APPLICATION OF A COMPUTER-AUTOMATED WETLANDS INVENTORY TO REGULATORY AND MANAGEMENT PROBLEMS

Carol A. Johnston[1], Bill Marlett[2], and Mark Riggle[3]

[1] *Natural Resources Research Institute*
University of Minnesota
Duluth, MN 55811

[2] *Water Resources Consulting*
Bend, OR 97701

[3] *(deceased)*

Abstract. Wisconsin Wetlands Inventory (WWI) maps prepared by the Wisconsin Department of Natural Resources (WDNR) were computerized to increase their versatility. Wetland boundaries and classifications determined by stereoscopic interpretation of 1:20,000 aerial photography were field checked and drafted onto reproducible 1:24,000 photographic base maps. Computer software developed by WDNR was used to: 1) semi-rectify the photographic base to 7.5 minute U.S.G.S. quadrangles, 2) convert the digitized linework and classification codes to a polygon format, 3) report acreage by classification code, and 4) generate map overlays.

The WWI maps have provided information for a variety of management, planning, and regulatory applications. Computer-plotted wetland overlays have been created for special needs: quantification of sandhill crane habitat, developing a non-point source pollution abatement plan, and regulating wetlands adjacent to navigable waters. The flexibility of a computer-automated wetlands inventory has enhanced WDNR's ability to carry out its management and regulatory mandates.

Key words: wetlands, inventory, GIS, automated, zoning, map, planning, Wisconsin, shoreland, vegetation, management

INTRODUCTION

The 1978 Wisconsin State Legislature mandated the Wisconsin Department of Natural Resources (WDNR) to map the wetlands of the State, "for the purpose of advancing the conservation of wetland resources" (Section 23.32,

Wisconsin Statutes). Inventory planners anticipated the maps would be used for a variety of purposes and designed the Wisconsin Wetlands Inventory (WWI) to:

1) be compatible with the Fish and Wildlife Service's National Wetland Inventory (Cowardin *et al.* 1979);

2) be sufficiently accurate and have a large enough scale to be suitable for regulatory purposes;

3) provide information to managers and researchers about wetland characteristics;

4) be conducive to revision;

5) generate standard format maps that could be disseminated quickly and inexpensively, as well as maps that could be formatted to specific user needs; and

6) operate within the budgetary and time constraints set by the State Legislature.

This paper describes how the WWI has met a variety of unanticipated needs, and how computerizing the Inventory has contributed to its accuracy and versatility.

INITIAL MAP PREPARATION

Initial map preparation took about 67 hours per township (Table 1). Wetlands were located, delineated, and classified using 1:20,000 black and white infra-red aerial photos taken during the summers of 1978 and 1979, the most recent statewide aerial photography available at the time (Johnston 1984). The stereoscopic air photo interpretation was supplemented by other sources of information, such as soil surveys, U.S.G.S. topographic maps, and existing wetland inventories (Johnston 1977). Selected wetlands were field checked in nearly every township mapped to verify the photo interpretation.

After field checking, the wetland and pertinent cultural information was transferred to a reproducible 1:24,000 photographic base. Although a Bausch and Lomb Zoom Transferscope was used to transfer obscure wetland boundaries, most of the boundaries were evident on the base photography. The photographic base also provides map users with important background information about an area. U.S.G.S. orthophotoquads were used where available because of their scale accuracy. Elsewhere, black and white photographic enlargements centered on Public Land Survey townships were used as base maps. The drafted wetland maps are quickly and inexpensively reproduced by exposing light-sensitive diazo paper in contact with the translucent map and developing it with ammonia fumes.

Table 1. Average time required to complete a photographic-based Wisconsin Wetlands Inventory map.

Task	Person-hours/36 sq. mi. township	
	Excluding leave time	Including leave time
Stereoscopic photo interpretation	15.3	17.6
In-house check of photo interpretation	5.0	5.8
Field check	6.3	7.2
Drafting	27.9	32.1
In-house check of drafting	3.8	4.4
TOTAL	58.3	67.1

Preliminary WWI maps were sent to each county for a 180-day public review period, which included at least one public hearing (Chapter NR 115, Wisconsin Administration Code). Comments about wetland delineation and classification were returned with the preliminary maps to WDNR at the end of the review period and the maps were revised accordingly. The preliminary mapping, review, and revision has been completed for the unincorporated areas of the state, with further map revisions to be made after cities and incorporated villages review the wetland maps (Chapter NR 117, Wisconsin Administrative Code). Map review and revision is expected to take 5 to 6 years for the approximately 450 incorporated municipalities in the State.

COMPUTER-AUTOMATED WETLAND MAPS

Creation of a digital wetland data layer is a process whereby mapped features are converted to digital (i.e., numeric) form. The WWI data layer is in a line/polygon structure, rather than a grid cell structure. Due to the lack of suitable commercially available geographic information systems (GIS) at the time the WWI was initiated, the system for creating the WWI data layer was developed by the WDNR.

The software fit each township-centered WWI photo base to its corresponding 7.5 minute U.S.G.S. quadrangle by entering the coordinates of five reference points common to each map and transforming the wetland map to the U.S.G.S. map. Referencing the WWI maps to the U.S.G.S. quads has the following advantages:

1) the U.S.G.S. quads provide township boundary and latitude-longitude information for digital input purposes;

2) WWI maps drafted on photo enlargements can be incrementally rectified to correct for photo distortion;

3) township-centered overlays can be prepared from WWI maps drafted on orthophotoquads, and 7.5 minute quad overlays can be prepared from township-centered photo enlargements;

4) by overlaying computer-generated wetland plots on U.S.G.S. quads, users can obtain information not shown on the wetland maps (e.g., geographic coordinates, topography, cultural features);

5)the WWI map data layer can be transformed into any geographic coordinate system (e.g., UTM, State Plane); and

6) the WWI data layer can be imported to other GIS software.

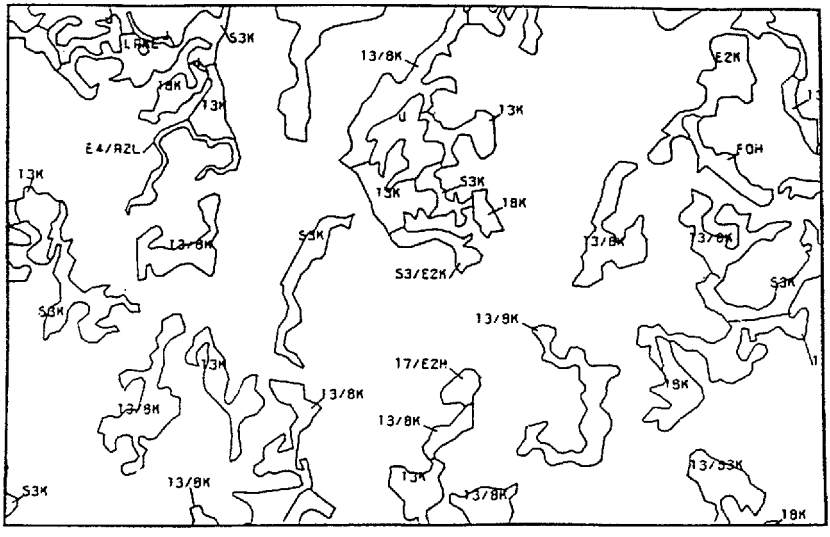

Figure 1. Portion of a computer-plotted Wisconsin Wetlands Inventory overlay. Letter and number codes denote different wetland types.

After reference information was captured from the U.S.G.S. quads and WWI maps, wetland boundary lines were digitized and classification codes entered. To process this data into the data layer, polygons were defined by the line segments

Table 2. Sample acreage summary for the Wisconsin Wetlands Inventory (Town 31 North, Range 01 West).

CLASS		ACREAGE
-E1K		0.70
-T3/S3K		9.30
E1K		46.54
E1Kg		54.08
E1Kv		3.22
E2K		87.40
E2Kg		178.74
S3/E1K		1.90
S3/E1Kg		27.47
S3/E2H		24.09
S3/E2K		211.91
S3/E2Ka		15.09
S3/E2Kg		13.36
S3H		14.84
S3K		628.09
S3Ka		6.57
S3Kg		47.27
T3/E2Kg		11.37
T3/S3K		487.19
T3/S3Kg		23.42
T3K		238.07
T7/E2K		12.28
T8/S3K		15.65
T8K		35.99
W0H		6.94
TOTAL AREA	=	2201.48

that circumscribe them. Topological relationships between polygons were determined (i.e., a wetland mapping unit may be part of a larger, more complex wetland), and each wetland classification code was matched with its appropriate polygon. Standard WWI computer products include wetland overlay maps (Figure 1) and acreage summaries for each township in the State (Table 2). Creation of the wetland data layer for the State's 1719 townships took about 17,190 hours, an average of 10 hours per township (Table 3).

Table 3. Average time required for computer processing a township-centered Wisconsin Wetlands Inventory map.

Task	Person-hours/36 sq. mi. township	
	Excluding leave time	Including leave time
Entering control	1.0	1.2
Digitizing	7.0	8.0
Finalizing (converting lines into polygons and generating acreage summaries)	1.5	1.7
Creating regulatory overlays	0.5	0.6
TOTAL	10.0	11.5

USE OF THE INVENTORY: MANAGEMENT AND PLANNING APPLICATIONS

The WWI maps and data have been incorporated into the National Wetland Inventory, making the U.S. Fish and Wildlife Service the major user of the WWI. Diazo copies of the photographic-based maps have also been used for other management and planning purposes: sanitary sewer service and environmental corridor designation, landfill and hazardous waste disposal siting studies, wetland acquisition, wildlife habitat research, and management of WDNR properties.

The International Crane Foundation of Baraboo, Wisconsin, has used the WWI maps for several years in its annual sandhill crane count. In 1985, they

obtained a set of computer-plotted wetland overlays and acreage summaries for two counties in south-central Wisconsin. By combining their knowledge of crane habitat preferences with the wetland vegetation and water classifications on the maps, they were able to estimate the acreage of suitable crane habitat in those key counties.

Computer-generated 7.5 minute wetland overlays were used by the Milwaukee Priority Watershed Project to help develop non-point source pollution abatement plans for each of the five watersheds identified within the Milwaukee River Basin. Project staff inventoried sediment and nutrient contributions from rural lands. By using wetland overlays to identify internally drained areas, they estimated that 10 to 15 percent of the basin surface area could be excluded from their inventory, resulting in a substantial time and money savings to the WDNR.

USE OF THE INVENTORY: REGULATORY APPLICATIONS

Almost as soon as the photographic-based maps were drafted, regulatory agencies began using copies for federal permits under Section 404 of the Water Pollution Control Act and state permits involving navigable wetlands. However, state-wide regulatory changes after initiation of the inventory created a major new use for the maps: zoning of wetlands along lakes and streams.

Wisconsin's Shoreland Management Program requires all counties to zone their shorelands in unincorporated areas to protect the natural values of the shoreland area. Shoreland areas are defined as lands within 1,000 feet of navigable lake, pond, or flowage, and lands within 300 feet of a navigable river or stream, or to the landward side of the floodplain, whichever distance is greater (Section 59.971 Wisconsin Statutes).

When the Shoreland Management Program was implemented in 1965, wetlands in shoreland areas were only protected if a county decided to include them in a conservancy district (Marlett 1983). However, an amendment of the Shoreland Management Program approved in 1980 (Chapter NR 115, Wisconsin Administrative Code) made it mandatory for counties to protectively zone all DNR-mapped wetlands located within shoreland areas (Schultz 1981, Marlett 1983). It established the WWI map review process, listed permitted wetlands uses, and described county and DNR administrative procedures for rezoning a shoreland-wetland district. The Wisconsin State Legislature passed a similar measure in 1982 for cities and villages (Sections 61.351 and 62.231, Wisconsin Statutes and Chapter 117, Wisconsin Administrative Code).

This new application of the WWI maps posed a problem that might have been more difficult to overcome without the digital wetland data layer. All manually-drafted WWI maps include wetland boundary and classification information that is unnecessary for zoning, and some show wetlands smaller than the

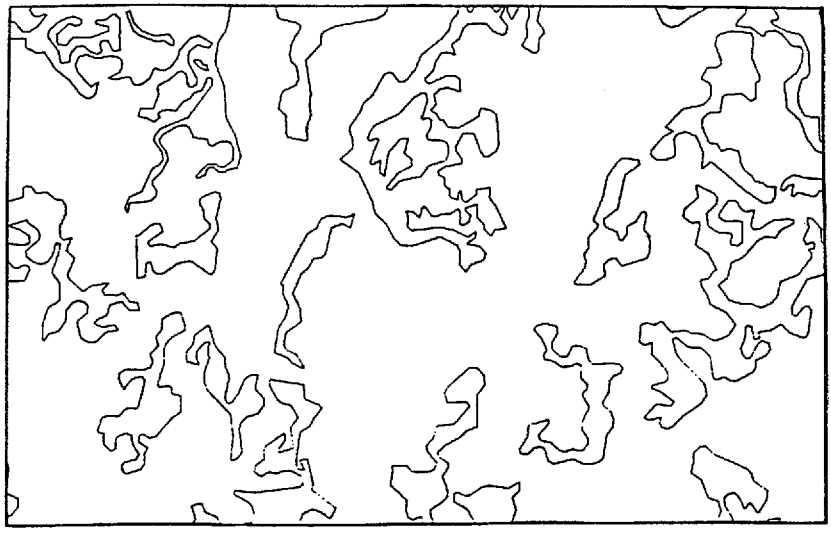

Figure 2. Computer-plotted regulatory overlay for the same area shown in Figure 1.

minimum size subject to regulation. To meet the need for a simplified regulatory version of the wetland maps, computer-plotted overlays were developed to show exterior wetland boundaries, township borders, and only those wetlands larger than the minimum size required to be regulated (Figure 2). Each 1:24,000 overlay covers a surveyed township. Because the wetland maps are rectified to the U.S.G.S. 7.5 minute maps series, the regulatory overlays can be directly overlaid on the appropriate U.S.G.S. quad.

The computerized map base will make it easier to revise regulatory overlays as counties rezone wetlands to a nonwetland status. WDNR will digitize zoning map revisions sent to it by counties, so the regulatory overlays can be periodically updated. This process will provide information about wetland conversion rates in the shoreland zone, but will not be a true update of the WWI because conversions of wetlands outside the shoreland area and wetlands smaller than the minimum regulated size (5 acres) will probably not be reported.

CONCLUSIONS

The initial cost of converting mapped information to a computerized form is very high, but can yield a number of benefits that justify this cost:

— the loss of wetlands can be monitored, and the information used in regulatory decisions regarding further wetland losses;

— acreage information can be extracted by classification code for any defined geographic area (Table 1);

— map products can be tailored to the individual user's need, such as the regulatory overlays created for the Shoreland Management Program;

— much of the scale distortion caused by using an unrectified photo graphic base can be corrected;

— map revisions and inventory updates can be done with a minimum of manual redrafting, greatly reducing their cost as compared with conventional map revision methods;

— by interfacing different types of data layers, users can address specific management questions that neither data layer could answer alone (e.g., overlaying wetland and watershed maps to find internally drained areas);

— the coordinate system and political boundaries digitized for the wetland maps can be used for other geographic inventories.

Automating the Wisconsin Wetlands Inventory has been slower and more costly than was originally predicted, but the added versatility has already proven valuable in accommodating unanticipated user needs. The International Crane Foundation, the Milwaukee Priority Watershed Project, and Wisconsin's Shoreland Management Program are the first of many users to benefit from the flexibility and utility of a digital wetlands inventory.

LITERATURE CITED

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Fish and Wildlife Service, Office of Biological Services, Washington, D.C., USA.

Johnston, C.A. 1977. Wetland mapping using existing information sources. pp. 290-305. *In* Wetlands ecology, values, and impacts. Proceedings of the Waubesa Conference on Wetlands, Madison, WI. Institute for Environmental Sciences, Madison, WI., USA.

Johnston, C.A. 1984. Mapping Wisconsin's wetlands. Wisconsin Natural Resources 8(5):4-6.

Marlett, W.P. 1983. Wisconsin's wetland protection program - a state/local partnership. pp. 69-74. *In* Proceedings of the 13th Regional Planning Conference. Southeastern Wisconsin Regional Planning Commission, Waukesha, WI., USA.

Schultz, C.J. 1981. Regulating shoreland-wetlands in Wisconsin. pp. 587-593. *In* B. Richardson (ed.). Selected Proceedings of the Midwest Conference on Wetland Values and Management, St. Paul, MN. 17-19 June 1981. Minnesota Water Planning Board, St. Paul, MN, USA.