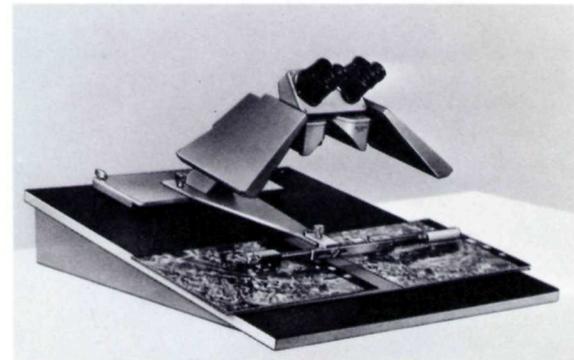


# REMOTE SENSING

## Archeological Applications of Remote Sensing in the North Central Lowlands



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**Craig Baker**  
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## Preface

This supplement is designed for use with *Remote Sensing: A Handbook for Archeologists and Cultural Resource Managers*, by Thomas R. Lyons and Thomas Eugene Avery. The handbook may be obtained by writing the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

Within the next several months, the National Park Service will publish other supplements to the

handbook dealing with regional applications of remote sensing for the archeologist and cultural resource manager. The reader may receive notification of these publications as they become available by writing the Superintendent of Documents (address above) and asking to be placed on mailing list N-557.

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## Introduction

Aerial photographs of Cahokia, a large Mississippian site near St. Louis, mark the birth of archeological applications of remote sensing in North America (Rowe, 1953:907-908). Those first aerial photographs of Cahokia were taken by Wells and McKinley in 1921 and 1922. In April of 1922, another individual, Lieutenant George Goddard, also took several photographs of Cahokia from an airplane. Over 50 years later, it was suggested that these early investigators probably had no knowledge of each other's activities (Fowler, 1977:65).

If, however, those early pioneers of aerial photography in archeology had the opportunity for rebuttal, they might well state that at present many

cultural resource managers in the Midwest have no idea of what others have done, or may be doing, with archeological applications of remote sensing!

The objective of this midwestern supplement to *Remote Sensing: A Handbook for Archeologists and Cultural Resource Managers* (Lyons and Avery, 1977) will be to present a discussion that should help resolve this problem. We attempt to provide the cultural resource manager, the archeologist, and the historical investigator with the basic principles of remote sensor data gathering, especially as they are appropriate to the midwestern environment and archeological remains.

## Section 2

# The Physiographic Area

The area of concern for this supplement on archeological applications of remote sensing is defined by the overlap of the interior plains (Goode, 1976:78) and the archeological area referred to as the eastern woodlands (fig. 1). For convenience, this area is referred to as the Midwest, and includes the following states: Minnesota, Wisconsin, Michigan, Iowa, Illinois, Indiana, Ohio and Missouri.

The area boundaries used in this report closely approximate the physiographic province known as the central lowlands as defined by Hunt (1967:206), which are different from the central lowlands of Fenneman (1938:449) and the interior lowlands of King (1959:Plate I). Although most authors agree on the physical characteristics of the province, their boundary definitions differ.

The Midwest is drained by the Mississippi River and its tributaries, the Ohio, Missouri, Illinois, Wabash, Des Moines, Wisconsin and others (fig. 1). Most of the area is characterized as plains country, of low elevation and slight local relief. The area is covered by a mantle of glacial deposits that mask the underlying strata of broadly warped sedimentary rock formations. The foundation materials of the central lowlands consist of Paleozoic sandstones, limestones, conglomerates, shales, and coal. These are nearly horizontal strata, and thin by comparison with the same formations underlying bordering mountain provinces (Atwood, 1940:188; Hunt, 1967:205).

There are five subprovinces within the central lowlands. These include the Great Lakes section, the small lakes section, the driftless section, the dissected till plain section, and the till plain section (fig. 1). These subprovinces are distinguished chiefly on the basis of differences in their glacial histories. Fenneman (1938) and Hunt (1967) provide a detailed discussion of these subprovinces.

## Landforms

Much of the area is characterized by land forms that are the result of glacial drift. These include terminal moraines, recessional moraines, ground moraines, drumlins, outwash plains, valley trains, kames, and eskers (Atwood, 1940). However, preglacial features such as natural bridges, arches, buttes, and rock towers are present.

The spatial distribution of classes of land-surface forms, according to the classification of Hammond (1964), are shown in Figure 2.

Cultural resources in the Midwest are often associated with rock shelters, beaches of glacial lakes, low terraces of large rivers, bluff summits, and bluff slopes. The relationship between settlement patterns and land forms in the Midwest have been discussed in Benchley (1976), Brose (1976), Brown and Cleland (1968), McGregor (1957), Roper (1974), Streuver (1968), and Winters (1967).

## Climate

An understanding of climate is important for the application of remote sensing in any region in that it is a major controlling variable affecting ground cover and cloud cover. A humid microthermal climate throughout most of the Midwest, along with the presence of fertile soils, makes the region one of the most productive grain producing areas of the world. The northern states of this area have a humid continental (cool summer) climate type, while the southern portion has a humid continental (warm summer) type.



Figure 1 Physiographic Sub-Provinces of the Midwest.

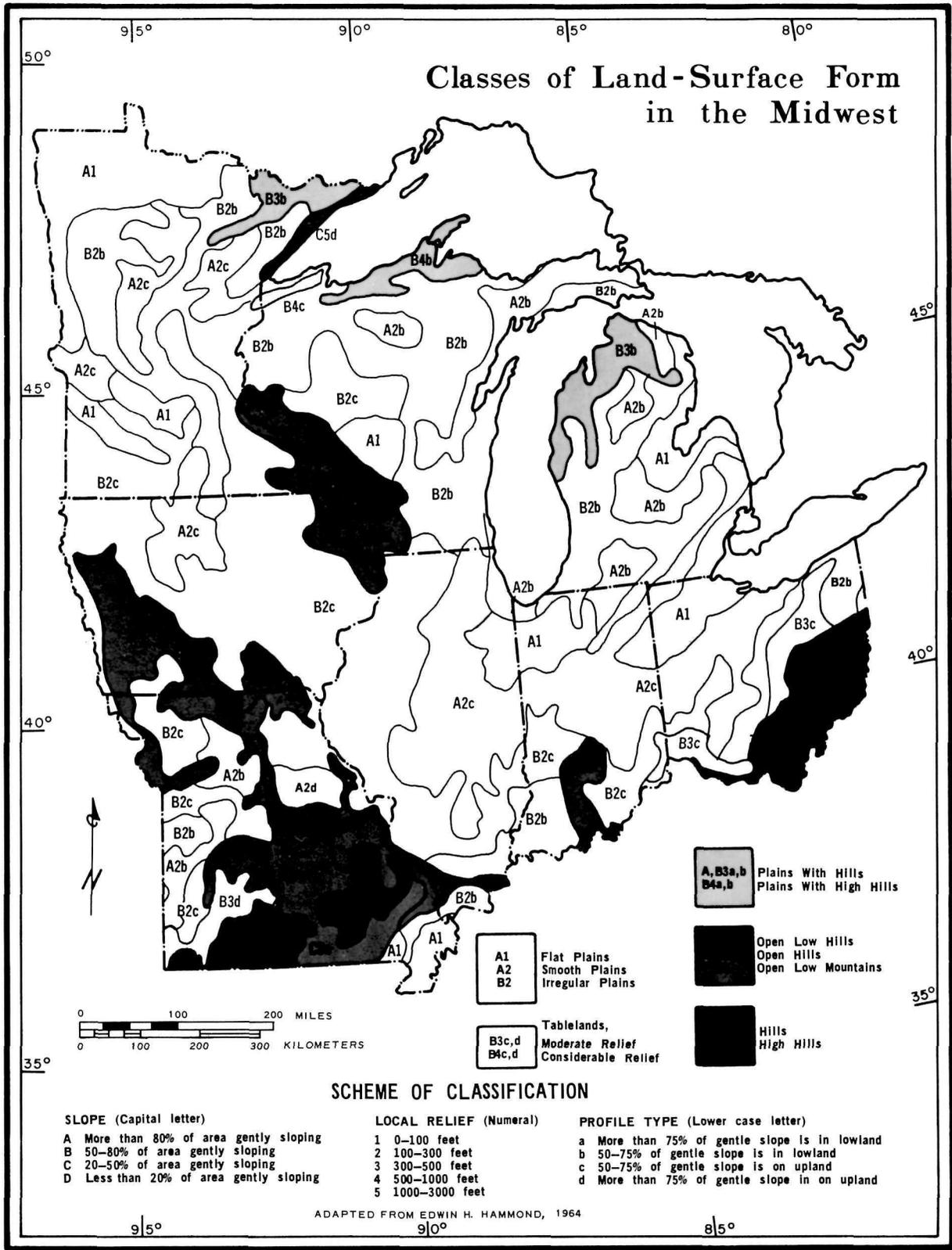


Figure 2 Classes of Land-Surface Form in the Midwest.

Average annual temperatures in the Midwest range from 35°-45°F. in the northern area to 45°-55°F. throughout the central and southern area. The freeze-free period is 100-140 days in the northern area and 140-180 days in the central and southern areas.

Annual precipitation varies from 20 inches in the northwest to 45 inches in the eastern and southeastern area.

## Vegetation

There are presently two views concerning the late glacial and early post-glacial natural vegetation of the central lowlands. The traditional view holds that vegetation maintained a zonal distribution in front of the ice sheet, with corresponding zonal cultural adaptations. The second view, supported by increasing evidence from ethnobotanical studies, suggests that the vegetation grew in a mosaic of boreal, deciduous, and grassland communities, with corresponding cultural adaptations to these ecological mosaics (Brown and Cleland, 1968:114).

Pre-modern natural vegetation of the central lowlands is characterized by a zonal distribution of vegetation communities (see fig. 3). These zones are the northern forests throughout northern Minnesota, Wisconsin, and Michigan. South of the northern forests is a broad zone of central hardwood forests, interspersed in central and northern Illinois with non-forested grasslands.

However, though early post-glacial and pre-modern natural vegetation are very important for understanding the ecological relationships of cultural adaptations in the Midwest, current semi-

natural and cultivated vegetation communities are by far more important for considerations of archeological applications of remote sensing. These present vegetation communities will be discussed under the heading of land resource regions.

## Land Resource Regions and Soils of the Central Lowlands

Three major land resource regions are recognized in the Midwest. These include the northern lake states forest and forage region, the lake states fruit, truck, and dairy region, and the central feed grains and livestock region. These regions, along with sub-regions, are described and illustrated in Appendix I. They are based on the Soil Conservation Service classification (Austin, 1966). This classification serves as a useful index to guide remote sensing projects for several reasons. First, the present vegetation communities for smaller areas are indicated, as are the predominant soil characteristics and distributions. And second, the general relief and topographic characteristics are summarized by area. This classification documents many of the relevant variables affecting the utility of remote sensing techniques in different localities in the Midwest. This natural variability within the Midwest indicates that there can be no predetermined cookbook formula for guiding the efforts to acquire remotely sensed data that is applicable to the midwestern region as a whole. Rather, it suggests that each project must take into consideration the specific vegetation, soil, and climatic conditions unique to the study area, as well as the nature of historic and prehistoric cultural resources present.

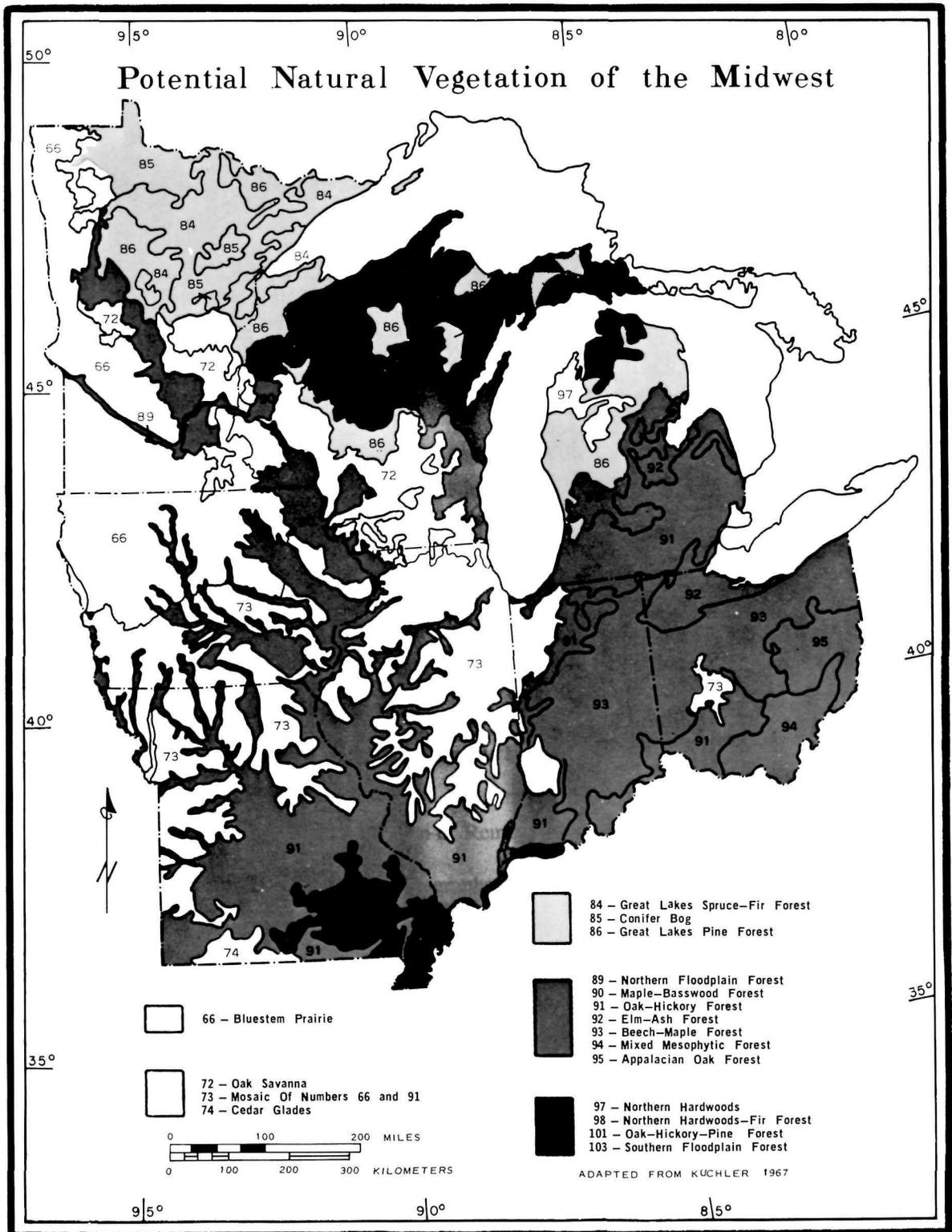


Figure 3 Potential Natural Vegetation of the Midwest.

## Section 3

# Scientific and Managerial Problems of the Midwest

It should come as no surprise that past and present activities of our own socio-cultural system pose the greatest continuing threat to the cultural resources present in the central lowlands. A favorable climate and fertile soils make the region ideal for both intensive and extensive cultivation. In many areas, sites and earthen mounds have literally been plowed away. Monitoring, or even assessing, the rate of destruction to prehistoric cultural resources resulting from cultivation practices is complicated by private land ownership. Several experiments have been conducted on plow zone archeological data (McManamon, 1976; Roper, 1976; Rudolph, 1977; Sterud and McManamon, 1976; Trubowitz, 1976; Weide, 1976). In addition, Tandarich (1975) has experimented with the use of multi-date United States Department of Agriculture (USDA) vertical aerial photographs to estimate the rate of destruction to known mound sites caused by cultivation.

The inevitable expansion within and around population service centers compounds the threat to cultural resources of the central lowlands. New subdivisions gobble up land previously under cultivation, while the wrecking boom of inter-city development casts an ominous shadow over the architectural historian's back. Benchley (1976) provides an example of an approach cultural resource managers may take to assess and forecast impact to cultural resources that occur in an urban environment. Cultural resource managers will also no doubt find the use of remotely sensed data, especially sources of extant aerial photography, increasingly valuable for investigations conducted in areas of rapid urban change (Fowler, 1977).

Greater leisure time and improved transportation networks combine to increase the rate of

destruction wrought by the activities of collectors. Driving several hundred miles for a weekend of fieldwalking is not unusual. Since public landholdings in the central lowlands are minimal, it is not possible to simply legislate and police the conservation and preservation of cultural resources. In the Midwest, cultural resource managers must come to face the problem of educating the public and eliciting their cooperation in the preservation of scarce resources. An excellent example of enlisting public support is evidence by Struever's work in Illinois, but the careless destruction, willful potting, and unscientific surface collection continues. In the role of custodians of a portion of our nation's cultural heritage, we must offer an alternative to those drawn to participation in the previous activities. An ethnography of the surface collector or pot-hunter might provide useful insights and contribute to a solution that satisfies both conservation and preservation approaches, as well as the individual interests of the collector.

A discussion of the general managerial problems of the Midwest cannot be complete without some mention of the concept of significance. Despite the growth in publications that address significance (King, Hickman, and Berg, 1977; Plog, 1978; Schiffer and Gumerman, 1977), the boundary between sites that deserve preservation and those that do not remains vague. The recognition of a basic difference between a conservation approach (Lipe, 1974; Schiffer and Gumerman, 1977) and a preservation approach is useful. As preservationists, significance is defined on the basis of achieving the preservation of a representative sample of our nation's cultural heritage. On the other hand, as conservationists, we recognize the threat to scarce, non-renewable cultural resources, and advocate

strict conservation of all those cultural resources whenever possible. A preservation approach may be viewed as a subset of the conservation approach. Unfortunately, compliance with the preservation approach, as mandated by legislation such as the National Historic Preservation Act of 1966, Archeological and Historic Preservation Act of 1974, and Executive Order 11593, does not insure compliance with a strict positive conservation ethic. The realization of both preservation and conservation of cultural resources will be achieved only when the barriers to effective and efficient participation by the conservationists within the preservation framework are removed. Plog (1978) suggests that these barriers are primarily procedural, and that in point of fact, there is no real problem with the concept or definition of significance. This is simply another way of saying that if those with a vested interest in cultural resources, i.e., conservationists, are allowed to participate in the planning and decision making process of the legislated preservation approach, the goal of both conserving and preserving cultural resources may be obtained. This would allow the avoidance of cultural resources whenever possible, regardless of their significance or eligibility for the National Register.

Techniques used for the discovery of significant cultural resources are subject to several problems in the central lowlands. Preservation surveys (King, Hickman, and Berg, 1977:105), archeological surveys (Plot, Plog, and Wait, 1978; Schiffer, Sullivan, and Klinger, 1978), and cultural resource inventories conducted in the central lowlands must address variables such as the obtrusiveness, visibility, and accessibility of cultural resources (Schiffer, and Gumerman, 1977; Schiffer, Sullivan, and Klinger, 1978). In the central lowlands, visibility and accessibility are dominant problems. In those areas of heavy vegetation cover, forest duff may effectively mask the presence of cultural resources. Experiments in sampling techniques suggested by Lovis (1976) and Chartkoff (1978) offer alternative solutions to this problem. Alluvial deposits may also mask the presence of cultural resources and may be of such a depth that shovel testing or similar methods are ineffective techniques for discovering the presence of certain cultural resources. Cultural resource managers will no doubt find that experimentation with remote sensing devices is useful in resolving the above. In addition, the variability in crop cover throughout the central

lowlands, and the effects this variability has on the discovery of certain archeological sites must be addressed. These considerations will be discussed further under the heading of preliminary reconnaissance.

## The Use of Remotely Sensed Data for Resolution of Specific Archeological and Cultural Resource Management Problems in the Midwest

The previous discussion addressed some general scientific and managerial problems associated with archeological research and cultural resource management in the Midwest. In the following, we will discuss the use of remotely sensed data for addressing problems associated with various types of site discovery, site prediction, preliminary reconnaissance, and the definition and mapping of intra-site features.

Of obvious significance to the archeologists in the Midwest is the problem of site discovery. Unfortunately, although the use of various forms of remote sensing data, primarily aerial photography, has proven valuable as a means of site detection in other areas, little success has accompanied previous efforts to utilize aerial photography for site detection in the Midwest. Indeed, it is common to hear the following view expressed: "Aerial photography may work well for purposes of site detection in the Southwest, but we have a couple of things here in the Midwest that they don't have—trees and grass."

It is suggested that this view forms the basis of a widespread bias against the use of remotely sensed data as a tool for site detection in the Midwest. In order to understand, in part, why this bias exists, and whether it is justified, a brief consideration of those factors contributing to successful site discovery through use of aerial photography in the Midwest will be pursued.

Lyons and Avery (1977:59-62) have described four techniques that may be used to discover archeological site locations from aerial photography. These are: 1) the direct observation of structural features from imagery, 2) the interpretation of soil marks, 3) the observation of and interpretation of plant marks, and 4) the observation of shadow

marks. Each of these techniques will be discussed as they relate to the Midwest.

### Site Discovery Through Observation of Structural Details

Several circumstances limit the detection of prehistoric site locations through observation of structural features visible on aerial photography. Many prehistoric sites in the Midwest are essentially lithic scatters with no remaining evidence of structures or midden deposits. This is especially true of Paleo-Indian and early Archaic sites. The scale of resolution available on most aerial photography prevents the detection of these lithic scatters. Also, even when evidence of raw material used in the construction of prehistoric structures is present, this evidence is rarely preserved at or above the present ground surface. Biodegradation and historic and modern cultivation practices contribute substantially to this factor. Recall, for example, that earthen mounds have been literally plowed away.

There are, however, several exceptions to those limitations. Many previous archeological applications of remote sensing in the Midwest have focused on the discovery of earthen mound sites (e.g., Crook, 1922; Fowler, 1977; Goddard, 1969; Reeves, 1936; Tandarich, 1975). In fact, some of these historic aerial photographs, taken by individuals such as Dache M. Reeves and George Goddard, may provide the only source of data for discovering mound locations that have been destroyed subsequent to the original aerial photographs.

In a recent study, Tandarich (1975) used standard United States Department of Agriculture (USDA) aerial photographs to systematically delineate anomalous landforms in an area of Webster County, Iowa. He found that by checking the locations of these anomalous landforms with site records for the area, 19 landforms or groups of landforms were found to correspond to the locations of known mound sites. There were, however, 14 additional landforms that were not listed as known mound sites. Tandarich concludes that these latter anomalies are to be considered potential mound sites that were not discovered through traditional ground survey. If these anomalous landforms were not discovered on aerial photographs, many of the sites would have been misclassified as occupation sites when, in fact, mounds may have once been present at the locations (Tandarich, 1975:40).

The discovery of prehistoric cultural resources through observation of structural details visible on aerial photographs may be limited to earthen mound sites. However, this is certainly not true for historic cultural resources. Aerial photographs can be used to examine large areas in search of signs of particular types of historic features. For example, the University of Wisconsin used standard aerial photographs, along with United States Geological Survey maps and original Army surveyor's notes, to discover the location of a military road that served as an important communication link between Fort Crawford on the Mississippi River and Fort Howard at Green Bay (Tishler and Townsend, 1977). Aerial photographs are also useful for detecting the location of such historic features as stone fences, lime kilns, mine shafts, dams, abandoned railroad lines, and cemeteries.

As is the case with aerial photographs taken of earthen mounds in the 1920's and 1930's, older photographs of some areas may be the only means of detecting the locations of historic sites, since subsequent land modification activities may have destroyed all vestiges of the structural details of the feature.

## Site Discovery Through Observation of Plant Marks

Plant marks, in some situations, appear to be of limited value for use in detecting prehistoric sites of shallow deposition in heavily forested areas. The reason is that when cultural deposits are confined to a shallow lens near the surface and under a forest canopy, chances are those deposits will not differentially affect the growth rate of trees sufficiently to produce plant marks. This is the case where the root structure of individual trees exceeds the physical limits of the cultural disturbance, preventing the differential availability of nutrients.

Although trees do limit the use of remote sensing data, it must be realized that most of the Midwest is not forested. The Soil Conservation Service data (Austin, 1966) reveals that 64 percent of the area in the central feed grains and livestock region (see fig. 9) is under cultivation. In the lake states fruit, truck, and dairy region, 43 percent of the land is under cultivation. In the northern lake states forest and forage region, 16 percent of the area is cultivated. For the total area of the Midwest (approximately 379,700 sq. mi.), over one-half is under cultivation (Austin, 1966:39-51).

This information should assist in resolving some of the confusion concerning the utility of plant and crop marks for use in prehistoric site discovery. Clearly, for the Midwest region as a whole, trees and grass do not obscure most of the land surface. Further, it must be assumed that when the negative comment referred to in the beginning of this section is voiced, the individual voicing it has confused the potential natural vegetation with the present vegetation communities. Quite simply, to emphasize an important point, trees and grass do not obscure all prehistoric site locations in the Midwest. This is especially true for the area below the 45° latitude. The examples discussed below offer evidence to support this contention.

Crop marks have been useful for identifying site locations in the Midwest. For example, crop marks revealed the presence of a moat-type enclosure at the Ogden-Fettie site, a Middle Woodland site located in the central Illinois River Valley (Munson, 1967). Another example of plant marks revealing the location of a prehistoric site



**Figure 4** Horseshoe Site.

is found in southern Illinois at the Horseshoe site (fig. 4 and plates 6 and 7). In these photographs, four negative crop marks clearly reveal the location of a Mississippian site. Slightly less visible in Plate 6 is a large basin, surrounded by what appears as additional house rings.

The important point here centers on the example this series of photographs serves for purposes of site detection. What appear to be four house rings are indicated by plant growth anomalies, in this case, negative plant marks. It appears that the borders of the structural features inhibit natural plant growth. Conversely, within each slight depression defined by the four negative crop marks, differential plant growth is selected for.

In the absence of additional information, it must be assumed that this differential growth is the result of two related conditions. First, the slight depressions formed by the rings probably retain greater soil moisture than the surrounding area. This might be caused by the

presence of a prepared, compacted surface beneath each depression. Moisture is caught in the shallow basins, and effectively trapped, preventing percolation to subsurface strata. The additional moisture tends to foster greater root development, hence, plant growth during what is obviously the early growing season. Second, the fill contained within the rings may contain a higher content of organic material than the surrounding native soil. This increased organic content could well be the result of behavior activities associated with the site, or the result of perishable materials that once formed the super-structure of the features. The presumed increased amount of organic matter in the soil matrix within each of the four rings might, in association with the increased soil moisture, foster differential plant growth due to greater nutrients in the soil. This would explain the lush plant growth in the center of each cultural feature. We might expect that as the growing season progresses, plant cover may become more homogeneous. This latter

expectation serves as a reminder that *scheduling* of aerial photographic coverage is very important in *planning* missions and acquiring extant aerial photography.

Plant marks observed on aerial photography have also proven of value for detecting historic cultural resources in the Midwest. For example, during 1967, the Laboratory for Applications of Remote Sensing, Purdue University, conducted flights over a farmer's field on the Wabash Flood Plain in Tippecanoe County, Indiana. Infra-red imagery revealed a square anomaly (plant mark). Subsequent investigations of the plant mark led to the discovery of the original site of Fort Ouiatenon (1717-1791), a French and British trading post. Whether through accurate interpretation or luck, the aerial photographs were of primary importance in the relocation of this most interesting site and are valuable for that reason, if no other (Vergil Noble, personal communication, Nov. 16, 1977).

Recapitulating briefly, this discussion on the use of plant and crop marks for use as a tool in site detection has covered several important points. First, contrary to common belief, trees and grass do not obscure the landscape to such an extent that plant and crop marks are of no value for site detection in the Midwest. Second, examples have been presented in which the presence of plant marks have been instrumental in the location of both prehistoric and historic sites that could not be detected during initial ground inspection. As a result, it is concluded that plant and crop marks should prove of value for use in detecting sites in those areas of cultivation. However, for those areas of heavy forest canopy, plant marks are probably of little value in detecting site locations.

## Site Discovery Through Observation of Soil Marks

The observation of soil marks on aerial photography should prove to be of great value for use in prehistoric site detection in the Midwest, especially for sites occupied post-2000 B.C. There are two reasons for this. First, at about 2000 B.C., a trend in settlement and subsistence resulted in the recurrent occupation—produced site locations with considerable midden deposits (c.f. Ford, 1974). As

a result of the deposition of refuse high in organic matter, those midden deposits generally contrast in color sharply with the native soil matrix. Therefore, anomalies in soil composition, color, and spectral reflectance should assist in the discovery of prehistoric site locations with midden deposits.

Secondly, soil marks are most easily seen when they occur in cultivated areas, and they are especially vivid right after plowing of a fallow field (Lyons and Avery, 1977:61). This is an important fact considering over one-half of the land surface in the Midwest is cropped yearly. These soil marks may remain visible for hundreds of years, provided the buried feature or disturbed soil is below plowing depth (Lyons and Avery, 1977:61).

There are several examples of the use of soil marks for purposes of prehistoric site detection in the Midwest. An example of soil marks revealing extensive midden deposits is illustrated in Figures 5, 6, and 7. Plate 2 is another example of soil marks caused by midden deposits. In Plate 1 and Figure 8, soil marks reveal individual structural features. And finally, individual prehistoric cultural features are discernible in the field shown in Plate 5. Obviously, in each of these illustrations, the observation of the soil marks has been greatly enhanced by the occurrence of recent cultivation. These sites were photographed during the spring season, and in most cases, just a few days after plowing. Soil moisture was moderate during photographic sessions.

## Site Discovery Through Observations of Shadow Marks

The use of shadow marks for detecting prehistoric sites in the Midwest has not proven to be a productive technique. This may be the result of the fact that few prehistoric structural features exist above the present ground surface, with the exception of earthen mound constructions. Also, historic and modern cultivation practices in the Midwest have the tendency to gradually smooth away any morphological indications of cultural features that would produce shadow marks. However, shadow marks should be of use in detecting such historic cultural features as roads, stone fence lines, open-pit mines, and foundations of historic structures.



**Figure 5** Carrier Mills Site.



**Figure 6** Black and White Infrared Photograph of Carrier Mills Site.

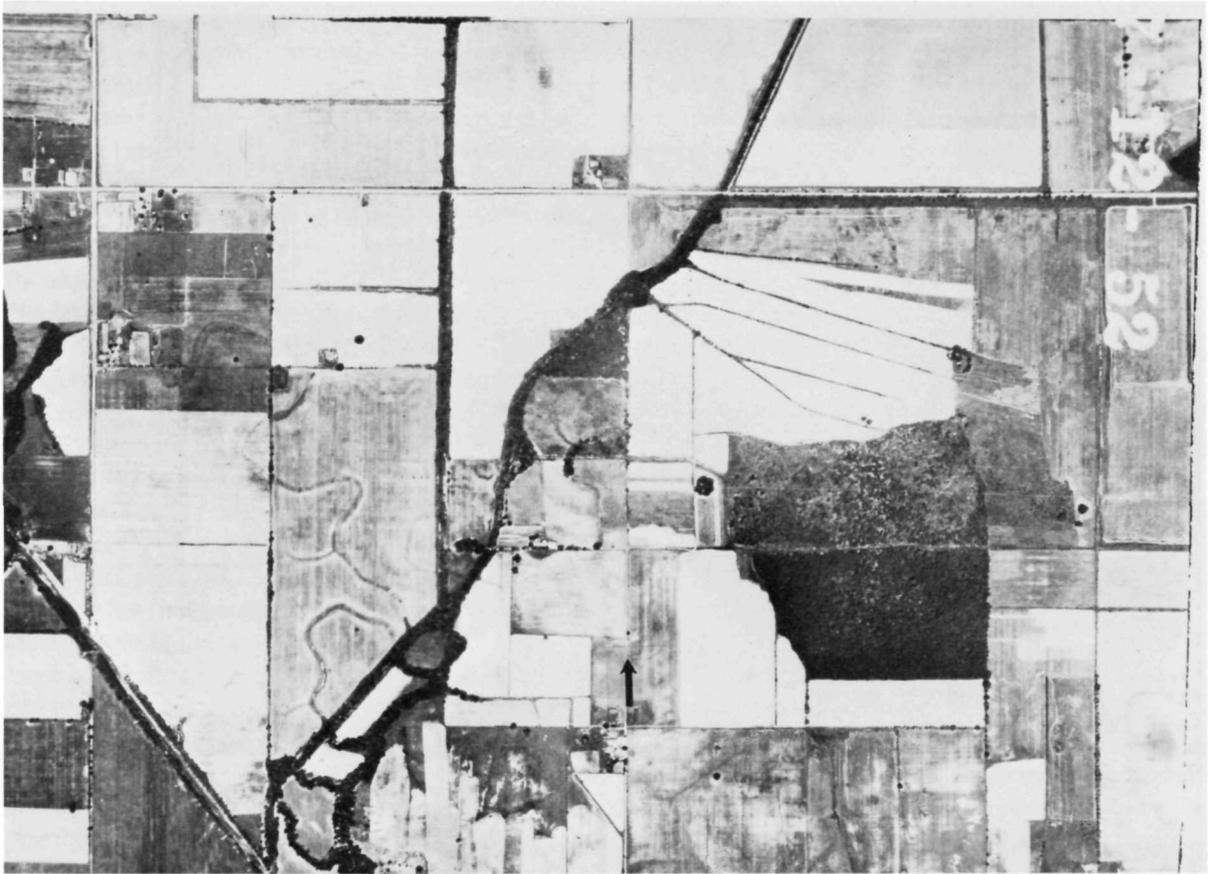


Figure 7 USDA Photograph of Carrier Mills Site.

### Concluding Comments on the Use of Remotely Sensed Data as a Tool for Site Discovery in the Midwest

We began this section by stating that there appeared to be a widespread belief that aerial photography does not work well for purposes of site detection in the Midwest. However, it is obvious that both prehistoric and historic sites can be discovered through the use of aerial photographs. Furthermore, we attempted to show that extensive areas of cultivation in the Midwest should facilitate the use of plant, crop, and soil marks on aerial photographs for purposes of site detection.

There are, of course, limitations that apply to the use of aerial photography for site discovery. For example, aerial photographs are of little value

for locating sites in areas of dense forest canopy. Also, aerial photography has not proven useful for locating certain types of sites, especially Paleo-Indian and early Archaic sites, since these are often lithic scatters, with no remaining evidence of structures or midden deposits. These limitations, though, are restricted, and should not prevent the use of aerial photography as a tool for site discovery.

And finally, our discussion concerning the use of remotely sensed data has itself been restricted to a consideration of aerial photography as a tool for use in site techniques. It should be recalled that additional remote sensing techniques applicable to the problem of site discovery are available. For example, at the U.S.S. Queen City Project, conducted by the University of Missouri, electromagnetic prospecting was carried out on a sunken

ironclad gunboat to detect and determine the extent of the site in the White River. Equipment included a Mark 7 underwater metal detector, a Raytheon fathometer, and an underwater television videoscanner system. These remote sensing devices permitted the location and mapping of a civil war gunboat. The turbidity of the White River at the location of the wreck prevents visual inspection by divers—thus, the remote sensing devices are the only means of ascertaining characteristics of the cultural resources (Erwan Garrison, personal communication, Oct. 18, 1977).

## The Use of Remotely Sensed Data for Preliminary Reconnaissance in the Midwest

Historically, the major applications of aerial photography in archeological research have been directed toward site discovery. However, aerial photographs and other forms of remotely sensed data are also of value for use in preliminary reconnaissance and exploration of a region (Brown and Ebert, 1978; Ebert, 1978; Gumerman and Neely, 1972; Lyons and Ebert, 1978; Schiffer, Sullivan, and Klinger, 1978). In the Midwest, where virtually all areas have been explored, mapped, surveyed, photographed, and described for various purposes, this is especially true. We will discuss several situations applicable to the Midwest for which preliminary reconnaissance of an area, through use of easily obtained aerial photographs, will prove of utility and value for the historian, archeologist, and cultural resource manager.

We are all aware that many investigations associated with cultural resources at present are of a contractual nature as a result of efforts to satisfy various state legislative requirements concerning cultural resources, the mandate of Executive Order 11593, the National Historic Preservation Act of 1966, the National Environmental Policy Act of 1969, and the Archeological and Historic Preservation Act of 1974.

We are equally aware that as a consequence of this increase in contractual obligations, institutions and organizations to which these contracts are awarded must now concern themselves with the presentation of sound, accurate budget proposals,

sufficient to finance the implementation of research designed to satisfy the legal and professional objectives of the cultural resource investigations. Of course, many considerations are taken into account when developing a research design for individual projects (Plog, Plog and Wait, 1978; Schiffer, Sullivan, and Klinger, 1978; Schiffer and Gumerman, 1978). These factors include the size of the study area, the sample to be taken of the area if a complete survey is not planned, the objectives of the agency or organization awarding the contract, the research objectives of the contractor, previous research in the area, and the nature of prehistoric cultural resources within the area of concern.

In these initial planning stages, some sort of graphic representation of the study area, such as a United States Geological Survey (USGS) topographic map, is often utilized to provide data for sampling strategies, plotting survey transects, planning ground crew access, etc. Unfortunately, topographic maps often do not provide critical types of information and detail available on aerial photographs. For example, if an emphasis is placed upon the use of both the cultural resources within a region and the artifacts present on the surface of sites within the region, preliminary development of sampling designs by necessity must consider the present ground cover of the area. The question is, how does a surface collection taken from a site situated in a field of mature soybeans compare to a collection taken from a site in a pasture of tame and native grasses or a site in a recently plowed field? Obviously this is not a trite matter, since we have already indicated that over 50 percent of the area in the Midwest is under cultivation. The variability in data recovery resulting from present ground cover, its effect on site discovery and surface collections, simply cannot be ignored.

Data concerning present classes of ground cover may also be of use for scheduling field work. Ground visibility and survey progress may be maximized by anticipating present ground cover, and subsequent scheduling of fieldwork.

Fortunately, standard USDA aerial photographs exist that indicate the current ground cover. The photographic coverage available may be several years old, but there is still a relatively accurate estimate of the areas under cultivation. Measurements on areas of specific classes of land cover may be taken directly from contact prints in regions of level to gently rolling topography (Avery,

1966:76). Several methods may be used to acquire these area measurements. Dot grids are the easiest and least expensive to use, as they require only a grided overlay (Avery, 1977:76; Avery, 1966:24; Lyons and Avery, 1977:21). Polar planimeters, also referred to as areameters, though more expensive than dot grids, are also easily used on aerial photographs to determine area measurements (Avery, 1977:77).

In summary, aerial photographs are of utility for solving several different problems addressed during preliminary planning of most research designs within the Midwest. They serve as a valuable source of information concerning present land use, which in turn can be used to construct sampling designs sensitive to the given land cover conditions. In addition, aerial photographs are valuable for planning survey access routes, plotting probable transects, and delimiting areas of planned reconnaissance. Further, the data available on aerial photographs is of use for scheduling the anticipated ground activities. All told, cultural resource managers and archeologists can no longer afford the luxury of waiting to get into the field to determine the kinds of conditions that will be encountered. This is not efficient, nor does it satisfy the obligation to the public interest of economizing and making fuller use of resources available for practical cultural resource management.

Historical investigators may also profit from the use of aerial photographs for purposes of preliminary reconnaissance. For example, the Historic Preservation Workshop at the University of Wisconsin examined U.S. Department of Agriculture Soil Conservation Service (SCS) aerial photographs before beginning field investigations. Early plat maps of the study region are first analyzed to locate remote vernacular log and stovewood structures built during the late 1800's and early 1900's by settlers in northern Wisconsin. The SCS aerial photos are then checked to determine if the structures on the plat maps still exist, whether they have been modified and if they are accessible (Tishler and Townsend, 1977:38). This preliminary reconnaissance permits large areas to be covered with less time and money spent on field investigations.

## The Use of Remotely Sensed Data as a Tool for Mapping and Defining Intra-site Features

In the preceding discussion, it was suggested that remotely sensed data were useful as a means of site discovery and as a source of data applicable to a variety of problems addressed during preliminary reconnaissance of an area. Remotely sensed data are also available in defining and mapping intra-site features as indicated by the following examples.

Aerial photographs taken of the Cahokia site (located along the Illinois side of the Mississippi River near St. Louis) assisted in the identification of an anomalous feature subsequently identified as a palisade. Without the photographs, the uncovering and detailed studies of the palisade would have been a chance occurrence (Fowler, 1977). Fowler also used aerial photographs, taken during a period spanning over 50 years, to locate earthen mounds, many of which had never been observed or recorded in the 100-year history of investigations at Cahokia. Aerial photographs also provided information on the locations of mounds that no longer exist, thereby assisting in the mapping of principal features of this huge site. Obviously, those same aerial photographs now provide the only source of data for establishing the size and shape of these now destroyed earthen mounds.

Aerial photography of Cahokia was also used to construct an aerial photogrammetric map of the site. Since Cahokia is estimated to cover 6.5 sq. mi., this was the most economical and efficient way to map the principal features of the site (Fowler, 1977).

Research conducted at the Angel Site, located on the Ohio River in southern Indiana, also utilized aerial photographs for defining intra-site features (Black, 1967). During the investigations conducted in 1939, ground observation revealed several areas where there appeared to be sharp lines of distinction between communities of semi-natural vegetation. Examination of a USDA aerial photograph taken of the site in 1938 provided a synoptic perspective from which these anomalies could be observed in their spatial context (Black, 1967:59). Mounds, ramps, stockade lines, historic features and disturbances, and present vegetation

were plotted on the USDA photograph, permitting, as was the case with research at the Cahokia site, investigations directed toward resolution of the anomalous features. Investigators at the Angel site also used multi-dated aerial photographic coverage spanning 20 years to determine natural and modern changes occurring at the site.

The investigations conducted at the Angel site included one of the first archeological applications of orthophotography (Black, 1967). Ebert, Lyons and Drager (1978) provide a discussion of this useful remote sensing technique and correctly identify misconceptions held by some archeologists. The technique used to produce the orthophoto map for the Angel site was essentially the product of a double exposure. A separate negative was made for both a topographic map and a standard USDA vertical aerial photograph. The two negatives were then manipulated to produce negatives of equal scale, and exposed simultaneously on photographic paper. The resulting orthophoto map emphasized and verified that points of interest observed on the original aerial photograph were also indicated by subtle change in contour (Black, 1967).

Cultural resource managers in the Midwest will no doubt profit from the use of orthophoto maps in examining study areas, site plans, floor plans, and specific features. Apparatus designed for taking vertical photographs of specific areas within a site are available. For example, Whittlesey (1966, 1975) has developed a telescoping aluminum bipod that holds a camera vertically over an excavation unit or exposed feature.

When terrain relief and camera tilt are minimal, conventional aerial photographic rectification will produce a useful orthophoto, that is, a product that is both a photographic and planimetric representation, all points of which are in correct geometric relationship with one another (Ebert, Lyons, and Drager, 1978). In point of fact, this is exactly what the investigators at the Angel site produced.

Ebert, Lyons, and Drager also note that unrectified, vertical photographs, such as those taken with a Whittlesey type bipod, or from aircraft, may be perfectly acceptable as a measurement base for most archeological purposes (Ebert, Lyons, and Drager, 1978). This serves as a reminder to the cultural resource manager that lack of equipment necessary for rectification does not necessarily prevent the use of orthophoto maps.

Standard USDA vertical aerial photographs of

the Ogden-Fettie site, located in the central Illinois River Valley, were instrumental in revealing a moat type enclosure (see plate 4). This interesting and unusual feature is revealed as both a crop mark and a soil mark on comparable coverage of different dates. The use of aerial photographs permitted the location of this feature, which previous ground investigations had failed to record (Munson, 1967: 391).

The previous examples provide evidence that aerial photographs are valuable for defining intra-site features on large earthen mound sites like Cahokia, Angel site, and Ogden-Fettie. Several additional examples will be presented to provide evidence that remotely sensed data are useful for intra-site definition of features on sites that are not simply earthen mound complexes.

Plate 1 is an oblique aerial photograph of the eastern end of Buckeye Bend Village, a Mississippian site located near the Spoon River in west-central Illinois (Harn and Weedman, 1975). The image clearly reveals several soil marks. A plaza (left-center) is partially surrounded by house sites (the large, square soil marks) and external features (small, round soil marks). The value of this single photograph for purposes of intra-site definition of features is obvious.

Structural features are also revealed (as soil marks) in the oblique aerial photograph of the Frazier site (plate 5). This aerial photograph serves as an excellent example of the value of remotely sensed data for defining intra-site features that are barely visible from a ground vantage point.

Several features, probably habitation structures, are clearly visible in the aerial photograph of the Horseshoe site, Plate 6. Plant marks assist in the identification of four obvious features, as well as in the identification of a slight depression surrounded by several less distinct features. The use of color film permits the identification of the slight depression; the four features appear on both color and black and white film.

A very low altitude oblique photograph of the Larson site (fig. 8) reveals the presence of a linear alignment of several square soil marks. To the left of these probable habitation structures a much larger soil mark, which is undoubtedly a midden, can be seen.

Although aerial photographs do have utility for intra-site definition on prehistoric sites, there are



Figure 8 Larson Site.

limitations, many of which also apply to the use of aerial photographs for purposes of site discovery. That is, for Paleo-Indian and early Archaic sites, it will no doubt be difficult to define intra-site features through the use of aerial photographs. The intra-site definition of features on any sparse lithic scatter, limited activity area, campsite, or field camp, will probably not be possible through the use of aerial photographs. Also, large midden sites are easily identified on aerial photographs as soil marks, but little information on intra-site definition of features is possible. Finally, dense vegetation covering a site will make the use of aerial photographs ineffective for definition of intra-site features. However, we should recall that these limitations apply only to the use of aerial photographs. The application of other sources of remotely sensed data, and the use of instrumental aids, may reduce many of these problems.

For example, at the Lilbourn site (23NM), near New Madrid, Missouri, aerial photographs were analyzed with a density slicing technique, utilizing a microdensitometer to separate shades of grey on the photograph. This technique allowed the identification of fortification walls and other features not normally visible on the ground surface, or easily observed without instrumental assistance on aerial photographs.

Soil resistivity surveys and proton magnetometer surveys are often applied to the problem of intra-site definition of cultural features. Resistivity surveying has met with limited success in identifying intra-site features when applied to prehistoric sites in the Midwest (Carr, 1977; Ford and Kelsin, 1969; Johnston, 1964; Nashold, 1977; Melburn D. Thurman, personal communication, Oct. 19, 1977). The reason for this, as noted by Carr, (1977:161) lies in the recognition that the elec-

trical resistivity of earthen archeological features often is not easily distinguishable from their soil matrices. However, even though Carr concludes that resistivity surveying may not be appropriate for delimiting intra-site features, he does suggest a means of using resistivity data for defining intra-site activity areas.

Investigators on the Meramac Park Lake Archeological Project, Crawford County, Missouri, found that the location and evaluation of cultural sites was hampered by dense vegetation. Site boundary determination and mapping of features delimited through use of a magnetometer proved effective on two prehistoric and three historic sites. The purpose of these instrumental surveys was to locate and evaluate the presence and extent of buried archeological sites and features. Equipment used on this project included a Geometrics B-816 portable proton magnetometer (1-0.25 gamma sensitivity) and a Metro Tech model 33a metal detector. Data obtained were correlated with systematically selected phosphate samples. The application of these instrument-oriented survey methods allowed the project to more efficiently utilize limited field time by delineating sites and features. Further work on the Meramac Archeological Project will utilize the methods as standard procedure in guiding excavation strategy (Ervan Garrison, personal communication, Oct. 18, 1977).

The detection of intra-site features on historic sites may be quite effective through application of instrumental surveys. For example, the Center for Archaeological Research (Southwest Missouri State University) has used a metal detector (Coinmaster II and TR-Discriminatory, manufactured by Whites Electronics Inc.) successfully on several historic sites. A late 19th-century iron mine was discovered through application of this technique. A transmitter-receiver metal detector was used to locate a cache of mining implements at the Molasses Spring Mines (Cooley and Fuller, 1977a). The use of a transmitter-receiver also allowed definition of a historic fill intrusion at another site (Cooley and Fuller, 1977b).

The use of a metal detector also proved effective for locating a 19th-century hand-dug well and delimiting associated historic features (Cooley and Fuller, 1977c). In addition, a transmitter-receiver metal detector was effective in defining two separate concentrations of metallic objects at site 23CN57. Excavation confirmed the location of a

cabin and associated work area dating from 1840 to 1904 (Cooley and Fuller, 1977d).

Throughout the previous discussions, it was suggested that remotely sensed data, primarily aerial photography, was not effective for use in site discovery or definition of intra-site features on Paleo-Indian sites, early Archaic sites, or any sparse lithic scatter. However, aerial photography may still prove useful for analysis of these types of sites. For example, during the survey of a power line right-of-way in northern Illinois, investigators discovered and recorded an early Archaic site. This site was primarily a sparse lithic scatter, with no remaining evidence of structures or features. When the archeologists plotted the distribution of the recovered lithics, they found a distinct overall pattern of distribution for all artifacts recovered. After examining an aerial photograph taken from a tethered balloon, they had evidence partially explaining the observed distribution (Ken Farnsworth, personal communication, June, 1977). The photograph revealed that the artifact distribution was confined to the spatial limits of a small beach associated with an extinct body of water. Thus, at least the overall distribution of the lithic scatter could be placed into the proper environmental context. This same technique may also be used to examine areas for these types of natural features, and predict the probable locations of prehistoric sites.

Aerial photography of the Crane site, located in central Illinois, is useful for analyzing the spatial distribution of artifacts (plate 3). This photograph revealed several plant marks distributed throughout the site. However, investigation of these anomalies revealed that they were the result of removing a stand of trees which once covered the site (Ken Farnsworth, personal communication, June, 1977). The investigators now have a record of the locations for which the spatial distribution of artifacts may be questioned, and subsequently regarded as disturbed from historic activity. This information may be quite useful if the spatial distribution of artifacts is subjected to statistical analysis, since the disturbed areas would skew the data.

This brief discussion focusing on the application of remotely sensed data to the problem of intra-site definition of features and subsequent mapping should make it clear that remotely sensed data may be quite effective in assisting the archeologist and historical investigator in their efforts

to define intra-site features. Aerial photography has been successfully used to identify and map features on many prehistoric sites. However, when aerial photography proves ineffective for these purposes, instrumental surveys appear to be at least partially effective for delimiting features (Carr, 1977; Ford and Kelsin, 1969; Johnston, 1964; Nashold, 1977; Melburn D. Thurman, personal communication, Oct. 19, 1977). Furthermore, these techniques may be applied to a wide variety of sites characterizing both prehistoric and historic cultural resources.

## The Use of Remotely Sensed Data for Resource Monitoring

Remotely sensed data may be used to monitor adverse impact to a variety of cultural resources in the Midwest. For example, aerial photography of the Angel site was used to determine potential damage to the site that might result from recurring flooding (Black, 1967). The Ohio River usually floods sometime during the first three months of the year near Evansville, Indiana. On March 9, 1962, when the river reached flood stage, aerial photographs were taken of the site and surrounding areas. Examination of the photographs revealed several features that were accentuated by flooding. Also, those portions of the site that were not subject to inundation were easily identified and mapped. That certain areas were invulnerable to flooding, a characteristic not easily identified on topographic maps, was undoubtedly a significant consideration for the prehistoric inhabitants as well. The information is also of value for monitoring the extent of flood damage that may occur to various parts of the site, allowing appropriate preservation strategies to be developed.

The use of standard black-and-white USDA vertical aerial photography has proven effective for analysis of site destruction. For example, Tandarich (1975) found that by examining aerial photographs taken during 1939, 1953, and 1958, changes that have occurred to known prehistoric sites as a result of cultivation practices may be estimated. He found that it is possible to determine the rate of change in visibility of mound sites in an area of Webster County, Iowa. Extrapolating

to the year 1975, Tandarich (1975:42) estimated that 45 percent of the known mound sites would no longer be visible on aerial photographs, which may indicate the rate of destruction to these cultural landforms. Cultural landforms have suffered considerable abuse throughout historic and modern times. The use of aerial photography for monitoring the rate of destruction to these prehistoric cultural resources should assist cultural resource managers in assessing the rate of destruction and assigning priorities in preservation strategies for these features.

The previous examples suggest that the monitoring of cultural resources in the Midwest through remotely sensed data may best apply to planning and management strategies. Large areas might be examined through the use of aerial photography, with the purpose of identifying known cultural resources. Extant multi-date aerial photography could then be used to assess natural and cultural impacts to those cultural resources that are revealed. These data could then be used to plan preservation strategies for other areas also identifiable on extant aerial photography with similar natural and cultural land use characteristics.

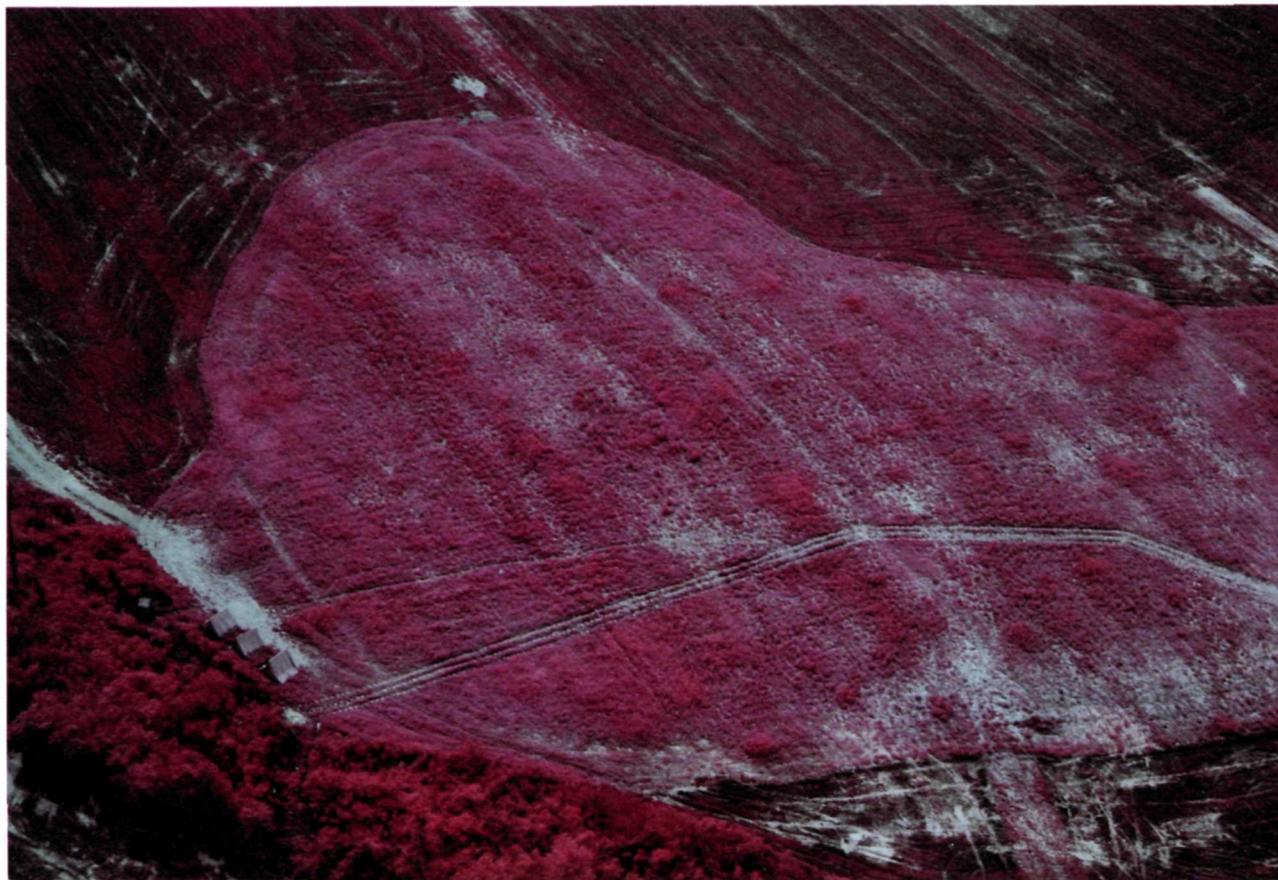
## **(Color Plates)**



**Plate 1** Aerial photograph of the eastern end of the Buckeye Bend village, a Mississippian site located near the Spoon River in west-central Illinois. Image reveals plaza (left-center) partially surrounded by house sites (large dark soil marks) and external features (small, round soil marks). Curved markings on the photo are shadow marks revealing disturbance from cultivation machinery. (Photo courtesy of Alan D. Harn, Dickson Mounds Museum.)



**Plate 2** Soil mark indicates presence and defines limits of Greer site, a multi-component site (Middle Woodland through Middle Mississippian) located in Perry County, Illinois. The field of mature soybeans (lower left) and the mixed deciduous hardwoods (upper right) shown in this photograph illustrate problems of ground visibility characteristic of the Midwest. However, the soil mark in the recently plowed field does illustrate that optimal scheduling of missions will facilitate site discovery through use of soil marks. (Photo courtesy of Michael McNerney.)



**Plate 3** False color infrared photograph of the northern portion of the Crane site, a Middle Woodland (ca. 300 B.C.-A.D. 200) village located on the banks of Macoupin Creek, a primary tributary of the lower Illinois River. Several interesting features appear to be represented by the plant marks. However, these are not cultural features, but instead represent evidence of recently uprooted trees. This information is valuable for evaluating the recent spatial disturbance of artifacts recovered during excavation. The linear feature traversing the lower portion of the photograph is a resistivity survey transect. (Photo courtesy of Ken Farnsworth.)



**Plate 4** Low altitude oblique false color infrared photograph of the Ogden-Fettie site, located in the central Illinois River Valley. Aerial photographs of this site were instrumental in revealing the moat type enclosure shown here. Darker vegetation to the west and southwest of the moat also delimits extent of village scatter. The vegetation shown represents weeds in a fallow corn field. However, USDA vertical photographs of this area when under mature crops also reveal (as crop marks) the presence of the moat type enclosure. (Courtesy of Wayne F. Shields, Dickson Mounds Museum.)



**Plate 5** Several cultural features are revealed in this low altitude oblique photograph of the Frazier site. The field is not in crop growth, facilitating the identification of subtle soil marks not visible at ground level. This example, along with that shown in Plate 1, illustrates the value of remotely sensed data for purposes of intra-site definition. (Photo courtesy of William Weedman, Illinois State Museum.)



**Plate 6** The locations of structural features and village orientations of the Horseshoe site, Jackson County, Illinois, are revealed in this oblique kodachrome exposure. This synoptic perspective permits the identification of what appear to be house rings, the intra-site definition of which was not possible from ground level. This field is usually in permanent pasture of tame and native grasses; therefore, optimal scheduling of this mission was critical for purposes of observing the plant marks resulting from a fall plowing, especially since fields in permanent pasture are plowed once every five to seven years. (Photo courtesy of Michael McNerney and Southern Illinois University Museum.)



**Plate 7** A very low altitude kodachrome exposure of the Horseshoe site (see also Plate 6). Three prehistoric cultural features are aligned vertically; a fourth is offset near the top. In addition, light green areas to the right of each of the circles, showing as negative crop marks, reveal the presence of additional cultural features. (Photo courtesy of Michael McNerney and Southern Illinois University Museum.)

## Specifications for the Acquisition of Remotely Sensed Data

Throughout the previous discussion, our efforts have been directed toward identifying specific problems for which remotely sensed data may prove of use for both the archeological and historic investigator. Although our comments herein have been confined to the cultural resources of the Midwest, others have also addressed the potential and actual utility of remote sensing data for a variety of problems in a variety of areas (e.g. Gumerman and Kruckman, 1977; Gumerman and Lyons, 1971; Gumerman and Neely, 1972; Jorde and Bertram, 1977; Lyons, 1976; Lyons and Avery, 1977; Lyons and Hitchcock, 1977). Success in the application of remotely sensed data to specific problems addressed by cultural resource managers in the Midwest cannot be guaranteed. There are many types and sources of remotely sensed data, and no single type or source may be appropriate for resolution of all potential problem applications. It is possible to increase the probability of success by acquiring remotely sensed data appropriate to the problems identified for examination. In the following, we will attempt to provide supplemental information useful to the cultural resource manager for purposes of acquiring remotely sensed data.

### Existing Imagery and Photography

There are many sources of existing imagery and photographic coverage for the Midwest. Often, archeologists may have the opportunity to use a source of existing imagery, but subsequently find *that* particular imagery unsuitable for their purposes. Existing imagery may be unsuitable because of age of coverage, season of coverage, film-filter

combinations, or scale. For example, archeologists at the Harry S. Truman Reservoir in southwestern Missouri found that aerial stereo pairs (scale of 1:24,000, provided by the Corps of Engineers) were of no use in locating sites or potential site locations. Although these photographs were of use for orienting survey crews in the field, the scale of the imagery provided was so large that little additional use was made of them (Donna Roper, personal communication, Oct. 17, 1977).

All too often, archeologists faced with the situation briefly described in the previous example conclude that the imagery available is unsuitable for their problem needs. Further, few projects are in the position of contracting with a commercial firm for acquisition or obtaining new imagery because of the high cost, and because of the lack of confidence in the utility or value of doing so.

This is an unfortunate situation for many reasons. First, there are usually many additional sources of existing imagery, especially for the Midwest, and of varying scales. Second, there are many sources of existing imagery of varying film-filter combinations. Third, there are many possibilities of obtaining previously collected imagery taken at different seasons. And finally, it is possible to acquire imagery of the same area spanning several years, a very important consideration for areas of the Midwest that have been subject to recent land modification activities.

The point being emphasized here is that many times archeologists and historical investigators conclude that existing imagery is unsuitable. Unfortunately, this conclusion is based on what may not be a representative sample of the imagery that does exist. It is not suggested that investigators reach this erroneous conclusion through careless-

ness, but rather, because of a lack of awareness of the extensive holdings of existing imagery available through government agencies. Therefore, the following discussion will focus on identifying sources of existing imagery and on briefly describing the products available from each.

The United States Geological Survey (USGS) holds negatives for many areas of the Midwest. Inquiries to the following address will result in information on those areas for which the USGS has coverage:

National Cartographic Information Center  
U.S. Geological Survey  
507 National Center  
Reston, Virginia 22092

Most of the coverage provided by the USGS is panchromatic black-and-white vertical photography, taken with a camera having a focal length of 6 inches. The scale of photography varies from 1:12,000 to 1:48,000.

The SCS also holds aerial photographic coverage for selected areas of the Midwest. The scale of imagery available from the SCS varies throughout the Midwest, as does the focal length of the camera used to obtain coverage. Inquiries to the following address will result in information on specific areas:

Cartographic Division  
Soil Conservation Service  
Federal Building  
Hyattsville, Maryland 20782

Information on imagery scale and coverage available may also be obtained directly from local SCS offices. In addition to the standard types of contact prints and enlargements projected to approximate scales, accurately scaled photographic reproductions in sheets of uniform dimension and with systematic layout are available for most of the areas for which photographic coverage is available at smaller scale. These reproductions are produced from negatives that have been rectified and scaled to obtain the best average scale of imagery for each sheet. All SCS photography flown prior to 1940, and several surveys flown through the period of 1940 to 1942 (which will not appear on status maps provided upon inquiry) have been transferred to the National Archives and Records Service (see below).

The Agriculture Stabilization and Conservation Service (ASCS), USDA, holds aerial photographic

coverage for most of the area within the Midwest. Requests for information regarding ASCS aerial photography should be addressed to:

Aerial Photography Field Office  
USDA-ASCS Administrative Services  
Division  
2505 Parleys Way  
Salt Lake City, Utah 84109

Most ASCS photography is secured at a scale of 1:20,000 with an 8.25-inch lens and is on panchromatic film. All ASCS photographic coverage secured on nitrate film during the years of 1936 through 1941 has been transferred to the National Archives.

The Forest Service, USDA, also holds coverage for many years in the Midwest. However, as would be expected, much of this coverage is restricted to Forest Service lands. Information regarding Forest Service holdings may be obtained from:

Division of Engineering  
Forest Service  
USDA  
Washington, D.C. 20250

Much of the aerial photographic coverage dating from the 1930's through 1942 is held at the National Archives and Records Service. A list of holdings and index sheet of all holdings may be obtained from:

National Archives and Records Service  
Cartographic Archives Division  
General Service Administration  
8th and Pennsylvania Avenue, N.W.  
Washington, D.C. 20408

The value of historical photography should not be underestimated. Many times, investigators are concerned with obtaining the latest possible coverage of an area of interest. However, cultural resource investigation at Cahokia (Fowler, 1977), the Ogden-Fettie site (Munson, 1967), and the Angel site (Black, 1967) illustrate the actual value of older photographic coverage for application to cultural resource management problems.

The Earth Resource Observation System (EROS) Data Center will provide a computer geographic search listing available imagery and photography for any specified area. The EROS Data Center handles Landsat data, aerial photography acquired by the U.S. Department of Interior, photography and other remotely sensed data acquired by the National Aeronautics and

Space Administration (NASA) from research aircraft and from Skylab, Apollo, and Gemini spacecraft. Inquiries should be addressed to:

EROS Data Center  
 U.S. Geological Survey  
 Sioux Falls, South Dakota 57198

The USGS also holds records of what firms have contracted privately for aerial imagery. Information on where this imagery is presently stored may be obtained from:

Central Region Engineer  
 USGS  
 Box 133  
 Rolla, Missouri 65401

Much of the imagery available from the agencies discussed above (with the exception of that provided by the EROS Data Center) consists of black-and-white stereo aerial photography. The range of products available is shown in Table 1. Examination of this table should assist the cultural resource manager in determining what he or she may obtain from existing sources of imagery. For example, if the existing imagery of a particular area of interest is available in a 9½ x 9½-inch

contact print, at an original scale of 1:200,000, the scale of the contact print will be 1 inch = 1667 feet. This scale will no doubt be too small for most problems regarding site discovery, plotting of site locations, etc. However, it should be clear that the imagery does not have to be rejected on the basis of the scale of the contact print. As Table 1 indicates, it is possible to have enlargements made of the original contact print to a scale of 1 inch = 400 feet. This larger scale should prove sufficient for most problems concerning site discovery, site plotting, and in some cases, the intra-site definition of features. Also, a scale of 1 inch = 400 feet will be sufficient for delimiting current ground cover, defining natural landforms, distinguishing soil contrasts, etc.

Both archeologists and cultural resource managers should recall that contact prints are simply an inexpensive means of examining the area of coverage. They are a tool for use in determining whether or not the coverage of the area is for the proper season, determining possible resolution, and other general use categories.

**Table 1.** Prices and types of products available from existing U.S. Department of Agriculture Agricultural Stabilization and Conservation Service *Black and White Aerial Photography*.

type of reproduction	size	approx. scale from 1:20,000 photography	approx. scale from 1:40,000 photography	cost per paper print	1/ polyester base positive transparencies
Contact Print	9½" x 9½"	1" = 1667'	1" = 3334'	\$ 2.00	\$ 3.00
Enlargement	12" x 12"	1" = 1320'	1" = 2640'	4.00	5.00
Enlargement	17" x 17"	1" = 1000'	1" = 2000'	5.00	6.00
Enlargement	24" x 24"	1" = 600'	1" = 1320'	6.50	10.00
Enlargement	38" x 38"	1" = 400'	1" = 800'	15.00	17.00
Enlargement	38" x 38"	1" = 200' Sectional	1" = 400' Sectional	15.00	17.00
Photo Index (No. of sheets per co. depends on size of co.)	20" x 24"			5.00	6.00

(Source: GPO 914-684)

## Multiband Photography

Little use has been made of multiband photography within archeological research in the Midwest, and therefore, details are lacking concerning the utility of this photographic sensor for purposes of archeological or historical investigations. However, the potential of this form of data gathering suggests that many of the limitations commonly associated with single camera systems might be effectively eliminated. Through proper combination of films and filters, photographic methods may be used to produce a set of multiband images. Combination of films and filters are selected in association with knowledge about the reflectance properties of earth surface features. Therefore, multiband images yield far more information than is available from a single image. We will briefly summarize the results of two multiband photography applications below.

Multiband photography of Mill Creek (Middle Missouri) villages in northwestern Iowa was taken during the fall of 1972 (Tandarich, personal communication, Jan. 17, 1978). The investigators used a Cessna 182 as a platform, and instrumentation consisted of:

Camera	Film	Filter(s)	Lens
Pentax Nikkormat	Panatomic-X High speed black and white infrared	25A, 11G 25A	50 mm. 50 mm.
Minolta 75	Ektachrome infra- red	12	50 mm.
Nikon F	High Speed Ektachrome	1A	50 mm.
Nikon F	High Speed Ektachrome	1A	135 mm.

Ektachrome infrared provided the best film for recording vegetative differences. The Pan-X and 11G combination seemed to provide the clearest black-and-white image.

Multiband photography was also taken of a historic site at Iowaville on the Des Moines River. The platform consisted of a Piper 250C single engine airplane. Instrumentation consisted of an

International Imaging System (I<sup>2</sup>S) Mark II Multiband camera (see Lyons and Avery, 1977:44-45). Film consisted of Kodak 2424 Infrared Aerographic. Settlement patterns, roads, and structure sizes were visible. Color infrared and black-and-white plus red filter proved most useful as combination on the I<sup>2</sup>S Additive Color Viewer.

The use of multiband photography provides greater latitude in the use of film filter combinations, a feature that may save airflight costs in the long run. However, the decreased air flight costs may well be offset by the expense of a multiband camera, as well as the necessity of using a multi-additive color viewer. These latter cost limitations should not prevent the application of this form of remote sensing to specific problem applications throughout the Midwest.

Previous applications of single camera systems conducted at the Cahokia site (Fowler, 1977) determined that the best film overall was panchromatic black-and-white aerial film. Of course, this is the type of film also most often used during governmental aerial photographic missions in the past and will, therefore, be the type of film most often available for existing imagery.

However, color film is superior for use in photo interpretation of crop marks, land cover types, and identification of landforms. Unfortunately, it is very expensive and the use of color imagery is therefore usually restricted to applications of low altitude oblique images for use in intra-site analysis.

## Multispectral Sensors

The most widely available form of multispectral scanning data is that provided by the Earth Resources Technology Satellites (formerly ERTS, now LANDSAT 1 and LANDSAT 2). These data are available through the Earth Resources Observation Systems (EROS) Data Center. These satellites have collected large quantities of high quality multispectral data which have been successfully applied to a wide variety of non-archeological problems. For example, analysis of ERTS-1 multispectral sensor data has been successfully used for surveying crops and forests, mapping land use patterns, and monitoring water and air quality (see Anuta and Bauer, 1973; Bauer and Cipra,

1973; Heller, 1975; Hoffer *et al.*, 1973; Henderson, Baumgardner, and Walker, 1974; MacDonald *et al.*, 1972). The scale of the imagery from LANDSAT 1 and LANDSAT 2 satellites, as well as the resolution, are not sufficient for most archeological and historical investigations.

ERTS imagery and SKYLAB color photography were used by the Center for Archeological Research (Cooley and Fuller, 1976b) in an investigation of a levee project in Charition County, Missouri. The SKYLAB color positive was enlarged using macrophotographic techniques. The objective was to determine whether or not a known archeological site could be detected on the image. The site was a large village mound, but could not be detected on the SKYLAB enlargement. Efforts were also directed toward examining the image to determine if locations of submerged steamboats in Cut-Off Lake could be detected. Neither the ERTS imagery nor the SKYLAB imagery were of use for detecting the locations of the steamboats or the archeological site.

It may be tentatively concluded that multispectral imagery obtained from earth-orbiting satellites is of little use for application to archeological and historical problems in the Midwest, not because of the characteristics of the multispectral sensor system, but rather because of the scale and resolution of the data available from the satellite platforms. These two variables are primarily a function of altitude. Therefore, prior to concluding that multispectral scanning data are not suitable for archeological and historical investigations, cultural resource managers within the Midwest may well profit by investigating the use of multispectral data obtained from a platform of lower altitude. For example, the University of Michigan owns a C-47 airplane equipped with a 12-channel multispectral scanner, and therefore, cultural resource managers within the Midwest do have access to a multispectral scanning system other than satellites. As a result, analysis of multispectral scanning data for archeological applications should assist in determining the utility of this type of remote sensing for archeological and historical research.

The costs of conducting a mission flown by a sensing system such as that operated by the University of Michigan may be prohibitive. Also, the analysis of multispectral data necessarily involves a great deal of statistical manipulation and computer

work. Therefore, although the potential of multispectral data for application to archeological and historical problems within the Midwest remains to be determined, the costs of analysis and data gathering may prevent cultural resource managers from ever applying this technique.

There is an alternative to assuming the high costs of having a C-47 mission flown in that there may be existing imagery. For example, in 1971, the Laboratory for Applications of Remote Sensing (Purdue University), the USDA, and the University of Michigan participated in Corn Blight Watch Experiment (MacDonald *et al.*, 1972), which involved the collection of medium altitude multispectral data for many areas in the Midwest. High altitude NASA research aircraft (RB-57F) carrying remote sensing systems also flew over the test area. Within this test area lies, in southern Illinois, an area known as Black Bottoms and a large prehistoric mound and village complex called the Kincade site. Previous investigations have been conducted at the Kincade site by the University of Chicago, and, more recently, by Southern Illinois University. Aerial photography has been used for limited problem applications during this research. However, remote sensing data have been restricted to oblique aerial photography and selected vertical photography. Unfortunately, the utility of high altitude imagery and medium altitude multispectral data available for this area has not been determined. This is unfortunate since high altitude data and medium altitude multispectral data already exist. It is obvious that archeologists and cultural resource managers in the Midwest have the resources necessary for applying multispectral data and high altitude imagery to prehistoric problems, but have simply failed to do so. This latter generalization serves to emphasize the point that it is profitable to attempt to determine what remotely sensed data exist for specific areas of study.

In conclusion, the small scale and low resolution of LANDSAT multispectral data should not prevent the application of multispectral data (obtained from low altitude platforms such as the C-47 aeroplane operated by the University of Michigan) to archeological and historical problems. Further, the use of data obtained from missions for other purposes not only lowers the cost to a point that overall analysis costs are well within the range of large scale cultural resources manage-

ment projects, but it is also an efficient means of economizing and making fuller use of existing resources!

## Scheduling

As discussed earlier, the interpretation of soil marks, correlated to recent cultivation, has proven to be one of the most successful techniques for use in archeological applications of remote sensing

within the Midwest. Obviously, time of cultivation is one of the most important considerations for scheduling aerial photographic missions. A calendar may be used to anticipate the time of year for which the optimum conditions of freshly plowed fields will be present (see table 2). Although the crop calendar indicates that some plowing may occur during the post-harvest season (November), previous applications appear to have been more successful during the spring planting season, rather than the post-harvest season. Fowler (1977), however, suggests that the optimal time for obtain-

**Table 2.** Crop calendar for three major crops in the Midwest.

month	winter wheat	corn	soybeans
January	Frozen or snow Vegetation brown	Frozen or snow Plowed, pasture or corn stalks	Frozen or snow Plowed or stubble
February	Frozen or snow Vegetation brown	Frozen or snow Plowed, pasture or corn stalks	Frozen or snow Plowed or stubble
March	Ground with vegetation brown	Plowed, pasture or corn stalks	Plowed or stubble
April	Becoming green to short green	Plowed pasture or disced stalk	Plowed or stubble
May	Green medium to tall	Planting, May 5 to June 20	Planting, May 10 to June 30
June	Yellow, harvest, June 20 to August 5	Short, green	Planting
July	Harvest or stubble	Green, ground covered	Dark ground, short green in rows
August	August 5—stubble or plowed	Green, full height	Green, ground essentially covered
September	Planting, September 10 to November 1	Drying starts, green to dry	Drying starts, harvest Sept. 10 to Nov. 1
October	Planting, dark soil and short green in drill rows	Harvest, Sept 25 to Dec. 5.	Harvest
November	Dark soil and short green in drill rows	Harvest and/or corn stubble	Plowed or stubble
December	Frozen or snow Vegetation in green to brown	Frozen or snow Corn stubble, some field cut for silo filling	Frozen or snow Plowed or stubble

(After Avery, 1977:209).

**Table 3.** Average number of days suitable for aerial photography in the Midwest.

State	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Illinois	4.9	4.7	4.8	5.1	5.1	4.5	6.3	6.5	7.9	9.0	6.4	5.1	70.3
Indiana	4.2	3.8	4.2	4.5	4.4	3.7	4.9	5.4	7.1	9.2	6.2	4.4	62.0
Iowa	5.8	5.4	4.8	5.3	5.0	4.8	7.2	6.6	7.8	8.9	5.9	5.4	72.9
Michigan	2.2	3.1	4.1	5.0	4.8	4.6	5.4	4.6	4.6	4.3	1.9	1.9	46.5
Minnesota	5.4	5.8	5.2	5.8	5.6	4.9	7.1	6.8	6.2	6.3	4.2	5.1	68.4
Missouri	7.4	7.1	6.8	6.8	6.8	6.8	9.2	8.9	9.9	11.6	9.2	7.3	97.8
Ohio	3.5	3.1	4.1	4.8	5.8	5.1	6.2	6.2	7.3	7.1	4.3	2.9	60.4
Wisconsin	4.9	5.3	4.6	5.1	5.4	4.6	7.0	6.5	6.4	7.2	4.4	4.7	66.1

Compiled from U.S. Weather Bureau Records. Figures shown represent the number of days per month with ten percent cloud cover or less. Averages should be used with discretion, as wide variations may occur from one part of a state to another. (After Lyons and Avery, 1977:85).

ing aerial photos revealing soil marks is during the month of February. In many cases, a rain had fallen on the area a few days prior to the photography. Lyons and Avery (1977) have suggested that the optimal soil moisture condition as it affects the observation of soil marks occurs three days after a rain. There is no evidence to suggest that this is not the case also in the Midwest.

Crop marks, though successfully used to define intra-site features at Cahokia (Fowler, 1977), the Ogden-Fettie site (Munson, 1967) and the Angel Site (Black, 1967), have not been fully investigated to determine the optimal times for observations. In the absence of explicit criteria for scheduling missions directed toward the observation of crop marks, we suggest that investigators attempt to obtain existing imagery for several different seasons. This will allow the researcher to determine at what point in the season crop marks for known archeological sites are most obvious. Aerial photography most suitable for identifying crop types is usually from the period of June 15 to July 30 (Goodman, 1959).

An important factor to be considered when obtaining seasonal coverage is the percent of cloud-free days. The percent of cloud-free days, by state and month of year, is summarized in Table 3. Lyons and Avery (1977:84) have noted that although the scheduling of aerial photography is

directly related to specific project objectives, optimum scheduling also varies spatially and temporally. Cloud cover may place a great restriction on the scheduling of aerial photographic missions in the Midwest, because of the relatively few cloud-free days throughout the year. In general, there are more cloud-free days during the months of July through November. Therefore, optimum scheduling of data collection missions to reduce the chance of obscuring clouds will be during this period. However, other factors also affect scheduling. Reconnaissance over humid regions is likely to be more successful when masking deciduous plants are leafless. Further, in areas of extensive cultivation, as in the Midwest, reconnaissance will be most successful prior to crop maturity. Therefore, optimum scheduling will most likely be during the early spring, just after planting or late summer and early fall, just after harvest plowing and after leaves have fallen. However, during this latter period, soil moisture may be excessive. In any case, it is obvious that scheduling of missions must take into consideration the climatic conditions as a priority (see Lyons and Avery, 1977:84).

## Scale

Imagery with a scale of 1:20,000 has been successfully used to delineate crop and soil marks. This is the scale of most USDA coverage. However, many cultural resource managers within the Midwest find a scale of 1:20,000 to be too small for general use in site discovery and intra-site analysis problems. Therefore, efforts to determine existing coverage should be focused toward determining whether or not a larger scale (1:10,000) is available for the area.

A scale of 1:2,000 was successfully used in the construction of a photogrammetric map of Cahokia. This scale and focal length of camera lens permitted the construction of a map with contour intervals of 1 m.

Imagery of 1:20,000 scale should be sufficient for many of the data needs regarding preliminary reconnaissance of regions within the Midwest. However, identification of individual tree species on imagery of this scale will be difficult, if not impossible. General land cover types, as well as landforms, may be defined on imagery of this scale (see photo interpretation keys in index).

High altitude NASA research imagery should also prove useful for identifying general landcover types, although little use has been made of this imagery for cultural resource investigations within the Midwest.

## Imagery Interpretation

Basic photointerpretation and analysis are largely the output of human observation and inference (Lyons and Avery, 1977:52). Highly skilled photointerpreters constitute a specialized occupational niche. Cultural resource managers may, however, successfully interpret imagery to resolve specific problems without contracting the services of a professional photointerpreter. Lyons and Avery (1977:48-67) have provided a discussion of general archeological photointerpretation skills. They suggest (1977:51) that interpreters who are expected to identify and evaluate physical and cultural patterns should have a sound knowledge of earth-surface features and the interrelationships of geology, soils, physiography, natural

vegetation, and climate. Many of the problems identified herein require only the visual inspection of aerial photography. Image recognition keys for selected natural phenomena and a summary of soils, surface features, physiography, and present vegetation applicable to the Midwest are presented in the attached appendix.

Additional reference materials include Bevan (1975:38-52), Denney *et al.* (1968), and Way (1973), as well as stereograms for selected surface features of the Midwest such as those provided by the Committee on Aerial Photography, University of Illinois. A visit to the local SCS office or Agriculture Stabilization and Conservation Service office and consultation with the photointerpreter will also assist in identification of surface features of particular interest. For example, the local SCS office might be able to provide assistance and image interpretation keys useful for the identification of small, elevated, well-drained soil locations. In many areas of the central lowlands, the location of prehistoric cultural resources may be correlated with these variables. Also, a visit to the local office of the U.S. Department of Agriculture, ASCS, may result in valuable assistance in identifying various agriculture crop covers present in the area of interest and provide interpretation keys useful for developing sampling strategies on these data.

Instrumental aids useful for interpreting aerial photographs for the problems identified herein may include only a five-power hand magnifying glass, a 10-power pocket stereoscope, and a prism- and/or mirror-reflecting stereoscope.

Multiband imagery interpretation is enhanced through use of a multiadditive color viewer (see Lyons and Avery, 1977:45). Multiadditive viewers are, however, expensive pieces of equipment, and access to them has in part limited the application of multiband photography to cultural resource management problems in the Midwest. An experimental do-it-yourself multiadditive viewer has been described as an alternative to expensive commercial models (Richardson, 1978). Since the cost of the system suggested by Richardson is under \$20, it may provide a realistic alternative instrumental aid in the analysis of multiband photography.

The use of computers also constitutes a valuable instrumental aid in the analysis of remotely sensed data (Conant, Reining and Lowes, 1975; Drager, 1978; Hamlin, 1977; Scollar, 1978:71-87; Tinney, Jensen and Estes, 1977:35-44). Hamlin

(1977) has provided a most useful and readable introduction to the machine processing of Landsat data. Hamlin addresses the analysis of satellite data, but the basic process is equally applicable to multispectral data acquired at lower elevations, such as those collected during the Corn Blight Watch Experiment (MacDonald *et al.*, 1972). Therefore, cultural resource managers with access to a computer may now take advantage of automated data processing, and need not rely on visual interpretation alone. It should be emphasized that machine processing of multispectral data may be far superior to visual inspection of photographic products derived from such data. Historical investigators may find the digital transformation of historical photographs especially useful for mapping purposes (Tinney, Jensen and Estes, 1977).

## Section 6

# Summary and Conclusions

The probability of successfully applying remotely sensed data to a wide variety of problems addressed by cultural resource managers within the central lowlands seems high. In the previous discussion, several examples were presented to provide indubitable evidence of the utility of remotely sensed data for application to archeological and historical investigations conducted in the central lowlands.

It is important to realize that the chances of success in the application of remotely sensed data to specific cultural resource management problems cannot be guaranteed. This is especially true when the limitations of remotely sensed data to the nature of the cultural resource problem are not considered. For example, natural vegetation (trees and grass) in the central lowlands may severely limit the use of remotely sensed data for purposes of site detection. This limitation, though, is restricted to less than one-half of the total land surface, and applies only to site detection. The knowledge of natural and semi-natural vegetation, as recorded through remotely sensed data, may be used to address a host of additional problems pertinent to the cultural resource manager.

Another important limitation regarding the use of remotely sensed data for resolution of problems addressed by cultural resource managers in the central lowlands has little to do with the nature of cultural resources in the central lowlands or the state of the art of remote sensing technology. Instead, this limitation may be described as a narrow perspective the cultural resource manager, archeologist, or historian brings to bear on the application of remotely sensed data to specific problems. Historically, archeologists have demonstrated a

preference toward the use of visual interpretation of aerial photographs. An altogether different approach to utilizing remotely sensed data depends upon automated machine processing. These techniques may be far superior to human inspection for certain purposes, and inferior for others (see Hamlin, 1977). Unfortunately, cultural resource managers in the central lowlands have little in the way of guidance to determine when the automated machine processing may be superior to human inspection of aerial photographs. Until experiments have been conducted to illuminate this deficiency, cultural resource managers will have to rely on traditional visual interpretation and instrumental ground surveys.

A further limitation of remotely sensed data for use by cultural resource managers in the Midwest concerns cost. In the previous discussions, we emphasized the use of existing imagery for application to many archeological and historical problems. This is because the costs of obtaining extant imagery are considerably less than the costs necessary for having new imagery collected. In addition, especially for the area of the central lowlands, sources of existing imagery may provide several different seasons of coverage for specific areas of interest. Extant remotely sensed data also serve as valuable historical documents.

The use of extant remotely sensed data should greatly reduce the cost limitation. For large scale cultural resource management investigations, the limitation of cost may be further minimized and technical expertise maximized by working hand in hand with state and federal agencies. In order to realize the gains derived from cooperation, cultural resource managers must plan in advance and

define the problem(s) for which they intend to use remotely sensed data (see Lyons and Avery, 1977: 66).

A final caution is offered for the cultural resource manager who plans to use remotely sensed data. The interpretation of remotely sensed data has been defined as the recognition of objects that are imaged by remote sensors and the formulation of hypotheses or conclusions about the features of interest (Lyons and Avery, 1977:49). This definition makes it obvious that the use of remotely sensed data cannot replace ground truth investigations. The latter tests the hypotheses of conclusions derived from the former. As a result, the use of remotely sensed data cannot replace traditional techniques of investigation. Instead, it offers a supplemental, efficient, nondestructive technique for providing pertinent information useful in cultural resource investigations.

In conclusion, the potential of remotely sensed data was realized by early pioneers of aerial photography, such as Goddard and Reeves, as early as 1922. The time is long past for cultural resource managers to exploit this potential.

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## SCHEME OF CLASSIFICATION

### NORTHERN GREAT PLAINS SPRING WHEAT SECTION

- 1 Red River Valley of the North
- 2 Western Minnesota Forest–Prairie Transition

### NORTHERN LAKE STATES FOREST AND FORAGE REGION

- 3 Northern Minnesota Swamps and Lakes
- 4 Minnesota Rockland Hills
- 5 Central Wisconsin and Minnesota Thin Loess and Till
- 6 Wisconsin and Minnesota Sandy Outwash
- 7 Superior Lake Plain
- 8 Northern Michigan and Wisconsin Stony, Sandy, and Rocky Plains and Hills
- 9 Northern Michigan Sandy Drift

### LAKE STATES FRUIT TRUCK AND DAIRY REGION

- 10 Southeastern Wisconsin Drift Plain
- 11 Western Michigan Fruit Belt
- 12 Southwestern Michigan Fruit Belt
- 13 Southern Michigan Drift Plain
- 14 Erie–Huron Lake Plain
- 15 Erie Fruit and Truck Area

### CENTRAL FEED GRAINS AND LIVESTOCK REGION

- 16 Loess, Till, and Sandy Prairies
- 17 Central Iowa and Minnesota Till Prairies
- 18 Eastern Iowa and Minnesota Till Prairies
- 19 Northern Mississippi Valley Loess Hills
- 20 Iowa and Missouri Deep Loess Hills
- 21 Illinois and Iowa Deep Loess and Drift
- 22 Iowa and Missouri Heavy Till Plain
- 23 Northern Illinois and Indiana Heavy Till Plain
- 24 Indiana and Ohio Till Plain
- 25 Cherokee Prairies
- 26 Central Clay Pan Areas
- 27 Southern Illinois and Indiana Thin Loess and Till Plain
- 28 Central Mississippi Valley Wooded Slopes

### EAST AND CENTRAL FARMING AND FOREST REGION

- 29 Ozark Highland
- 30 Kentucky and Indiana Sandstone and Shale Hills and Valleys
- 31 Kentucky Bluegrass
- 32 Highland Rim and Pennroyal
- 33 Western Allegheny Plateau
- 34 Cumberland Plateau and Mountains
- 35 Central Allegheny Plateau

### MISSISSIPPI DELTA COTTON AND FEED GRAINS REGION

- 36 Southern Mississippi Valley Alluvium
- 37 Southern Mississippi Valley Silty Uplands

### NORTHEASTERN FORAGE AND FOREST REGION

- 38 Eastern Ohio Till Plain

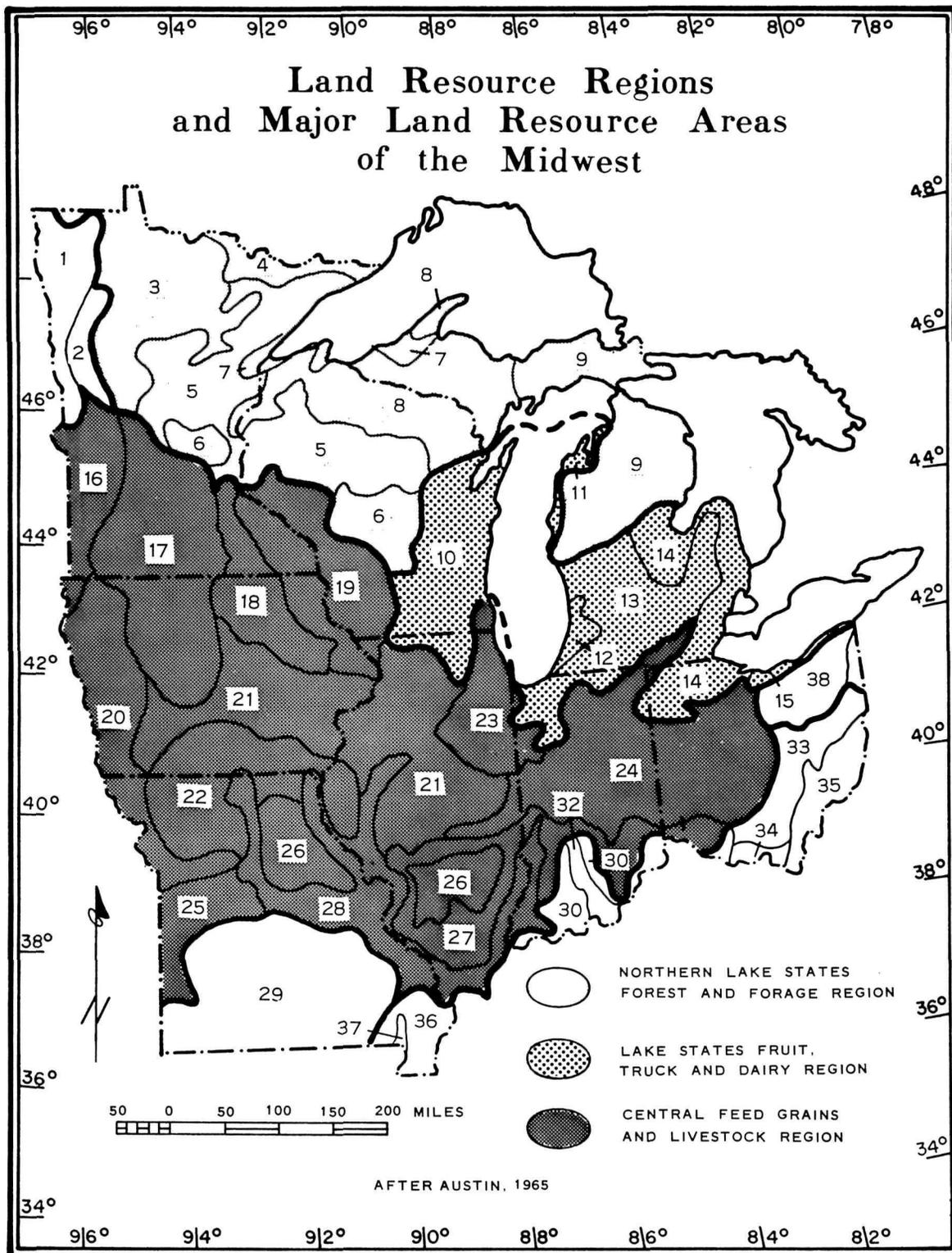


Figure 9 Land Resource Regions of the Midwest.

## Land Resource Regions and Photo Interpretation Keys

The detailed classification of land resources is a useful guide for remote sensing applications in that it provides a local description of predominant soil characteristics, vegetation, and topography. Descriptions for most of the areas shown in Figure 9, which are based on the Soil Conservation Service Classification (Austin, 1965), are presented below. Information on those areas not covered below may be found in Austin (1965), from which the following is derived.

**Central Iowa and Minnesota Till Prairies:** Nearly all of this area is in farms, with three-fourths in cropland. Corn, soybeans, and other feed grains are the major crops. Between 10 percent and 15 percent is in permanent pasture of tame and native grasses. Narrow bands of woodland on steep slopes border stream valleys, and some of the wet bottom lands are also forested. Elevations range from 1,000 to 1,300 ft. Topography is generally level to gently rolling till plain, with a few morainic hills in the east. Soils: brunizems (Clarion and Nicollet) and soils transitional between gray-brown podzolic soils and brunizems (Lester) in medium-textured calcareous glacial till are dominant. Gray-brown podzolic soils (Hayden) occur on the morainic hills in the east. Associated soils on wet flats and in depression are humic gley soils (Webster and Glencoe).

**Eastern Iowa and Minnesota Till Prairies:** Almost all the area is in farms; more than three-fourths is cropland. Corn, soybeans, and other feed grains are the major crops. Less than 10 percent is in pasture of tame and native grasses. Also, less than 10 percent is wooded, mainly wet bottom land but also steep slopes bordering stream valleys. Elevation

ranges from 1,000 to 1,200 ft.; topography is nearly level to gently sloping till plain with a thin mantle of loess. Dissection is greater in the east. Soils: brunizems (Kenyon and Ostrander) and soils transitional between gray-brown podzolic soils; brunizems (Kasson) from leached glacial till are dominant. Humic gley soils (Floyd and Clyde) are dominant on flats and wet drainage ways.

**Northern Mississippi Valley Loess Hills:** Most of the area is in farms but only two-fifths is cropland. Feed grains and hay are the principal crops. About one-fifth is in permanent pasture of tame and native grasses. One-third, mainly the areas of great slope, is in forest. Elevation varies from 600 ft. on valley floors to 1,200 ft. on the highest ridgetops. Sloping to hilly uplands are thoroughly dissected by both large and small tributaries of the Mississippi River. Soils: gray-brown podzolic soils (Fayette, Dubuque, Seaton, and Gale) from a loess mantle over bedrock or glacial till are dominant. Brunizems (Tama, Dodgeville, and Muscatine) occur on gently sloping broad ridgetops. Lithosols (Boone) and steep rocky and toney land are extensive on steep slopes bordering the major valleys.

**Iowa and Missouri Deep Loess Hills:** Most of the area is farmland, with about three-fifths in cropland. Corn, feed grains, and hay are the principal crops. One-fifth is permanent pasture of tame and native grasses. One-tenth of the area is forested, mainly narrow belts of steep slopes bordering stream valleys. Elevations range from 800 to 1,500 ft. on the highest ridgetops in the north. Much of this rolling to hilly loess-mantled plain is intricately dissected. Soils: brunizems (Marshall, Sharpsburg, and Monona) from moderately deep to very deep

loess on gentle to rolling slopes. On the steep slopes that support a deep mantle loess, regosols (Ida and Hamburg) are extensive, with gray-brown podzolic soils (Knox) in narrow bands where moisture supplies are sufficient for forest growth. Humic gley soils (Marcus) are on the upland flats and in depressions where loess is underlain at a moderate depth by glacial till. Alluvial soils (McPaul, Albaton, Haynie, and Sarpy) occur on the well-drained bottom lands, with humic gley (Wabash, Colo, and Luton) dominating the wet bottom lands.

**Illinois and Iowa Deep Loess and Drift:** Most of this area is farmland, with about three-fourths in cropland. Corn, soybeans, and other feed grains are cultivated on land of slight slope. Hay and pasture are grown on areas of steeper slope. Ten percent of the area is in pasture of tame and native grasses, with about 5 percent of the land in forest, usually narrow bands on steep valley sides and wet bottom land. Elevations range from 500 ft. on the low valley floors to 1,000 ft. on the highest uplands. The area is a dissected loess mantle glacial plain, rolling to hilly, with some broad uplands away from the large streams. Soils: brunizems (Tama, Muscatine, Flanagan, Sharpesburg, Shelby, and Mahaska) from loess are dominant soils throughout the area, with humic gley soils (Sable, Taintor, and Drummer) on flats and in depressions. Gray-brown podzolic soils (Fayette, Seaton, Clinton, and Lindley) occur on the sides of steep valleys. Alluvial soils (Nodaway and Lawson) are on the broader flood plains, with humic gley soils (Colo and Zook) on wet bottom land.

**Iowa and Missouri Heavy Till Plain:** Most of the area is farmland with more than one-half in cropland. Corn, feed grains, and hay are the main crops. About one-fourth is in pasture of tame and native grasses and 10 percent is woodland. Elevations range from 700 ft. in the lowest valleys to 1,100 ft. on the highest ridges. A thin loess mantle covers this dissected till plain. Brunizems (Shelby, Seymour, and Grundy) from fine textured glacial till or thin loess are the main soils. Planosols (Edina) occur extensively on broad upland flats, with humic gley soils (Haid) associated in the wettest areas. Alluvial soils (Nodaway) and humic gley (Colo and Wabash) are on the flood plains.

**Northern Illinois and Indiana Heavy Till Plain:** Mostly farmland, except for expanding urban and suburban area surrounding Chicago. Woodland occupies less than 5 percent of the area, and is confined to wet flood plains and steeply sloping valley sides, or to morainic ridges. Elevations range from 600 to 800 feet. Shallow stream-cut valleys head on this level and descend to gently sloping glaciated plain. Soils: brunizems (Saybrook, Elliott, Swygert, and Clarenc) from calcareous glacial till are the major soils. On flats and in depressions, associated with the brunizems are humic gley soils (Drummer, Ashkum, Bryce). Gray-brown podzolic soils (Morely, Miami, and Blount) from the glacial till are dominant on small tracts of formerly forested land in the northern area.

**Indiana and Ohio Till Plain:** About 90 percent of the area is in farms; 80 percent is cropland. Corn, soybeans, feed grains, and hay are main crops. Small areas of woodlots and permanent pasture make up the remainder of the area. Elevation ranges from 700 to 1,000 ft. The area is gently sloping glacial-till plain broken in places by hilly moraines, kames, and outwash terraces. Soils: gray-brown podzolic soils (Miami, Blount, Russell, Crosby, Fincastle, Cardington, and Morley) derived from calcareous glacial till, mantled by silt in the south, are the principal soils. Associated with these in flats and in depressions are humic gley soils (Brookston) and bog soils (Carlisle, Houghton, Edwards). Gray-brown podzolic soils (Fox and Ockley) and humic gley soils (Westland) are dominant in areas of gravelly glacial outwash.

**Central Claypan Areas:** Mostly farmland, with about three-fifths in cropland. Corn, soybeans, and feed grains are main crops. One-tenth is in permanent pastures of tame and native grasses. About one-sixth, mostly on steep slopes and wet bottom lands, is in forest. Elevations range from 750 to 950 ft. in Missouri and 500 to 600 ft. in Illinois. Most of the area is nearly level to gently sloping silt-mantled old till plains. There is very little local relief, varying from a few feet to a few tens of feet. Soils: Planosols (darker colored Putnam and Mexico in Missouri and lighter colored Hoyleton, Cowden, Cisne, Wynoose and Bluford in Illinois) with a claypan, mostly from loess overlying old glacial till, are the dominant soils. Gray-brown

podzolic soils (Lindley, Hickory, Weller, and Gara) are the principal soils on hilly and steep valley sides. Alluvial soils (Westerville and Sharon) and humic gley soils (Wabash) occur on narrow flood plains.

**Southern Illinois and Indiana Thin Loess and Till Plain:** Nearly all the area is in farms, but only one-half is cropland. Corn, soybeans, feed grains, and hay are principal crops. One-fifth of the area is in forest, some in large holdings. Elevations range from 400 ft. on valley floors to 1,200 ft. on ridgetops. The area is a dissected old glacial-till plain with a moderately thick mantle of loess. Ridgetops are narrow, and ridge slopes and valley sides are steep. Stream valleys are one to several hundred feet below the adjoining uplands. Soils: planosols (Blueford, Vigo, Avonburg, and Clermont) from the moderately thick loess over old glacial till on the level to sloping ridgetops. Gray-brown podzolic soils (Cincinnati and Rossmoyne) are the principal soils on the sloping uplands, and rendzinas (Fairmount) occur in shaly limestone materials on valley sides. Alluvial soils (Haymond, Belknap, and Bonnie) occur on the relatively narrow flood plains.

**Central Mississippi Valley Wooded Slopes:** Most of the area is in farms but only two-fifths is cropland. Feed grains and hay are the dominant crops. One-third of the area is forested, some in large tracts. Much of the remainder is in pasture of tame and native grasses. Elevations range from 400 ft. on the main valley floors to 1,000 ft. on the ridgetops. This is an area of dissected glacial-till plain with rolling narrow ridgetops and hilly to steep ridge slopes and valley sides. Valley floors are one to several hundred feet below the adjoining hilltops. Soils: Gray-brown podzolic soils (Menfro, Alford, Princeton, Lindley, Weller, and Weldon in loess over old glacial till and bedrock on rolling to steep slopes, and Gara and Lindley in till areas lacking the loess mantle) are the principal soils. On the ridgetops in the southern area, gray-brown podzolic soils with fragipans (Hosmer, Genada, and Union) are dominant. Alluvial soils (Genesee, Haymond, Sharon, Beaucoup, Westerville, and Allison) and humic gley soils (Wabash and Darwin) occur on the level flood plains.

**Southeastern Wisconsin Drift Plain:** Over 90 percent of the area is in farms, with almost 66 percent in cropland. Feed grains and hay are the main crops. Five to 10 percent of the area is in pasture of tame grasses. Ten to 20 percent of the area is in woodlots. Elevations range from 600 to 950 ft. Most of the area consists of glacial plain and belts of morainic hills, beach ridges, and outwash terraces. Drumlins are dominant in the southwest. Local relief is slight, with the exception of moraines and drumlins, which rise 100 to 250 ft. above the adjacent lowlands. Soils: Gray-brown podzolic soils (Miami, Kewau-nee, and McHenry) occur in medium- to fine-textured glacial drift that has a thin silt mantle. In the southern area, brunizems (Warsaw, Saybrook, Parr, Wea, Dodgeville, and Tama) occur on the nearly level prairie outliers on the drift plains. Podzols (Emmet and Onaway) occur in coarse-textured material in the northeast. Humic gley soils (Poygan, Kokomo, and Broodston) and bog soils (Carlisle) occur on the wet bottomlands.

**Western Michigan Fruit Belt:** Almost 66 percent is in forest, primarily farm woodlots, but 10 percent is in state and national forests. Thirty-three percent is in cropland, with about 5 percent in pasture. Elevations range from 600 to 1,100 ft. Topography of rolling to hilly moraines and beach ridges, with some level plains. There is slight local relief. Soils: podzols (Montcalm, Kalkaska, Emmet, and Rubicon) occur in moderately coarse-textured drift. Associated with these are regosols (Grayling) in deep acid sands. Low-humic gley soils (Roscommon), also in deep sands, are conspicuous but of small total extent. Gray wooded soils (Nester, Kawkawlin, and Seldirk) occur in fine-textured drift in the south, and bog soils (Carbondale, Lupton) occur on the many small and a few large flats and depressions.

**Southwestern Michigan Fruit and Truck Belt:** Eight percent of the area is in farms, with a little more than 50 percent in cropland. Most of the remaining land is in woodlots. Most of the non-farm-land is in state forest and parks. Elevations range from 600 to 800 ft., with a few hills of 1,000 ft. This is an area of nearly level glacial-drift plain with scattered, gently to strongly rolling morainic hills. Soils: gray-brown podzolic soils (Kalamazoo and

Oshtemo) from moderately coarse and coarse glacial drift are the dominant soils. In association with these, occurring in the coarsest deep sands, are regosols (Plainfield). Bog soils (Carlisle) are found in small to medium-sized depressions and basins throughout the area.

**Southern Michigan Drift Plain:** Almost 75 percent of this area is in farmland. Almost 50 percent is cropped. Corn, other feed grains, and hay are the primary crops. Just a little less than 10 percent of the area is in pasture, and the remainder is in small farm woodlots. The elevation in this area ranges from 750 to 1,000 ft. This is an area of broad glaciated plain, deeply mantled by till and outwash. Topography is that of level to gently rolling, and local relief is slight, except along the belts of morainic hills, which exhibit stronger slopes and relief of a few tens of feet to 100 to 200 ft. Soils: gray-brown podzolic soils (Fox, Kalamazoo, Oshtemo, Hillsdale, Miami, Lapeer, and Conover) occur in medium to coarse-textured acid and calcareous glacial drift and are dominant throughout the area. Associated with these are humic gley soils (Brookston Gilfor, Maumee, and Newton) in flats and depressions. In the northwest portion of this area, podzols (Montcalm, Kaldaska, Emmet, and McBride) are the dominant soils. Associated with these, in the wet areas, are humic gley soils (Roscommon, Edmore, and Ensley) and bog soils (Carbondale and Lupton). Brunizems (Warsaw and Door) occur on the prairie outliers in the south portion of this area.

**Erie-Huron Lake Plain:** Ninety percent of this area is in farms, with about 66 percent in cropland. Corn, winter wheat, soybeans, and hay are the primary crops. Much of the remainder of this area is in pasture and small farm woodlots. The elevation of this area is 600 to 800 ft. There is very little local relief on this broad lake plain. Soils: medium- and fine-textured humic gley soils (Toledo, Brookston, Parkhill, Colwood, Sims, Hyotville, and Wauseon) are the dominant soils. Associated with these are low-humic gley soils (Brevort, Paulding, and Latty). Gray wooded soils (Kawkawlin and Capac) occur on the areas of good drainage in the north portion of this area.

**Northern Minnesota Swamps and Lakes.** Over 80 percent of this area is in forest land and lakes.

Only about 10 percent to 15 percent is cropland, with only 3 percent to 4 percent in pasture. The elevation of this area ranges from 1,100 to 1,500 ft. This area is a broad lake plain in the north, and rolling glacial moraine broken by areas of outwash in the southern portion. Soils: gray wooded soils (Nebish, Rockwood, Beltrami, and Taylor) derived from calcareous glacial till and clays are the dominant soils. In the area of the Lake Agassiz basin, bog soils occur on broad level areas, with podzols (Hiwood) and low-humic gley soils in other areas.

**Minnesota Rockland Hills:** Nearly the entire area is in national forest. Elevations range from 1,200 to 2,000 ft. Lakes, swamps, and other wet lowlands are scattered throughout the irregular low hills. Soils: large areas of acid and basic crystalline rock outcrops are intermingled with extensive spreads of lithosols. For much of the area, detailed information on soils is lacking (Austin, 1965:39).

**Wisconsin and Minnesota Sandy Outwash:** Ninety percent of this area is in farms. Ten percent, mostly in Wisconsin, is owned by federal and state governments. Almost 33 percent of the area is cropland. Feed grains and forage for livestock are the main crops. Ten percent of the area is in forest. Elevation ranges from 900 to 1,100 ft. Topography is irregular on this nearly level to gently rolling outwash plain. Soils: dominant soils are weakly developed gray-brown podzolic soils (Coloma) and regosols (Plainfield and Zimmerman) in sandy glacial outwash. Associated on wet lowlands underlain by outwash are humic gley soils (Newton, Dillon and Isanti), low humic gley soils (Roscommon, Granby, and Kinross) and bog soils.

**Superior Lake Plain.** Over three-quarters of this area is in forest. Five to 10 percent of the area is in cropland. Only 1 percent to 2 percent is in pasture. Elevations range from 600 to 1,000 ft. on this nearly level lake plain (which has some inclusions of rocky knobs, hills, and low mountains). Local relief on the lake is slight, but in the adjoining hills and mountains, there is a difference of 100 to several hundred feet. Soils: gray wooded soils (Ontonagon, Watton, and Hibbing) derived from fine-textured, lacustrine sediments and glacial till are dominant. Low-humic gley soils (Pickford and Gergland) occur in wetter areas and podzols

(Munising, Iron River, Gogebic and Hiawatha) occur in acid sandy materials.

**Northern Michigan Sandy Drift:** Eighty percent of this area is forested. Only 1 percent to 2 percent of the land is in crops and pasture. Elevations range from 600 to 970 ft. in the Upper Peninsula, increasing from the shores of the Great Lakes inland. In the Lower Peninsula, elevation is 600 ft. along the lakeshores to more than 1,500 ft. in the central portion. This area is a broad glacial-drift plain and includes belts of morainic hills, especially in the Lower Peninsula. Local relief is slight, but on the morainic hills relief can be from a few tens of feet to a few hundred feet. Soils: podzols (Rubicon, Kalkaska, Montcalm, Bride and Emmet) from sandy glacial drift are the principal soils. Associated with these are regosols (Grayling) in excessively drained deep sands; low-humic gley soils (Roscommon, Ensley, and Edmore) occur on poorly drained flats and in depressions. Gray wooded soils (Nester, Kawkawlin, and Ontonagon) are found in fine-textured materials containing more lime on wet lowlands, as are low-humic gley soils (Pickford) and humic gley soils (Gergland, Bruce, and Sims). Bog soils (Carbondale and Lupton) are found extensively in basins and depressions throughout the area.

**Table 4.** A photointerpretation key for landforms occurring in the midwest.

Landform	Topography	Drainage	Tone	Gullies	Vegetation & Land Use
Till					
Thick					
Young	Flat plain	Deranged	Mottled	Few to soft	Cultivated, gridded
Old	Dissected plateaus	Dendritic, medium	Subdued mottles	Box-shaped	Cultivated and forested
Thin					
Young	Rock controlled	Rock controlled	Light gray	Vary	Cultivated and/or forested
Old	Rock controlled	Rock controlled	Dull gray	Vary	Cultivated and/or forested
End moraine	Undulating to rugged	Deranged	Light to dark	Vary	Cultivated and/or forested
Drumlin	Drumlin-shaped	None	Light gray	None to few	Cultivated and/or forested
Glaciofluvial					
Esker	Snakelike ridges	None	Light	None	Natural cover
Kame	Cone or ridged hills	None	Light	Few V-shape	Natural cover
Outwash					
Plain	Flat plains	Internal, channel	Light	None	Cultivated or natural
Pitted	Pitted plains	scars	Light	Few V-shape	Cultivated or natural
Valley train	Flat valley bottom	Internal			
Glaciolacustrine					
Lake beds		Internal	Light	None	Cultivated or natural
Sandy	Flat plains	Internal and ditches	Light dull gray	None	Cultivated
Clay	Flat plains	Broad meanders	Dull gray	Ditches	Cultivated

(After Way, 1973)

**Table 5.** A dichotomous photointerpretation key to several forest tree species among the northern conifers.

1. Crown small, or if large, then definitely cone-shaped
  2. Crown broadly conical, usually rounded tip, branches not prominent .....Cedar
  2. Crowns have a pointed top, or coarse branching, or both:
    - Crowns narrow, often cylindrical, trees, frequently grow in swamps ..Swamp-type black spruce
    - Crowns conical, deciduous, very light toned in fall, usually associated with black spruce .....Tamarack
    - Crowns narrowly conical, very symmetrical, top pointed, branches less prominent than in white spruce .....Balsam fir
    - Crowns narrowly conical, top often appears obtuse on photograph (except northern white spruce), branches more prominent than in balsam fir .....White spruce, black spruce (except swamp type)
    - Crowns irregular, with pointed top, has thinner foliage and smoother texture than spruce and balsam fir .....Jack pine
1. Crowns large and spreading, not narrowly conical, top often not well defined:
  3. Crowns very dense, irregular or broadly conical:
    - Individual branches very prominent, crown usually irregular .....White pine
    - Individual branches rarely very prominent, crown usually conical .....Eastern hemlock
  3. Crowns open, oval (circular in plan view) .....Red pine

(After Avery, 1977:240)

**Table 6.** A dichotomous photointerpretation key to several forest tree species occurring in the central hardwoods forests (for use with color transparency film).

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- 1. Branching is layered, radially triangular; crown margin is serrate, crown foliage is light green to moderate green .....White pine
  - 1. Branching not radially triangular; crown margin is not serrate .....Go to 2
    - 2. Leaves mostly inconspicuous, tree branches virtually bare .....Go to 3
    - 2. Leaves present in crown .....Go to 5
  - 3. No foliage present; dark colored bole and branches completely bare .....White basswood
  - 3. Very little foliage remaining (less than 5%) .. .....Go to 4
    - 4. Branching gives crown a fine-textured appearance .....White ash or black walnut
    - 4. Branching appears medium textured .....Yellow buckeye
  - 5. Crown foliage thinning; trees losing a significant portion (40%) of leaves in early fall ...Go to 6
  - 5. Crown foliage is dense or full; leaves abundant on branches .....Go to 8
    - 6. Branching appears finely divided or dissected; crown margin shape is circular or oval and usually large. Branches are silver gray. Crown foliage is finely textured, crown color is a moderate orange yellow to dark orange yellow .....American beech
    - 6. Branching appears more massive and is moderately divided; crown shape and size is variable .....Go to 7
  - 7. Crown apex domed or tufted, crown margin moderately sinuate; crown foliage colors are a moderate red and/or moderate reddish orange .....Blackgum
  - 7. Crown apex rounded, crown size small, crown color dark pink to grayish red .....Sweetgum
    - 8. Crown margin shape circular or oval and generally entire .....Go to 9
    - 8. Crown margin shape is generally irregular with medium to large sinuations; crown apex is domed, tufted, or billowy .....Go to 10
  - 9. Crown texture fine and feathery; crown small with random lineation. Predominant crown colors are moderate olive green to yellow green. Shortleaf pine or Virginia pine
  - 9. Crown texture very fine, crown apex rounded to broadly oval, small sized crowns with tufted or parted appearance, crown color is light yellowish green .....Black locust
    - 10. Large masses of foliage divided and part crown. Crown foliage is moderate yellow green to moderate yellowish green .....White oak
    - 10. Predominant crown colors are light grayish red, grayish red or dark yellowish pink ..Scarlet oak
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(After Thorley, et al., 1975: 1356; and Krumpke, 1971)



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As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. administration.

