

2 mix

Project for the Use of Remote Sensing
in Land Use Policy Formulation

NASA-CR-136271) THE USE OF COLOR
INFRARED PHOTOGRAPHY FOR WETLANDS MAPPING
WITH SPECIAL REFERENCE TO SHORELINE AND
WATERFOWL HABITAT ASSESSMENT (Michigan
State Univ.) 36 p HC \$4.00 CSCL 08B

N74-13109

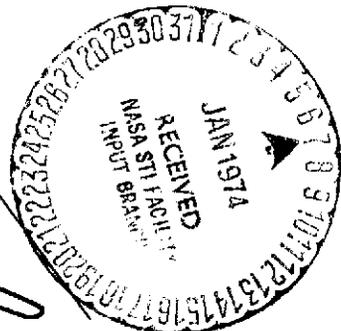
Unclas
24852

58

THE USE OF COLOR INFRARED PHOTOGRAPHY FOR WETLANDS MAPPING

with special reference to
Shoreline and Waterfowl Habitat Assessment

COLOR ILLUSTRATIONS REPRODUCED
IN BLACK AND WHITE



MICHIGAN STATE UNIVERSITY
October 1973

ACKNOWLEDGEMENTS

This document was made possible through a National Aeronautics and Space Administration grant to Michigan State University. The research grant, NASA NGL 23-004-083, is administered by the NASA Office of University Affairs.

The Use of Color Infrared Photography for Wetlands Mapping: with special reference to Shoreline and Waterfowl Habitat Assessment was authored by William R. Enslin of Michigan State University's Project for the Use of Remote Sensing in Land Use Policy Formulation. Assistance was provided by Mark C. Sullivan; the graphics were prepared by Peter N. Gibson, Mary Daup and William R. Enslin. Professor Myles Boylan, of the School of Urban Planning and Landscape Architecture and Dr. Raymond D. Vlasin, of the Department of Resource Development are the Principal Investigators for the MSU Project, which is under the day-to-day management of Stephen Schar.

In its overall project, MSU cooperates closely with the Environmental Research Institute of Michigan, previously called the Willow Run Laboratories of the University of Michigan.

In addition, the effort at Michigan State University involves staff from the Department of Forestry and the Department of Crop and Soil Sciences as well as the Michigan Agricultural Experiment Station.

THE USE OF
COLOR INFRARED PHOTOGRAPHY FOR WETLANDS MAPPING

with special reference to
Shoreline and Waterfowl Habitat Assessment

October 1973

PROJECT FOR THE USE OF REMOTE SENSING
IN LAND USE POLICY FORMULATION

Michigan State University

TABLE OF CONTENTS

Introduction	1
Study	2
Purpose	2
I. Data Collection	8
II. Shoreline Assessment	12
Photo-Base Map Construction	12
Evaluation of Shoreline Erosion	13
Identification of Shoals	13
Evaluation of Adjacent Land	14
III. Waterfowl Habitat Assessment	17
Inventory of Vegetative Patterns	17
Evaluation of Vegetative Patterns	20
Summary and Conclusions	27
Bibliography	28
Appendix	32

INDEX OF TABLES

TABLE I Relative Comparison of Different Film Types in Meeting
the Five Objectives 9

TABLE II Summary of Data Sources 11

TABLE III Respective Color Signature for Selected Vegetative Types . . . 19

TABLE IV Location of Selected Vegetative Communities 24

INDEX OF FIGURES

FIGURE 1 Pointe Mouillee State Game Area 3

FIGURE 2 Pointe Mouillee, 1935 Shoreline 4

FIGURE 3 Pointe Mouillee, 1971 Shoreline 5

FIGURE 4 Land Cover Map 16

FIGURE 5 Transect Location 18

FIGURE 6 Vegetative Communities Map 21

FIGURE 7 Vegetative and Topographic Patterns 23

A. Height of dominant vegetation

B. Relief of marsh bottom and vegetative community location

Introduction

Inland and coastal wetlands are now receiving considerable interest because of their valuable ecological role. To preserve these delicate ecological features, detailed analysis and mapping are needed.

Until recently, wetlands mapping was expensive, time consuming, and often inaccurate. Generally, the inaccessible nature of wetland areas imposed substantial constraints on conventional ground surveying methods. McDonald, who spent three years doing field work in the Pointe Mouillee Marsh, noted in his dissertation: "The great difficulty, at times the impossibility, of traversing the marsh prevented the procuring of certain desired data, particularly information from large numbers of quadrats."¹

Poor trafficability and the difficulties associated with operating surveying equipment in a wetland environment would seem to restrict accuracy and increase mapping time and expense. In addition, marshes tend to change rapidly, and require frequent remapping. It is this change, both seasonal and yearly, which causes most of the problems encountered in trying to manage wetland areas. Many seasonal changes in the wetlands are recorded only in the manager's memory. If this individual is transferred, much of his knowledge of existing conditions and trends may be lost.

These problems resulted in research to determine whether remote sensing techniques could be used to analyze wetland areas. Remote sensing techniques have spatial, spectral, and temporal advantages over conventional methods. Spatially, remote sensing can provide aerial images of an extensive wetland area, thus affording a synoptic view of the environment not achievable through ground surveys. Spectrally, remote sensing can provide information about the vegetation and surface conditions using a number of spectral regions of the electromagnetic spectrum, both visible and invisible. Identification and delineation of different types and conditions of vegetation, submarine features, shoreline configuration, soil types, and soil moisture is made easier by selecting the appropriate region of the spectrum to be imaged. Temporal advantages include: 1) a permanent record of existing conditions at date of imagery and 2) rapid mapping and interpretation time. In addition, remote

¹Malcolm E. McDonald (1951). "The Edge of the Pointe Mouillee Marsh, Michigan, with Special Reference to the Biology of Cat-Tail (Typha)." University of Michigan, Doctoral Dissertation Series, Publication #2421.

sensing techniques facilitate periodic updating of all or part of the wetland being studied.

Recent remote sensing studies of wetlands focused on mapping and inventorying vegetative communities of coastal salt marshes. Researchers in Maryland (Egan and Hair, 1971), Georgia (Reimold, Gallagher and Thompson, 1973), Florida (Schneider, 1966), Maine (Olson, 1964), and New Jersey (Anderson and Wobber, 1972) have had excellent results with their programs. Inland wetlands, although they have received considerably less attention than coastal salt marshes, have also been studied using remote sensing techniques, e.g. Nevada (Seher and Tueller, 1973).

Study Area

This report deals with a somewhat different wetland ecosystem than other recently published wetland studies because the area studied was a fresh water "coastal" marsh in Michigan. The study site was Pointe Mouillee, the delta and estuary area of the Huron River as it enters Lake Erie (Figure 1). This 1100 hectare marsh, owned by the State of Michigan, has been managed for many years by the Michigan Department of Natural Resources (DNR). Within the marsh, a 148 hectare controlled flooding area has been managed as a wildlife refuge by the DNR since the mid-1960's following the construction of a water-level-control dike.

By regulating water levels within the diked area, the DNR attempts to encourage vegetative types that provide food for the ducks on the north-south flyway during migration. Pointe Mouillee has a valuable ecological role for waterfowl in this region since only two other viable wildlife refuges exist on Lake Erie. In addition, it serves as a major recreation area for hunters.

Purpose

Recently, the marsh manager has become concerned about massive erosion of the area at Pointe Mouillee. Lake Erie's water level changes yearly and recently is at a record high. Hence, the lake encroaches on the marsh. In addition, storms create heavy surf which pounds on this fragile environment. From Figures 2 and 3 it is apparent that between 1935 and 1971, a large amount of marsh area has been lost.

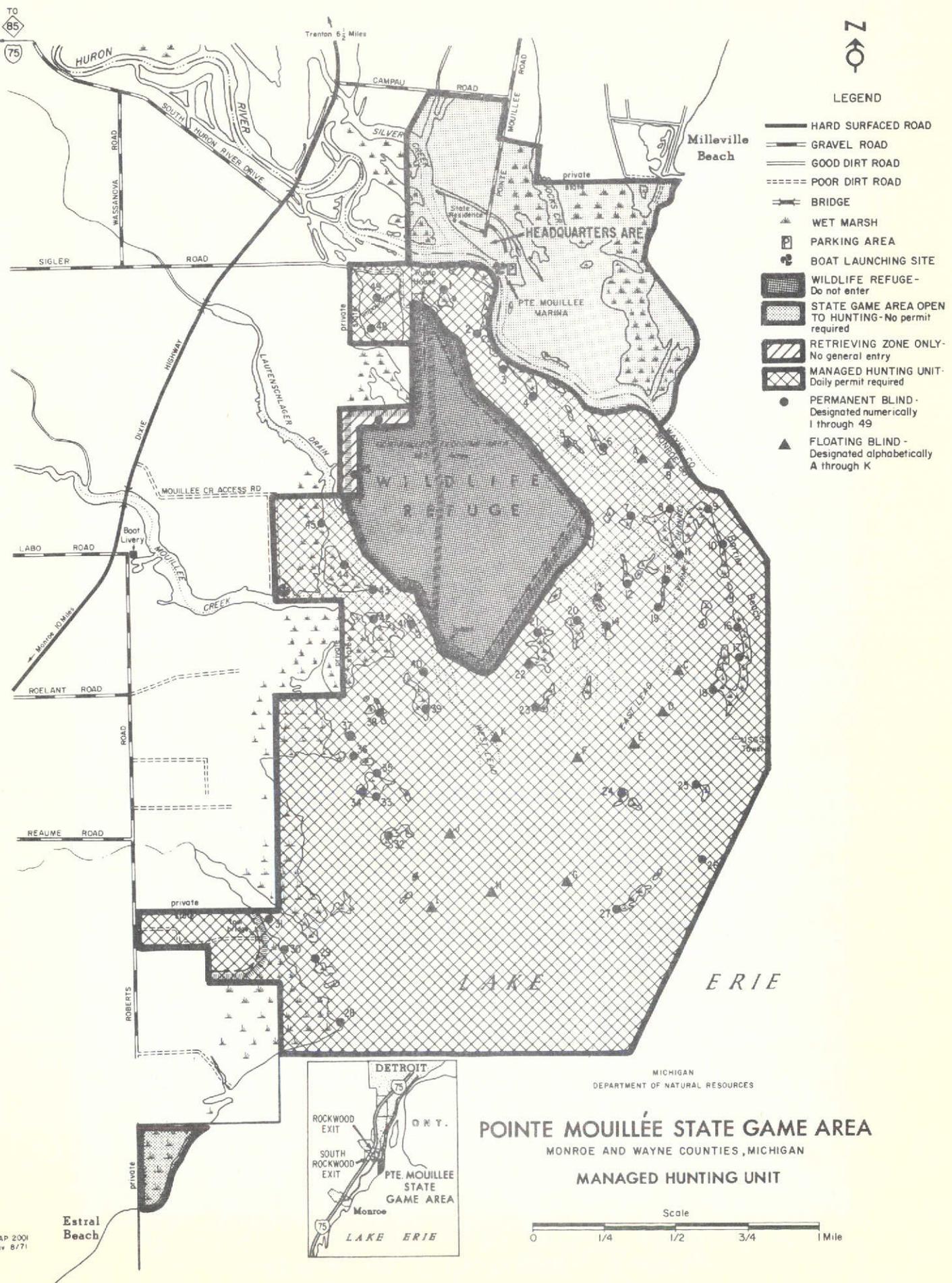


FIGURE 1. POINTE MOUILLEE STATE GAME AREA

MAP 2001 Rev 8/71



FIGURE 2. POINTE MOUILLEE, 1935 SHORELINE

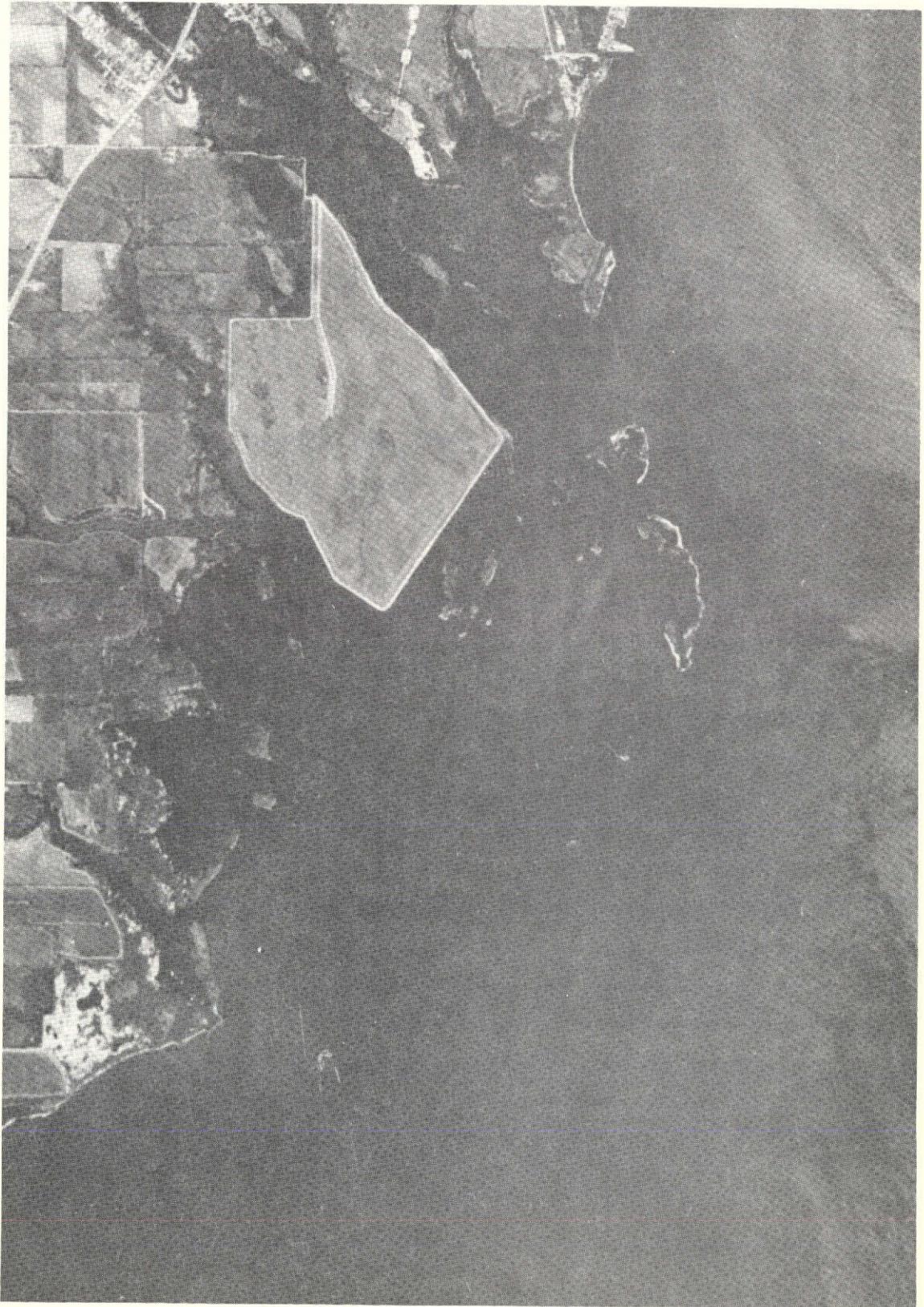


FIGURE 3. POINTE MOUILLEE, 1971 SHORELINE

The effect of erosion on cattail islands, which serve as permanent hunting blind sites, was noted by the marsh manager: "In almost every blind, except for a few way back inland, the marsh had receded and we had to pick a new site, maybe 30 or 40 feet from it. I know these things, but there's no documentation. There's no way that I can go to Lansing, and go to the Commission and say that this marsh is being destroyed at this and this rate. We can't let it go, we'll have to do something."² The Michigan Department of Natural Resources faces a serious problem in trying to save the marsh.

Another problem is the manager's desire to obtain quantitative information pertaining to the viability of the marsh as a waterfowl habitat. The marsh manager knows that the marsh contains certain vegetation types that are important for food or cover, whereas other areas produce no useful vegetation. He does not, however, know their quantitative distribution or the extent of various vegetation types. His management decisions are based mainly on intuitive perception of current and past conditions within the marsh. Documentation of current conditions and management practices within the marsh is needed as expressed by the marsh manager: "I've been here 15 years and if I should get transferred or take another job, there'd be practically nothing on record to guide the next guy. He'd start over where I was 15 years ago on this job."³ Specifically, there is a need to map and inventory the vegetative communities at Pointe Mouillee to provide information for effective management of this important waterfowl habitat.

Detailed interpretation, mapping and analysis of the marsh environment at Pointe Mouillee was cooperatively undertaken by the Project for the Use of Remote Sensing in Land Use Policy Formulation and the Environmental Research Institute of Michigan (ERIM) to provide the information needed for solving both problems. A program for the collection and analysis of remote sensing and other information was designed for the following objectives: (1) measurement of past and present island and shoreline destruction, (2) inventory and evaluation of land adjacent to the marsh area as potential replacement for areas lost due to erosion, (3) inventory and assessment of emergent vegetation, (4) mapping of shoal areas, and (5) mapping of submerged aquatic vegetation.⁴

²From an edited transcription of a meeting with Mr. Jim Foote, Wildfowl Specialist, Pointe Mouillee State Game Area, DNR, August 25, 1972.

³Ibid.

⁴Most of the submerged vegetation beds lie at the mouth of the Detroit River in proximity to Celeron Island, i.e., outside the Pointe Mouillee State Game Area boundary. The mapping of this vegetation was considered as a separate study and, therefore, is not discussed in this report.

A detailed analysis of the inventory results and subsequent recommendations are included as a part of the report on the Pointe Mouillee research being prepared jointly by ERIM and the Remote Sensing Project at Michigan State University (Istvan et al, 1973). An analysis of the extent of shoreline erosion, the capability of adjacent lands to support marsh vegetation and uses, and the inventory of emergent vegetation are discussed in that report. This document is intended to provide technical support for those analyses, and to outline the procedures employed in identifying and inventorying the physical components of the Pointe Mouillee environment.

I. DATA COLLECTION

The aerial photography available for the Pointe Mouillee site was very limited. Only frames of high altitude NASA photography (RB-57, 1:120,000) and outdated black and white aerial photography were available. A low-altitude mission was flown in May 1972, but due to poor quality and excessive sun glitter it was of limited value. Also, the diked area was flooded at this time, prohibiting a detailed vegetation inventory.

Because of limited knowledge of interpretation and mapping of wetland areas, a test flight was scheduled to help plan a detailed data gathering mission. In July, low-altitude oblique photography was obtained from a helicopter using three hand-held camera systems. These systems - Fairchild K-20 (4 x 5½ black and white panchromatic film), Canon 35mm SLR with 100mm telephoto lens (color infrared film), and Mamiya Super 23 (70mm color film) - provided a variety of film types, formats and scales. Three runs were made at different altitudes, providing scales from 1:1800 to 1:7200 over selected test sites. An optimum scale could be determined by utilizing the above range, which would yield a working scale large enough for adequate interpretation yet small enough to meet cost limitations.

Following this test flight, the photography was evaluated. Differences in capabilities of equipment between the hand-held camera systems and the standard aerial survey 9-inch format camera were also taken into account. It was determined that the value gained by the larger scales does not seem to warrant the increased cost. The photography at a scale of 1:7200 (1" = 600') depicted approximately the same differentiation in vegetation as the largest scale, except for small patches of submerged aquatic vegetation. A recent study by Seher and Tueller (1973) cited that a scale of 1:10000 was adequate for identifying most large wetland communities. This seems to further substantiate our findings.

An evaluation of the selected film types with respect to the previously stated objectives appears in Table I. The subjective film ratings in Table I were based on an evaluation of the Pointe Mouillee imagery in conjunction with researched literature. The respective ratings for color and black and white panchromatic reflects capabilities of these film types with minimal atmospheric attenuation; in areas where hazy conditions persist, their capabilities would lessen.

TABLE I

RELATIVE COMPARISON OF DIFFERENT FILM TYPES IN MEETING THE FIVE OBJECTIVES

	<u>Color</u>	<u>Color Infrared</u>	<u>B&W Pan.</u>	<u>B&W Infrared</u>
Shoreline Delineation- Destruction	A	A	A	O
Inventory-Adjacent Land	A	O	A	A
Marsh Vegetation Inventory	A	O	M	M
Mapping Shoals	O	M*	A	U
Submerged Aquatics	O	M*	M	M

O - optimal, A - adequate, M - marginal, U - unattainable

* - may be adequate if target is within a foot or two of the water's surface

Color infrared film (CIR) was selected as the best overall type of film with respect to the five objectives because of its superior ability to differentiate vegetative types in the marsh (our major priority), without being substantially affected by the ever present hazy conditions at Pointe Mouillee. The color infrared imagery exhibited better tonal image contrast, especially between water and land, due to its infrared nature. This film was also able to depict submerged vegetation near the surface of the water in the Pointe Mouillee area. The definition of shoals was only slightly better on the true color film because of turbid water conditions in the area. The color photography was also substantially affected by the hazy conditions over Pointe Mouillee which caused the imagery to be less sharp than the CIR.

As a result of this evaluation, 9-inch CIR photography at a scale of 1:8000 was requested over the entire marsh; additional 1:4000 scale photography was requested over the controlled flooding area. The additional larger scale photography was requested because of the detailed mapping nature of our objective in this area. The larger scale would facilitate interpretation and delineation of vegetative communities within the diked area.

In late August, just prior to the flooding of the wildlife refuge, a flight was conducted over the area with a NASA-supported C-47 aircraft operated by ERIM. During the flight, 9-inch color infrared photography (1:8000 and 1:4000) and multispectral scanner data were collected. The imagery was taken at mid-morning (about 10a.m.) to reduce sun glitter. The film was delivered a month later and was of good quality, suitable for interpretation.

In addition to the 9-inch vertical photography, numerous oblique photographs were provided from the helicopter flight. These were valuable as additional references for interpretation.

Detailed ground data were collected in late August for the area within the dike, providing both transect maps and ground photography. The procurement of ground data at that time was necessary because subsequent ground truth efforts would be hampered by flooding of the diked area in early September. Therefore, two carefully selected transects, which traversed areas characterized by a wide variety of vegetation types, were made within the dike to:

1. establish locally representative areas of various vegetation types so that the corresponding image signature could be determined for each type encountered, thus facilitating the development of a photo interpretation key.
2. provide additional information about vegetative conditions in the area; specifically, average height of each vegetative species, and the elevation of the marsh bottom.

Both transects were approximately a half mile long and 2 chains wide (about 132 feet). The vegetative patterns encountered within both swaths were sketch-mapped, and the elevation of the marsh bottom and the height of the dominant vegetation at each chain mark were recorded.

A summary of the data sources available for the study is shown in Table II.

TABLE II

SUMMARY OF DATA SOURCES

<u>PHOTOGRAPHY</u>	<u>FORMAT</u>	<u>FILM TYPE</u>	<u>SCALE</u>	<u>DATE</u>	<u>REMARKS</u>
1) High-altitude, NASA RB-57	9-inch	CIR	1:120000	7 Jul. '71	Synoptic view of area used for the illustration of 1971 shoreline configuration (see figure 3).
2) DNR Mosaic	---	B&W Pan	---	1935	Used for the illustration of the 1935 shoreline configuration (see figure 2).
3) Low-altitude, ERIM C-47	(a) 9-inch	B&W IR	1:8000	5 May '72	Not used due to poor quality and season flown.
	(b) 70mm	CIR	1:31580	5 May '72	
	(c) 9-inch	CIR	1:8000	29 Aug. '72	Coverage of entire area used for general cover type mapping.
	(d) 9-inch	CIR	1:4000	29 Aug. '72	Coverage of diked area used for detailed vegetative mapping.
4) Low-altitude obliques, helicopter	(a) 4" x 5 ^{1/2} "	B&W Pan	1:1200 1:2400 1:4800	11 Jul. '72	Coverage of selected test sites.
	(b) 35mm	CIR	1:1800 1:3600 1:7200	11 Jul. '72	Specification of C-47 mission requirements.
	(c) 70mm	Color	1:1800 1:3600 1:7200	11 Jul. '72	Supplement to C-47 photography.
5) Ground Photography	35mm	Color	---	5 May '72 22 June '72 10 Jul. '72 29 Aug. '72	Record of site conditions and documentation of transect vegetation.
<u>MAPS</u>				<u>DATE</u>	<u>REMARKS</u>
1) DNR Pointe Moulllee State Game Area				Aug. '72	Location map (see figure 1).
2) U.S.G.S.				(a) 1952 (topo 1940) (b) 1967	Determination of shoreline change.
3) MSU transect sketch maps of vegetative patterns				18 Aug. '72	Evaluation of vegetative patterns.

II. SHORELINE ASSESSMENT

Photo-Base Map Construction

A up-to-date base map of Pointe Mouillee was constructed prior to mapping the interpretative results. This was essential because existing U.S.G.S. maps of the Pointe Mouillee area do not reflect the present configuration of the shoreline. The photo-base map was constructed using outdated U.S.G.S. topographic maps and recent aerial photographs of Pointe Mouillee.

Generally, the procedure was to transfer changes in shoreline detail (depicted on the photography) into the framework of existing map detail using a Bausch and Lomb Zoom Transfer Scope (ZTS). The first step in the procedure was to construct a reference map at approximately the same scale as the photography. This reference map was made by enlarging (3X) an existing U.S.G.S. (1967) 1:24,000 map of the area on a Kargl Reflecting Projector and then transferring the map detail (e.g., lakes, streams, buildings and road network).

This map was needed in order to establish reference points (control points - road intersections) so planimetric detail from the photography could be placed within the framework of existing map detail. Control points were needed to correct distortion in photography due to attitude changes of the aircraft (tip and tilt), as well as scale changes. Corrections for scale changes and common imagery distortions can be made through controls on the ZTS if the photography detail is matched to existing map detail.

The present shoreline and any other changes (e.g., buildings, inland lakes and streams) were then plotted on the reference map using the 9-inch CIR photography (1:8000) and the ZTS.

The above procedure yielded an accurate⁵ base map revision at a scale of 1:8000 reflecting the present shoreline configuration. It was subsequently used to graphically depict the inventory results.

The area being mapped imposed limitations on the accuracy of the final map product, due to the lack of control points. The ZTS only views a small portion of a 9-inch photograph, thereby requiring many control points

⁵ Researchers have found the ZTS to be capable of accurate map revision with an accuracy comparable to a second-order photogrammetric instrument. Robert F. McGivern, Don B. Martin, and John E. Benjamin, "Planimetric Map Revision with the Bausch and Lomb Zoom Transfer Scope." Proceedings of the 38th Annual Meeting of the ASP (Mar. 12-17, 1972), pp. 615-616. (Abstract).

throughout the mapping area (if accuracy is essential) as well as time-consuming readjustments, e.g., orienting a single frame several times in order to transfer the detail contained in the entire frame. The absence of control points within the marsh area of the Pointe Mouillee State Game Area lowered the planimetric accuracy of this portion of the base map. This did not affect the usefulness of the final product in any way, because strict planimetric accuracy was not essential to the study.

Evaluation of Shoreline Erosion

Land losses to the marsh habitat have been substantial over the years; however, the rate and extent of the destruction have never been documented. A comparative study was made of past records of the area to determine long-term shoreline changes (i.e., which areas have been eroded, the amount of marsh area lost, and the rate at which the erosional process has occurred).

Using the 1940 and 1967 U.S.G.S. maps of the area and the constructed base map indicating the 1972 conditions, two maps were made indicating shoreline changes from 1940 to 1967 and 1967 to 1972. Area measurements of marshland lost between these years were made by means of a planimeter. Area losses to the marsh between 1940 and 1967 were 173.0 acres (70 hectares).⁶ An additional 716.6 acres (290 hectares) were lost from 1967 to 1972.

Our review of the constructed shoreline change maps indicates that the rate of marshland destruction has accelerated significantly in recent years, and that the entire marsh shoreline has been appreciably altered in the Pte. Mouillee area. These findings substantiate the importance of immediate DNR action to: (1) counter the destruction of the marsh, and (2) acquire and develop additional land suitable as waterfowl habitat.

Identification of Shoals

The DNR was also interested in mapping the shoals in the area because they may indicate the nature of the water action and are important to the total biological activity of a lake. Careful study of shoals may indicate the nature of currents related to erosion and deposition, especially if comparative imagery is acquired on a temporal basis.

⁶ According to McDonald, 51.8 acres (21 hectares) were lost between 1940 and 1949 (McDonald, 1951, p. 49).

Very little effort was put towards the mapping of shoals because:

(1) this objective had lower priority, and (2) the specific imagery acquired did not effectively depict shoals. CIR film is not the optimum film type to use for identifying underwater features; however, it differentiates vegetative types (our major priority) without being substantially affected by atmospheric attenuation.

True color film would seem to be a more appropriate film type; however, an evaluation of the acquired hand-held photography showed that the definition of shoals was only slightly better on true color film due to turbid water and the normal hazy conditions over Pointe Mouillee.

For the above reasons mapping of shoals was not attempted. Special film types are now being studied. One in particular, Anscochrome 2 layer CIR film (green and infrared), is being investigated for possible good water penetration capability.

Evaluation of Adjacent Land

The DNR is planning to add to its holdings in the Pointe Mouillee area by extending its boundaries through acquisition of adjacent land. The land will provide a buffer from non-compatible land use in the vicinity and offset land lost through erosion. An inventory and assessment of adjacent lands in respect to vegetative cover, soil and hydrology were made to help the DNR determine the suitability of selected areas for conversion to marshes. Vegetative cover types were identified and delineated from the acquired aerial photography; other data were collected from existing survey information.

A generalized classification scheme was employed outside the diked area because: (1) only general information on land cover was needed to determine suitability for conversion of non-marsh areas to wetland situations, and (2) the variety of aquatic plants was quite small (cattails being the predominant plant life). Land cover areas were classified in a seven-category system: (1) herbaceous ground cover, (2) brush, (3) forest, (4) cultivated land cover, (5) aquatic vegetation, (6) water, and (7) non-vegetated areas. These seven categories were identified on 9-inch CIR (1:8000) photography and delineated on the previously constructed base map using the Zoom Transfer Scope. During the photo interpretation, numerous ground checks were made to insure accuracy. However, no detailed ground surveys were necessary due to the generalized classification scheme and large agricultural component of the area.

The above procedure yielded a land cover map of the adjacent lands (Figure 4) and was a major factor in determining lands suitable for marshland development because soil type and nutrient levels were not considered limiting factors. Thus, the relative suitability of an area was determined by (1) the feasibility of water level controls (i.e., the presence or absence of existing dike structures), and (2) the type of land cover (e.g., existing marsh areas are more suitable than forest areas). To indicate the general suitability of the area, the amount of land in each land cover category was determined using a planimeter. The results of these measurements are tabulated in the appendix.

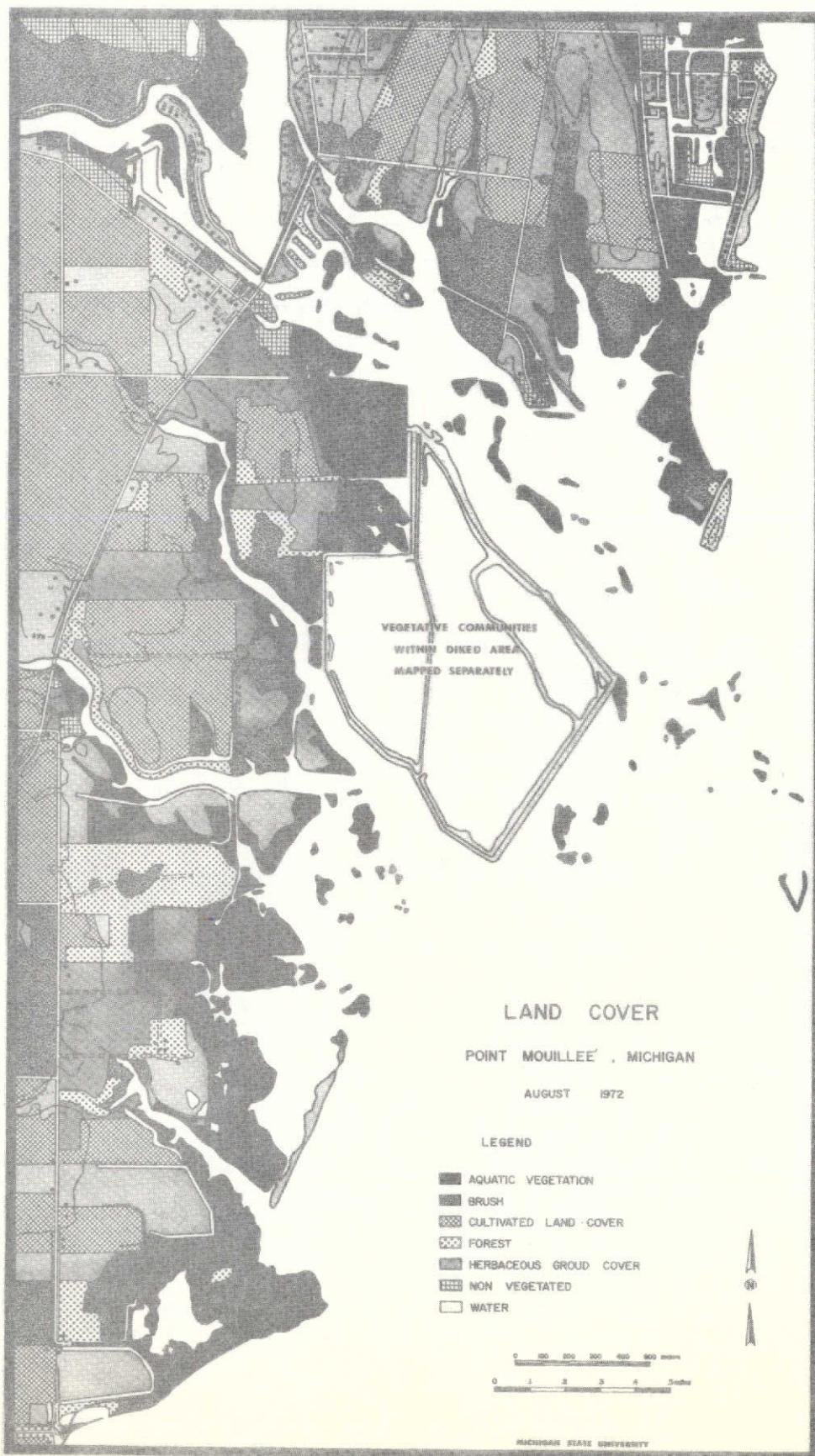


FIGURE 4. LAND COVER MAP

III. WATERFOWL HABITAT ASSESSMENT

Inventory of Vegetative Patterns

The diked area is an intensively managed area, where the water level can be controlled for the growing of various waterfowl food plants. This area is the major source of surface duck food for the entire marsh; other areas contain mostly cover vegetation. Because of the importance of this area and current management practices, a detailed vegetation inventory was needed. At the present time, the vegetation is monitored but no attempt is made to obtain quantitative information. Detailed quantitative information would allow the DNR to modify its practices, i.e., produce more plants suitable for duck food and minimize unsuitable vegetation.

The selection of a vegetation classification scheme was not made prior to the photo interpretation, but was determined from what vegetative types could be identified from the photography with the aid of ground surveys. During the data collection phase, transect ground markers were not necessary because of the fragile nature of the vegetation in the management area. Just the physical act of walking along the transect as it was being laid out as well as tramping down the vegetation around each chain mark resulted in a visible pattern of this activity on the photography over this area (Figure 5). This simplified the task of pinpointing the location of the various vegetative communities encountered along the transect. The representative tonal signature of each vegetative type was determined by interpolating between the transect pattern depicted on the photography and the actual ground transect data.

Vegetative cover areas within the dike area were then identified and delineated on acetate overlays using the 9-inch (1:4000) color infrared transparencies. Additional field checks were made to determine vegetative composition of areas where tonal signature was sufficiently different from those previously classified along the transect.

The representative color signature for selected vegetative types identified on the August (1:4000) CIR film were matched to ISCC-NBS Centroid Color Chips.⁷ The resultant color designation for each species is listed in Table III.

⁷The Inter-Society Color Council - National Bureau of Standards System of Color designations can be located in NBS Circular 553 which includes a supplement of centroid color charts. The Manual of Color Aerial Photography, (American Society of Photogrammetry, 1968), also includes a complete set of centroid color charts in Appendix III, with color chip packet affixed to back cover.

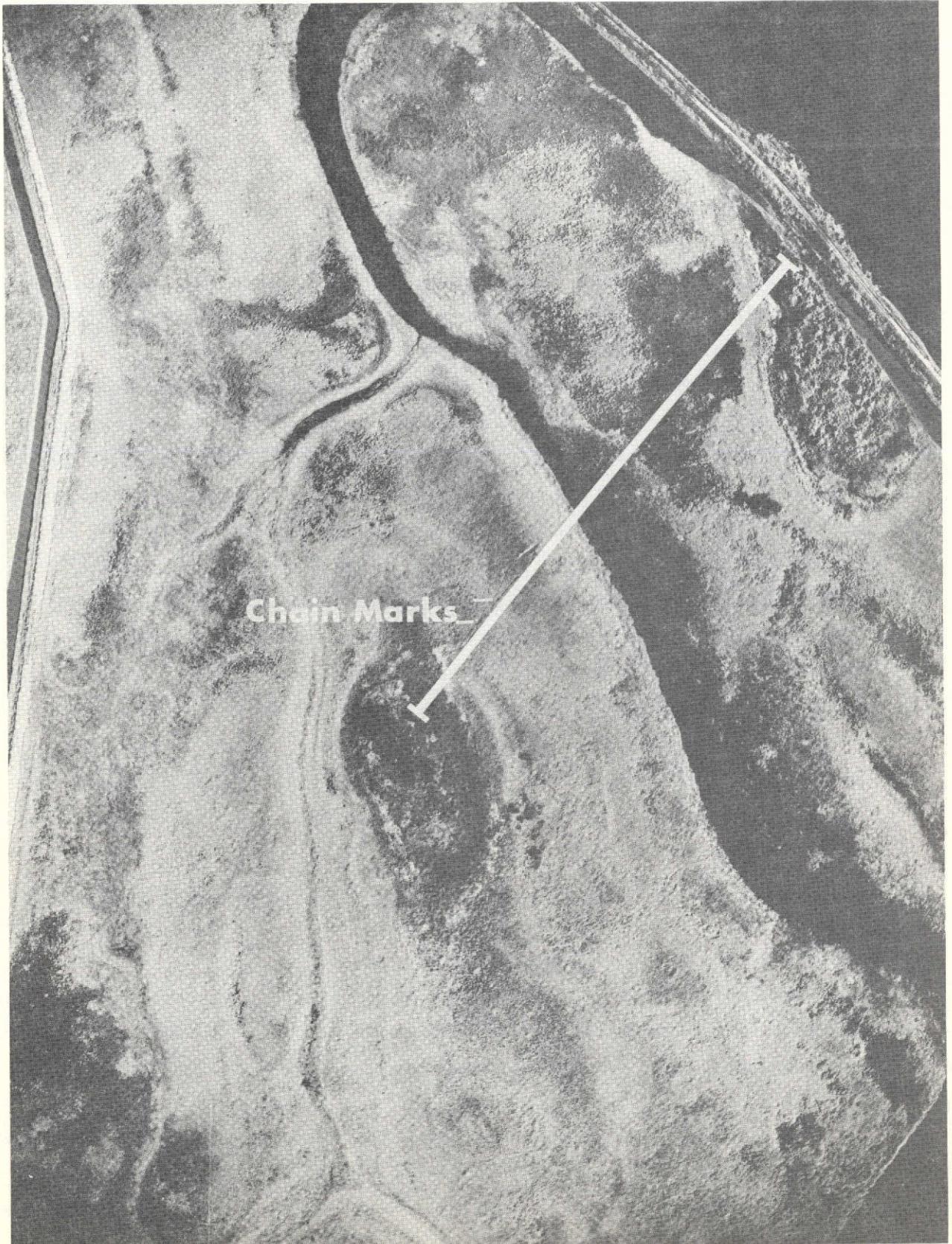


FIGURE 5. TRANSECT LOCATION

TABLE III
RESPECTIVE COLOR SIGNATURE FOR SELECTED VEGETATIVE TYPES*

<u>Vegetation</u>	<u>Color</u>
Smartweed (mature)	dark purplish pink, strong purplish pink
Smartweed (immature)	medium purplish pink
Bulrush	medium red brown to dark gray red brown
Pigweed	dark pink, strong pink to gray brown
Dead Vegetation	brilliant green blue to dark green blue
Mixed Grass, Mint, Primrose	gray blue
Fire-weed	gray red orange to brown
Jewelweed	brilliant purplish pink
Water (Diked)	brilliant blue
Beggar's Tick	deep pink
Tall Grass	blue gray
Bur-reed	gray red brown, dark red to deep blue green
Cattail	deep brown to blue green
<u>Hibiscus</u>	deep pink

*These color designations conform to the Inter-Society Color Council - National Bureau of Standards System of Color designations (1964) and apply to August 1:4000 CIR Photography.

Several problems were encountered with respect to color signature during the photo interpretation. Generally, the intensity of tones varied within a frame as well as between frames due to changes in sun angle, light intensity, and/or variations in color film processing; however, the range of tonal signature relative to species composition remained fairly constant. More specifically, there were color shifts within certain vegetative communities as indicated by the color ranges for some vegetative types listed in Table III. Please note in Table III that cattail and bur-reed range in color from brown or red to blue-green. A possible explanation for such a range is that both

types of vegetation have two-ranked linear sheathing leaves (vertically oriented) which expose a large percentage of background soil and water, particularly true of low-vigor stands (Anderson and Carter, 1972).

The respective color ranges for fire-weed and pigweed seem to be related to density and purity of the stand, whereas the red-brown color signature of bulrushes darkens as site conditions become wetter. The other vegetation types seem to have more constant color signatures on August CIR film. The color designations listed in Table III are relative because seasonal changes in the reflectance of plant species and their distribution, as well as shifts in plant orientation and site conditions, can alter the color signature. Scale changes and variations in atmospheric conditions can also result in color differences from those cited in this study.

The color determination for the selected vegetative types listed in Table III applies mainly to pure stands. Many subtle shade differences were encountered in areas of mixed vegetation, due to changes in species composition. These areas were the most difficult to interpret, and additional ground truth was necessary to establish vegetative composition.

Without this additional ground truth - that is, based solely on the two transects - the interpreter achieved an accuracy of 77%. This figure is based on a random sample of 50 points that were set up to check the accuracy of the interpretation. An accuracy of 94% was achieved when mixed vegetative areas were properly ground truthed.

Evaluation of Vegetative Patterns

A vegetative communities map of the controlled flooding area (Figure 6) was made using the interpretative process outlined above. Area measurements of the extent of coverage of each vegetative community were made using a planimeter and the mapped data. These measurements, coupled with information on the relative value of each vegetative community to waterfowl, give a general indication of the viability of the area as a waterfowl habitat (see the appendix).

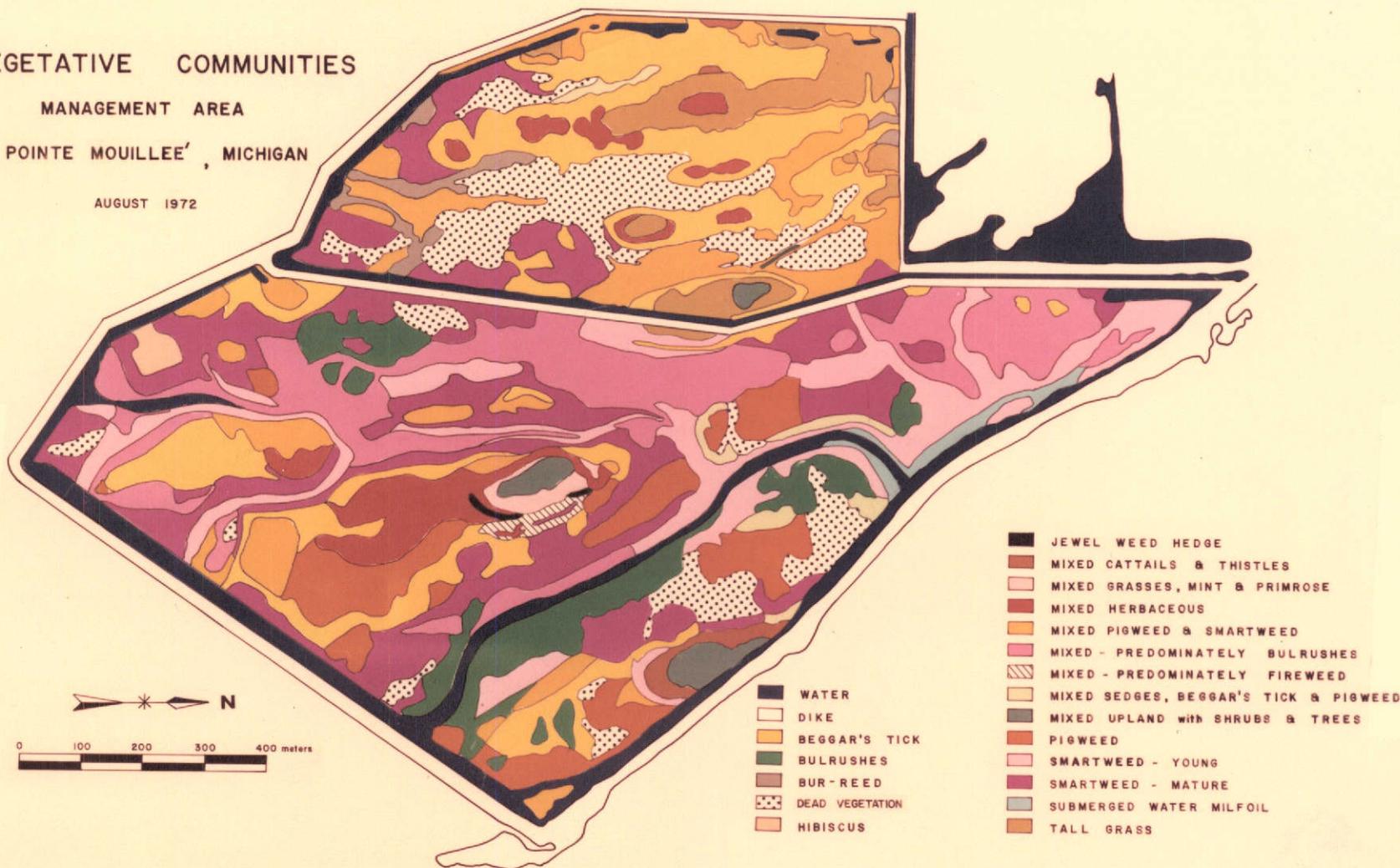
The predominant plant species are quite different between the two sections within the diked area (Figure 6). The eastern section (the larger area) contains a variety of species of vegetation desirable for duck food and cover, specifically smartweed, pigweed and bulrushes. The vegetation productivity of species suitable for duck habitation is significantly less in the western section where upland grass, beggar tick, and large unvegetated areas

VEGETATIVE COMMUNITIES

MANAGEMENT AREA

POINTE MOUILLEE', MICHIGAN

AUGUST 1972



MICHIGAN STATE UNIVERSITY

FIGURE 6. VEGETATIVE COMMUNITIES MAP

prevail.⁸ A thorough discussion of the magnitude of this situation is presented in the primary ERIM-MSU report on the Pointe Mouillee activities (Istvan et al, 1973). The transect data provided additional information concerning the nature of the vegetative patterns, and the evaluation of this information is presented in the following discussion.

The areas of dead and undesirable vegetation, mapped from remote sensing imagery, indicate areas where a revision in current management practices would seem to be warranted.⁹ Presently, the manager attempts to encourage species of emergent vegetation desirable for duck food by regulating the water level within the dike. The general procedure is to drain the diked area in the spring, allow the vegetation to mature, and then flood the area so the ducks can feed on the vegetation. The distribution of the emergent vegetation is determined basically by physiological limits of wetting of the plant species (Reid, 1961, p. 301). Therefore, in areas where water level can be regulated, the location of emergent vegetative communities would seem to be related to: (1) date of drawdown, (2) rate of drainage, and (3) the topography of the area.

Topography is an important factor affecting site moisture conditions because it determines relatively how long a respective site will be covered by water during drawdown, and after drawdown, how far above the water table it will be. The transect data afforded an opportunity to check if a relationship does exist between local relief and plant location. Figure 7B gives a graphic representation of plant location with respect to relief of the marsh bottom as encountered along the first transect (Figure 5).

Upon closer examination of the data in Figure 7B, there does seem to be a relationship between the two parameters. Specific information on species location with respect to local relief from standing water has been extrapolated from the graph data and appears in Table IV. The relief ranges in the table do not denote universal limits for the location of the selected vegetative communities, because variables other than topography, also affect plant location.

⁸The unvegetated areas, where no substantial vegetative growth occurred during the 1972 season, were classified as dead vegetation because of the predominance of dead smartweed (previous year's growth) in these areas. Isolated patches of arrowhead were the only new growth evident in these areas.

⁹The areas of dead vegetation may be an important component in the waterfowl habitat since these areas provide open water for the ducks after the area is flooded. However, it is questionable whether the areas should be as extensive as they are.

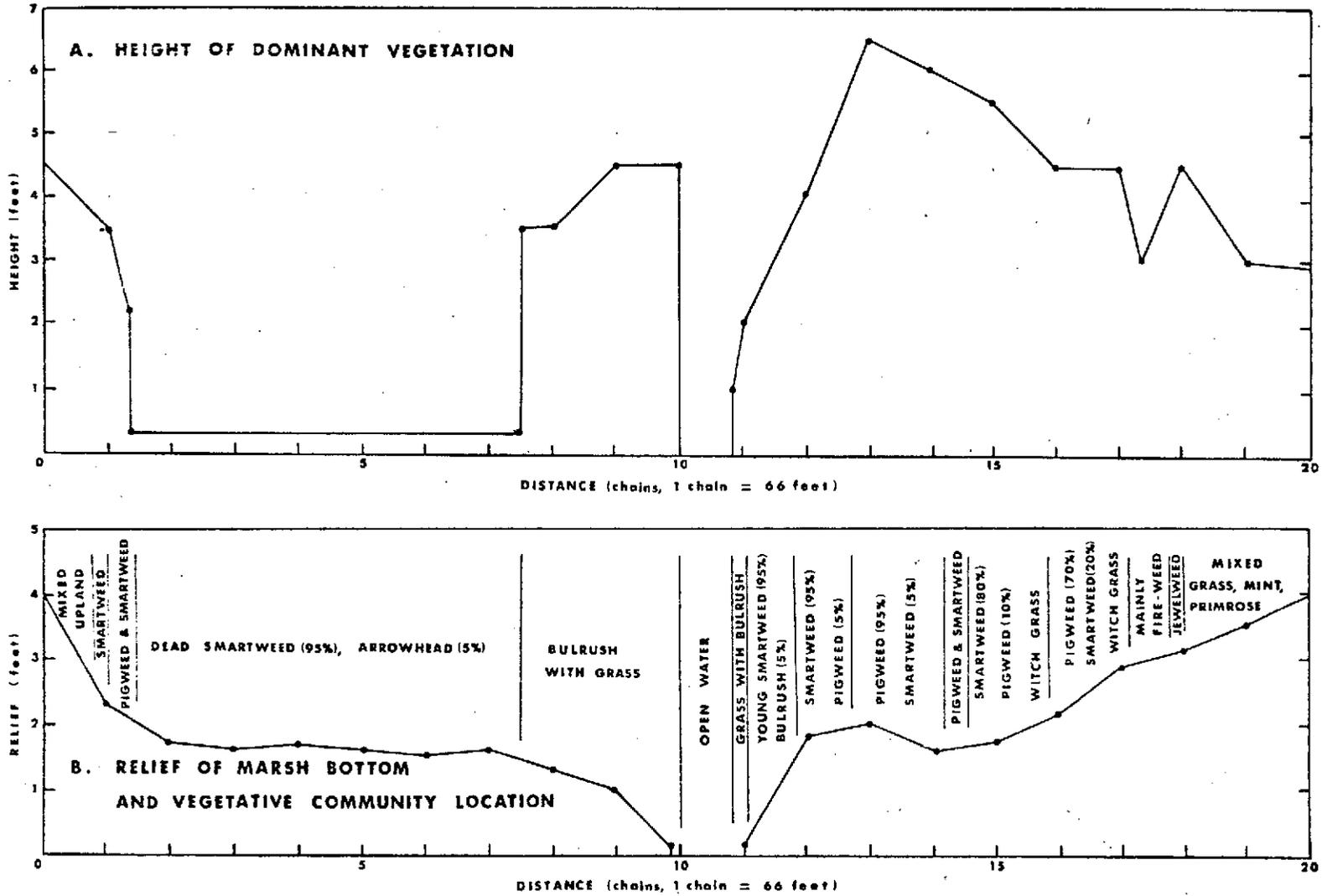


FIGURE 7. VEGETATIVE AND TOPOGRAPHIC PATTERNS (FIELD NOTATIONS, TRANSECT NO. 1, 18 AUGUST 1973)

TABLE IV
LOCATION OF SELECTED VEGETATIVE COMMUNITIES

<u>Vegetation</u>	<u>Site Height above Water Table (in feet)*</u>	<u>Remarks</u>
Bulrush	0 - 1 1/2	Usually found in wettest areas along drainage ways or in depressions and normally in or adjacent to standing water.
Smartweed (Immature)	0 - 1 1/2	Mainly located along drainage ways or in other sites that were the last to be drained.
Dead Vegetation	1 1/2 - 2	Normally found in relatively large flat areas that were drained late.
Smartweed (Mature) & Pigweed	1 1/2 - 3 **	Usually found in the driest previously flooded sites, i.e., the earliest sites that were drained. In mixed smartweed-pigweed areas, normally the percent of pigweed is higher on drier sites.
Upland Vegetation	Above 3 **	On the highest and driest sites that are usually above water level throughout the year.

* The cited elevation distances were extrapolated from the graph data in Figure 7B.

** The upper limit (3 feet) is the approximate location of the water level after fall flooding.

However, the knowledge of the relative location of each community with respect to standing water or certain terrain features is often a valuable clue in photographic interpretation.

When a photo image cannot be identified by direct recognition, an interpreter will often look for additional clues that will lead to a convergence

of evidence,¹⁰ supporting a probable identification. Site and association are important elements of photographic interpretation because they may lead to a correct identification when integrated with other image properties (i.e., shape, size, tone, shadow, pattern, and texture).

Another relationship seems to exist between areas of dead vegetation (mainly smartweed) and low, level terrain when comparing the two parameters (Figure 7B). A possible explanation is that during drawdown an extensive low, flat area may be more susceptible to wave action, high turbidity and fluctuating water levels. Reid stated that, "Fluctuating water levels are usually very damaging, and reservoirs and lakes subject to such fluctuations generally have little rooted aquatic vegetation." (Reid, 1961, p. 301). The presence of scattered patches of arrowhead (Sagittaria) within these areas may indicate that the water was too turbid, since arrowhead was cited as one of the most likely plants to survive in turbid waters (Martin and Uhler, 1939, p. 121).

Data on the height of the dominant vegetation at each chain mark and at intermediate points of vegetative transition were also collected and are graphically depicted in Figure 7A. In comparing the two graphs (Figure 7A and 7B), a relational inference can also be made between the height of smartweed and distance above the water table. Generally, the taller the smartweed, the farther above the water table it is. From this, one can infer that not only plant location but also plant productivity is related to topography and drawdown. The distribution pattern of young smartweed within the dike adds a measure of validity to the above statement, since they are located mainly along drainage ways (see Figure 6).

The above data and discussion are not an attempt to establish exact quantitative limits for plant community location or plant productivity but rather the crucial significance of drawdown and topography on desirable vegetation. Both factors exert restraining influences on plant location, distribution and subsequently productivity due to differences in species requirements or tolerances to standing water or a high moisture regime during their germination and early growth stage. There are other limiting factors, such as water

¹⁰In 1954, Colwell showed how an integration of interpretations could lead to an accurate identification and he called this approach the "convergence of evidence" (Colwell, 1954). This approach is also discussed in the Manual of Photographic Interpretation (American Society of Photogrammetry, 1960, pp. 109-111).

temperature, currents, turbidity, soil quality and weather, yet the manager has virtually no control over these parameters.

To determine the method of drawdown most conducive to optimizing the areal extent and productivity of desirable vegetation, records should be kept on the date, rate, and base level of drawdown. In addition, annual vegetative patterns should be mapped and inventoried so the effects of changes in management practices can be monitored. Through a comparative study of both records over an extended period, management practices that maintain the wetland wildlife habitat at its optimum can be determined.

SUMMARY AND CONCLUSIONS

- (1) Evaluation of low altitude oblique photography obtained by hand-held cameras was useful in determining specifications of operational mission requirements for conventional smaller-scaled vertical photography.
- (2) Remote sensing techniques were used to assess the rapid destruction of marsh areas at Pointe Mouillee. In an estuarian environment where shoreline features change yearly, there is a need for revision in existing area maps. Accurate base map revisions reflecting the present configuration of the shoreline can be made from aerial photography and a Zoom Transfer Scope. This procedure facilitates monitoring of areas most susceptible to erosion, the rate at which erosion is taking place, and the amount of land that has been lost.
- (3) A land cover inventory, mapped from aerial photography, provided essential data necessary for determining adjacent lands suitable for marshland development.
- (4) To quantitatively assess the wetlands environment, a detailed inventory of vegetative communities (19 categories) was made using color infrared photography and intensive ground truth. The viability of the marsh was assessed by analyzing the inventory results.
- (5) A carefully selected and well laid-out transect was found to be a key asset to photo interpretation and to the analysis of vegetative conditions. Transect data provided the interpreter with locally representative areas of various vegetative types. This facilitated development of a photo interpretation key. Additional information on vegetative conditions in the area was also obtained by evaluating the transect data.

LITERATURE CITED

- American Society of Photogrammetry. 1960. Manual of Photographic Interpretation. George Banta Co., Menasha, Wisconsin. 868 pages.
- American Society of Photogrammetry. 1968. Manual of Color Aerial Photography. George Banta Co., Menasha, Wisconsin. 550 pages.
- Anderson, R. R. and Virginia P. Carter. 1972. "Interpretation of Wetland Imagery Based on Spectral Reflectance Characteristics of Selected Species." Pp. 580-595. In Kosco, W. J., Chairman. Proceedings of the 38th Annual Meeting, American Society of Photogrammetry. American Society of Photogrammetry, Falls Church, Virginia. 636 pages.
- Anderson, R. R. and F. J. Wobber. 1972. "Wetlands Mapping in New Jersey." Pp. 530-536. In Kosco, W. J., Chairman. Proceedings of the 38th Annual Meeting, American Society of Photogrammetry. American Society of Photogrammetry, Falls Church, Virginia. 636 pages.
- Colwell, R. N. 1954. "A Systematic Analysis of Some Factors Affecting Photographic Interpretation." Photogrammetric Engineering. 25(5): 712-736.
- Cottam, Clarence. 1939. "Food Habits of North American Diving Ducks." U. S. Department of Agriculture, Technical Bulletin 643. 140 pages.
- Egan, W. C. and M. E. Hair. 1971. "Automated Delineation of Wetlands in Photographic Remote Sensing." Pp. 199-200. Summaries Seventh International Symposium of Remote Sensing of Environment. University of Michigan, Ann Arbor, Michigan. 218 pages.
- Fassett, Norman C. 1940. A Manual of Aquatic Plants. The University of Wisconsin Press, Madison, Wisconsin. 405 pages. (1956 ed. with Revision Appendix by Eugene C. Ogden.)
- Foote, Jim. From an edited transcription of a meeting with Jim Foote, Wildfowl Specialist, Point Mouillee State Game Area, DNR, August 25, 1972.
- Istvan, Laurence B. et al. 1973. Waterfowl Habitat Management at Pointe Mouillee. Report No. 193400-1-T, Environmental Research Institute of Michigan, Ann Arbor, Michigan
- Martin, A. C. and F. M. Uhler. 1939. "Food of Game Ducks in the United States and Canada." U. S. Department of Agriculture, Technical Bulletin #634. 308 pages.
- McDonald, Malcolm E. 1951. "The Edge of the Pointe Mouillee Marsh, Michigan, with Special Reference to the Biology of Cat-Tail (Typha)." University of Michigan, Doctoral Dissertation Series, Publication No. 2421.

- McGivern, Robert F., Don B. Martin, and John E. Benjamin. "Planimetric Map Revision with Bausch and Lomb Zoom Transfer Scope." Proceedings of the 38th Annual Meeting American Society of Photogrammetry. American Society of Photogrammetry, Pp. 615-616. (Abstract).
- Olson, D. P. 1964. "The Use of Aerial Photographs in the Study of Marsh Vegetation." Maine Agriculture Experimental Station Technical Bulletin 13. 62 pages.
- Reid, George K. 1961. Ecology of Inland Waters and Estuaries. New York, Van Nostrand Reinhold Company. 375 pages.
- Reimold, Robert J., John L. Gallagher, and Donald E. Thompson. 1973. "Remot Sensing of Tidal Marsh." Photogrammetric Engineering 34(5): 477-488.
- Schneider, W. J. 1966. "Water Resources in the Everglades." Photogrammetric Engineering 32(5):958-965.
- Seher, J. Scott and Paul T. Tueller. 1973. "Color Aerial Photos for Marshland." Photogrammetric Engineering 34(5):489-499.

ADDITIONAL REFERENCES

Remote Sensing of Wetlands

- Anderson, R. R. 1969. "The Use of Color Aerial Photography in Marshland and Estuarine Studies." Proceedings, Seminar on New Horizons on Color Aerial Photography, New York.
- _____. 1971. "Multispectral Analysis of Aquatic Ecosystems in the Chesapeake Bay." Proceedings, 7th International Symposium on Remote Sensing of Environment, Ann Arbor, Michigan.
- Colwell, R. N. 1960. "Some Uses of Infrared Aerial Photography in the Management of Wildlife Areas." Photogrammetric Engineering 26(5):774-785.
- Eitel, Dean F. 1972. "An Overview of Remote Sensing for Wetlands Investigations." Remote Sensing of Earth Resources, Volume 1, edited by F. Shahrokhi, The University of Tennessee Space Institute, Tullahoma, Tennessee.
- Gibson, Buckley and Whitmore. 1965. "New Vistas in IR Photography for Biological Surveys." Journal of the Biological Photographic Association 33(1):1-33.
- Hair, M. E. 1970. "Ecological Interpretation and the Application of Remote Sensing to a Wetland Survey of Calvert County, Maryland." An Experimental Survey of a Wetlands Study Site, Grumman Ecosystems Corporation, 1971.

- Kolipinski, M. C., A. L. Higer, N. S. Thompson, and F. J. Thompson. 1969. "Inventory of Hydrobiological Features Using Automatically Processed Multispectral Data." Proceedings, 6th International Symposium on Remote Sensing of Environment. University of Michigan, Ann Arbor, Michigan. Pp. 79-95.
- Leedy, D. L. 1948. "Aerial Photographs, Their Interpretation and Suggested Uses in Wildlife Management." Journal of Wildlife Management 12(2): 191-210.
- _____. 1953. "Aerial Photo Use and Interpretation in the Fields of Wildlife and Recreation." Photogrammetric Engineering 19(1):127-137.
- Lukens, John E. 1968. "Color Aerial Photography for Aquatic Vegetation Surveys." Proceedings, 5th Symposium on Remote Sensing of the Environment. University of Michigan, Ann Arbor, Michigan. Pp. 441-446.
- Sayn-Wittgenstein, L. 1961. Phenological Aids to Species Identification on Air Photographs. Department of Forestry, Canada, Forest Research Branch, Technical Note 104. 26 pages.
- Schneider, W. J. 1968. "Color Photographs for Water Resources Studies." Photogrammetric Engineering 34(3):257-262.
- Thompson, Donald E., James E. Ragsdale, Jr., Robert J. Reimold and John L. Gallagher. "Season Aspects of Remote Sensing Coastal Resources." Contribution No. 263, The University of Georgia Marine Institute, Sapelo Island, Georgia. (In press.)
- Aerial Photography and Hand-held Techniques
- Aldrich, R. C. 1959. "Large Scale 70-mm Color Photography Techniques and Equipment and Their Application to a Forest Sampling Problem." Photogrammetric Engineering 25(5):747-754.
- _____. 1966. "Forestry Applications of 70 mm Color." Photogrammetric Engineering 32(5):802-810.
- Anson, A. 1966. "Color Photo Comparison." Photogrammetric Engineering 32(2):286-297.
- Avery, Gene. 1958. "Helicopter Stereo-Photography of Forest Plots." Photogrammetric Engineering 24(4):617-624.
- Chaves, J. R. and R. L. Schuster. 1968. "Color Photos for Highway Engineering." Photogrammetric Engineering 34(4):375-379.
- Colwell, R. N. 1956. "The Taking of Helicopter Photography for Use in Photogrammetric Research and Training." Photogrammetric Engineering 22(4):613-621.
- Duddek, Manfred. 1967. "Practical Experiences with Aerial Color Photography." Photogrammetric Engineering 33(10):1117-1125.

- Fritz, Norman L. 1967. "Optimum Methods for Using Infrared-Sensitive Color Films." Photogrammetric Engineering 33(10):1128-1138.
- Lyons, E. H. 1961. "Preliminary Studies of Two Camera, Low-elevation Stereo-photography from Helicopters." Photogrammetric Engineering 27(1):72-76.
- _____. 1964. "Recent Developments in 70 mm Stereo-photography from Helicopters." Photogrammetric Engineering 30(5):750-756.
- Sorem, A. L. 1967. "Principles of Aerial Color Photography." Photogrammetric Engineering 33(9):1008-1018.
- Robison, F. B. and L. I. Withem. 1967. "Helicopter Photography and Mapping." Photogrammetric Engineering 33(10):1167-1170.

Effects of Drawdown

- Givens, L. S. and T. Z. Atkeson. 1957. "The Use of Dewatered Land in Southeastern Waterfowl Management." Journal of Wildlife Management 21(4):465-467.
- Harris, S. W. 1957. "Ecological Effects of Drawdown Operations for the Purpose of Improving Waterfowl Habitat." Ph.D. Thesis. University of Minnesota, Minneapolis. 209 pages.
- Hopkins, R. C. 1962. "Drawdown for Ducks." Wisconsin Conservation Bulletin 27(4):18-19.
- Kadlec, J. A. 1960. "The Effect of a Drawdown on the Ecology of a Waterfowl Impoundment." Michigan Department of Conservation, Lansing. 181 pages.
- Meeks, Robert L. 1969. "The Effect of Drawdown Date on Wetland Plant Succession." Journal of Wildlife Management 33(4):817-821.
- Uhler, F. M. 1956. "New Habitats for Waterfowl." Trans. N. Am. Wildl. Conf. 21:453-469.

APPENDIX

AREA MEASUREMENTS OF LAND COVER^a

Controlled Flooding Area (Dike)^b

<u>Desirable Vegetation^c</u>	<u>Distribution</u> (percent)	<u>Area</u> (hectares)	<u>Remarks</u> (value to ducks ^d)
Smartweed	24.6	36.8	Good to excellent
Bulrush	16.3	24.4	Good to excellent
Bur-reed	0.8	1.2	Fair, essentially a cover plant
Arrowhead	(approx. 5% of dead vegetation areas)		Fair
Beggar-tick	14.3	21.3	Generally slight or nil, occasionally fair
Water-Milfoil	0.5	0.8	Generally slight to fair
Pigweed	4.4	6.5	
Mixed Pigweed & Smartweed	<u>8.1</u>	<u>12.1</u>	
<u>Subtotal</u>	69.0	103.1	
<u>Other Vegetation</u>			
Dead Vegetation	8.5	12.7	
Fire-weed	0.3	0.4	
<u>Hibiscus</u>	0.4	0.6	
Jewelweed	0.1	0.2	
Mixed Cattail & Thistles	0.7	1.0	
Mixed Grass, Mint & Primrose	0.4	0.6	
Mixed Herbaceous	3.4	5.1	
Mixed Sedges, Beggar-tick & Pigweed	0.7	1.1	
Mixed Upland with Shrubs & Trees	1.1	1.6	
Tall Grass	4.2	6.2	
Water	<u>11.2</u>	<u>16.7</u>	
<u>Subtotal</u>	31.0	46.2	
<u>Total</u>	100.0	149.3	

Adjacent Areas^e

<u>State Land (Non-Dike)</u>	<u>Distribution</u> (percent)	<u>Area</u> (hectares)
Aquatic Vegetation	54.1	103.2
Brush	18.8	35.9
Cultivated Land Cover	2.0	3.8
Forest	3.1	6.0
Herbaceous Ground Cover	<u>22.0</u>	<u>41.9</u>
<u>Total</u>	100.0	190.8

<u>Non-State Land^f</u>	<u>Distribution</u> (percent)	<u>Area</u> (hectares)
Aquatic Vegetation	24.4	83.4
Brush	3.9	13.2
Cultivated Land Cover	24.4	83.5
Forest	14.5	49.5
Herbaceous Ground Cover	<u>32.8</u>	<u>112.3</u>
<u>Total</u>	100.0	341.9

^aA thorough discussion of these statistics is presented in the primary ERIM-MSU report on the Pointe Mouillee activities.

^bHectare data were obtained from the vegetative communities map (Figure 6) by means of a planimeter.

^cThe vegetative categories are ranked according to the amount of vegetation consumed by ducks (based on stomach samples) as cited by (Martin and Uhler, 1939).

^dThe remarks on the value of specific vegetation to ducks were noted in (Martin and Uhler, 1939; and Fassett, 1940). Additional information on the food habits of specific ducks can be found in (Cottam, 1939).

^eHectare data were obtained from the land cover map (Figure 4) by means of a planimeter.

^fThis area includes all non-state land east of Roberts Road and Dixie Highway, and south of Sigler Road (see Figure 1).