FINAL REPORT

Phase One Development of a Comprehensive GIS for the Mentor Marsh and its Proximal Watershed

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INTRODUCTION

The Mentor Marsh is a 351-hectare wetland that occupies the abandoned ancient bed of the Grand River between Fairport Harbor, Ohio on the east and Mentor, Ohio on the west, approximately 50 km east of Cleveland, Ohio (Figure 1). It is fed by two surface streams, Blackbrook and Marsh Creek, that drain a small watershed to the south of the marsh. Little is know about the hydrology of the Marsh, including the relative importance of surface and groundwater and its connection to the hydrology of Lake Erie

The Marsh has experienced significant changes in vegetation over the past two hundred years (Fineran, 2003) brought about by natural and human-induced changes in its hydrology and chemistry. The most recent change occurred as a result of salt contamination after 1966. Prior to 1966, much of the marsh basin was occupied by swamp forest. The salt contamination destroyed much of that forest; remnant stands still occupy areas of low salinity along the shoreline. Since 1966, the common reed (*Phragmites australis* (Cav.) Steudel.) has come to occupy most of the Marsh.

Scientists from several universities and the Cleveland Museum of Natural History are currently studying the marsh in an effort to understand the interaction of physical, biological and social factors that have brought about changes in the marsh in the past and continue to do so today. Also, local governmental agencies and citizen groups have organized to protect and possibly restore the marsh to its pre-1966 condition. Both of these efforts must deal with ecological and social complexity that is inherent in the spatial and temporal context that is the Mentor Marsh. To facilitate both efforts, a comprehensive geographic information system (GIS) has been developed for the Mentor Marsh and its proximal watershed. This GIS will allow scientists, planners, and decision makers to store and manipulate complex sets of data on the Marsh ecosystem and its use.

OBJECTIVE AND SYSTEM DESIGN

The ultimate objective of this project was the construction of a geographic information system to organize data relevant to scientific study of ecological change and natural resource management of Mentor Marsh. The GIS comprises computer data files in various formats that can be aligned in layers and analyzed. Common spatial data formats and standards are used where possible, but other alternative formats are also provided to make the data available to a broad spectrum of potential users.

METHODS

The creation of the GIS involved two phases: (1) Data needs identification, and data assembly and (2) The construction of a Digital Elevation Model for the Marsh and its proximal watershed. Phase 1 was supported largely by Lake Erie Protection Fund grant SG 120-99. While the initiation of Phase 1 of necessity predated Phase 2, the identification and assembly of data actually continued throughout Phase 2.

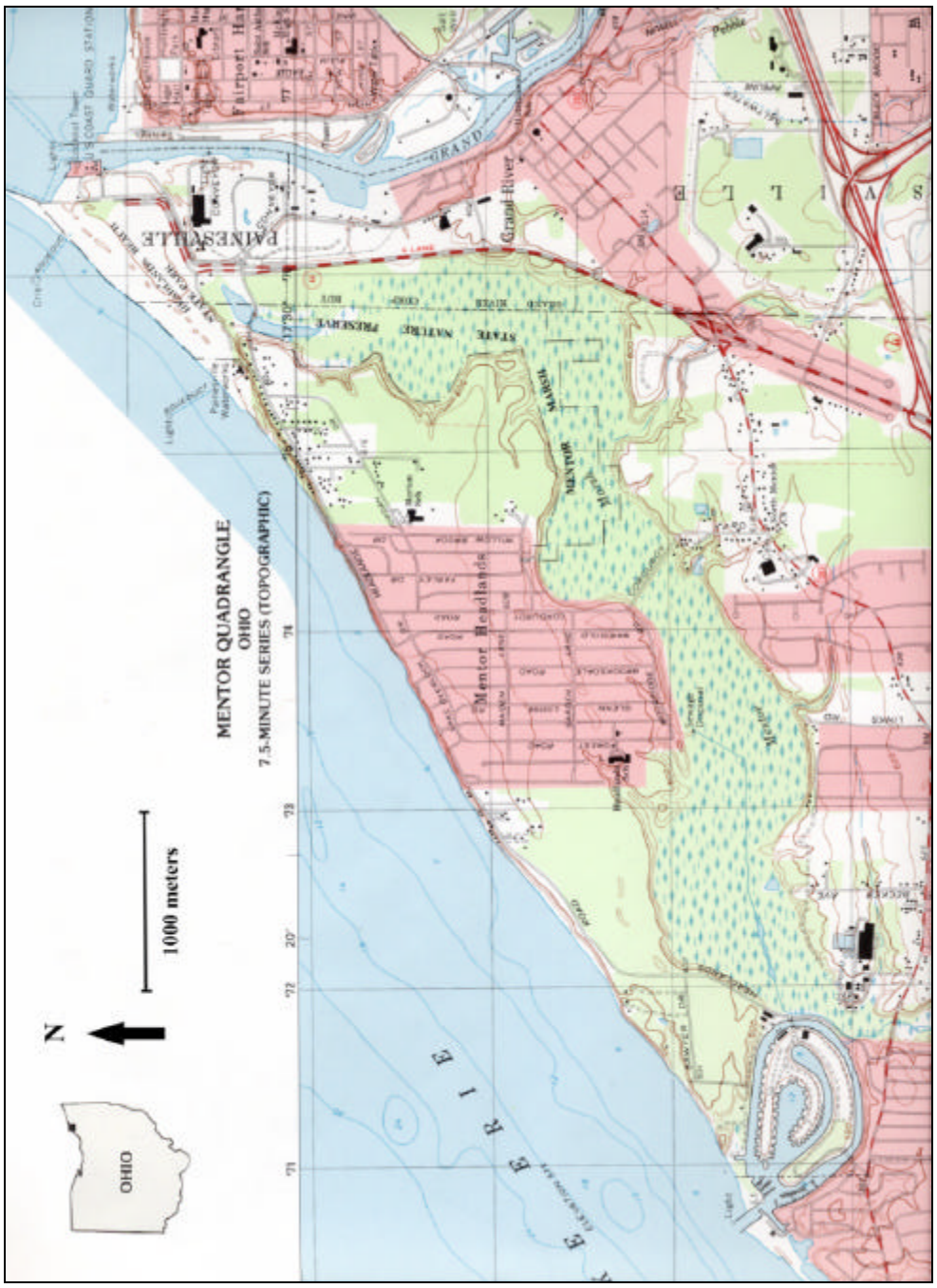

Figure 1. Location of the Mentor Marsh in Lake County, Ohio.

Phase 1

Phase 1 included three steps: (1) Stakeholder consultation to identify the spatial data needs of potential user groups, and (2) The identification of data sources and (3) the collection and capture of relevant data

1. ***Stakeholder consultation***: Early in the project, meetings were held with individuals and groups with an interest in the ecology and management of the Marsh. These included:
    a. City of Mentor (City Manager and the Director of Parks, Recreation and Public Lands
    b. Lake County GIS Office
    c. The Nature Conservancy, Northeast Ohio Program Manager
    d. Ohio Department of Natural Resources, Division of Natural Areas and Preserves, Division of Geological Survey
    e. Cleveland Museum of Natural History, Curator of Botany
    f. Ohio Sea Grant District Program Specialist
    g. Lake County Soil and Water Conservation District.
    h. Various academic researchers from Ohio State University, Cleveland State University, and the University of Toledo
    i. Marsh Area Regional Coalition

    Meetings were held with each stakeholder to discuss the role that a GIS could play in their work and to assess their data storage and manipulation needs. The major focus of this consultation was the Marsh Area Regional Coalition. During our involvement in meetings of the coalition and its task forces we were able to develop an understanding of their planning and decision-making information needs and how we might structure the GIS to provide that data base.

    With all of our interactions with stakeholders we tried to determine data and information needs in terms of required data sets and applications. We learned that most stakeholders had access to public collections of spatial data, but that much of those data were scattered in various locations and in a variety of formats. Particular needs were expressed concerning the capture of historical data on ecological change in the Marsh.

2. ***Data Sources – Public and Private:*** Large amounts of spatial data in GIS compatible formats are available from various sources including the World Wide Web, and from public and private agencies. Consistent with our aim to collect data relevant to the ecology of Mentor Marsh we located major public data sources and also purchased private data where necessary. Table 1 lists major sources of geospatial data we collected.

Data	*Sources*
Historical aerial photography	Ohio Department of Transport Ohio Department of Natural Resources United States Geological Survey
Modern aerial photography: digital, color	Kucera International, Inc.
Modern terrain data: elevation contours, and spot heights	Kucera International, Inc. Lake County GIS Office
Historical maps	Lake County Historical Society Cleveland Museum of Natural History Library of Congress
Remote sensing images	Ohio View
Land-use and cover data: digital	Ohio Department of Natural Resources
Base map layers: administrative boundaries, infrastructure	Ohio Department of Natural Resources
Natural Resources: soils, geology, wetlands, pollution sources, etc.	Ohio Department of Natural Resources

Table 1. Major sources of geospatial data used in the project.

3. Data Collection and Capture

Existing GIS Data

Relevant spatial data sets were collected in digital format and imported into the GIS. Where necessary, data were re-projected (e.g. to UTM) for overlay with other data layers. Most data collected covered a larger area than needed. Those data were generally clipped to the watershed boundary or limited to coverage of Lake County where this seemed useful. Figure 2, a soil map extracted form the SSURGO data for Lake County illustrates a coverage clipped the boundary of the watershed supporting Mentor Marsh. Table 2 lists the public GIS data provided in Arc Interchange format on CD-ROM.

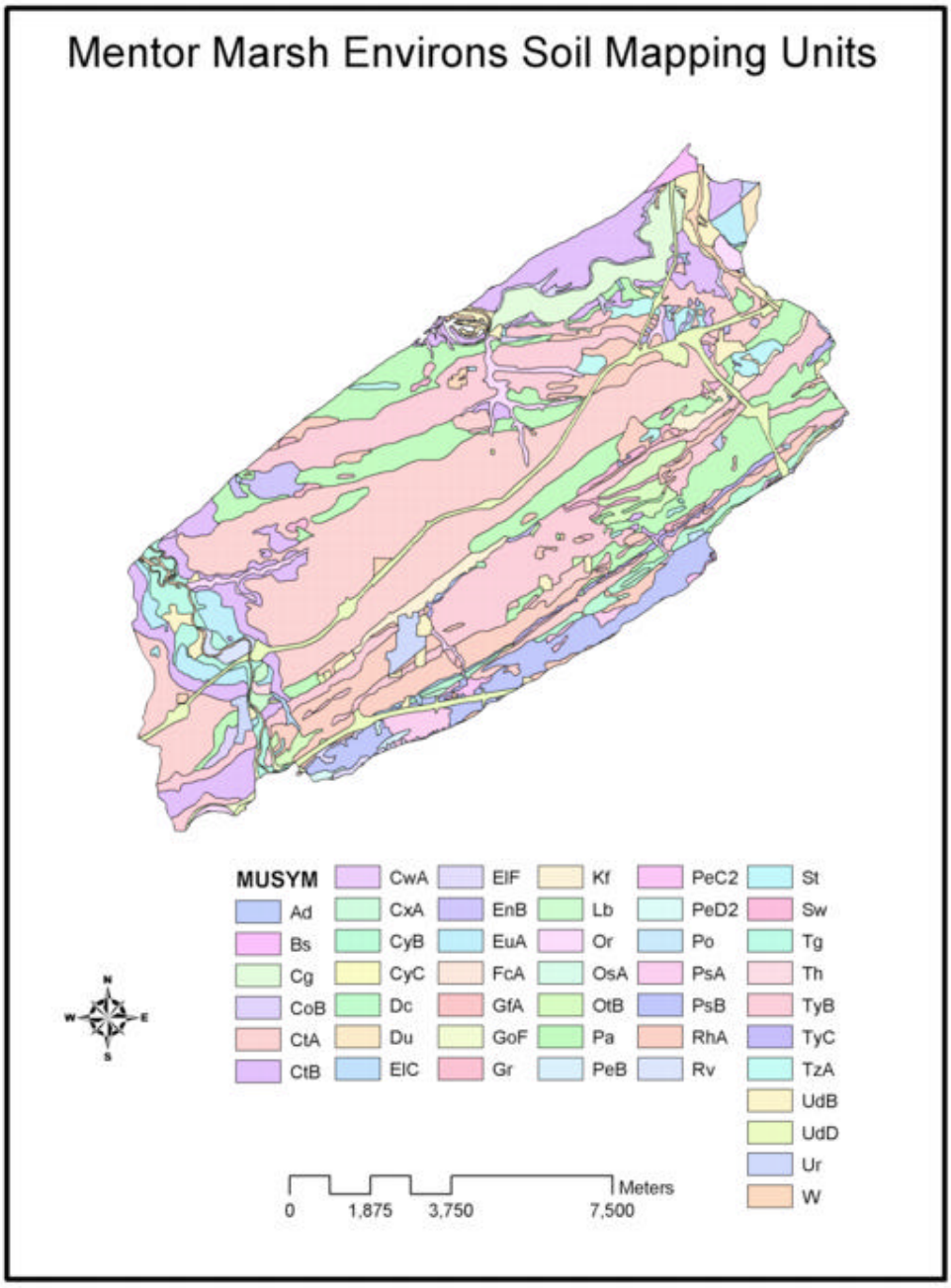

Figure 2. GIS soil type layer extracted from the SSURGO data for Lake County, Ohio

File name	Coverage	Theme	Source	Comments
lkboundry	County	Metro boundaries	ODNR	
lkfhfeutm	County	Flood hazard areas	ODNR	
lklkuchng	Watershed	Land use change for zoning	ODNR	77 - 85 remote sensing
lklu85utm	Watershed	Land use 1985	ODNR	OCAPLCP
lkpcsi	Watershed	Permitted point sources	EPA	
lkzotum	County	Zoning for Lake County	ODNR	
mine	Watershed	Abandoned underground mine	ODNR	
railrd	Watershed	Railroad	ODNR	
SSURGO	County	SSURGO Soil survey map	NRCS	
wsansew	Watershed	Sanitary sewer	ODNR	1977 sanitary sewer
wsaqre	Watershed	Aquifer recharge areas	ODNR	
wscov	Watershed	Landuse/landcover 1994	ODNR	
wsdtutm	Watershed	Drift thickness	ODNR	Coverage for OCAPLCP
wsgwpp	Watershed	Groundwater pollution potential	ODNR	
wshp	Watershed	Hypsography	USGS	10' contour intervals
wslk85pk	Watershed	Land use change analysis	ODNR	77 - 85 remote sensing
wsowi	Watershed	Ohio wetlands inventory	ODNR	From May 87 Landsat
wsrdtral	Watershed	Roads and trails	USGS	
wssoils	Watershed	Soil survey map	NRCS	
wstranspipe	Watershed	Utilities-transmission pipe	USGS	

Table 2. Data coverages captured in the Mentor Marsh GIS.

New Spatial Data

In addition to collecting existing GIS data, we developed new spatial data for the area. Based on the objective of providing information relevant to understanding ecological change in Mentor Marsh and in informing management decisions, we determined that three major opportunities existed for developing critical new spatial data:

1. A collection of historical aerial photography captured in digital format and re-sampled in orthographic format for use in the GIS with other data sets;

2, A high resolution digital elevation model based on recently developed topographic data;

3. A series of historical maps and documents containing spatial referencing and information on the dynamic ecological condition of the Marsh, particularly concerning vegetation associations.

Aerial Photography

Where possible, we collected data in digital format. For example, we purchased color digital aerial photos for the Marsh and environs as 0.05 feet pixel resolution files. (These are large files, each photograph being about 350MB).

Other aerial photos were scanned at a high resolution compatible with reasonable file sizes (usually 300-1200 pixels per inch).

Aerial photos were registered and geo-rectified either in ArcGIS or using OrthoMapper software. In this process boundaries of the photographs are first located with coordinates then *control points* on the photographs are matched with corresponding known locations on digital ortho-photographs or background maps in the GIS. A digital elevation model provided final ortho-correction. Figure 3 illustrates geo-rectified photographs from 1951 and 1958, showing how features align in the GIS. Many of the historical photographs do not cover the complete Marsh and its watershed, but they provide very useful information on the changing natural resource conditions.

Ortho-rectified photo images were imported into ArcGIS and exported (saved) as Arc grids. Since grids maintain integrity when copied, providing all the files are kept together, and since Interchange format grids become impractically large, the photo GIS files have been copied to CD in Arc grid format. To use these files in GIS, the relevant folder(s) should be copied to a hard drive (e.g. to c:\airphoto\ together with the INFO folder, which has been included on the first airphoto CD only. The files can then be opened in ArcGIS or converted to other raster formats in Arc Toolbox. Table 3 describes photo grids provided on CD-ROM.

File name	*Scan Resolution (PPI)*	*Data Source*	*Date*	*Coverage*
lk51	1200	City of Mentor	5/51	East Section, Fairport Harbor
lk58s	1200	ODOT	4/58	Central Marsh
lk62	1200	ODOT	11/62	East section, Grand River
lk65	1200	ODOT	4/65	East and west Marsh
lk69ag	1200	ODOT	3/69	West Harbor
lk71/bg	1200	ODOT	4/71	Central Marsh
lk72cg	1200	ODOT	4/72	Central Marsh to West Harbor
marsh75	1200	ODNR	6/75	All Marsh except extreme east
85d	1200	ODNR	4/85	All Marsh except extreme east

Table 3. Photo grids provided on the Mentor Marsh GIS CD-ROM.

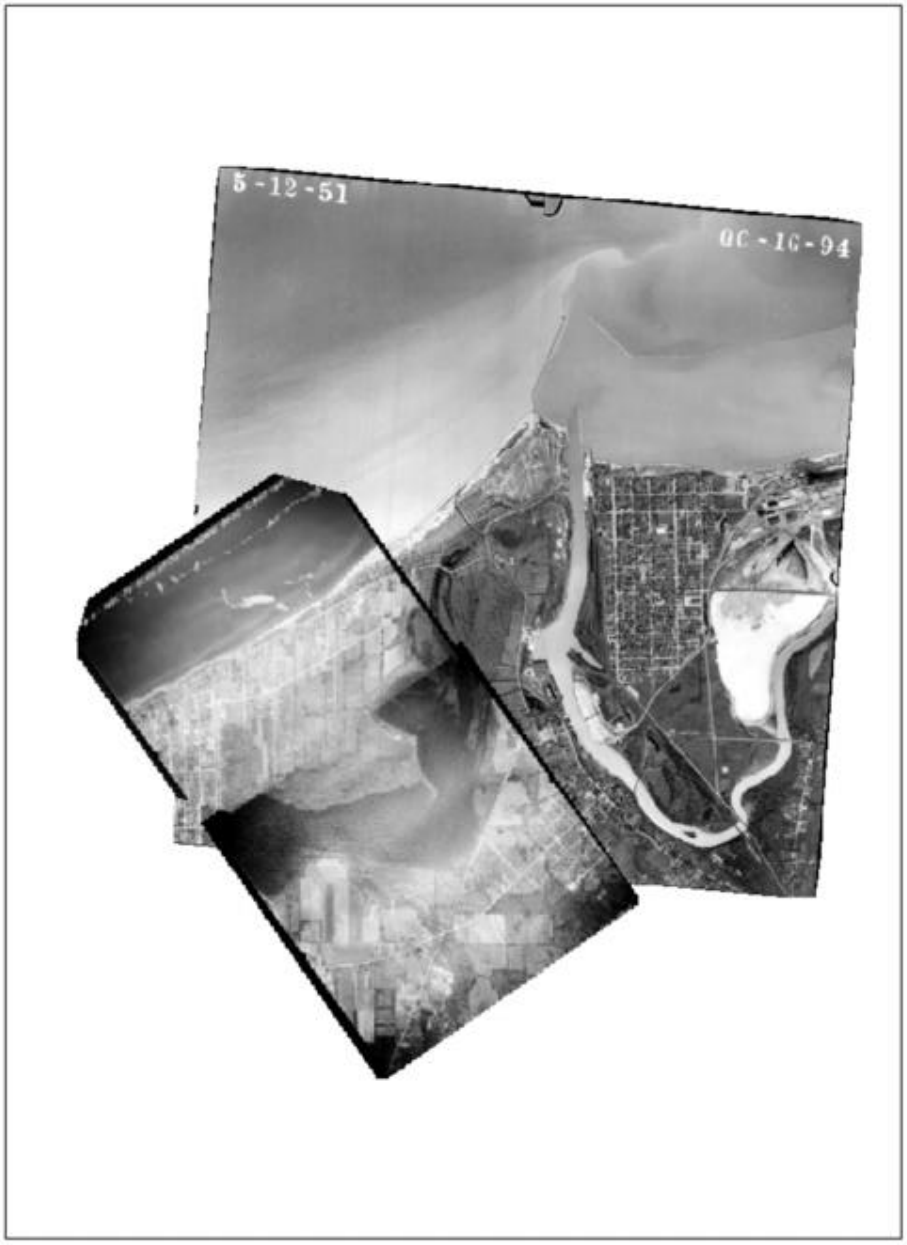

Figure 3. Example of Mentor Marsh Environs Geo-rectified Aerial Photographs

Metadata

For all datasets we collected we developed detailed meta-data providing information on the source, availability, and condition of the data according to established spatial data standards. The metadata were entered by using the new metadata facility built into ArcGIS (i.e. in ArcCatalog). Metadata were recorded by using the ESRI template, which is consistent with the Federal Geographic Data Committee (FGDC) standard. Metadata in ArcCatalog are saved in .XML format and can consequently be converted easily to many other formats including the original FGDC template, text or .html for compatibility with web browsers and word processors. Metadata are conserved when ArcGIS coverages including it are exported in Interchange format. The coverages included on the CD-ROM include metadata where the appropriate information could be obtained. Hence the metadata can be viewed after the .e00 files are re-imported into coverages (the XML files will then be available).

RESULTS

Digital Elevation Model (DEM)

Once all available data had been entered in GIS format, a digital elevation model was developed for the Mentor Marsh and its proximal watershed. Digital elevation models provide a basis for terrain analysis and hydrologic modeling. We are using these techniques to analyze such environmental attributes as the dynamics of Marsh water levels and solar radiation incidence and shading, as a means of gaining understanding of the major factors involved in vegetation change over time.

Development of a high-resolution digital terrain model was an important objective in our project. Excellent digital contour data (2 foot interval) were available based on photogrammetry of year 2000 air photography. The data, in CAD format, were converted to GIS format, and data elements not considered useful for DEM construction were edited. Numerous spot heights were also available with the contour data. We digitized coverage of stream lines and waterways to provide extra information for construction of the digital elevation model. We chose to make a model with a grid resolution of 5 meters, as a compromise between the input data quality and the resulting size of the model file.

The DEM was produced by using ANUDEM 4.6.3 (Hutchinson, 1997). Terrain models produced using this software have the advantage of being hydrologically correct, hence being more useful for analysis of surface water movement significant in the Marsh and its contributing watershed. The DEM has high resolution and covers a large geographic area but it may be partitioned for more manageable manipulation and application. We have used the DEM to generate GIS coverages of a number of terrain attributes such as slope, slope curvatures, and solar radiation. In addition, the model is useful for visualization purposes. Figures 4 is an example of output from the digital elevation model. It clearly shows the geomorphic features of the Marsh area, especially the form of the Marsh as a lake-captured estuary and its original connection to the Grand River.

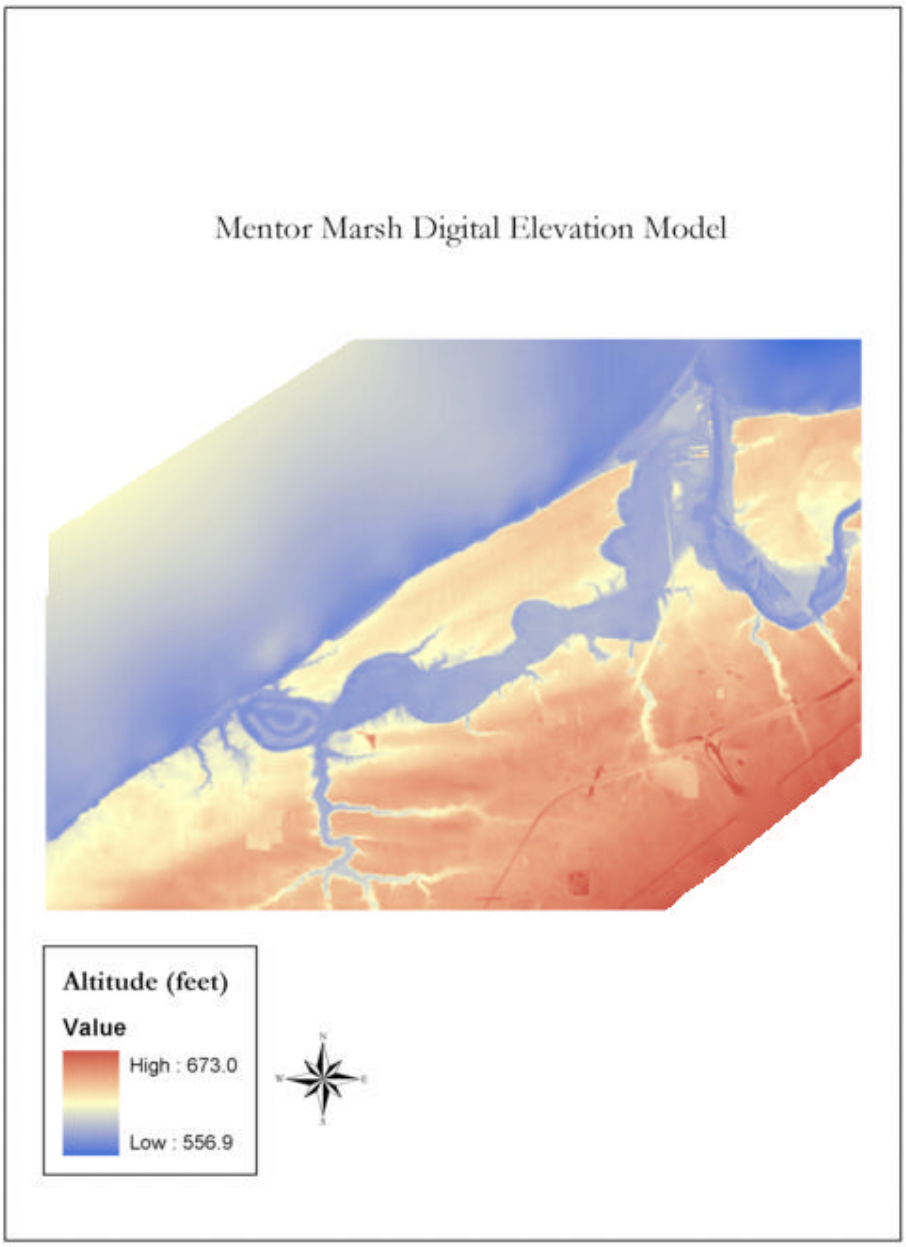

Figure 4. A 5-meter digital elevation model for the Menor Marsh and its proximal watershed.

IMPORTANCE

The GIS for the Mentor Marsh is a system that allows researchers, planners, decision makers and any citizen with a means for storing and manipulating vast amounts of information about present and past conditions in the Marsh and its proximal watershed. Outputs such as the DEM allow users to pursue answers to complex questions about the ecology of the Marsh, cause and effect factors, or likely future changes in the Marsh owing to specific or anticipated human actions. The GIS is not a static data base; it can be expanded to include any spatially-oriented data that might be useful to those concerned with the Marsh and watershed.

DISSEMINATION

The digital elevation model is supplied on CD-ROM as an ArcGIS grid, together with the input datasets and the ANUDEM log file which provides the parameter settings used to create the model. There are plans to make the GIS available on the WEB in the near future.

REFERENCES

Fineran, Stacey A. 2003. Assessing Spatial and Temporal Vegetative Dynamics at Mentor Marsh, 1796 to 2000 A.D. Ph.D. dissertation, Ohio State University.