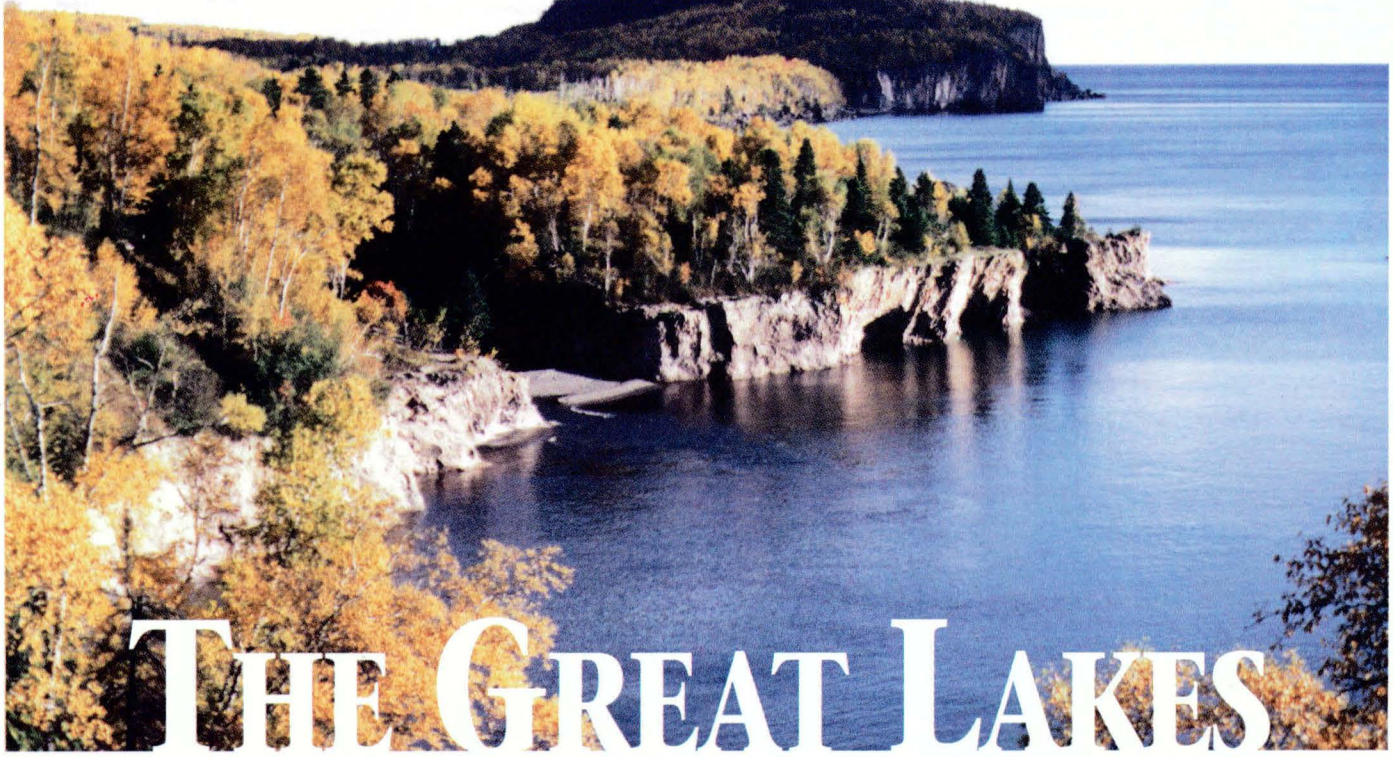


# MONITORING WETLANDS ACROSS LARGE-SCALE ECOSYSTEMS

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The Great Lakes ecosystem is a tremendous international resource shared by the United States and Canada. Its five freshwater bodies provide water for human consumption, transportation, power and recreation. The Great Lakes Watershed area is home to more than one-tenth of the U.S. population and one-fourth of all Canadians (Botts and Krushelnicki 1987).

The Great Lakes are subject to a wide range of environmental impacts. It's estimated that 43 harbors and embayments within the ecosystem have impairments posing ecological and human health risks (U.S. Environmental Protection Agency 1993). Topsoil runoff; changing water levels; and industrial, residential, silvicultural and agricultural development influence the ecosystem's lakes, shorelines, marshes and tributaries.

The U.S. Fish and Wildlife Service (USFWS) labels the Great Lakes Watershed a priority resource area (see Figure 1). Since 1991, the agency and other resource specialists have been gathering current, detailed information as part of the Wetlands Status and Trends (WST) study. Analyzing this region for wetland changes helps define linkages among aquatic (deep water), wetland and upland landscape systems.

This ecosystemwide approach requires integrating and analyzing land-based GIS coverages to identify important habitat types and interactions. Urban and rural growth patterns, coupled with agricultural and silvicultural activities, affect land use patterns that can impact wetlands. Monitoring such land use changes has been accomplished by USFWS in other areas of the country (Young and Dahl 1994).

## Analyzing Lake Superior Drainage

The initial phase of the WST study of the entire Great Lakes Watershed began with Lake Superior's U.S. drainage area. The area encompasses more than 11 million acres across northeastern Minnesota, northern Wisconsin and Michigan's Upper Peninsula (see Figure 2). Lake Superior—the largest, deepest Great Lake—is considered the most pristine as well (Hartman 1988). There's little information, however, quantifying the region's specific wetland resources or trends.

A comprehensive inventory of the area's entire landscape would be cost prohibitive and time consuming. Sample-based estimates of wetland resources provide a cost-effective alternative. A sample equal to 10% of Lake Superior's drainage provides statistically robust estimates of the wetland area by type. A random selection of 434 four-square-mile sample plots within the drainage boundary meets the 10% threshold.

A program developed in cooperation with the U.S. Geological Survey, Madison, Wis., uses ARC/INFO GIS software from ESRI, Redlands, Calif., to locate random sample plots at a specified sample intensity and provide georeferenced locations. Comparing aerial photography from the 1980s with similar photography from the 1990s facilitates measuring and analyzing wetland area changes. GIS, along with routines developed with SAS statistical software from SAS Institute Inc., Cary, N.C., produces acreage trends.


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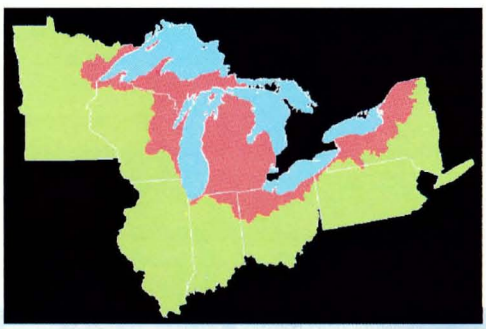
## Building a GIS-Based Model

A GIS–based model for further wetlands analysis within the study area must include data layers representing natural and human influences on wetlands. Acquiring the data layers can be the most expensive part of developing such a model. When acquiring data, key elements to consider are the data's timeliness, cost (whether purchasing or creating the data) and usefulness (i.e., the format, scale and presence of applicable attribute information).

The easiest way to obtain data is to find those that already exist. Although such searches can be time consuming, the Internet and its various search engines ease the process. Unfortunately, timely, useful datasets often don't exist. When digital data aren't found, but adequate source material is available, USFWS creates its own digital data layers via scanning and vectorizing, heads–up digitizing and/or board-digitizing.

A wetland/upland data layer is the WST study's responsibility. A hard-copy source created by aerial photography analysis is drafted to standardized map scale and board-digitized into GIS format. Each sample plot is tied to geographic coordinates and provides the land use classification within a four-square-mile sample plot border generated by the GIS (see Figure 3).

Source materials used to create digital files are from two different eras. Therefore, each polygon in the digital data layer is associated with two land classification attributes—one for the earlier era and one for the later era (see Figure 4). For example, an area converted from a freshwater emergent marsh to agricultural land within the study's time frame is identified as emergent wetland in the earlier era and upland agriculture in the later era. Those data are used to generate information regarding the area of wetland and upland types sampled in both eras, as well as the types and extent of conversions that have occurred. Regional estimates then can be generated with a known degree of confidence.



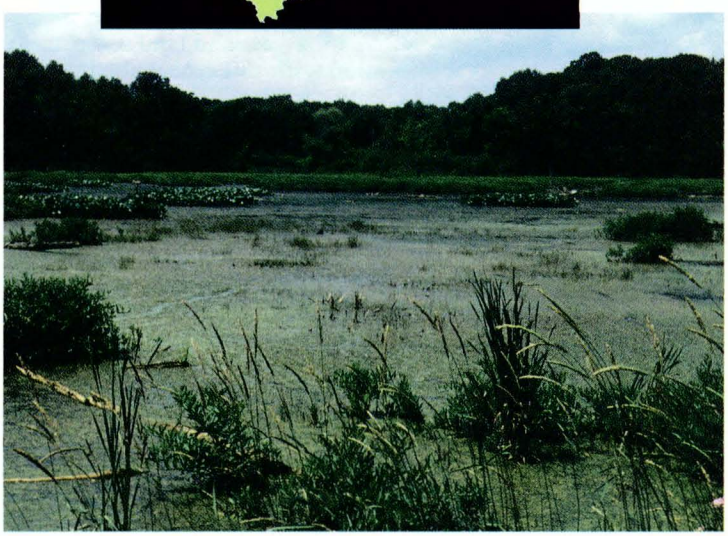


*Figure 1. The U.S. Fish and Wildlife Service identifies the Great Lakes Watershed (inset) as a priority resource area. In the United States, the watershed covers portions of eight states, encompassing sparsely populated northern forests, and some of the world's largest concentrations of industrial complexes.*

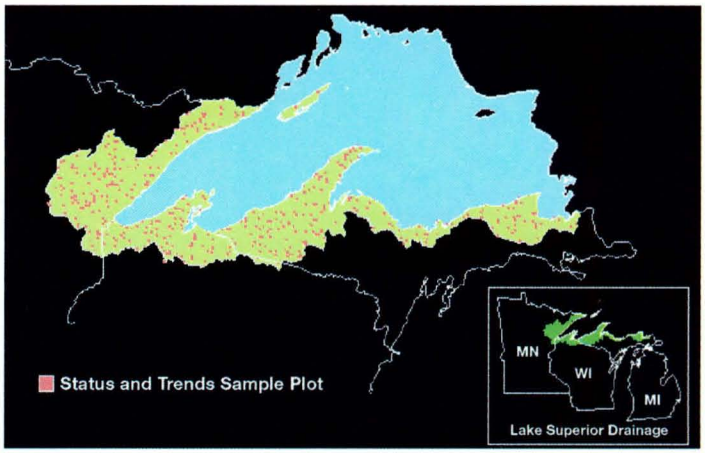



*Figure 2. Lake Superior drainage (U.S. portion) represents approximately 14% of the entire Great Lakes Watershed. A random selection of 434 sample plots within the drainage boundary is enough to provide statistically robust estimates of the wetland area by type.*

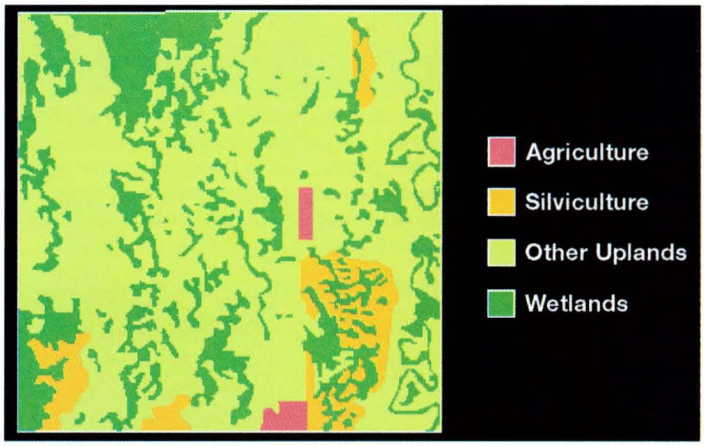



*Figure 3. Wetland and upland land use classifications are displayed within a four-square-mile sample plot. Individual wetland types are all represented here, using a single color (green) to simplify the graphic.*

## GIS Expands Landscape-Level Analysis

The challenge of previous WST studies was rapidly collecting and analyzing data to produce accurate wetland acreage information. Upland land use was captured as an artifact of the photo interpretation and the area measurement process. Those data were scanned to obtain area measurement, but never were converted or stored in a georeferenced digital format. Now all land use data are captured in a GIS, enabling analysts to glean considerably more information about wetlands, their position on the landscape and how they interface with other land use types. Such analysis is possible because the WST team captures sufficiently large portions of the landscape and classifies the entire land surface—wetland, deep water and upland—within the sampled area.

Landscape-level analysis can help address more complex questions, such as how an area changed over time and what spatial patterns exist, and assist in modeling future land use trends. In the Lake Superior Drainage study, a data layer containing wetland/upland classifications for all 434 sample plots will be created by merging individual sample plot data files into one coverage for the entire study area.

One WST goal is to identify the wetlands most susceptible to loss or conversion. For example, emergent wetlands bordering existing agricultural lands have been converted more often than those isolated

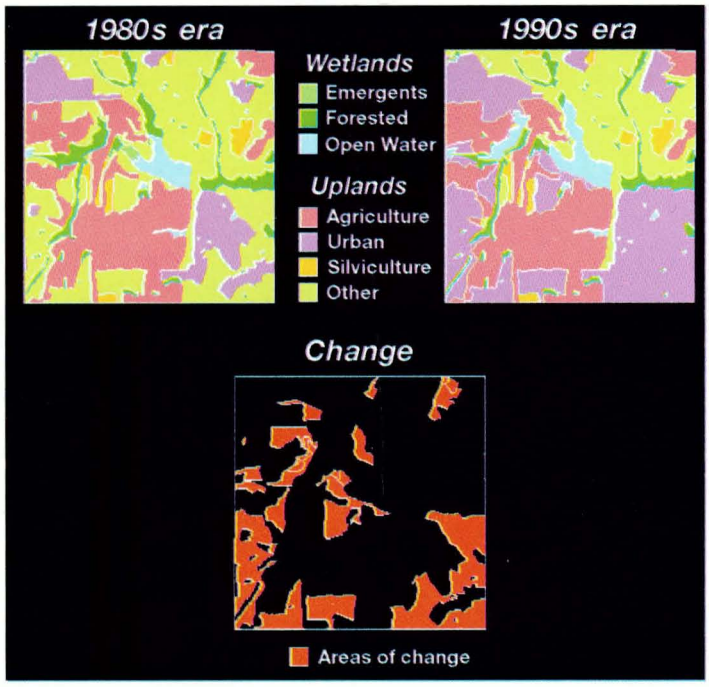



*Figure 4. Each polygon within a GIS representation of a four-square-mile sample plot has associated with it land use attribute information from two eras of photography. From these data, graphics can be generated to show land use classifications for the earlier era (top left) or the later era (top right), as well as highlighting the areas that have experienced a change in classification between the two eras (bottom).*

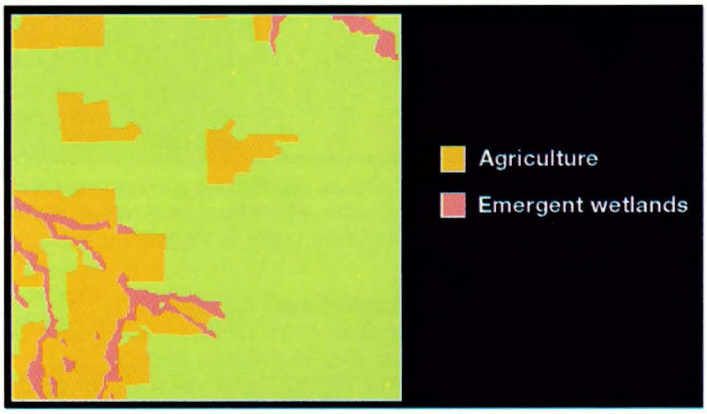



*Figure 5. GIS was used to identify emergent wetlands within a four-square-mile sample plot that are most likely to be converted to agricultural use (shown in red) based on juxtaposition to existing agricultural land use, underlying soil type and land ownership.*

from such activities. Examining ancillary data reveals a relationship between drained emergent wetlands, soil type and land ownership. Using that information, all remaining emergent wetlands adjacent to existing agriculture are intersected with the appropriate soils coverage and bounded by land ownership to identify those potentially susceptible to conversion (see Figure 5).

## Further Investigation

Analyzing digital datasets in conjunction with ancillary data layers can aid in locating wetlands susceptible to change. A landscape profile can be developed to apply throughout the study area to aid in a variety of land management decisions and activities. Strictly interpreting the wetland/upland data layer yields only quantitative information regarding the region's wetland resources. GIS analysis, however, allows the study team to examine

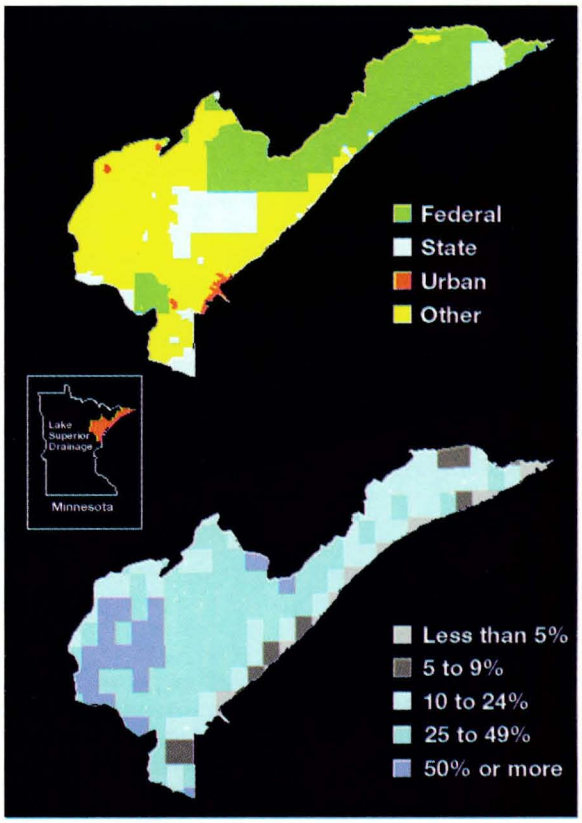



*Figure 6. Regional coverages, such as one defining public lands and urban areas of the Lake Superior drainage of Minnesota (top), assist in analyzing wetland area changes in and around identified land use categories. A comparison with a layer showing the relative distribution of wetlands in the region (bottom) reveals that the wettest areas (dark blue) are outside the public lands. This has implications regarding potential impacts to wetlands in this portion of the drainage.*

spatial relationships within and among data layers to get insights into the qualitative aspects of the wetlands (see Figure 6).

For example, certain conclusions can be made about the condition of wetlands that are contained within, or adjacent to, such intensive land use activities as urban development, agriculture and silviculture based on their landscape position. Similarly, resource managers and land use planners may use this information with soil type and land ownership data to help identify wetlands that are likely candidates for restoration projects. Possibilities are limited only by the GIS analyst's imagination and the availability of suitable ancillary data layers.

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