APPLICATIONS OF REMOTE SENSING
IN ARCHEOLOGICAL SITE IDENTIFICATION

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Applications of Remote Sensing

In Archeological Site Identification

One of the most prevalent conceptual positions in archaeology today is that culture consists of those human capabilities which serve to mediate between man and his environment. "Culture is all those means whose forms are not under direct genetic control which serve to adjust individuals and groups within their ecological communities" (Binford, 1972). It is clear that a conceptual stand of this nature demands that the archeologist must consider the environmental factors which impinge upon the lives of any group of people which he is studying.

In line with this it should be noted that the explanation of the spatial distribution of sites which represent each major period of occupation and each component of the total range of activities carried out by the peoples under examination is one of the primary problems facing any archaeologist attempting to synthesize regional archeological data. This, too, necessarily involves some consideration of ecological variables which could influence site selection by the aboriginal occupants of an area (Chang, 1972; Gumerman, 1971; Rouse, 1972; Trigger, 1968).

Therefore, both the conceptual view of culture held by many modern archeologists and the specific concern with "settlement patterns" demand that the archeologists compile data relating the archeological sites to specific, local, ecological factors. Nevertheless, it is also true that most archeologists have not been specifically trained in the techniques of gathering or evaluating detailed ecological data. Coupled with this lack of training is the further problem of the ever increasing sophistication of the environmental data gathering techniques.

Clearly what is called for is an interdisciplinary approach whereby the archeologist can utilize the expertise of those who are specifically trained to gather and evaluate ecological data and can then apply their findings in the construction and the testing of models to explain the cultural patterns which have been identified in the archeological data. The recognition of this need for an interdisciplinary approach is far from new. Archeologists have long realized their need for experts in such diverse areas as botany, zoology, palynology, locational geography, geology, physics, demography, and economics to mention only a few. However, the recognition of the need has often not resulted in the opportunity to utilize interdisciplinary expertise, especially in the area of ecological data collection.

This paper does represent such an attempt to develop an archeological model to explain the distribution of a limited range of sites in terms of environmental and cultural variables and to utilize remote sensing imagery to provide environmental data by which the distribution model could be tested in the field. The settlement pattern model and the remote-sensing interpretation were carried out by Frank Miller, Associate Professor of Forestry at Mississippi State University, and Michael Walls, a student in Anthropology at Mississippi State University.

It is recognized that the settlement pattern model is at best quite preliminary and also that it deals only with a limited spectrum of both the temporal and the activity range of the occupation of the study area. The model is only applicable to those sites which were initially utilized as permanent settlements, and which were occupied by peoples who were partially dependent upon agricultural products for their subsistency. Furthermore, to fully account for the distribution of even this limited portion of the occupational spectrum the model would require further development. Nevertheless, the quantity of environmental data which Miller and Walls have been able to develop for the testing of the model from the study of color infrared coverage of the study area is impressive. It would appear that the utilization of remote sensing imagery for the construction of environmental maps which could then be used for the testing of hypothetical settlement models is a reasonable expectation from studies of this type, and the preliminary model developed below by Miller and Walls represents the first major step in this direction for the interpretation of the archeological settlement patterns in the upper central Tombigbee River Valley.

REVIEW OF LITERATURE

Literature which deals specifically with practical applications of remote sensing for location of "unknown" sites in the South is sparse. There are, however, several studies in other areas which have bearing on the general subject. Martin (1971), working in the Rhineland of Germany, found that in that humid climate, porous soils will have more obvious site locations in a wet year. On loessial soils the best identification was made during a soil water desorption cycle following a period of precipitation. It should be noted that the study was made on cleared, agricultural lands. The work of Strandberg (1967) dealt with the combination of film, filter, scale, and time of day which would provide optimum signatures for archeological sites along the Missouri River in South Dakota. The author concluded that both natural color and color infrared imagery at a scale of 1:10,000 provided the best interpretation medium, although pan minus blue could also be utilized but with a greater time expenditure. No attempt was made by Strandberg to identify previously unknown sites. Gumerman and Neely (1972), working in the Tehuacan Valley in Mexico, utilized MacNeishs' Tehuacan Archaeological - Botanical Project as ground truth for a test of infrared imagery. The authors concluded that the greatest value of infrared imagery lay in the ability to delineate microenvironmental zones which, in turn, serve as a guide to location of cultural features. Abrupt changes in vegetative type or vigor were necessary before known sites could be identified. The authors also pointed out that many of the positive characteristics of infrared imagery were equally valid for panchromatic film, and that best results would be obtained by supplementing pan film with infrared. Another study which suggests the use of a combination of sensors is that of Gumerman and Lyons (1971). Using known sites in Arizona and New Mexico, the authors concluded that panchromatic film used in conjunction with black and white prints of color infrared negatives supplied the maximum information output concerning prehistoric modifications of the environment. One of the more extensive recent bibliographies in the area of archeological application of aerial photography has been prepared by Kruckman (1972).

STUDY AREA

The study area lies between the general vicinity of the junction of the Luxaphalila and Tombigbee Rivers, and Aberdeen, Mississippi. The great majority of the area lies within the floodplain of the Tombigbee River and its associated older terraces. (Figure 1).

The study area does, however, pass through two different ecosystems recognized by Miller, et. al. (1973) in a previous study. The Tombigbee Sand Hills Ecosystem extends south from Aberdeen, Mississippi to a point on the river approximately 2.8 miles west of Columbus Air Force Base. This Ecosystem was formed by the cutting of the Tombigbee River into the Tombigbee Sand Member of

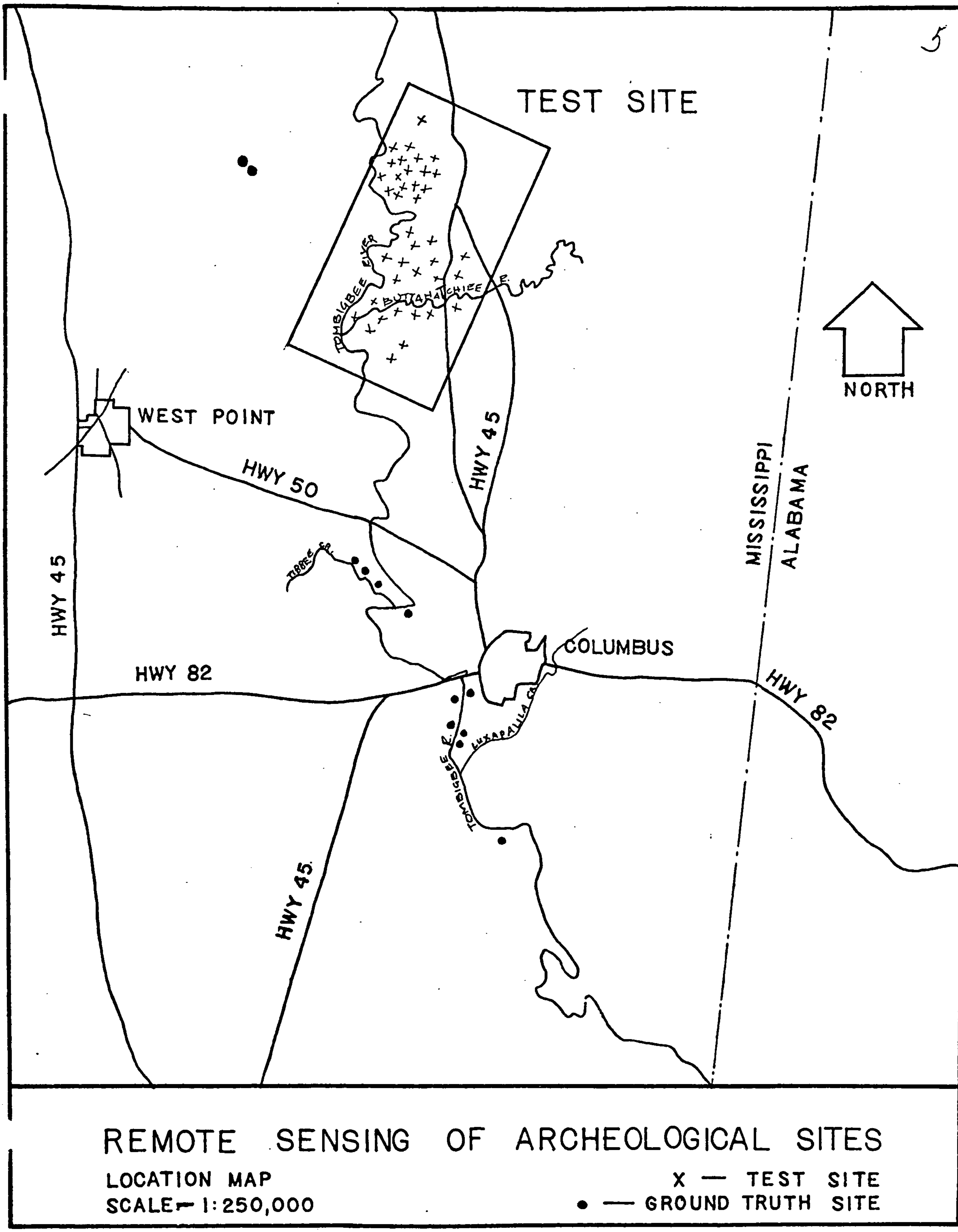

5
TEST SITE
TOMBIGBEE RIVER
BUTTAHATCHIE R.
NORTH
WEST POINT
HWY 50
HWY 45
HWY 45
HWY 45
MISSISSIPPI
ALABAMA
TIBBEE CR.
COLUMBUS
HWY 82
HWY 82
TOMBIGBEE R.
LUXAPALILA CR.
REMOTE SENSING OF ARCHEOLOGICAL SITES
LOCATION MAP
SCALE — 1:250,000
X — TEST SITE
● — GROUND TRUTH SITE

FIGURE 1

the Eutaw Formation, leaving a large terrace on the east side of the river and developing a bluff on the west side. The area is generally characterized by parallel to subparallel drainage patterns on the Mooreville Chalk Formation which lies from two to four miles west of the river. The area is also characterized by the well developed dendritic patterns on the Tombigbee Sands immediately to west of the river, and the weakly developed dendritic patterns on the acid terraces immediately east of the river. In the bottomlands, the cypress-tupelogum association is very prevalent and overcup oak frequently occurs. The major bottomland species are cherrybark oak, water oak, willow oak, sweetgum, and various elms.

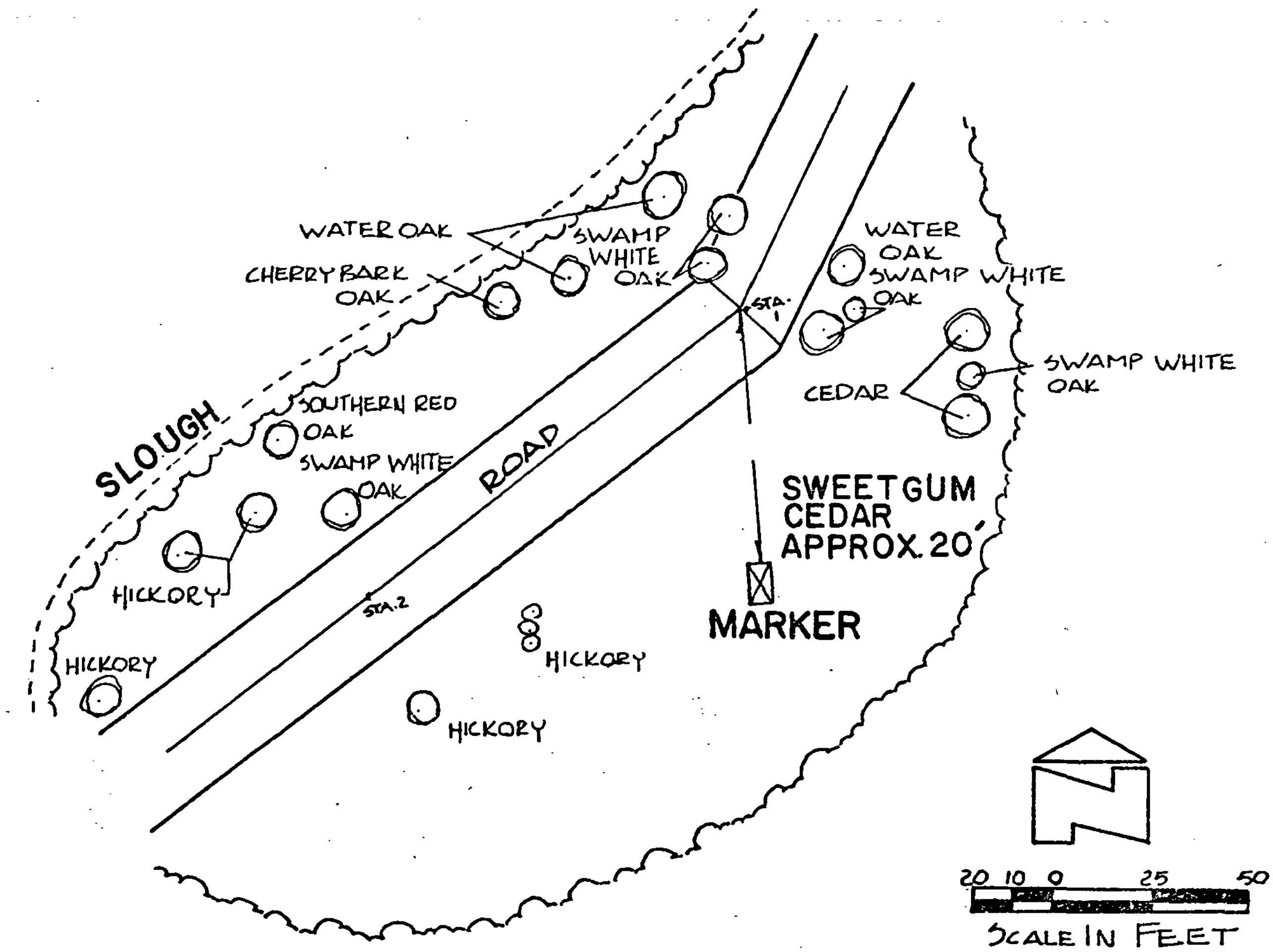
The Prairie Ecosystem is the other major ecosystem in the study area, and the uplands are characterized by gently rolling, subdued terrain with poorly and somewhat poorly drained clay soils derived from marls and chalks. Narrow ridges on interstream divides may be capped with acid clays; the so-called "Post Oak Prairie" soils. In this area the river cuts through the Tombigbee Sands just north of Columbus, Mississippi, and flows through the Mooreville and Demopolis Chalk Formations. The calcareous influence is pronounced in the area and the river achieves its maximum width for the study area. Broad meanders are characteristic and large oxbow lakes with associated cypress-tupelogum are quite common. Common bottomland species are similar to the previous region, but silver maple largely replaces red maple in areas along the river.

PROCEDURE

Although two potential methods of archeological site location were to be investigated, visual interpretation and multispectral scanning, the MSS was not obtained and consequently this report deals only with the method of visual interpretation of color infrared imagery. Flights were obtained from NASA, Marshall Space Flight Center, on March 14, 1974, and June 20, 1974. For both Missions, color infrared film was used in the primary sensor. The scale of the earlier flight was 1/12,000 and 1/6,000, and the later flight was taken at 1/12,000. The data quality was acceptable. Coverage from NASA Mission 215, Site 293, was used as a supplementary source of data. Immediately prior to the first flight, a field crew consisting of personnel from the Departments of Forestry and Anthropology visited 12 pre-selected archeological sites, and marked each area with strips of cheesecloth. Six of the sites were in a forested or partially forested condition, and six in an agricultural environment. All sample sites were of moderate size, with moderate midden concentration (2-6 in.); however, in certain areas, concentrations may be somewhat deeper. Minor mounding occurs on some sites, but with no pronounced topographic visibility. Only one site contains artificial earthwork. Within limits of the analysis of surface collections, periods of the site occupations are also approximately equal. All twelve sites have been classified village sites of a long-term, multi-component nature, and all fall within the period of occupation from Early Woodland to Early Mississippian. In the period following the first flight, the sites were re-visited and a plane table survey was made of each site. The surveys were referenced to some readily visible landmark in the vicinity, and maps were constructed at an original scale of 1 in. = 10 ft. (Fig. 2,3).

In addition to the known sites, an area which was known from previous ground surveys to contain occupation sites was also flown. No attempt was made to locate these sites prior to the study, and the area served as the test area within which the techniques developed in this work were evaluated for reliability.

FIGURE 2

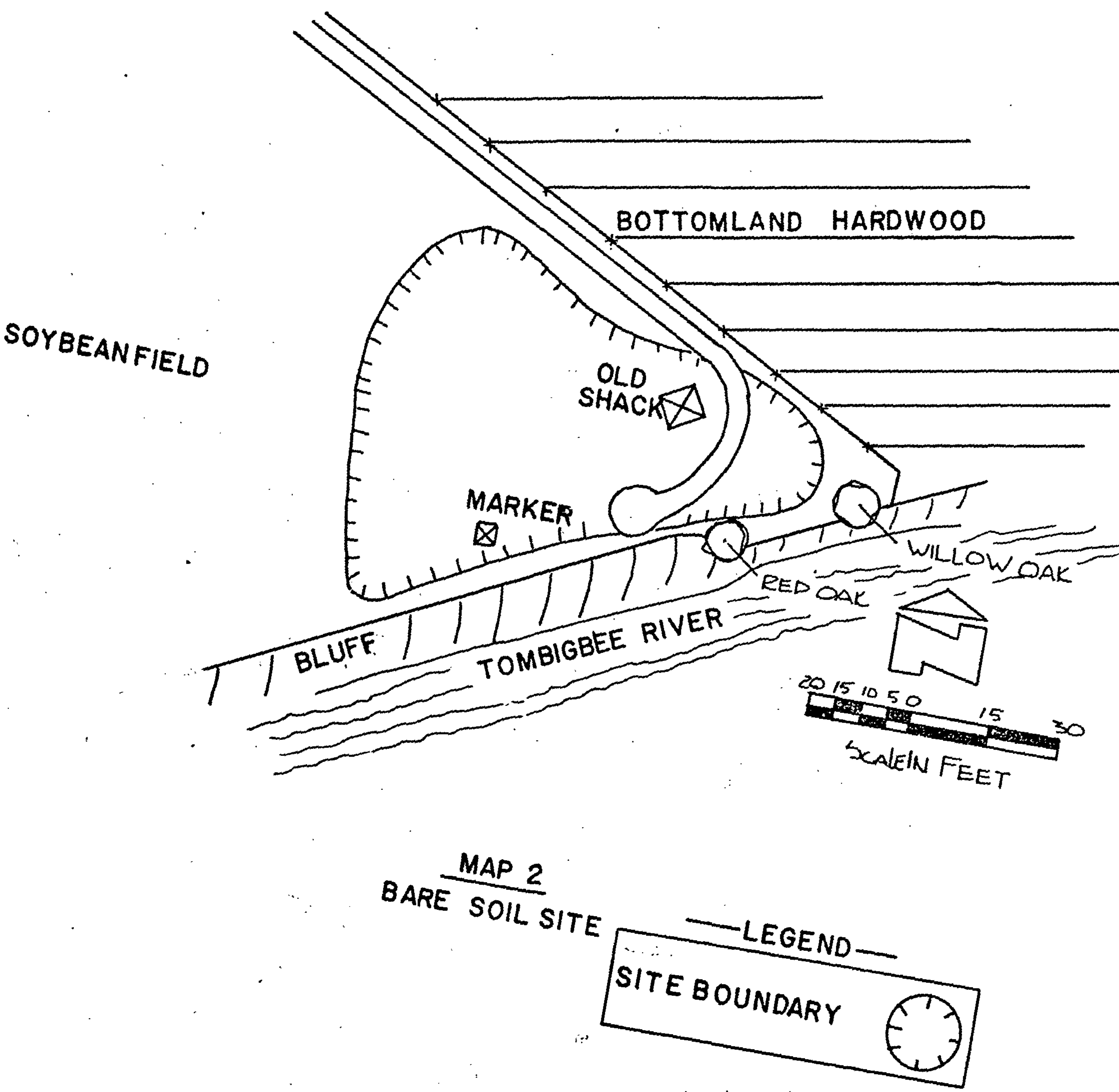


MAP I
VEGETATED SITE

LEGEND

MIDDEN BOUNDARY	
SLOUGH BOUNDARY	

FIGURE 3


BOTTOMLAND HARDWOOD
SOYBEANFIELD
OLD SHACK
MARKER
WILLOW OAK
RED OAK
BLUFF
TOMBIGBEE RIVER
20 15 10 5 0 15 30
SCALE IN FEET
MAP 2
BARE SOIL SITE
LEGEND
SITE BOUNDARY

An undergraduate student majoring in Anthropology, Mr. Michael D. Walls, was introduced to the concept of terrain analysis with specific reference to color infrared imagery. The known sites were examined with particular attention being focused on site locations relative to prominent terrain features such as old meander scars and oxbow lakes. Where visible, soil characteristics indicating relative wetness classes were also examined, as were vegetation differences between the occupation sites and surrounding terrain.

A preliminary predictive model based solely on topographic factors was prepared. After examination of known sites on the June imagery, a predictive model based on soil and vegetative indicators was prepared.

Following development of the models, the test area was examined and areas for which the models indicated a high probability of site occurrance were identified. The identification process proceeded along the following general guidelines:

(1) An initial scan of the test area to detect obvious color anomalies in agricultural areas was made.

(2) Areas of obvious topographic relief within the alluvial plain were examined to determine if these areas met other topographic criteria.

(3) Areas in the vicinity of, and adjacent to, meander scars and oxbow lakes were carefully examined and evaluated on the basis of the various criteria.

Field verification of the areas followed.

RESULTS

Model Development

The models developed in this study are designed only to indicate the probable locations of long-term occupation sites which were based on farming activity. However, a site utilized primarily for other activities such as defense but which also met the requirements for subsistence on a farming level would have a high probability of being identified.

Because much of the model development is dependent upon the nature of the settlement activity, certain assumptions concerning settlement patterns are necessary.

A location should exhibit certain edaphic characteristics, somewhat modified by the cultural repertoire of the society, before it would be considered as a probable site. Additional imposed cultural criteria, such as defense, may further act to modify the final choice of a location, but settlement will occur only when the site is acceptable for the major activity intended.

For the purposes of this study, the settlement assumptions were made. Other criteria could be considered equally as important, but it seemed advisable to place as few restrictive requirements upon location as possible in order to minimize errors due to incomplete knowledge of conditions during occupation, and due to our own cultural biases. The following list of assumptions provides the framework within which the models were developed. A better understanding of aboriginal farming settlement patterns will modify these assumptions.

Assumption I. Adequate supplies of potable water must be available to support the population without a great expenditure of effort.

Assumption II. Some protection must exist from the danger of inundation by light to moderate flooding by local streams, and there should exist some escape route during periods of severe flooding.

Assumption III. The site must be adequately drained, both the occupation site and the field areas adjacent.

Assumption IV. Because of the above criteria, there exists a strong tendency for a site to have occupancy by several cultures, either continuously or intermittently.

The assumptions were based upon study of a number of known sites in the study area, and are designed to reflect the requirements for a predominantly farming culture. Multiple utilization of sites with time would indicate that these locations were considered optimum for that activity.

The Topographic Model

Because the first three settlement assumptions are terrain-related factors, major emphasis was placed on physical description of the terrain situation occurring on known sites. An intensive analysis of the imagery available for the study area allowed the interpreter to begin to develop an intuitive ability to site recognition and delineation. As data accumulated, the intuitive ability began to assume a more substantial form. Such an ability, however, is of little value unless the ability can be systematized and explained to other interpreters. Therefore, a preliminary interpretive Topographic Model was developed as a means of quantification.

The model was designed to identify those terrain situations which have a high potential for occupancy because the conditions fulfill the basic requirements for long-term subsistence as indicated by the four assumptions formulated above.

1. Sites on Streams

   A. Major Drainages

      Hypothesis #1. On larger streams, a site will be located on the natural fronts (or levees), secondary fronts, or other higher ground on, or close to, the banks of the stream. The secondary fronts are due to stream migration.

Hypothesis #2. A site is more likely to occur on the outside, or high bank, on a migrating stream than on the inside, due to the following characteristics of soils developed from accretion deposits:

a. low relief, poorly drained

b. lack of soil profile development and consolidation

c. danger of later river cutting, or isolation by chute development

Hypothesis #3. A multiple component site is more likely to be located on the downstream side of a bend while the recent, single-component sites will be located on the outside center of the bend.

Hypothesis #4. Confluence of smaller streams with a larger stream frequently creates higher depositional forms at the point of juncture. Some areas are almost always occupied, particularly when the tributary enters counter to the flow of the major drainage.

Hypothesis #5. When the free meander of a stream is checked by some less erosive geologic formation, a protected bend frequently develops. If there is reasonably easy access to the stream, the site will be located on the obstructing formation.

B. Tributary Drainages

Hypothesis #6. On smaller streams, sites will be located either at the confluence with a major drainage, or on older well drained terraces on the tributary lying behind the overflow area of the major drainage.

Hypothesis #7. Sites will lie well above flood stage on well drained areas. Such areas may be old terraces, secondary fronts, or erosional remnants of old geologic formations. Very old terraces, or uplands, with no recent alluviation are beyond the scope of this study, and are not considered here.

C. Overflow Areas and Floodplains

Hypothesis #8. Sites will border the outer, or upland edge of the overflow areas unless the series of secondary fronts occur within the overflow area.

Hypothesis #9. Early sites will fit the same criteria as those on active streams since they were probably occupied when the active channel was in the immediate vicinity.

Hypothesis #10. Sites occupied after the meander was rendered inactive will frequently be located on the inside center of the scar.

Hypothesis #11. In the case of multiple scars, or of land between a scar and an active channel, if the immediate area is sufficiently large and well drained, the site will occupy the widest point near the center of the area. It is assumed that minor stream drainage will exist adjacent to the sites, and that a stream drainage of some intermediate rank will drain the immediate vicinity of the site.

D. Land Form

Hypothesis #12. Filled-in stream scars of obvious antiquity may be treated as minor drainage features in terms of their site selection influence. The scars themselves, however, will always indicate poorly drained soils unsuitable for cultivation.

Hypothesis #13. Any local elevation increase over a limited area which is not readily explained by depositional or erosional processes may be assumed to be of human origin, until ground survey or other data prove otherwise.

The relationship between the hypotheses of the Topography Model and the settlement assumptions stated earlier is generally clear. Equally clear is the interrelationship between the selection criteria. Some criteria overlap in their application and sites within the research area and are generally indicated by several discreet topographic criteria.

Vegetative-Soil Factors - A Supplementary Model

Without substantiation by the multispectral scan data, it is felt that the vegetation and soil indicators of site locations are too imprecise to be accorded equal status with the Topographic Model; therefore, this model should serve only as a supplement. The supplemental role of vegetation and soil does not run counter to the predicted importance of the various parameters. Archeological experience indicates a priority being placed on topographic factors in terms of subsistence requirements and social interaction. The changes which are brought about by settlement are largely responsible for factors discussed in the supplemental model; therefore, these factors played no role in the initial selection process. Thus the supplemental factors are indicators of disturbance or actual degree of utilization of the sites, and serve as an enhancement of signatures indicative of settlement.

Within general limits, the occupation of an area by any of the aboriginal cultures of the region would produce much the same debris buildup. The size and intensity of the buildup would depend upon occupational duration and intensity. This buildup, called midden when visually distinct from surrounding soils, consists of human excrement, trash from manufacturing activities, scraps from cleaning and butchering game, cooking debris, vegetable material from numerous sources, bodies of the dead, and numerous other components. This organic deposit is quite different from the organic-rich mucks of a marsh or slough remnant, in that there is a higher percentage of phosphorus, potassium, and amino acids from the faunal remains.

The well-drained nature of most sites indicates that soil weathering processes have been active, thus hastening decomposition of faunal remains. However, the depth of many deposits has inhibited full development of the soil profile and archeological strata rarely correspond to soil horizonation. The sites often offer a sequence of strata from a buried soil profile to post-occupational surfaces.

This general discussion of the physical aspects of site deposits indicates numerous differences from surrounding soil pedons. Many of these differences are beyond the scope of the present study, both in time and expertise, but offer excellent research opportunities for later work. Those of immediate utility are discussed below.

Soil Indicators

Hypothesis 1: Sites will be located in areas of good to excessive drainage; usually at the best drained location available in a desirable area as defined by the Topographic Model. Drainage may be due to the nature of the topography or of the underlying soil, but will most likely be due to topography.

Hypothesis 2: Within the alluvial plain, changes in the nature of the alluvium are frequently denoted by color changes. Care must be taken to distinguish between the conditions conducive to settlement and those of similar appearance but which are not conducive. For example, dark-colored soils frequently indicate poorly-drained conditions, and provide strong negative evidence of site location in an area.

Hypothesis 3: Cresent-shaped areas of light-colored soil separated by areas of darker soil of slightly lower elevation denote a bar-and-swale system formed by migration of a river bend. When sufficiently mature, the bars may provide habitable ground on the higher portions.

<u>Hypothesis 4</u>: Circular areas of lighter-colored soil within an area of darker, more poorly-drained soils denote slightly higher ground suitable for habitation if other criteria are met.

<u>Hypothesis 5</u>: Lighter areas along banks of streams or terrace edges that exhibit slight elevation increases may indicate well-drained areas suitable for habitation. Care should be taken to distinguish between such areas and recently deposited alluvium.

<u>Hypothesis 6</u>: Darker areas indicate either high organic content of the soil or high moisture content. Those distinguishable by their minor topography from poorly drained or post-aquatic soils can be assumed to be of a cultural nature if the total area is small enough. An area larger than two acres is not likely to be a settlement site.

<u>Hypothesis 7</u>: If a mottling effect of darker areas within a generally dark area such as described above occurs, recent activity may have exposed trashpits or similar cultural features of the site, assuming the general area is slightly elevated.

The degree of probability in detecting past occupation by soil indicators is not as high in the South as in more arid climates. To a large degree, soil indicators function best as negative evidence. For the stated settlement activity, it is easy to eliminate large areas of the alluvial plain from consideration because of the poorly-drained nature of the soils. Likewise, several classes of potential sites can be eliminated by examining soil moisture.

The positive aspects fall into two categories. First, some guidelines are available for terrain features, such as large, relatively level sections of old terrace, not covered to a large degree by the Topographic Model. Second, under certain conditions it is possible to state with a high degree of probability that a site does indeed exist at a postulated location.

Vegetative Indicators

Hypothesis 1: The enriched nature of midden soils gives an increase in rate of growth of vegetation. This is most noticeable in the early spring. Thus, an anomalous early growth or an especially vigorous growth of plants over a fairly small area may be indicative of a site.

Hypothesis 2: The ability of organic soils to retain moisture will tend to promote more uniform growth rates through minor fluctuations in rainfall. Thus, areas with uniform growth may be occupational sites.

Hypothesis 3: Textural changes in otherwise uniform vegetative cover, especially in the form of enhanced growth, is probably an indication of a site with appreciable midden deposits.

Hypothesis 4: Those characteristics which led to aboriginal occupation of that area have frequently led to American occupation of the same area. Thus the majority of sites in the alluvial bottom are in locations utilized for crops or other exploitation in recent times.

A major difficulty in evaluating vegetative indicators arose in our sample. In the southeast the archeologist finds it almost impossible to locate sites in the dense vegetation, but must depend upon cleared land, such as fields. As a result, there is a skewed sample of known site locations. Although it seems likely that Hypothesis 4 is correct, the built-in bias will not allow a definite conclusion. The relative lack of sites for study under forest cover other than pine plantations also preclude any real conclusions about species preference or differential growth.

Model Testing

The test area, located between Aberdeen and Columbus, Mississippi (Figure 1) was studied intensively on both the March and June imagery. A total of 62 occupation sites were tentatively identified and field checked. The laboratory identification procedure was to first utilize the Topographic Model, and then to verify it, if possible, with supplemental soil and vegetation factors. Again indicating the "cultivated land bias", 45 sites (72.6%) were selected from fields in row-cropping, 10 (16.1%) in pastures or recently abandoned farmlands, six sites (9.7%) in a forested condition, and one site (1.6%) in a residential area.

An analysis of the identification process indicates that on the average, three hypotheses were utilized to designate an area with a high potential for settlement. The number one priority for identification was one of the topographic hypotheses in 79% of the areas, and a soil hypothesis the highest priority in 21% of the areas. In no instance was a vegetation indicator considered as having the highest priority in identification.

Of the 62 areas designated and visited, 52 sites (84%) were verified as being settlement sites, 9 areas (14%) were not verified as being sites, and 1 area (2%) was classified as a doubtful site. This site was classified as doubtful due to the dominant influence of historic occupation.

A more detailed analysis of the identification factors utilized in correct identification again indicates the preponderance of the topographic hypotheses; 76% of the areas had as a highest priority a topographic factor while a soil factor received first priority on 24% of the areas (Fig. 4). Irrespective of the priority level, topographic factors were cited 71% of the time; soil factors 24%; vegetation 5%. Of the topographic hypotheses, the most commonly cited was #13, local elevation differences (26%), followed by #7, terrace position (24%), and #11, location between scars (18%). An examination of those predicted areas which did not contain sites indicates that caution must be exercised in using Hypotheses 2 and 13. Of the nine areas identified which did not contain sites, four utilized Hypothesis #2 as the first priority factor, four utilized #13, and one utilized a vegetative indicator. Thus the need for additional revision of the Hypotheses is indicated.

SUMMARY AND CONCLUSIONS

Based on an intensive visual examination of terrain conditions in and adjacent to 12 known settlement sites in East Central Mississippi along the Tombigbee River, a Predictive Topographic Model was developed. This development was followed by the preparation of a Supplementary Model based on soil and vegetative factors. The concepts developed in these Models were utilized in the analysis of a test area containing settlement sites for farming activities of unknown location. Imagery used throughout the study was supplied by NASA - Marshall Space Flight Center and consisted of color infrared positive transparencies at scales of 1:6,000 and 1:12,000 taken in March and June, 1974.

Within the test area, 62 potential site areas were identified and field checked. A predictive accuracy of 84% was achieved with field verification of 52 sites. Nine areas were not verified as settlement sites and one area was considered doubtful due to the extensive influence of historical occupation.

An analysis of the frequency of use of hypotheses within the Topographic Model indicates that there is a high probability of settlement areas occurring in the vicinity of meander scars or oxbow lakes. There is also a high probability of occurrence on locally elevated ground, provided, however, that this situation is substantiated by supporting criteria such as size of the area, and soil and vegetation factors; half of the probable areas not verified by field examination utilized local elevation as a primary selection criteria.

Based on the results of this study, it was concluded that visual interpretation of color infrared imagery of scale 1:12,000 will indicate terrain-related areas which have a high probability of containing Early Woodland - Early

Mississippian settlement sites. It was further concluded that, although 84% of the predicted areas contained sites, refinement of the Models by additional sampling would result in a practical tool for archeological reconnaissance in the alluvial valley ecosystems of the Southeast.

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