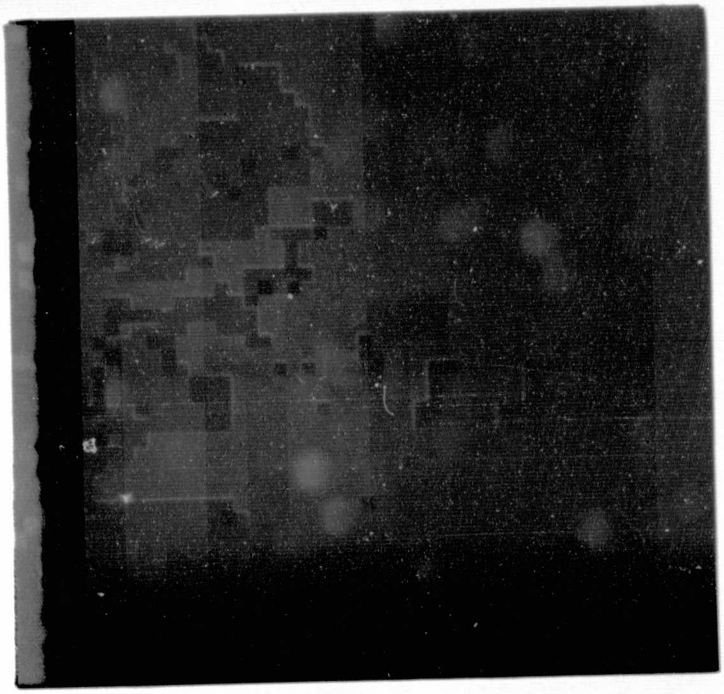


Figure 8. Blow-Up of Mine Area From Color CRT.

Light Blue = Water

Dark Blue = Shadow/Water

Red = Mine

sand erosion, are aesthetically pleasing, and are consistent with tourist attraction and use and local commercial activities.

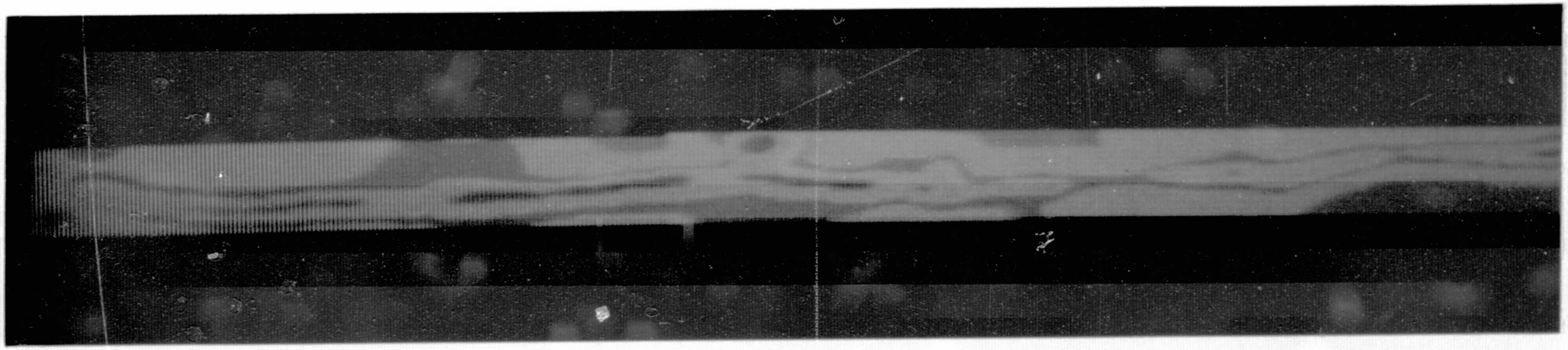
Accomplishments

All thirteen of the stated tasks have been completed, and a final report is in manuscript form. Only those portions of the results considered highly pertinent are presented here.

The first major accomplishment is that manipulation of Landsat data resulted in identification of dry, blowing sand areas of beach. The primary procedure used was the analysis of analog Landsat data on the I^2S signal slicer located at the EROS facility, National Space Technology Laboratories at Bay St. Louis, Mississippi. Comparison of radiance value patterns (Figure 9) with ground truth in the form of sand moisture content zones (Figure 10) indicated correlation between high reflectivity and dry sand, and lower reflectivity and moist sand. These correlations were verified by the use of a LARSYS-EOD clustering algorithm (ISOCLS) implemented in the MSU UNIVAC 1180 computer. Various other techniques were tested, but the signal slicing method appears to be adequate for the purpose, and since the EROS facility is located in close proximity to the Gulf Coast, most convenient for future use by the users.

An extensive weather analysis of the Gulf Coast area established a relationship between the magnitude of the beach erosion problem and frequencies and extremes of meteorological/climatological parameters.

Figure 9. Radiance Values of Sand Moisture in Beach Study Area.



Dark Green = Wet

Light Yellow = Less Wet

White = Drier

Purple = Unclassified

Figure 10. Beach Erosion Zones

Legend

High Erosion (Dry Sand)

Moderate Erosion (Alternating Wet & Dry Sand)

Slight Erosion (Moist Sand)

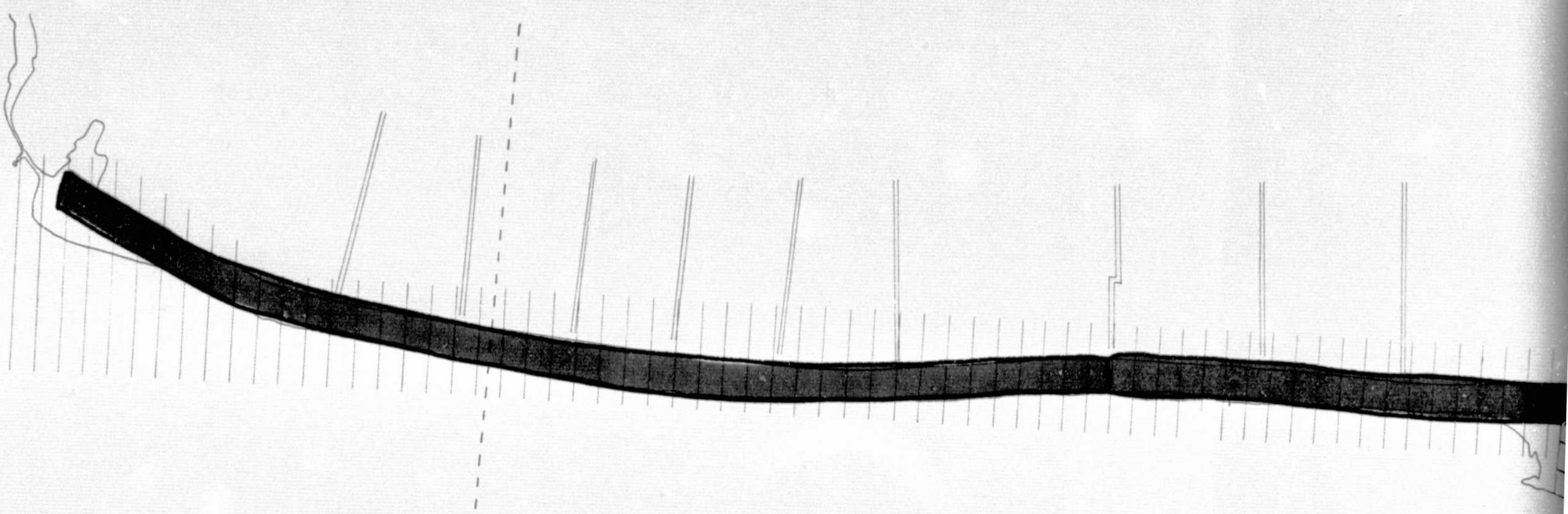
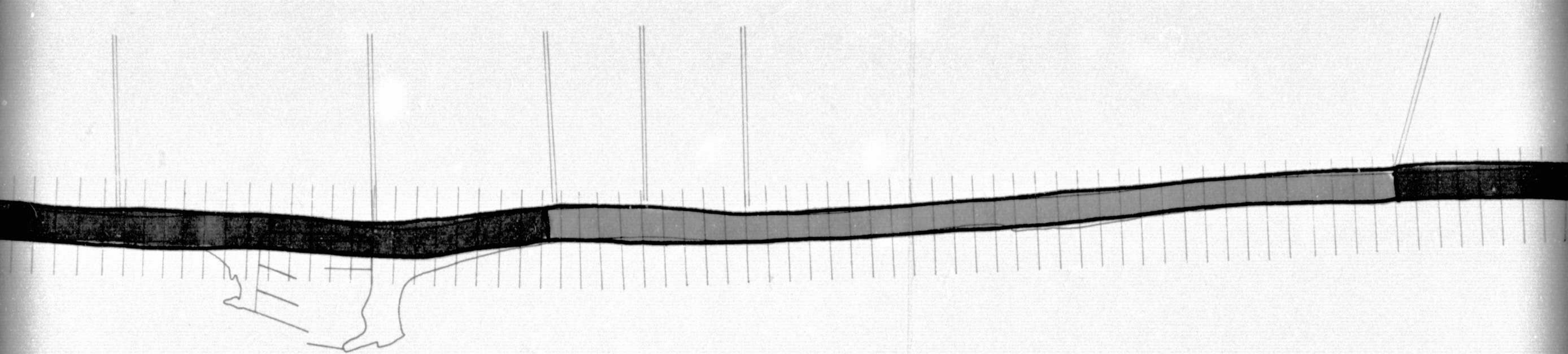


FIGURE 10.

1 FOLDOUT FRAME



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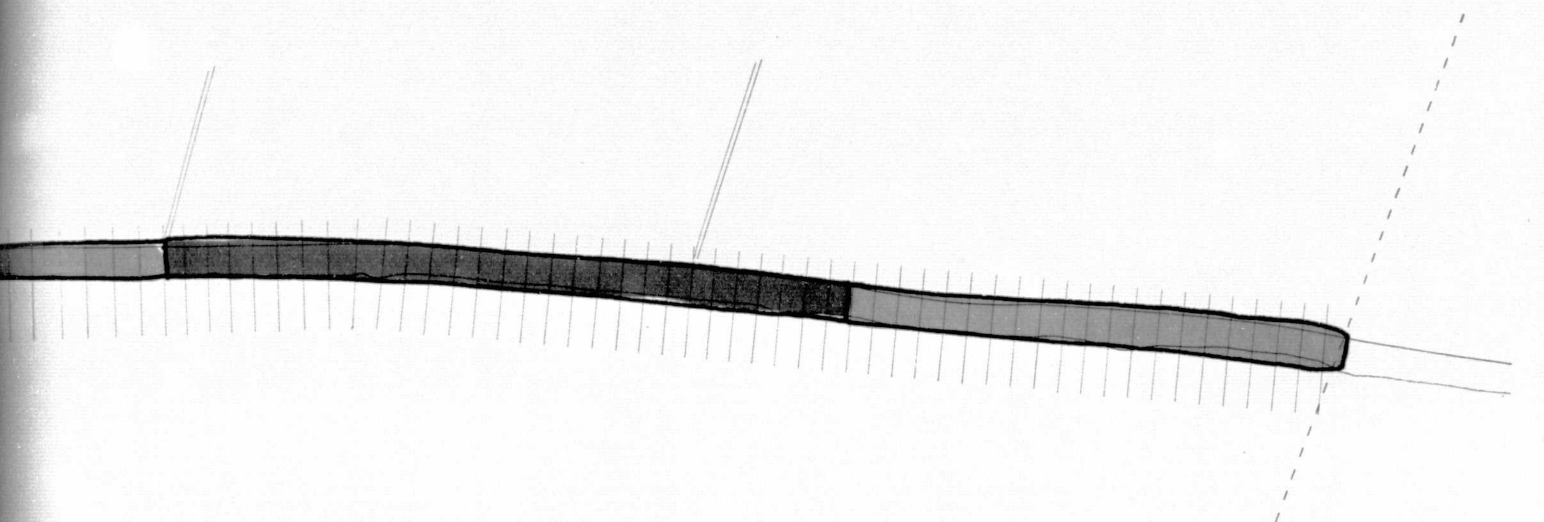


3 FOLDOUT FRAME

Collectively, these parameters operate to influence the erosion pattern of the study area, and to produce the zones illustrated in Figure 10.

Based on the information gathered in the preceding work, a design effort was made to modify the nature of the defined erosion zones and preserve or improve the aesthetic, recreational, and economic values of the area.

The scope of design work in this study is necessarily at a conceptual rather than a work-plan level because of legal, consent, and judicial restrictions. Principally, these limitations are based on the fact that the Mississippi Practice Act prohibits the practice of landscape architecture without a license. Also, sound legitimate design procedures require consent and input from local citizens and interest groups, and judicial and permit limitations have been established regarding the erection of structures or modifications on the beach. These factors, together with normal development procedures, suggest a course of development involving design refinement, public input, and activity approval before construction modification.

The landscape architectural processes utilized for conceptual problem solution involved the steps of:

1. site analysis observations, focusing on human use, and natural condition;
2. interpretation of implications;
3. generalization of solution; and
4. presentation of conceptual plan.

Based on these observations, the following accomplishments would be beneficial in improving the recreational quality of the beach and reducing erosion:

1. providing a separation distance and wind obstruction system between erosive sand beach areas and the roadways;
2. increasing the volume and variety of vegetation on the beaches, or between the beach and road;
3. creating certain attractive high-use zones to attract users within the broad expanse of the beach study area, thereby lessening the population pressure on the undeveloped, main portion of the beach, and allowing natural processes to effect stablization in low-use zones;
4. establishing additional or expanding existing Least Tern areas in the undeveloped portion of the beach on which human activity will be at a minimum;
5. establishing or encouraging natural processes within the backshore beach area of the greater expanse of large undeveloped areas (backshore) to the extent that natural vegetation is allowed to establish a micro-stabilizing environment;
6. providing services and facilities at high-use areas to increase beach utility.

Generalized Plan

Given the above implications of and generalizations regarding present extensive random and disordered beach-use patterns, low levels of user service, associated inevitable inefficiencies of maintenance and erosion potential, the possibility exists to provide greater tourist beach satisfaction and reduced erosion through a strategy of beach facility design, arrangement, and location which will influence user behavior. The key component of such a strategy would be an environment structured in such a way as to encourage people to use selected special areas very intensively, and to avoid other areas entirely.

The two principal mechanisms employed to influence this behavior are the design and establishment of designed attractive amenity sites, and the setting of restrictions. The attractive amenity sites of the strategy include vegetation, berms or dunes, activity elements and adjacent selected off-road parking areas (see Sheets 4, 5, and 6 of 6). Activity elements proposed as a part of the designed site would provide not only physical facilities, but also a psychological atmosphere conducive to recreational use.

The psychological factors of this atmosphere would be based on the theory that design elements act as a reference point to provide variety in the visually uncomplicated and simple environment of the beach. This is illustrated by the fact that vertical tree trunks provide a sense of psychological security, while the overhead foliage provides shade and enclosure. The psychological role of such elements can be conceptualized by visualizing the sensation of walking through a large, freshly plowed field and experiencing the feeling of exposure in contrast to the feeling of walking through a forested area of the same size.

Several generalizations relating to the design of stabilization systems are:

1. That erosion appears to occur throughout the study area and seems most severe in three zones.

2. The transport and deposition factors of sand regulating its accumulation on road and inland public and private property are related to narrow separation between beach and roadway, narrow traffic islands, and general absence of vegetation.

3. The presence of intensive human pressure (tourist use and maintenance activities) is not conducive to the development of wind-stable beach areas.

4. Generally, even at very high use periods, the beach zone studied exhibited low levels of occupancy with peak period concentrations as low as 25 people per mile. Highest concentrations were noted in the vicinity of Henderson Point and the Pass Christian Marina.

Based on these generalizations, a conceptual design was developed (Sheets 1-6).

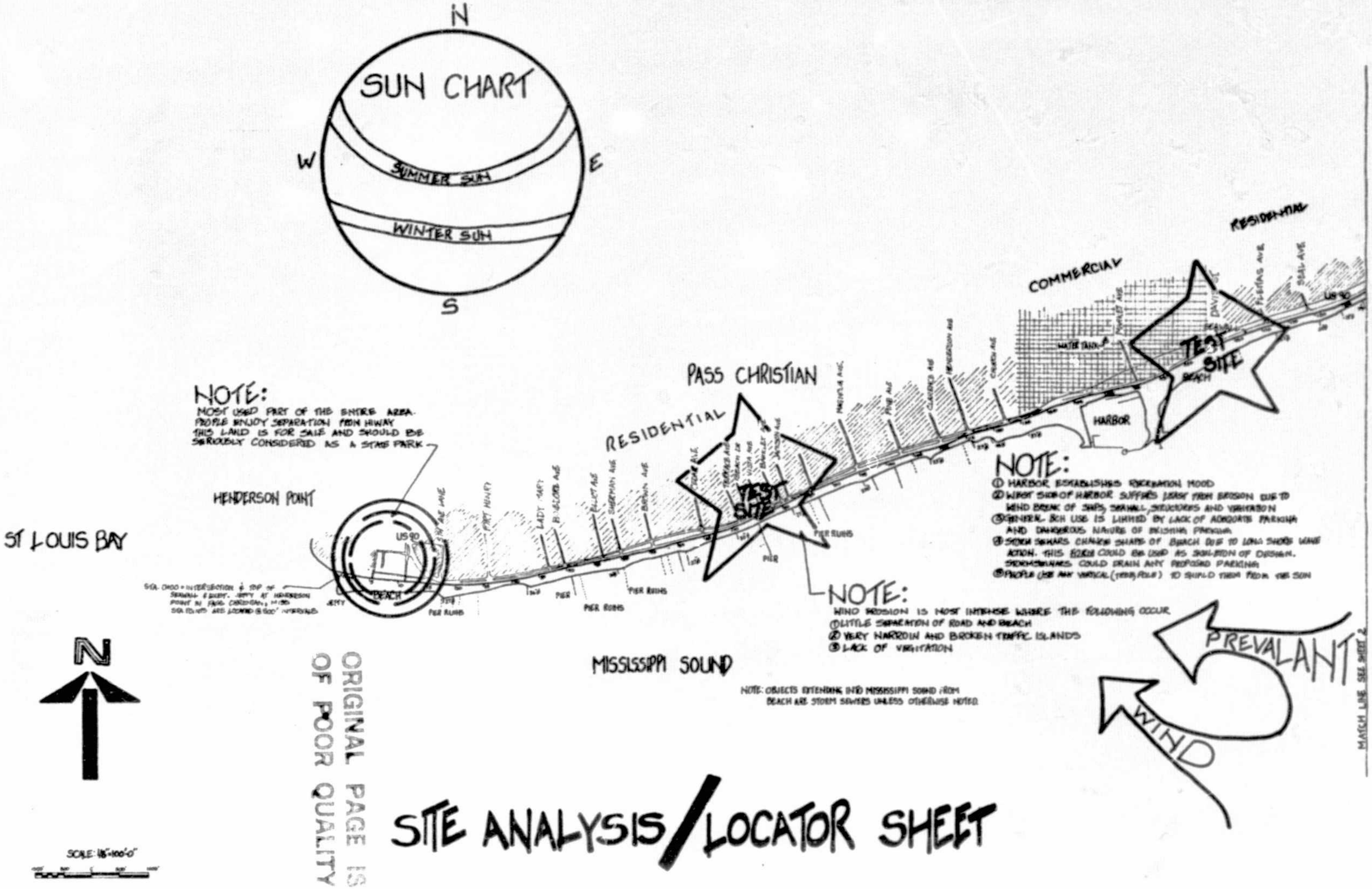
Current Status

The only activity is in manuscript preparation and development of materials for presentation to the cooperating agencies.

Plans

Several meetings are being scheduled with representatives of the cooperating agencies. These meetings will be for the purpose of presenting pertinent results, obtaining a commitment to install the recommended structures, and educating the groups for future use of the technique.

Follow-on activities would include training of selected personnel for cooperating agencies in the use of the technique.



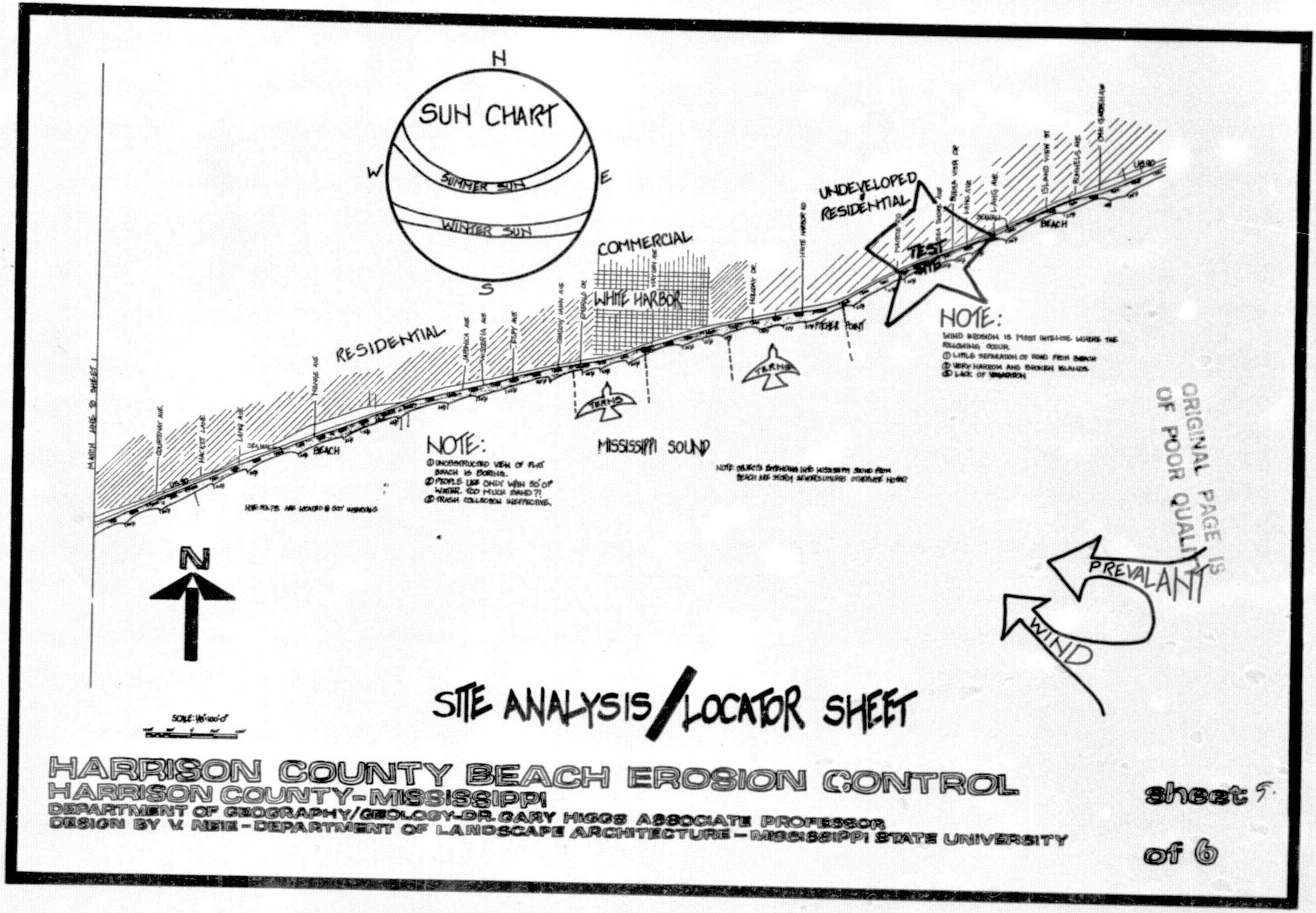
SITE ANALYSIS/LOCATOR SHEET

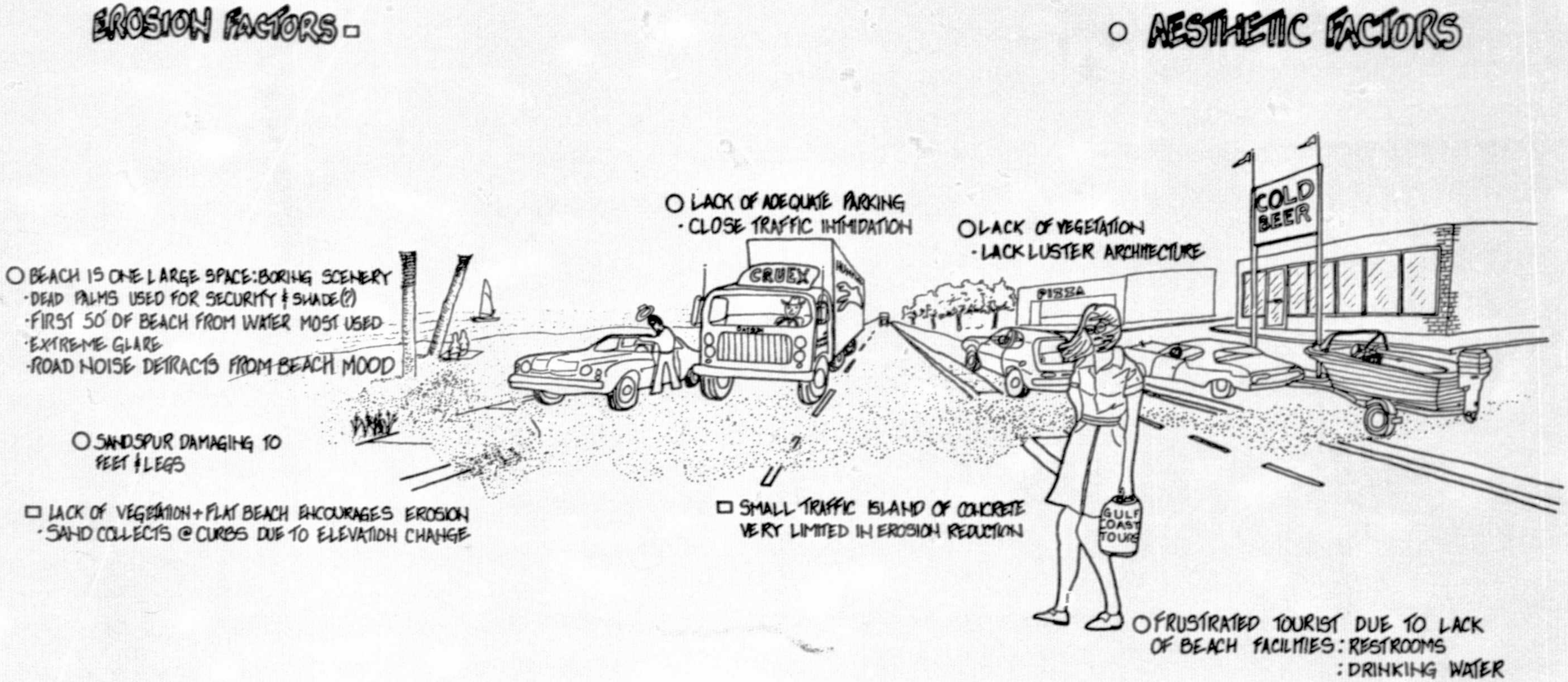
HARRISON COUNTY BEACH EROSION CONTROL

HARRISON COUNTY-MISSISSIPPI

DEPARTMENT OF GEOGRAPHY/GEOLOGY.
DESIGN BY V. NEIE-DEPARTMENT OF LANDSCAPE ARCHITECTURE-MISSISSIPPI STATE UNIVERSITY

sheet I of 6


SUN CHART
N
W
E
S
SUMMER SUN
WINTER SUN
RESIDENTIAL
COMMERCIAL
WHITE HARBOR
UNDEVELOPED RESIDENTIAL
TEST SITE
BEACH
MISSISSIPPI SOUND
TERNS
NOTE:
① UNOBSTRUCTED VIEW OF FLAT BEACH IS BORING.
② PEOPLE USE ONLY WITHIN 50' OF WATER. TOO MUCH SAND?!
③ TRASH COLLECTION INEFFECTIVE.
NOTE:
WIND EROSION IS MOST INTENSE WHERE THE FOLLOWING OCCUR
① LITTLE SEPARATION OF ROAD FROM BEACH
② VERY NARROW AND BROKEN ISLANDS
③ LACK OF VEGETATION
N
PREVALANT WIND
SITE ANALYSIS/LOCATOR SHEET
HARRISON COUNTY BEACH EROSION CONTROL
HARRISON COUNTY-MISSISSIPPI
DEPARTMENT OF GEOGRAPHY/GEOLOGY-DR. GARY HIGGS ASSOCIATE PROFESSOR
DESIGN BY V. NEIE-DEPARTMENT OF LANDSCAPE ARCHITECTURE-MISSISSIPPI STATE UNIVERSITY
sheet 5 of 6



EROSION & AESTHETICAL PROBLEMS

HARRISON COUNTY BEACH EROSION CONTROL

HARRISON COUNTY-MISSISSIPPI

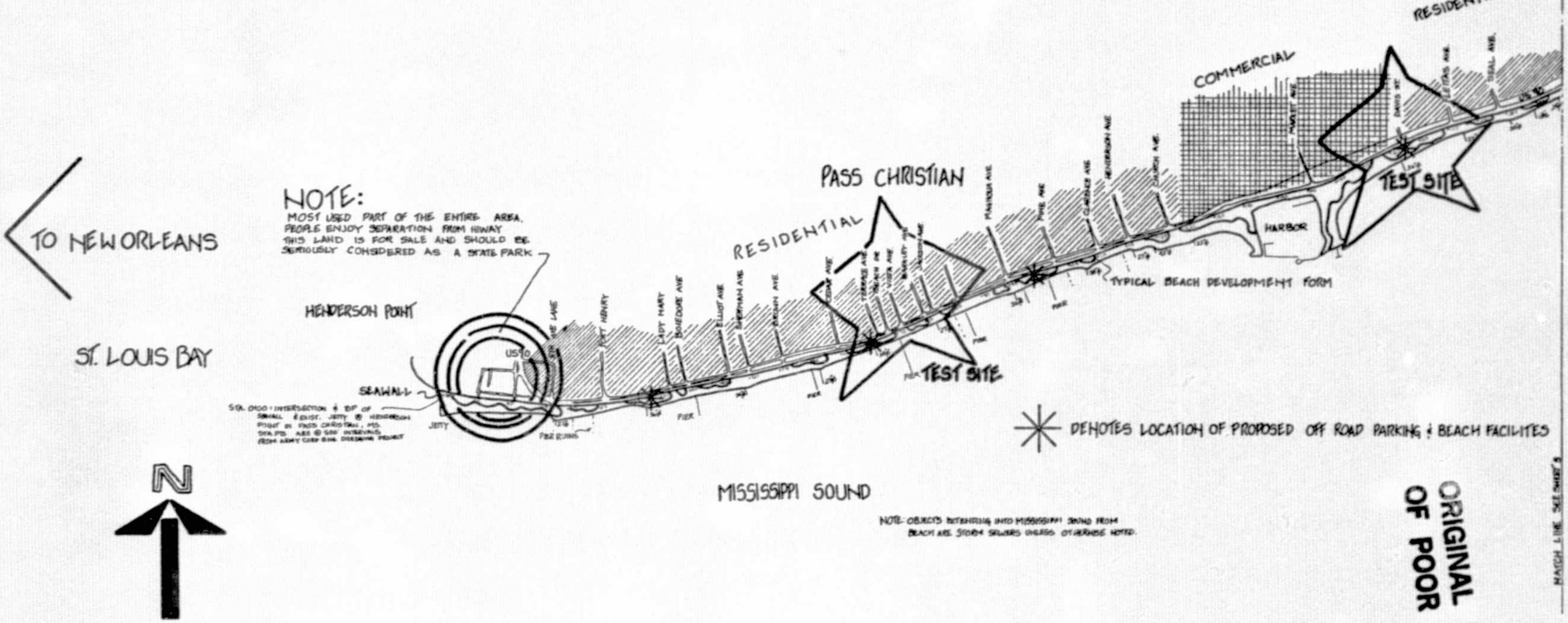
DEPARTMENT OF GEOGRAPHY/GEOLOGY-DR. GARY HIGGS ASSOCIATE PROFESSOR

DESIGN BY V. NEIS-DEPARTMENT OF LANDSCAPE ARCHITECTURE-MISSISSIPPI STATE UNIVERSITY

sheet 3 of 6

•DESIGN GOAL•

- STOP/RETARD AEOLIAN EROSION WITH AN AESTHETICLY UNIFYING CONCEPT FOR THE MISSISSIPPI GULF COAST WITH REGARD FOR:
  - USER NEEDS AND SAFETY
  - TOURIST INDUSTRY
  - BEACH AND HIWAY MAINTENANCE



PRELIMINARY BEACH PLAN

HARRISON COUNTY BEACH EROSION CONTROL

HARRISON COUNTY-MISSISSIPPI

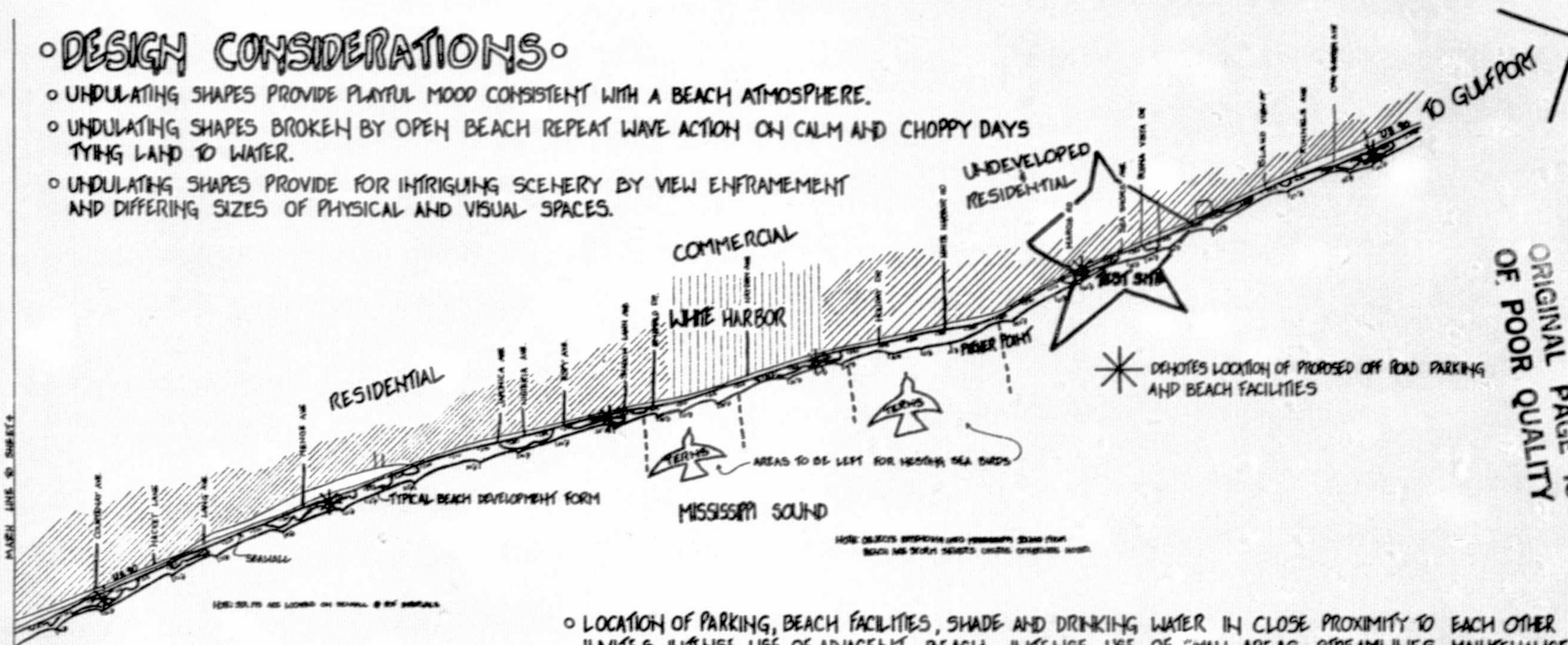
DEPARTMENT OF GEOGRAPHY/GEOLOGY

DESIGN BY V. NEIE - DEPARTMENT OF LANDSCAPE ARCHITECTURE - MISSISSIPPI STATE UNIVERSITY

sheet 4 of 6

DESIGN CONSIDERATIONS

- UNDULATING SHAPES PROVIDE PLAYFUL MOOD CONSISTENT WITH A BEACH ATMOSPHERE.
- UNDULATING SHAPES BROKEN BY OPEN BEACH REPEAT WAVE ACTION ON CALM AND CHOPPY DAYS TYING LAND TO WATER.
- UNDULATING SHAPES PROVIDE FOR INTRIGUING SCENERY BY VIEW ENFRAMEMENT AND DIFFERING SIZES OF PHYSICAL AND VISUAL SPACES.



- LOCATION OF PARKING, BEACH FACILITIES, SHADE AND DRINKING WATER IN CLOSE PROXIMITY TO EACH OTHER INVITES INTENSE USE OF ADJACENT BEACH. INTENSE USE OF SMALL AREAS STREAMLINES MAINTENANCE.
- EXISTING STORM SEWERS CAN DRAIN PROPOSED PARKING.
- OFF ROAD PARKING AND FACILITIES ADJACENT TO BEACH WILL STOP AND ATTRACT MORE PEOPLE THEREBY BOOSTING LOCALE TOURIST TRADE.
- VEGATATIVE BUFFERS WILL SLOW AEOLIAN EROSION, PROVIDE SHADE AND SCREEN HIWAY NOISE.

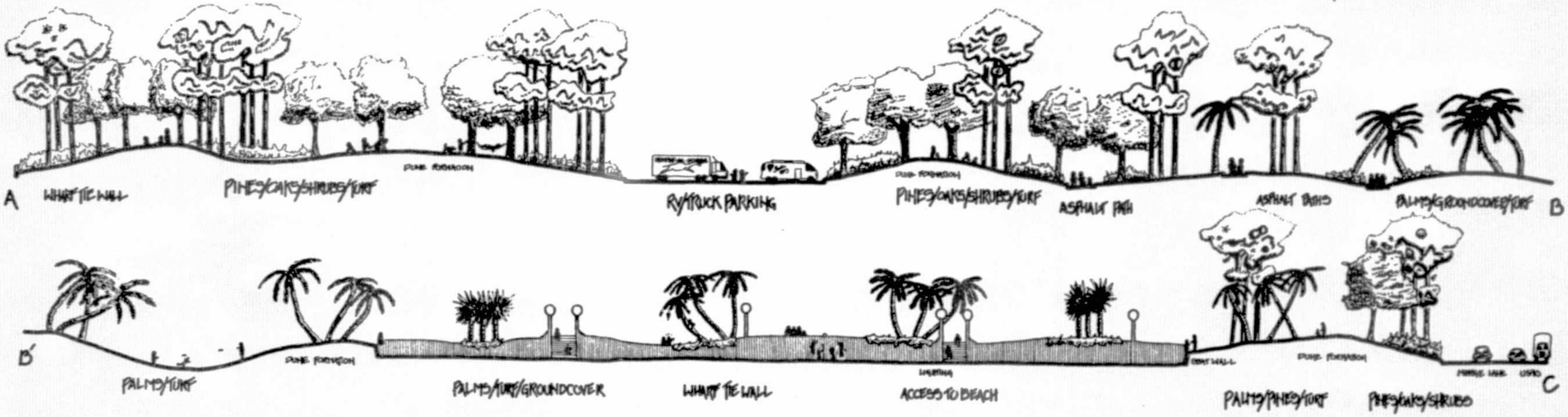
PRELIMINARY BEACH PLAN

HARRISON COUNTY BEACH EROSION CONTROL

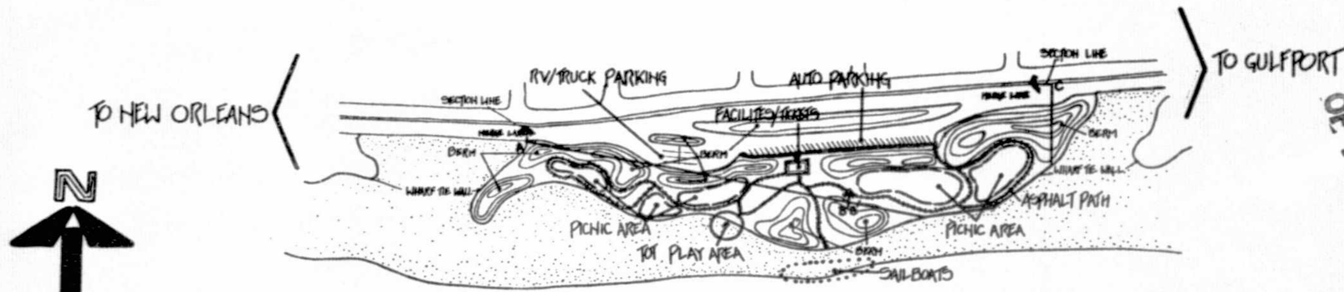
HARRISON COUNTY-MISSISSIPPI

DEPARTMENT OF GEOGRAPHY/GEOLOGY-DR. GARY HIGGS ASSOCIATE PROFESSOR
DESIGN BY V. NEIE-DEPARTMENT OF LANDSCAPE ARCHITECTURE-MISSISSIPPI STATE UNIVERSITY

sheet 5 of 6



SECTION SCALE: 1"=20'



PLAN SCALE: 1"=100'

SCALE AS SHOWN

TYPICAL DEVELOPMENT

HARRISON COUNTY BEACH EROSION CONTROL

HARRISON COUNTY-MISSISSIPPI

DEPARTMENT OF GEOGRAPHY/GEOLOGY-DR. GARY HIGGS ASSOCIATE PROFESSOR
DESIGN BY V. NEIE-DEPARTMENT OF LANDSCAPE ARCHITECTURE-MISSISSIPPI STATE UNIVERSITY

Sheet 6 of 6

D. White-Tailed Deer Habitat Evaluation Using Landsat Data

Objectives

In order to provide a basis for sound natural resource management in Mississippi, the Mississippi Game and Fish Commission has undertaken to develop a State-wide data base describing various components of the State's ecosystems. The high priority of the white-tailed deer in the Commission's management policies has dictated that various types of deer "habitat" be mapped and evaluated on a State-wide basis. These "habitats" will be delineated on the basis of several variables, one of which is vegetation.

The overall objective of this project, then, is to develop a cost-effective procedure for detecting and evaluating the various types of vegetation compatible with the various deer habitat types.

Landsat multi-spectral scanner (MSS) data, owing to its temporal, synoptic characteristics, will be used as the basis for vegetation evaluation. Both supervised and unsupervised classification of the data will be tried to determine the most accurate but cost-effective means of mapping vegetation.

Reflectance profiles suitable for supervision of automated classification of Landsat data will be constructed via reflectance measurements of each habitat type. These data will be collected from light aircraft using a hand-held radiometer (Exotech Model #100). The results of the profile-supervised classification will be compared with conventionally supervised and unsupervised techniques to select that method having highest accuracy.

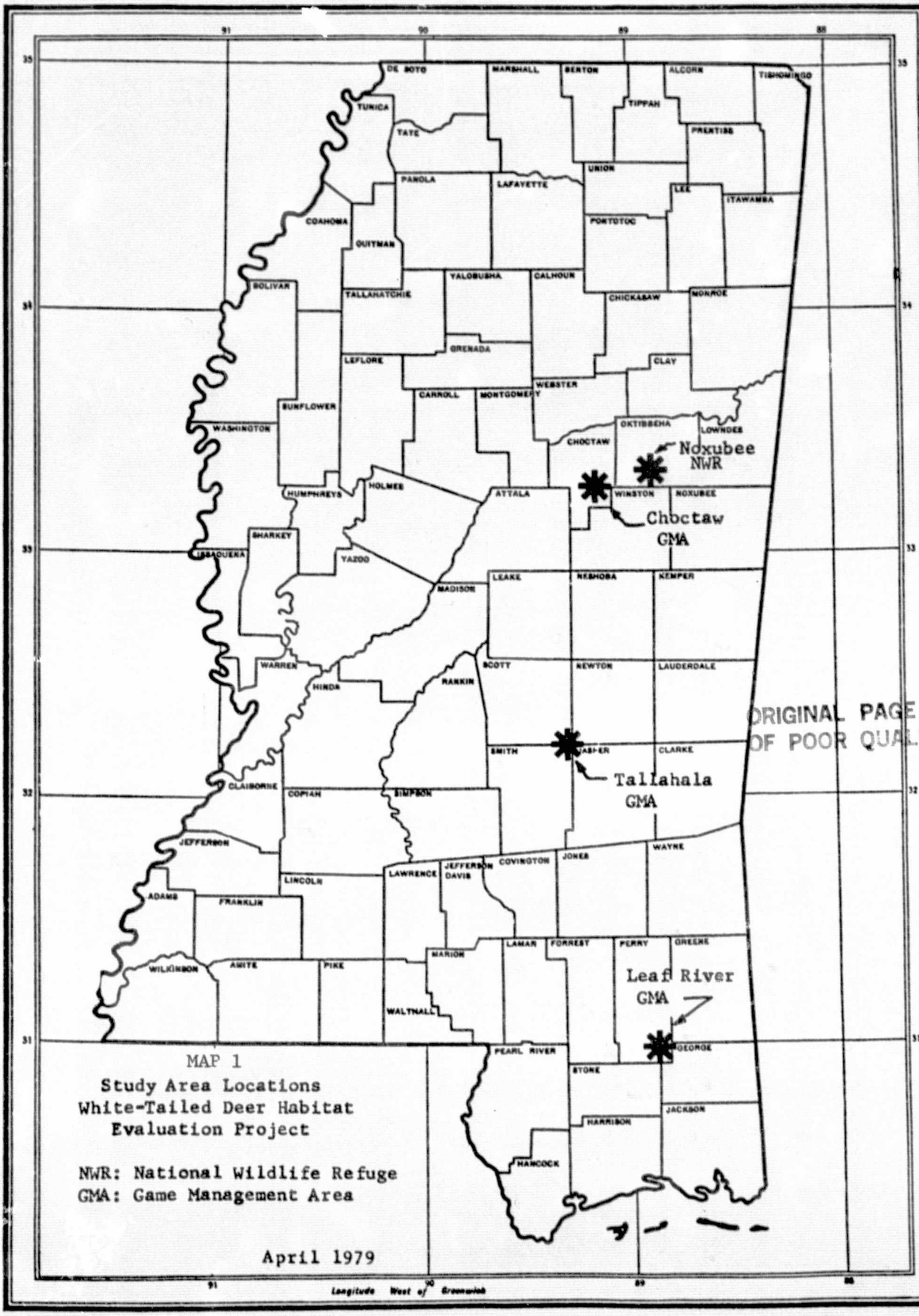
At present three tasks are being pursued which will provide the basis for an operational procedure for deer habitat mapping. These task areas are:

1. to determine a four-band (Landsat MSS bands) spectral profile of each of several vegetation associations which have been identified as important habitat types for white-tailed deer in Mississippi.
2. to evaluate the feasibility of using an airborne non-imaging radiometer to measure reflectance of vegetation stands for purposes of constructing said spectral profiles.
3. using the spectral profiles determined by airborne radiometry, to classify the Landsat CCTs into the various vegetative associations. The accuracy of this classification will be evaluated.

Accomplishments

1. Study Area Selection

Four areas have been selected to represent different physiographic regions of white-tailed deer habitat: the Choctaw, Tallahala, and Leaf River game management areas, and the Noxubee National Wildlife Refuge (Map 1). These areas were chosen from a larger number of controlled wildlife management areas for their accessibility and, more importantly, the availability of data on the deer herd of a particular management area.



MAP 1
Study Area Locations
White-Tailed Deer Habitat
Evaluation Project

NWR: National Wildlife Refuge
GMA: Game Management Area

April 1979

6¢

The Choctaw Game Management Area is (as are the Tallahala and Leaf River areas) cooperatively managed by the Mississippi Game and Fish Commission and the USDA Forest Service. The area is entirely within the Tombigbee National Forest and is in the Lower Clay Hills pysiographic region. The topography is deeply dissected; typical soils are sandy loams over a sandy clay to clay subsoil.

The Noxubee National Wildlife Refuge is exemplary of the forested, Interior Flatwoods physiographic regions. Topography is flat to gently rolling. Soils are clayey, formed from deltaic deposits of acid clays and acid, soft shales of the Porters Creek formation.

The Tallahala Game Management Area lies within the Jackson Hills Region. Topography is moderately rugged with deep loamy and sandy soils.

The Leaf River Area is in the Lower Coastal Plain; specifically, the Southern Loam Hills Region. As estuarine features and soils are not present, this area is sometimes termed the "middle" coastal plain. Loamy sand and sandy loam soils with sandy clay loam subsoils predominate. Topography is formed by rugged hills of the Citronelle geologic formation.

a. Terminology

For the convenience of the reader, a word about terminology is appropriate here.

"Study area" or simply "area" is used in identifying one of the four large game management areas selected for this investigation.

Within each of these areas, "stands" of forest land have been chosen to represent distinct forest vegetative conditions. Stands will range in size from 40 to 300 acres. The term "site" will occasionally appear and is synonymous with the term "stand."

A "station" is one of several points along a transect within a stand which seves as the sampling unit for this investigation. Several stations together are used to characterize a stand.

2. Stand Selection

Manual air photo interpretation combined with aircraft overflights of each area lead to the selection of specific sampling sites. These sites are stands of forests representative of the various vegetative conditions of the deer habitats discussed earlier. Every attempt was made to locate as many different habitat types in each of the four study areas as possible. Intrinsic and cultural features at each area did not allow all habitat types to be represented in each area. Table 1 shows the distribution of various stand types over the four study areas.

3. Digital Data Acquisition

Landsat multispectral scanner data tapes (CCTs) have been ordered for the Noxubee and Choctaw areas for autumn 1978 (1 Nov 1978). Tapes for the Tallahala and Lead River areas during fall 1978 will also be obtained. Landsat data for all study areas will be obtained for spring 1979 and late summer 1979, the former to observe infloration, the latter to observe maximum biomass production.

TABLE 1

Stand Locations

Stand Type	Size/Age	Canopy Density	Symbol	Noxubee NWR	Choctaw GMA	Tallahala GMA	Leaf River GMA
Pine	Saw	Dense	PSD	6,7		2	
		Moderate	PSM	11,14	3A,3,22,13,21	1	2, 8,15
	Pole	Dense	PPD	9	9,10	5	13
		Moderate	PPM				
Mixed	Saw	Dense	MSD	2,3,4,5	2,4,6	4,6,8,9,10	1,6,6A,7,7C
		Moderate	MSM				7B,7D
	Pole	Dense	MPD	12,15			
		Moderate	MPM				
Hardwoods	Saw	Dense	HSD	1	14,15,17,18,19	11,12,13	H3,10,3
		Moderate	HSM	1			12,H1
	Pole	Dense	HPD	1	16,20	7	H2
		Moderate	HPM	1	23,24,25,26		
Regeneration	Old	-	RO		1,5		RO1,RO2,RO3
	Young	-	RY		8,11		RY1,RY2,RY3,9, 9A,9B,9C

At the onset of this deer habitat evaluation project, it was planned that the vegetative component of deer habitats would be examined using a supervised-classification of Landsat multispectral scanner data. This supervised classifier was to have been calibrated by a library of spectral signatures obtained through the use of an airborne radiometer at each stand-type.

Originally, it appeared that a radiometer could be borrowed from one of several federal agencies. Unfortunately, none of these agencies could make the instrument available during this study. Hence, the plans for using a radiometer in the supervised classification approach have been suspended. The deletion of this task will not, however, jeopardize the attainment of overall project objectives. Deer habitat will still be evaluated using a supervised classifier. Ground training sites will be used instead to develop training statistics for use in supervised classification algorithms.

Present Efforts

The majority of effort at this time is being directed towards the refinement of field measurement techniques to be employed at all study sites beginning in May of this year. At the present time, stands at the Choctaw Game Management Area are being visited. These ground trips are intended to verify stand selections made through aerial techniques and to test the suitability of several ground truthing methods. Figure 11 is an example of the field data sheets presently being used. One pair of forms will be used for each station. Several stations shall be located in each stand, but the exact number in each stand type will be based upon the variability of the measured properties observed during the first few weeks of field work. It is anticipated that the number of stations per hectare will vary between stand types.

Stations will be located along a transect within each stand. The first station, i.e., the beginning of the transect, will be located by walking into the stand on a known compass bearing until the observer feels that the effects of edge disturbance have been overcome (about 3 chains). Subsequent stations shall be located along the same compass heading at 3-4 chain intervals. If the required number of stations cannot be completed in one transect, a second, parallel transect will be located 3-4 chains from the first.

Observations at all stations will be as follows:

a. Facing the original ("cardinal") transect direction, the area around the station is divided (visually) into 90^{o} quarters.

b. Select the first dominant overstory tree in each of the quarters and measure their height, diameter breast high, crown diameter, and age.

This step will be repeated for a "mid-story" if one is present.

Figure 11

FIELD NOTEBOOK

Date________ Stand _____ Station____

Photo: Vert.______

Horiz._____

Remarks:

TopoPosition____________ Slope_______ Aspect_____

Soil A Thickness_____ Texture_________

Color ______ Drainage _______

Pan _______

Vegetation:

Dominants spp. dbh cr. dia. age hgt.

1.

2.

3.

4.

basal area:________

Codominants spp. dbh, cr.dia. hgt.

1.

2.

3.

4.

basal area:_________

Understory plot1 plot2 plot3 plot4

sp.______________________

sp.______________________

sp.______________________

sp.______________________

sp.______________________

sp.______________________

sp.______________________

sp.______________________

sp.______________________

sp.______________________

Understory hgt. & general remarks:

c. Four, mil-acre plots (7.45 ft diameter circular) will be located at a yet-to-be-determined distance from the station, 0^o, 90^o, 180^o and 270^o from the transect cardinal direction. These plots will be used to characterize the understory.

d. One horizontal and one vertical (towards the zenith) color photograph will be taken with a wide angle (28mm) lens on a 35mm SLR camera. These will serve as permanent documentation of understory condition and crown closure, respectively.

e. Using a soil auger, the thickness, color, texture, drainage and structure of the "A" horizon will be observed.

Study Plans for 1979

For the balance of April 1979, "final" stand selections will be made for all study areas. An excess of stands will be located so that in the event areas have been cut over, alternate stands will be available. During this time, field measurement techniques will be finalized and logistics for the summer field work formalized.

The month of May will be used to measure the stands at the Choctaw area. The Tallahala area will be visited in June, the Leaf River in July, and the Noxubee Rufuge in August. The balance of the growing season (September and October) will be left available for additional field work, especially where highly variable stand conditions exist (hardwoods, pine/hardwood mixtures, rugged topography).

During autumn of 1979, computer-assisted Landsat data analysis will begin. A supervised and an unsupervised approach will be used for each study area.

Interagency Coordination

Three of the study areas are entirely within National forests. Further, they are cooperatively managed by the Mississippi Game and Fish Commission and the USDA, Forest Service for wildlife production. The Game and Fish Commission's Area Manager for each area, and the appropriate Forest Service district office will be contacted. It is intended that through these contacts a close technical working relationship will be developed with these two agencies. Coordination with Game and Fish Commission and Forest Service personnel at the Choctaw area has already resulted in a vast savings of time in stand selection.

U. S. Fish and Wildlife Service personnel at the Noxubee National Wildlife Refuge have been briefed as to the nature of this study. They have offered their assistance in stand selection and have made available all of their forest inventory data.

Compartment prescription data describing forest stand descriptions over the National forests will be solicited from Forest Service personnel.

E. Remote Sensing Data Analysis Support Systems

Objectives

To effectively implement the remote sensing applications and projects of the Applications Program, particularly those involving the Landsat multispectral data, it is essential that reasonably sophisticated computer-based data processing and data analysis systems be developed. Considerable effort is required to develop new computer software, to adapt existing software, and to install needed hardware facilities. This is in addition to the operational data processing and data analysis needs of each demonstration project.

More specifically, it is the objective of the Data Analysis Support Systems to provide the data collection and processing capabilities necessary to support the various demonstration projects and to provide a low-cost operational center so that such projects can have a continuing input into the overall objective of the Applications Program.

Accomplishments and Current Status

With the exception of the Varian Statos electrostatic plotter, the graphics/image processing minicomputer system has been installed and accepted. The major activities and accomplishments of this reporting period were in the area of software development. Two phases of activity were conconcurrent: (1) developing appropriate software for the minicomputer such that there is an interactive capability for display and analysis of remotely sensed data; and (2) developing and refining software for image data base management and land use modeling.

The capability now exists to display all four channels of Landsat multispectral scanner data, false color composites, and in addition, provide a zoom function for the displayed data. A version of an interactive training sample selection algorithm has also been developed, and is currently undergoing enhancement. The direction of the enhancements is toward increased statistical and classification outputs. Another activity was the correction of errors in the Lexidata software. An additional accomplishment in this area was the development of compaction routine for image display of CCTs or other remotely sensed data. A cursor function was also added to the track ball for enhanced Lexidata capability.

With respect to image data base management and land use, the two major accomplishments were 1) moving the data base from the UNIVAC to the minicomputer system and 2) writing routines to compact the data in run-length format - from 3.4 million to 1.3 million bytes. Moving the data base from the UNIVAC to the Data General involved:

1) the generation and inclusion of 16 proximity variables;
2) registration, collapsing, and inclusion utilizing decision-tree analysis of the LARSYS land cover classification;
3) correct registration and inclusion of NCIC data;
4) smoothing routines to correct erroneous data.

The compaction routines were developed because of limited disk storage availability.

Routines (software) have been developed to interactively manipulate the data base. Variables can be displayed, overlayed, and zoomed, and a program has been developed to overlay data base variables and land use models with township and range lines.

The interactive CALUP program includes capabilities to:

1) review data base variables (display, overlay, zoom);

2) interactively develop models:

   a) revision of new or existing models,

   b) statistical output includes percent weights and histograms,

   c) storing model on disk both in map form and model input form.

These capabilities were utilized during a recent workshop for Lowndes County officials.

Several programs as well as a library of data files have been created for the purpose of demonstrations, and continued support was supplied to the various projects of the Applications Program.

Plans

It is anticipated that the modeling activity can be made more efficient through additional work to optimize the program, and by examining and changing the structure of the data base. The ability to interactively develop search or proximity variables and interactively update the data base will also be developed. Work will also proceed to implement pattern recognition classification routines on the minicomputer system, to develop software for an interactive, band-ratioing capability, and to develop image processing language for use by non-programmers.

IV. LIST OF SPECIAL ASSISTANCE OFFERED

A. Other Program Activities

The Remote Sensing Laboratory moved to a new facility in the basement of Dorman Hall in February 1979. Although this location is temporary pending renovation of a University-owned house across the street from our present facility, the larger work space enhances the organization of Remote Sensing Applications Program equipment and personnel. In addition to assisting MSU faculty and students, Program personnel were kept busy providing tours of the Remote Sensing Laboratory facilities to various governmental organizations and legislative committees, and briefing the interested parties on the applications of remote sensing, the equipment available and current projects. Demonstrations were given to the following people during this reporting period:

Golden Triangle Planning and Development District (Crawford, et al.)
Mississippi State, Mississippi

Mr. Nick Faust/Mr. Bill Clerke
Remote Sensing Laboratory
Georgia Institute of Technology
Atlanta, Georgia

Tour for interested banking officials,
Agricultural Finance Day
Sponsored by the Department of Agricultural Economics
Mississippi State University

Legislative Visit
Mississippi Senator Dale Ford and Party
Sponsored by Mississippi Agricultural and Forestry Experiment Station (MAFES)

Mississippi Research and Development Center Staff Visit
Sponsored by MAFES/MSU

Information Supplied or Publications Supplied

In addition to the demonstration and educational activities cited above, information or publications were supplied to the following:

Dr. Vernon O. Shanholtz
Department of Agricultural Engineering
Virginia Polytechnic Institute & State University
Blacksburg, Virginia 24061

Mr. Dick Myers
Boise Southern Company
Box 1000
DeRidder, Louisiana 70634

Mr. Mark E. Schultz
1513 Albany Terrace
Albany, California 94706

Mr. Tom Terry
Weyerhaeuser Company
Columbus, Mississippi 39701

Mr. Terry Henwood
Environmental Data Section
NOAA
Dauphin Island, Alabama

Eastern Kentucky University
Division of Natural Areas
Keith Building, Room 134
Richmond, Kentucky 40475

Brice, Petrides & Associates, Inc.
191 West Fifth Street
Waterloo, IA 50701

Dr. Armando de la Cruz
Department of Biological Sciences
Mississippi State University
Mississippi State, Mississippi 39762

Mr. Ray Gildea
Lowndes County Civil Defense Director
Columbus, Mississippi

Mr. Bill Della Valle
Lowndes County Data Processing Manager
Columbus, Mississippi

Monitoring and Assessment Research Centre
Chelsea College
University of London
London, England

Mr. Walter Weldy
Bureau of Indian Affairs
Philadelphia, Mississippi

Also, the Program Coordinator gave a presentation at the Engineering Design Graphic Division, Midwinter Conference, on January 4, 1979, at MSU entitled "New Cartographic Methods in Education;" this presentation concerned the use of remotely sensed data in cartographic education.

Publications by Remote Sensing Applications Program Personnel

Two research papers were published as a direct result of activities within the Remote Sensing Applications Program during this reporting period:

W. Frank Miller and Bradley D. Carter, "Rational Land Use Decision-Making: The Natchez State Park," Remote Sensing of Environment, 8:25-38 (1979). (See related picture in Appendix V).

J. L. Solomon, W. F. Miller, and D. A. Quattrochi, "Development of a Tree Classifier for Discrimination of Surface Mine Activity from Landsat Digital Data," Proceedings of the American Society of Photogrammetry, Volume II, 45th Annual Meeting, March 18 - March 24, 1979, Washington, D.C.: 607-613.

B. Short Courses and Workshops

Program personnel were involved with the presentation of two continuing education courses in remote sensing:

1. January 7-11, 1979. A Remote Sensing Workshop for University Faculty Members. Sponsored by NASA/Earth Resources Laboratory, Slidell, Louisiana. Utilization of state-of-the-art remote sensing techniques in college level courses by assisting individual faculty members to develop instructional units.

2. March 22, 1979. Computerized Data Base for Lowndes County, Mississippi: Workshop for Elected Officials and Representatives of State and Federal Agencies. Utilization of remotely sensed data, digital Landsat data, and CALUP data base software for everyday governmental planning activities (see Appendix V).

C. Guest Lectures

The Remote Sensing Applications Program in conjunction with the MSU Mathematics Department sponsored a guest lecture during this reporting period. Dr. Larry F. Guseman, Jr., Associate Professor of Mathematics at Texas A & M University, gave presentations on topics related to remote sensing on April 24 and 25, 1979. Dr. Guseman's talks were open to the entire University community and the public was invited to attend (see Appendix V).

APPENDIX I

Table 1. Lowndes County Data Base

5 acre cells (467' square)

Variable 1		Elevation (more than 12 classes)
Variable 2		Slope per cent class (more than 12 classes)
Variable 3		Aspect
	Subvariable 0	Undefined
	Subvariable 1	North facing
	Subvariable 2	Northeast facing
	Subvariable 3	East facing
	Subvariable 4	Southeast facing
	Subvariable 5	South facing
	Subvariable 6	Southwest facing
	Subvariable 7	West facing
	Subvariable 8	Northwest facing
Variable 4		Slope length (more than 12 classes)
Variable 5		Soil Association
	Subvariable 0	Missing
	Subvariable 1	Floodplain - Leeper
	Subvariable 2	Floodplain - Jena
	Subvariable 3	Floodplain - Cahaba
	Subvariable 4	Upland - Prentiss
	Subvariable 5	Upland - Savannah
	Subvariable 6	Upland deep - Smithdale A
	Subvariable 7	Upland deep - Smithdale B

Variable 5 - Continued

Subvariable 8	Over chalk - Vaiden
Subvariable 9	Over chalk - Okolona
Subvariable 10	Over chalk - Sumpter
Subvariable 11	Over chalk - Kiplings

Variable 6 Surface water

Subvariable 0	No water
Subvariable 1	Stream - 3rd order
Subvariable 2	Stream - 2nd order
Subvariable 4	Stream - 1st order
Subvariable 6	Ponds
Subvariable 7	Lake (at least 100 acres)
Subvariable 8	Water-way water
Subvariable 9	River (at least 100 ft. width)

Variable 7 Land cover classification I

Subvariable 0	Unclassified
Subvariable 1	Forest - pine
Subvariable 2	Forest - hardwood
Subvariable 3	Open land/pasture
Subvariable 4	Cropland
Subvariable 5	Cropland (wet)/water
Subvariable 6	Gravel pits
Subvariable 7	Forest - pine/hardwood

Variable 8		Land cover classification II
	Subvariable 0	Unclassified
	Subvariable 1	Pine
	Subvariable 2	Hardwood
	Subvariable 3	Mixed
	Subvariable 4	Pasture
	Subvariable 5	Cropland
	Subvariable 6	Open
	Subvariable 7	Inert
	Subvariable 8	Water
Variable 9		Existing cultural land use
	Subvariable 0	None
	Subvariable 3	Residential - low density
	Subvariable 4	Residential - high density (4 homes/acre)
	Subvariable 5	Cemetery
	Subvariable 6	Public facilities
	Subvariable 7	Commercial
	Subvariable 8	Industrial
	Subvariable 9	Recreation
Variable 10		Transportation
	Subvariable 0	None
	Subvariable 1	Tenn-Tom Waterway
	Subvariable 3	Roads - unimproved
	Subvariable 4	Roads - light duty
	Subvariable 5	Roads - medium duty

Variable 10 - Continued

Subvariable 6 Roads - heavy duty

Subvariable 8 Railroads

Subvariable 9 Airport

Variable 11 Utility rights-of-way

Subvariable 0 None

Subvariable 1 Gas or oil pipeline

Subvariable 3 REA lines

Subvariable 5 TVA transmission lines

Variable 12 Aquifer recharge areas

Subvariable 0 Absent

Subvariable 1 Present

Variable 13 Flood limits

Subvariable 0 Above 100 year flood limits

Subvariable 1 Within 100 year flood limits

Variable 14 Incorporated towns

Subvariable 0 Outside city limits

Subvariable 1 Within city limits

Variable 15 Utilities

Subvariable 0 None

Subvariable 1 Electricity only

Subvariable 3 Water only

Subvariable 5 Electricity and water

Subvariable 7 Electricity, water, and sewage

Subvariable 9 Gas, electricity, water, and sewage

Variable 16 Sixteenth section boundaries

- Subvariable 0 Absent
- Subvariable 1 Present

Variable 17 Soil character

- Subvariable 0 Unclassified
- Subvariable 1 Medium textured B horizon, noneroded
- Subvariable 2 Medium textured B horizon, eroded
- Subvariable 3 Fine textured B horizon, noneroded
- Subvariable 4 Fine textured B horizon, eroded
- Subvariable 5 Soil disposal area

Variable 18 Soil wetness

- Subvariable 0 Unclassified
- Subvariable 1 Wetness index 84-100 (dry)
- Subvariable 2 Wetness index 77-83
- Subvariable 3 Wetness index 49-76
- Subvariable 4 Wetness index 33-48 (wet)

Variable 19 Proximity to city limits

- Subvariable 0 Cell within city limits
- Subvariable 1 Cell 1 cell away from city limits
- Subvariable 2 Cell 2 cells away from city limits
- Subvariable 3 Cell 3 cells away from city limits
- Subvariable 4 Cell 4 cells away from city limits
- Subvariable 5 Cell 5 cells away from city limits
- Subvariable 6 Cell 6 cells away from city limits

Variable 19 - Continued

Subvariable 7 Cell 7 cells away from city limits

Subvariable 8 Cell 8 cells away from city limits

Subvariable 9 Cell 9 or more cells away from city limits

Variable 20 Proximity to aquifer recharge areas

Subvariable 0 Aquifer recharge area in cell

Subvariable 1 Aquifer recharge area 1 cell away

Subvariable 2 Aquifer recharge area 2 cells away

Subvariable 3 Aquifer recharge area 3 cells away

Subvariable 4 Aquifer recharge area 4 cells away

Subvariable 5 Aquifer recharge area 5 cells away

Subvariable 6 Aquifer recharge area 6 cells away

Subvariable 7 Aquifer recharge area 7 cells away

Subvariable 8 Aquifer recharge area 8 cells away

Subvariable 9 Aquifer recharge area 9 or more cells away

Variable 21 Proximity to REA lines

Subvariable 0 REA line in cell

Subvariable 1 REA line 1 cell away

Subvariable 2 REA line 2 cells away

Subvariable 3 REA line 3 cells away

Subvariable 4 REA line 4 cells away

Subvariable 5 REA line 5 cells away

Subvariable 6 REA line 6 cells away

Subvariable 7 REA line 7 cells away

Subvariable 8 REA line 8 cells away

Subvariable 9 REA line 9 or more cells away

Variable 22		Proximity to row crop
	Subvariable 0	Row crop in cell
	Subvariable 1	Row crop 1 cell away
	Subvariable 2	Row crop 2 cells away
	Subvariable 3	Row crop 3 cells away
	Subvariable 4	Row crop 4 cells away
	Subvariable 5	Row crop 5 cells away
	Subvariable 6	Row crop 6 cells away
	Subvariable 7	Row crop 7 cells away
	Subvariable 8	Row crop 8 cells away
	Subvariable 9	Row crop 9 or more cells away
Variable 23		Proximity to water (all classes)
	Subvariable 0	Water in cell
	Subvariable 1	Water 1 cell away
	Subvariable 2	Water 2 cells away
	Subvariable 3	Water 3 cells away
	Subvariable 4	Water 4 cells away
	Subvariable 5	Water 5 cells away
	Subvariable 6	Water 6 cells away
	Subvariable 7	Water 7 cells away
	Subvariable 8	Water 8 cells away
	Subvariable 9	Water 9 or more cells away
Variable 24		Proximity to 1st order streams, lakes, water-way, river
	Subvariable 0	Water in cell
	Subvariable 1	Water 1 cell away

Subvariable 2	Water 2 cells away
Subvariable 3	Water 3 cells away
Subvariable 4	Water 4 cells away
Subvariable 5	Water 5 cells away
Subvariable 6	Water 6 cells away
Subvariable 7	Water 7 cells away
Subvariable 8	Water 8 cells away
Subvariable 9	Water 9 or more cells away
Variable 25	Proximity to water-way
Subvariable 0	Water-way in cell
Subvariable 1	Water-way 1 cell away
Subvariable 2	Water-way 2 cells away
Subvariable 3	Water-way 3 cells away
Subvariable 4	Water-way 4 cells away
Subvariable 5	Water-way 5 cells away
Subvariable 6	Water-way 6 cells away
Subvariable 7	Water-way 7 cells away
Subvariable 8	Water-way 8 cells away
Subvariable 9	Water-way 9 or more cells away
Variable 26	Proximity to 1st or 2nd order streams
Subvariable 0	Stream in cell
Subvariable 1	Stream 1 cell away
Subvariable 2	Stream 2 cells away
Subvariable 3	Stream 3 cells away
Subvariable 4	Stream 4 cells away
Subvariable 5	Stream 5 cells away

Subvariable 6	Stream 6 cells away
Subvariable 7	Stream 7 cells away
Subvariable 8	Stream 8 cells away
Subvariable 9	Stream 9 or more cells away

Variable 27 Proximity to residential land use

Subvariable 0	Residence in cell
Subvariable 1	Residence 1 cell away
Subvariable 2	Residence 2 cells away
Subvariable 3	Residence 3 cells away
Subvariable 4	Residence 4 cells away
Subvariable 5	Residence 5 cells away
Subvariable 6	Residence 6 cells away
Subvariable 7	Residence 7 cells away
Subvariable 8	Residence 8 cells away
Subvariable 9	Residence 9 or more cells away

Variable 28 Proximity to residential, cemetery, commercial, recreational land use

Subvariable 0	Land use in cell
Subvariable 1	Land use 1 cell away
Subvariable 2	Land use 2 cells away
Subvariable 3	Land use 3 cells away
Subvariable 4	Land use 4 cells away
Subvariable 5	Land use 5 cells away
Subvariable 6	Land use 6 cells away
Subvariable 7	Land use 7 cells away
Subvariable 8	Land use 8 cells away
Subvariable 9	Land use 9 or more cells away

Variable 29		Proximity to public facilities or industrial land use
	Subvariable 0	Land use in cell
	Subvariable 1	Land use 1 cell away
	Subvariable 2	Land use 2 cells away
	Subvariable 3	Land use 3 cells away
	Subvariable 4	Land use 4 cells away
	Subvariable 5	Land use 5 cells away
	Subvariable 6	Land use 6 cells away
	Subvariable 7	Land use 7 cells away
	Subvariable 8	Land use 8 cells away
	Subvariable 9	Land use 9 or more cells away
Variable 30		Proximity to roads
	Subvariable 0	Road in cell
	Subvariable 1	Road 1 cell away
	Subvariable 2	Road 2 cells away
	Subvariable 3	Road 3 cells away
	Subvariable 4	Road 4 cells away
	Subvariable 5	Road 5 cells away
	Subvariable 6	Road 6 cells away
	Subvariable 7	Road 7 cells away
	Subvariable 8	Road 8 cells away
	Subvariable 9	Road 9 or more cells away

Variable 31		Proximity to unimproved or light duty roads
	Subvariable 0	Road in cell
	Subvariable 1	Road 1 cell away
	Subvariable 2	Road 2 cells away
	Subvariable 3	Road 3 cells away
	Subvariable 4	Road 4 cells away
	Subvariable 5	Road 5 cells away
	Subvariable 6	Road 6 cells away
	Subvariable 7	Road 7 cells away
	Subvariable 8	Road 8 cells away
	Subvariable 9	Road 9 or more cells away
Variable 32		Proximity to medium or heavy duty roads
	Subvariable 0	Road in cell
	Subvariable 1	Road 1 cell away
	Subvariable 2	Road 2 cells away
	Subvariable 3	Road 3 cells away
	Subvariable 4	Road 4 cells away
	Subvariable 5	Road 5 cells away
	Subvariable 6	Road 6 cells away
	Subvariable 7	Road 7 cells away
	Subvariable 8	Road 8 cells away
	Subvariable 9	Road 9 or more cells away
Variable 33		Proximity to light, medium, or heavy duty roads
	Subvariable 0	Road in cell
	Subvariable 1	Road 1 cell away
	Subvariable 2	Road 2 cells away

Variable 33 - Continued

Subvariable 3	Road 3 cells away
Subvariable 4	Road 4 cells away
Subvariable 5	Road 5 cells away
Subvariable 6	Road 6 cells away
Subvariable 7	Road 7 cells away
Subvariable 8	Road 8 cells away
Subvariable 9	Road 9 or more cells away

Variable 34 Proximity to railroads

Subvariable 0	Railroad in cell
Subvariable 1	Railroad 1 cell away
Subvariable 2	Railroad 2 cells away
Subvariable 3	Railroad 3 cells away
Subvariable 4	Railroad 4 cells away
Subvariable 5	Railroad 5 cells away
Subvariable 6	Railroad 6 cells away
Subvariable 7	Railroad 7 cells away
Subvariable 8	Railroad 8 cells away
Subvariable 9	Railroad 9 or more cells away

Variable 35 Slope (regrouped)

Subvariable 0	Not classified
Subvariable 1	0-2% slope
Subvariable 2	2-5% slope
Subvariable 3	5-8% slope
Subvarialbe 4	8-12% slope
Subvariable 5	12-15% slope
Subvariable 6	15-20% slope
Subvariable 7	20-45% slope

APPENDIX II

SUITABILITY INDEX EVALUATION FORM

Suitability Index Name CROP FLOOD HAZARD

Study LOWNDES (Della Valle, Miller)
Date 10/31/78: Revised 3/01/79

Variable	No.	0	1	2	3	4	5	6	7	8	9	10	11	Weight	Weight Percent
Slope	35	0	9	8	6	0	0	0	0	0	0	0	0	10	
Soil Association I	5	0	9	9	8	0	0	0	0	0	0	0	0	8	
Proximity to 1&2 Order Streams	26	9	9	9	8	7	1	1	0	0	0	0	0	10	
Land Cover II	8	2	0	0	9	0	0	0	0	0	0	0	0	10	
Flood 100 yr.	13	0	9	0	0	0	0	0	0	0	0	0	0	0	

Rate each value for each variable from 1 (low to 9 (high)

To reject a cell on a particular condition, code a 0 under those particular variable values.

Weight - relative contribution of each variable to attractiveness or vulnerability

SUITABILITY INDEX EVALUATION FORM

Suitability Index Name WATERWAY INDUSTRIAL

Study LOWNDES

Date 3/21/79

Variable	No.	0	1	2	3	4	5	6	7	8	9	10	11	Weight	Weight Percent
Floods	13	9	0	0	0	0	0	0	0	0	0	0	0	0	
Proximity to Roads	30	9	9	9	9	8	8	8	6	4	2	0	0	12	
Proximity to Railroads	34	9	9	9	9	9	9	8	8	7	5	0	0	6	
Proximity to Waterway	25	0	9	9	9	8	7	5	3	2	2	0	0	12	
Slope	35	0	8	9	9	6	3	0	0	0	0	0	0	9	
Proximity to Residences	27	0	0	0	3	5	7	8	9	9	9	0	0	6	

Rate each value for each variable from 1 (low to 9 (high)

To reject a cell on a particular condition, code a 0 under those particular variable values.

Weight - relative contribution of each variable to attractiveness or vulnerability

SUITABILITY INDEX EVALUATION FORM

Suitability Index Name SANITARY LAND FILL

Study LOWNDES (Miller)

Date 3/21/79

Variable	No.	0	1	2	3	4	5	6	7	8	9	10	11	Weight	Weight Percent
100 Yr. Flood	13	9	0	0	0	0	0	0	0	0	0	0	0	0	
Proximity to Aquifer	20	0	0	0	0	0	3	5	9	9	9	0	0	9	
Soil Association	5	0	0	0	0	2	5	7	9	6	4	0	4	12	
Existing Cultural Use	9	9	0	0	7	0	0	1	0	2	0	0	0	6	
Proximity to Surface Water	23	0	1	3	5	7	9	9	9	9	9	0	0	9	
Slope Percent	35	0	9	9	8	5	2	1	0	0	0	0	0	10	
Proximity to City Limits	19	0	0	0	0	3	5	7	9	9	9	0	0	6	
Proximity to Roads	30	0	1	5	9	8	7	6	6	6	3	0	0	6	

Rate each value for each variable from 1 (low to 9 (high)

To reject a cell on a particular condition, code a 0 under those particular variable values.

Weight - relative contribution of each variable to attractiveness or vulnerability

SUITABILITY INDEX EVALUATION FORM

Suitability Index Name RECREATION - INTENSIVE Study LOWNDES

Date 5/02/78

Variable	No.	0	1	2	3	4	5	6	7	8	9	10	11	Weight	Weight Percent
Slope	35	0	8	9	9	6	3	3	3	0	0	0	0	12	
Proximity to City Limits	19	9	9	9	9	9	8	6	4	2	1	0	0	10	
Proximity to Water	24	0	9	9	9	8	7	6	5	1	1	0	0	3	
Cultural Use	9	7	0	0	8	9	0	5	3	1	9	0	0	9	
Soil Association	5	0	0	0	0	3	5	9	9	5	5	1	3	9	
Proximity to Roads	33	0	9	9	9	8	6	3	2	1	0	0	0	9	

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Rate each value for each variable from 1 (low to 9 (high)

To reject a cell on a particular condition, code a 0 under those particular variable values.

Weight - relative contribution of each variable to attractiveness or vulnerability

SUITABILITY INDEX EVALUATION FORM

Suitability Index Name: HIGH VOLUME INSTITUTIONAL COMMERCIAL

Study: LOWNDES

Date: 5/02/78

Variable	No.	0	1	2	3	4	5	6	7	8	9	10	11	Weight	Weight Percent
Flooding	13	9	0	0	0	0	0	0	0	0	0	0	0	0	
Slope	35	0	9	7	2	1	0	0	0	0	0	0	0	9	
Soil Characteris.	17	0	9	8	5	2	5	0	0	0	0	0	0	9	
Utilities	15	1	0	1	1	0	4	0	7	0	9	0	0	6	
Proximity to Transporta.	33	9	9	7	5	3	2	1	1	1	1	0	0	10	
Proximity to City Limits	19	9	9	9	9	9	9	9	9	9	7	0	0	6	
Proximity to Land Use	27	0	3	7	8	9	9	9	7	5	1	0	0	8	

Rate each value for each variable from 1 (low to 9 (high)

To reject a cell on a particular condition, code a 0 under those particular variable values.

Weight - relative contribution of each variable to attractiveness or vulnerability

SUITABILITY INDEX EVALUATION FORM

Suitability Index Name: WILDLIFE HABITAT

Study: LOWNDES

Date: 5/2/78

Variable	No.	0	1	2	3	4	5	6	7	8	9	10	11	Weight	Weight Percent
Proximity to Row Crops	22	2	9	9	9	9	9	8	7	6	5	0	0	10	15.4
Surface Water	6	2	0	0	0	9	0	9	5	5	9	0	0	9	13.8
Transportation	10	9	1	0	9	3	1	1	0	7	0	0	0	6	9.2
Soil Character.	17	0	9	7	5	3	1	0	0	0	0	0	0	6	
Soil Wetness	18	0	3	5	7	9	0	0	0	0	0	0	0	6	
Land Cover II	8	4	0	0	9	2	1	7	1	1	0	0	0	12	
Proximity to City Limits	19	0	0	0	0	0	1	3	7	8	9	0	0	9	

Rate each value for each variable from 1 (low to 9 (high)

To reject a cell on a particular condition, code a 0 under those particular variable values.

Weight - relative contribution of each variable to attractiveness or vulnerability

SUITABILITY INDEX EVALUATION FORM

Suitability Index Name RESIDENTIAL

Study LOWNDES

Date 5/2/78

Variable No.		0	1	2	3	4	5	6	7	8	9	10	11	Weight	Weight Percent
Flood	13	9	0	0	0	0	0	0	0	0	0	0	0	0	
Surface Water	6	9	0	0	0	0	0	0	0	0	0	0	0	0	
Soil Characteris.	17	0	9	7	5	3	1	0	0	0	0	0	0	12	
Slope Percent	35	0	7	9	9	5	3	3	1	0	0	0	0	12	
Proximity to Transporta.	33	0	3	7	8	9	8	7	7	6	6	0	0	4	
Existing Land Use	9	9	0	0	9	9	0	0	0	0	4	0	0	9	
Soil Water	18	0	9	9	5	0	0	0	0	0	0	0	0	10	
Proximity to Comm. Resid.	28	0	9	9	9	9	9	9	7	7	1	0	0	9	
Prox. to Public Faci. & Indus	29	0	0	0	4	4	4	7	9	9	9	0	0	9	

Rate each value for each variable from 1 (low to 9 (high)

To reject a cell on a particular condition, code a 0 under those particular variable values.

Weight - relative contribution of each variable to attractiveness or vulnerability

SUITABILITY INDEX EVALUATION FORM

Suitability Index Name INDUSTRIAL-GENERAL

Study LOWNDES

Date

Variable No.		0	1	2	3	4	5	6	7	8	9	10	11	Weight	Weight Percent
Aquifer	12	9	0	0	0	0	0	0	0	0	0	0	0	0	
Flood Limits	13	9	0	0	0	0	0	0	0	0	0	0	0	0	
Proximity to Roads	32	9	9	9	9	8	8	7	5	3	1	0	0	12	
Proximity to Railroads	34	0	9	9	8	7	5	3	1	1	1	0	0	12	
Slope	35	0	8	9	8	4	2	2	0	0	0	0	0	9	
Soil Characteris.	17	0	9	8	4	2	5	0	0	0	0	0	0	9	
Proximity to Residences	27	0	0	0	3	5	7	7	8	8	9	0	0	7	

Rate each value for each variable from 1 (low to 9 (high)

To reject a cell on a particular condition, code a 0 under those particular variable values.

Weight - relative contribution of each variable to attractiveness or vulnerability

SUITABILITY INDEX EVALUATION FORM

Suitability Index Name RECREATION-EXTENSIVE

Study LOWNDES
Date 5/2/78

Variable No.		0	1	2	3	4	5	6	7	8	9	10	11	Weight	Weight Percent
Proximity to Surface Water	24	9	9	8	5	3	1	1	1	1	1	0	0	12	
Land Cover	8	1	0	0	9	3	1	0	0	0	0	0	0	12	
Soil Characteris.	17	0	9	8	6	4	2	0	0	0	0	0	0	4	
Wetness	18	0	9	9	5	1	0	0	0	0	0	0	0	4	

Rate each value for each variable from 1 (low to 9 (high)

To reject a cell on a particular condition, code a 0 under those particular variable values.

Weight - relative contribution of each variable to attractiveness or vulnerability

APPENDIX III

DEVELOPMENT OF A TREE CLASSIFIER FOR DISCRIMINATION OF SURFACE MINE ACTIVITY FROM LANDSAT DIGITAL DATA

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BIOGRAPHICAL SKETCH

J. L. Solomon is Associate Professor of Mathematics at Mississippi State University. Solomon received his B.S. from the University of Mississippi, his M.S. from Mississippi State University, and his Ph.D. from Texas A&M University. His main research interests are in fixed point theory and statistical pattern recognition.

W. F. Miller is Associate Professor of Forestry, and Program Coordinator, Remote Sensing Applications Program at Mississippi State University. Miller received his B.S.F. from Pennsylvania State University and his M.F. from Duke University. He has served as remote sensing consultant to the Office of the Chief, Corps of Engineers, the Department of Interior, and several law firms and private companies. His research interests are in remote sensing and land capability classification. He is a member of the American Society of Photogrammetry and the Society of American Foresters.

D. A. Quattrochi is Research Assistant in the Remote Sensing Applications Program at Mississippi State University. Quattrochi received his B.S. in Geography from Ohio University and his M.S. in Geography from the University of Tennessee. His research interests in remote sensing are image interpretation and the digital processing of Landsat data for land use analysis. He is a member of the American Society of Photogrammetry, the Association of American Geographers, and the American Geographical Society.

ABSTRACT

In a cooperative project with the Geological Survey of Alabama, the Mississippi State Remote Sensing Applications Program has developed a single purpose, decision-tree classifier using band-ratioing techniques to discriminate various stages of surface mining activity. The tree classifier has four levels and employs only two channels in classification at each level. An accurate computation of the amount of disturbed land resulting from the mining activity can be made as a product of the classification output. The utilization of Landsat data provides a cost-efficient, rapid, and accurate means of monitoring surface mining activities.

INTRODUCTION

Strip mining has become the most cost-effective method of extracting coal resources that lie near the Earth's surface. Unfortunately, the problems involved in mitigating the environmental impacts of surface mining reduce its cost-effectiveness. Impacts on both surface and ground water supplies, soil loss, and loss of aesthetic values are all by-products of surface mining activities. In order to lessen the effects of surface mining on the environment, Congress and several states have enacted strip mine reclamation laws which assure that mined lands will be restored to an economically and aesthetically acceptable condition.

One state which has recognized the need for a comprehensive surface mining reclamation law is Alabama, which adopted the Alabama Surface Mining Act in 1975. This legislation was enacted to establish regulations and controls to provide for the reasonable and responsible reclamation of lands mined for surface coal. The Act further creates the Alabama Surface Mining Reclamation Commission which is empowered to collect reclamation performance bonds that are not released until it is determined that reclamation of affected lands is successful and conforms to the standards of the Act. The Geological Survey of Alabama (GSA) serves as technical advisor to the Reclamation Commission and assists in determining the extent of surface mining activity in the State.

The passage of the Alabama Surface Mining Act has created a need for the GSA to establish an efficient, low cost, and repetitive means for monitoring strip mine activity and the effectiveness of reclamation efforts. The task of collecting information on the location, extent, and characteristics of surface coal strip mining activity in Alabama is presently performed using aerial imagery. Because of the expense in both time and money involved in acquiring and interpreting aircraft data, the GSA wishes to accomplish its goals with the minimum manpower and cost. As an alternative to aerial imagery, Landsat data with its low cost in comparision to aircraft coverage or "windshield" surveys, its temporal nature, and its digital format, offers an advantage over other data collection techniques for acquiring the data necessary to monitor surface mine activity and reclamation efforts.

BACKGROUND AND STUDY AREA

For the past two years, the Remote Sensing Applications Program at Mississippi State University has been cooperating with the GSA on the development of a software package for the thematic extraction of active and reclaimed strip mines from Landsat digital data. A single purpose, decision-tree classifier was employed to discriminate surface mining activity in various stages within a portion of the Warrior Coal Basin in Walker County, Alabama (Map 1). The area is located northwest of Birmingham and northeast of Tuscaloosa in the Cumberland Plateau-Mountain Province[1] of northwest

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[1]Superscripts refer to similarly numbered entries in the Literature Cited Section.

Alabama. The study area, approximately 684 sq. km. (264 sq. mi.), is characterized by deeply dissected, strongly sloping terrain with relatively flat and narrow ridges. Soils are formed from the Pottsville Formation which consists of interbedded sandstone, coal seams, and shales. The dominant soil series are Montevallo, Townley, and Enders, and vegetation is composed primarily of hardwoods with pine and pine-hardwood mixtures found in old field situations. The Mulberry Fork of the Warrior River acts as the principal drainage system within the study site, and streams in the area exhibit fault-controlled characteristics.

Landsat data taken on February 23, 1976 (ID#5310-15180) in digital format was used to classify the strip mines within the study area. Color infrared 1:24,000 scale, aircraft imagery taken January 30, 1976, supported by field trips, was used as ground truth data for the study.

METHOD

Previous studies have indicated that signatures obtained from the four bands of Landsat MSS data have large variations for different types of strip-mining surfaces. One approach to circumvent this problem has been to employ the technique of band ratioing. Some rationale for employing band ratioing can be found in Kriegler[2] where he indicates that illumination, transmittance, reflectance, and gain effect the signal in a multiplicative manner, whereas the effects of altitude, sun angle, and haze are additive.

Preprocessing of Landsat multispectral data resulted in nine channels of data:

channel 1 - band 4;
channel 2 - band 5;
channel 3 - band 6;
channel 4 - band 7;
channel 5 - ratio of channel 1 to channel 3;
channel 6 - ratio of channel 2 to channel 3;
channel 7 - ratio of channel 4 to channel 3;
channel 8 - ratio of channel 1 to channel 2;
channel 9 - ratio of channel 4 to channel 2.

After preprocessing the Landsat 2 data of the study area, a small portion was selected to obtain signatures of various cover types employing clustering analysis. All classification and analysis was performed on a UNIVAC 1108 computer using the Earth Observations Division Version of the LARS software package.[3]

The preliminary signatures fell into six broad classes and several subclasses. The next stage in the development of a tree classifier was to determine the "best" four channels; i.e., the four channels which maximize the separability criteria. The weighted average transformed divergence was chosen as the measure of separability. A without-replacement procedure was used to determine the best four channels; that is, the channel which maximizes the separability is chosen. Next, the remaining eight channels are paired with the best single channel in selecting the best pair of channels. The best triplet is obtained by combining the six channels remaining with the best pair, and finally, the best four channels are found by combining the remaining five channels with the best triplet. Using this procedure, channels 2, 5, 6, and 8 were determined to be the best four channels. Anderson, et. al.[4,5] determined that channel [illegible] (ratio of band 5 to band 6) yielded the most consistently accurate results of a single channel in extending a single mine signature to three different Landsat images.

Figure 1 illustrates the decision-tree classifier developed as a result of feature selection. It should be noted that only two channels are used at each level of the classifier.

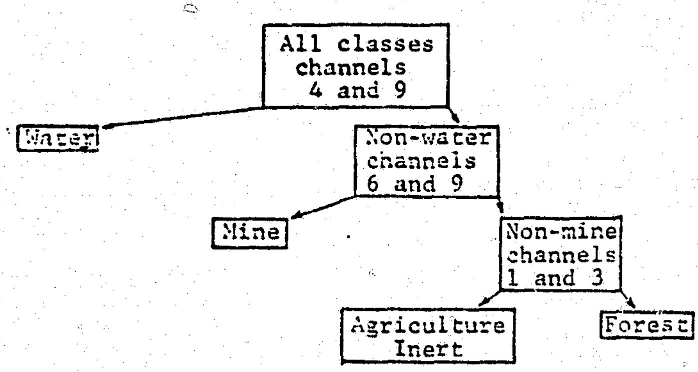

Figure 1. Decision-tree classifier

RESULTS AND DISCUSSION

Because of the close agreement between the dates of the aircraft imagery and the satellite data, image interpretation supported by three field trips formed the basis for the empirical evaluation of classification products. Initial clustering analysis of several mines within the study area highlighted two areas of concern; the misclassification of shadowed areas as carbonaceous materials and water associated with active mining, and a similar confusion factor between the agricultural pasture and reclaimed mine areas. Due to the deeply incised river course, the shadowing problem was particularly acute adjacent to the major drainage of the area, but it was also noticeable adjacent to many of the high walls of both active and older, abandoned mines. Signatures were developed for the deeply shadowed areas of the river valleys since their extent was much greater than the high wall shadows. In the case of pasture versus reclaimed areas, clusters were refined until accurate discrimination was achieved. This procedure was followed for other problem areas, and in general, the number of classes was increased only to the point where separability criteria indicated clear discrimination of mine activity from all other classes. Based on field examination, image interpretation, and signature variability, spoil materials throughout the study area are quite uniform because of the high proportion of shale strata.

The final classification utilizing channels 1,3,4,6, and 9 resulted in the discrimination of the following land cover classes and subclasses:

1. forest
2. agricultural/inert
3. scrubland: forest-pasture interface, and recently logged areas
4. urban
5. water
6. shadow
7. mining activity
    a. rough spoil
    b. smoothed (less than 30% slope)
    c. smoothed and partially revegetated

Consultation with personnel of GSA together with a detailed examination of the aerial imagery indicated that all recent mining activity was identified; only in the case of the older or narrow "contour" mines was the classifier unable to discriminate the cover condition.

In addition to the detection of mining activity, determination of the active mine area is quite important for verification of areas where reclamation bonds have been posted. Five mines ranging in size from 16 ha (40 ac) to 202 ha (500 ac) were selected for analysis. The GSA determined the individual mine areas by transferring imagery detail from the January flight to U. S. Geological Survey 7½ minute quadrangle sheets by means of a Bauch and Lomb Zoom Transfer Scope; the amount of disturbed land for each mine was determined from the quadrangle sheets by a polar planimeter. Using these "true" values as the dependent variable, a pixel count of appropriate signatures was used as the independent variable (Table 1.). A linear regression analysis was performed and the resulting prediction equation

$$y = -2.8370 + 1.200x$$

was highly significant ($r^2 = 0.9985$). The mean and standard error of estimate $(x \pm s_{y} t_{05})$ was 268.8±11.61 or 4.18%.

Table 1.

Pixel Count(x)	"True" Area(ac)	Predicted Area(y)
39	41	43.9
148	175	174.7
233	297	282.7
288	331	342.7
419	500	499.9

Future plans include a test of signatures in an area north of the present study area where the sandstone members of the Pottsville Formation are more dominant, resulting in less carbanaceous spoil material. It is anticipated that signatures obtained in channels 1 and 3 will not transport well; however, it is noted in the tree classifier (Figure 1.) that channels 6 and 9, obtained by band ratioing, are responsible for mine discrimination. Another test will be temporal extension; a CCT from a growing season overflight will be obtained and analyzed.

The cost of classifying the study area was determined to be .0927¢/acre, from tape acquisition to classification, compared with 17¢/acre for the aerial data. It is felt that with further refinement in the classifier software, computer costs can be reduced.

CONCLUSIONS

The methodology described in this paper satisfactorily discriminated surface mining activity in a portion of the Warrior Basin of Alabama. Although problems still exist in identifying older contour mines, these are not critical in the acceptance of the methodology. Based upon initial results presented in this paper, the single purpose, classifier is cost efficient for monitoring strip mining activity in Alabama.

ACKNOWLEDGEMENTS

The support of NASA's Office of Space and Terrestrial Applications, Technology Transfer Division, University Applications Program, through Contract NGL 25-001-054 is gratefully acknowledged, as is the support of Mr. Tom Joiner, State Geologist, Mr. J. Drahauzel, and Mr. Donald Russell of the GSA.

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APPENDIX IV

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APPENDIX V

C-2

FAYETTE CHRONICLE
Fayette, Mississippi
WEEKLY

MAR-15-79

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Natchez State Park Groundbreaking Ceremonies Held Monday

Groundbreaking ceremonies were held Monday morning for the 4,000-acre Natchez State Park which will be located just over Jefferson County's boundary line at Stanton in Adams County.

The proposed 8 to 10 million dollar project is to be completed between now and 1985.

Development plans call for a 460 acre lake, a swimming beach, bathhouse, picnic area, camping and tent facilities, lighted tennis courts and baseball and softball fields and other sports activivities.

Also proposed is a 10-mile hiking area with bicycle and nature trails.

A visitor and information center, 200 picnic units and amphitheater is also planned.

Governor Cliff Finch was on hand for the groundbreaking ceremonies, along with Adams County Board of Supervisors, Natchez Mayor Tony Byrne, and Aldermen, Senator Troy Watkins and other legislators were present.

Governor Finch stated that about $2.5 million would be spent on land alone; $1.5 on the construction of the lake and dam and $4 more for improvements and that the park would serve the 10 or 15 surrounding county area.

Governor Finch told those present that the park would be the most progressive park, the largest and the best, not only in Mississippi but in the South.

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Briefed on MSU Project

A group of Columbus and Lowndes County officials, including county data processing manager Bill DellaValle (center) and city-council Civil Defense director Ray Gildea (right), recently toured the Remote Sensing Application Project at Mississippi State University. The project. which is supported by the national Aeronautics and Space Administration (NASA), involves the use of satellite-borne sensing equipment to provide local, state and federal government agencies with data on a wide range of subjects. Lowndes County projects include development of a generalized model for industrial waste land-fills and location of agricultural lands with specialized flood hazard potential. Reviewing the data with the two officials is Frank Miller (left), program coordinator.

THE REMOTE SENSING APPLICATIONS PROGRAM
AND
THE DEPARTMENT OF MATHEMATICS
MISSISSIPPI STATE UNIVERSITY

PRESENT

DR. L. F. GUSEMAN, JR.

ASSOCIATE PROFESSOR OF MATHEMATICS
TEXAS A & M UNIVERSITY

You are invited to attend his lectures

Tuesday, April 24, 1979, 2:30 P.M., Dorman 128

"Area Estimation for Crop Inventories Using Landsat Data"

Wednesday, April 25, 1979, 9:00 A.M., Allen 414

"Mathematical Problems Related to Remote Sensing"