ASSESSING CUMULATIVE LOSS OF WETLAND FUNCTIONS IN THE PAW PAW RIVER WATERSHED USING ENHANCED NATIONAL WETLANDS INVENTORY DATA

Chad J. Fizzell
Wetlands GIS Specialist
MI Department of Environmental Quality
Land and Water Management Division
Wetlands, Lakes, and Streams Unit
E-mail: fizzellc@michigan.gov

Abstract: The emergence of watershed management planning is driving an interest in understanding the relationship between wetland loss and degraded surface water quality. In addition to quantifying wetland loss, there has been a strong push recently to interpret loss of wetland function on a landscape level, and to incorporate that information into a watershed management context. In a 1990 report to Congress, The Michigan Department of Natural Resources (MDNR) and the U.S. Department of the Interior estimated that Michigan had lost approximately 50% of its original wetland resource base.

Though calculations on wetland quantity can give us an idea of overall impact, studies in the Northeast have shown the available spatial information can be enhanced to estimate qualitative loss of wetland function. Based on a technique developed in the US Fish and Wildlife Service' Northeast Region (USFWS-NE), additional information can be added to the National Wetland Inventory database to characterize 9 general wetland functions at a landscape level. In cooperation with the Paw Paw River Watershed Council, this technique was applied to assist local planners with wetland conservation and restoration strategies for their watershed.

Wetland databases for presettlement and 1998 conditions were prepared to allow comparison of wetland condition in these two eras. Before European settlement, the Paw Paw River watershed contained 65,254 acres of vegetated wetland or 23% of the total watershed area. By 1998, the total wetland area had been reduced to 57% of its original extent. Conversion to farmland was the main reason for wetland loss. Conversion of forested wetland to emergent/scrub-shrub wetland due to logging practices and drainage also played a role in the cumulative impact of wetland functional loss.

INTRODUCTION

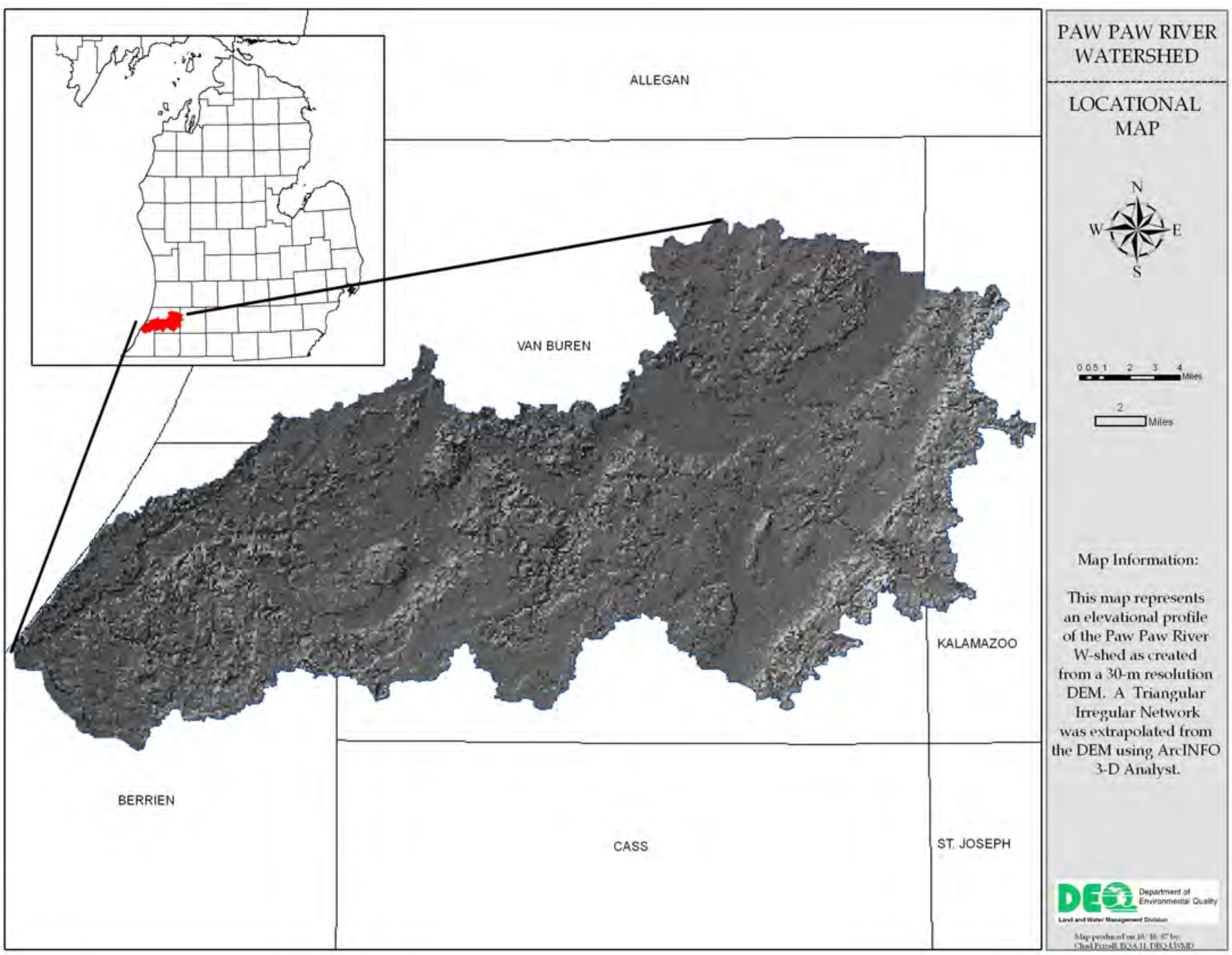
The U.S. Fish and Wildlife Service (USFWS) have been conducting the National Wetlands Inventory (NWI) for over 25 years. The NWI Program has produced wetland maps for 91% (78% final) of the lower 48 states, all of Hawaii, and 35% of Alaska. Wetlands are classified according to the Service's official wetland classification system (Cowardin et al. 1979). This classification describes wetlands by ecological system (Marine, Estuarine, Lacustrine, Riverine, and Palustrine), by subsystem (e.g., water depth, exposure to tides), class (vegetative life form or substrate type), subclass, water regimes (hydrology), water chemistry (pH and salinity), and special modifiers (e.g., alterations by humans). The availability of digital data and geographic information system (GIS) technology make it possible to use NWI data for various geospatial analyses.

In the 1990s, the NWI Program for the Northeast Region recognized the potential application of NWI data for watershed assessments, but realized that other attributes would have to be added to the data to facilitate functional analysis. Dr. Mark Brinson had recently developed a hydrogeomorphic (HGM) approach to wetland functional assessment (Brinson 1993a). This approach provided the impetus for developing other attributes to expand the NWI database and make it more useful for functional assessment.

In the mid-1990s, a set of HGM-type descriptors were developed to describe a wetland's landscape position, landform, and water flow path (Tiner 1995, 1996a,b). These projects were watershed characterizations that included a preliminary assessment of wetland functions as a main component or the prime component of the study. Of the 4 LLWW descriptors, as they're referred to in Tiner's Nanticoke Watershed study in Maryland (Tiner, 2005), three were derived from the three core components in Brinson's (Brinson, 1993) approach to wetland functional classification. Geomorphic Setting (Landscape position) refers to the topographic location of the wetland within the surrounding landscape. Water source and its transport (relates to Landform) refers to the hydrologic input into a given wetland, which has been adapted and refined in this analysis. Hydrodynamics (Water Flow Path) refers to the motion of water and the capacity of that water to do work (i.e., transport sediments, transport nutrients to root surfaces) (Brinson, 1993).

In conducting these studies, USFWS worked with local and regional wetland experts to develop correlations between these wetland characteristics as recorded in the database and wetland functions. These correlations reflect the best approximation of what types of wetlands are likely to perform certain functions at significant levels based on the characteristics we have in the wetland database (Tiner, R.W. 2003). Given that the functional correlations were developed for the Northeast Region of the country, a consideration of similarities and differences of the two regions may be considered in future analyses. However, there is defensible logic in connecting fundamental wetland properties with ecological significance (Brinson, 1993). This type of analysis assumes that given sufficient information on geomorphic setting, water source, and water movement, it should be possible to make reasonable judgments on how these physical properties can be translated into wetland functions.

This pilot project was an effort to translate these techniques, as developed by Tiner in his Nanticoke study, to the Midwest region to evaluate its effectiveness in classifying wetland function at a landscape level in the Great Lakes basin. Currently in Michigan, a two-phase update of NWI data to 1998 and 2005 conditions is ongoing in a joint effort with the MDEQ and Ducks Unlimited-Great Lakes/Atlantic Regional Office (DU-GLARO). This effort is being partially funded by the US Environmental Protection Agency (EPA) Region 5 and DU-GLARO. This pilot project was an effort to evaluate the feasibility of adding HGM-type descriptors to those mapping updates, for use in future landscape level functional assessments.



Study Area

The Paw Paw River Watershed begins in the western portion of Kalamazoo County and the Eastern portion of Van Buren County. The watercourse flows from its headwaters in a southwesterly direction to its mouth on the shores of Lake Michigan, in Berrien County. The watershed itself covers an area of 445 square miles, and is the largest watershed in Van Buren County. The river and the lands in the watershed border a mix of agriculture and rural villages and cities, with large portions of the main branch still flowing through a channel bordered by undisturbed floodplain forested wetland.

The surface geology of Van Buren County is complex and diverse, including outwash plains, ice-contact topography, moraines of varying texture, sand lake plain, and sand dunes (Comer, 1996). While much of this area has gently rolling hills that are well drained, poorly drained flats and depressions are common (Comer, 1996).

METHODS-General

The Paw Paw Landscape Level Wetland Functional Assessment involved the completion of 4 major tasks:

1. Spatial Data Collection and Integration
2. Classification and Enhancement of NWI data with LLWW descriptors
3. Functional Correlations and Assessment
4. Post-Evaluation

The first task assigned was to collect and integrate all GIS spatial data for the watershed that could be used to attempt an automated classification of the NWI polygons from a HGM perspective. This data collection included:

Layer Name	**Data Source**	**Description**
National Wetlands Inventory	US Fish and Wildlife Service, National Wetlands Inventory	Digital data based on 1:24000 aerial photos from the late 1970's and early 1980's
National Hydrography Dataset- Medium Resolution	US Geological Survey and EPA	Based upon Digital Line Graph (DLG) hydrography at 1:100,000 scale
Digital Raster Graphic (DRG) topography and DEM	US Geological Survey	Scanned USGS Topo quads
SSURGO Soil Surveys	Natural Resource Conservation Service	Digitized from Paper Soil Surveys at 1:24000
NAPP 1998 Digital Orthophoto Mosaics	US Geological Survey	Usable at 1:12000
CGI Framework Data	MI Center for Geographic Information	Includes roads, political boundaries, hydrography, census figures, etc

Each dataset was necessary to complete one piece of the HGM classification. Of these datasets, topography and hydrography were the most utilized to determine the LLWW descriptors for each wetland in NWI. Results of this classification were then checked against the NAPP photography to ensure consistency with current conditions. These datasets were integrated into a Geodatabase for use in ESRI ArcINFO 9.1 software. A geodatabase is a GIS data format that allows integration of disparate data sources into one centralized database, from which, all data can be accessed independently. This approach eases the difficulty in managing multiple GIS datasets concurrently.

The second task involved the actual HGM classification of NWI polygons for the Paw Paw River watershed. Classification of hydrogeomorphic descriptors included populating the NWI database with information on; landscape position, landform, water flow path, and waterbody type. Vegetated wetlands and open-water wetlands were handled differently during this phase of the classification. See Appendix 1 for Simplified Keys to the LLWW classification. Rivers, lakes, and ponds present in the NWI spatial data were classified in terms of waterbody type, and waterflow path. Lakes and ponds were separated at the 5 acre mark, all open-water polygons less or equal to 5 acres were classified as ponds, while all open-water polygons larger than 5 acres were classified as lakes. The 5 acre cutoff was chosen to remain consistent with previously existing DEQ regulations. Polygonal features associated with the main branch of the Paw Paw River were the only features given a waterbody type classification of River.

Task number three involved connecting the HGM-coded NWI polygons with the functional correlations prepared by USFWS Region 3. Appendix 2 presents a complete listing of the functional correlations applied in this analysis.

The final task involved a post-evaluation of the effort by the LWMD, including how the work was to be utilized and the effectiveness of the methodology chosen.

METHODS-Presettlement Wetland Inventory

Estimating the extent of historic wetlands was completed through the use of several data sources, all of which required a level of assumption to ascertain the information needed for a useful and accurate functional classification. Given that fact, it is obvious that this dataset represents a best-guess approximation of wetland extent and condition in presettlement times. The location and condition of presettlement wetlands were derived from two major sources: 1) soil survey data from the U.S.D.A. Natural Resource Conservation Service (NRCS) based on 1:15,840 soil maps and 2) Michigan Natural Features Inventory presettlement vegetation maps derived from General Land Office Survey (GLO) maps created between 1816 and 1856. The former source was relied upon much more heavily with the secondary source filling in gaps in the classification of wetland type.

Hydric soil map units were culled from the soil survey data, including all major hydric units as well as complexes where hydric soils were deemed to be a significant part of the soils series. All hydric soil polygons were deemed historic wetland polygons for the purposes of this analysis. The polygons were classified based on NWI type, with information on each soil series used to determine vegetation class and water regime. These results were cross-referenced with the presettlement vegetation maps to further discern changes in forest type (coniferous vs. broad-leaved), emergent and scrub-shrub areas, and wet prairies. Limited cross-referencing was done with the 1998 NWI to assist in culling out certain water regime information, which could indicate the location of Fringe and Slope landforms in presettlement times.

In addition to the 4 LLWW descriptors, information was gathered on wetlands in a headwater position relative to the watershed as a whole. Wetlands polygons adjacent to ponds had this relationship noted in the database. A distinction was drawn when dealing with floodplain wetlands in terms of landform. Depending on the assigned water regime of the NWI polygon, the floodplain wetland was further classified as either basin or flat.

The result of these assumptions is a dataset that is very simplified in comparison to the 1998 NWI, however it provides an adequate base at the landscape level to perform a basic assessment of lost wetland function. Appendix 3 presents maps that illustrate presettlement wetland extent, and a comparison of extent over the two time periods studied.

METHODS-1998 Wetland Inventory

The distribution, extent, and classification of 1998 wetlands were based on NWI mapping. Wetlands were classified according to the FWS's official wetland classification system (Cowardin et al. 1979). The LLWW descriptors were added to the digital NWI database to provide HGM-type information to each wetland polygon. Similar to the presettlement approach, information was gathered on wetlands in a headwater position relative to the watershed as a whole, wetland polygons adjacent to ponds, and basin and flat landforms in a floodplain situation.

As part of this effort, while the HGM descriptors were being added to the NWI database, LWMD staff also performed an update on the 7500 NWI polygons contained within the Paw Paw River Watershed to ensure consistency with wetland conditions on the ground as of 1998. Though an update was performed on the MI NWI to 1998 conditions by Ducks Unlimited-Great Lakes/Atlantic Regional Office, further update was necessary in some areas of the watershed. Appendix 3 presents maps illustrating wetland extent in 1998.

Preliminary Assessment of Wetland Functions

This study employed a landscape-level wetland assessment approach called "Watershed-based Preliminary Assessment of Wetland Functions" (W-PAWF). W-PAWF applies general knowledge about wetlands and their functions to produce a watershed profile highlighting wetlands of potential significance for numerous functions. The method was developed to predict wetland functions for large geographic areas, particularly watersheds, from NWI data. To do this, two steps must be undertaken: 1) the digital NWI database must be expanded by adding LLWW descriptors, and 2) correlations between wetland characteristics in the database and wetland functions must be developed. Many wetland functions are related to physical properties, while others are dependent on a combination of biological and physical characteristics. For example, floodplain and depressional wetlands temporarily store surface water, whereas slope wetlands do not; wetlands that are sources of streams are vital for streamflow maintenance; marshes provide habitat for waterfowl and waterbirds (Tiner, 2005).

Of the 10 functions evaluated in the W-PAWF approach, 9 were evaluated in this study. The coastal storm-surge detention function does not apply to this watershed. 1) surface-water detention 2) streamflow maintenance 3) nutrient transformation 4) sediment and other particulate retention 5) shoreline stabilization 6) provision of fish and shellfish habitat 7) provision of waterfowl and waterbird habitat 8) provision of other wildlife habitat, and 9) conservation of biodiversity (rare or imperiled wetland habitats in the local region with regional significance for biodiversity). Stream shading was also evaluated as a sub-function of fish and shellfish habitat. The rationale for correlating wetland characteristics with these functions for the Northeast is described in Tiner (2003b). Correlations are based on a review of appropriate literature and application of best professional judgment from many wetland biologists and resource specialists in the Northeast (Tiner, 2005).

Once the digital databases had been constructed for both eras, including LLWW descriptors, correlations were applied to both datasets to produce a preliminary assessment of wetlands performing functions at significant levels. The correlations are applied to the databases with analyses that take into account NWI classification as well as HGM codes constructed from the LLWW descriptors. The conservation of biodiversity function was evaluated using a Rare and Imperiled Wetlands spatial dataset prepared by MNFI. These wetlands were intersected in a GIS environment with the NWI wetlands in the 1998 coverage, and assigned a level of significance for this function. In the presettlement dataset, this intersection was extrapolated to include larger wetland complexes (where applicable) where it was obvious that fragmentation of the resource had occurred.

After completing the NWI Enhancement and the Functional Correlation analyses, maps can now be produced to highlight wetlands that are performing these functions at significant levels. Two classes of significance were used to cull out wetlands performing functions at high and moderate levels based on their physical and biological characteristics. "Significance" is a relative term and is used in this analysis to identify wetlands that are likely to perform a given function at a level above that of wetlands not designated (Tiner, 2005). Appendix 3 presents a subset of the functional maps that can be created with the enhanced NWI.

RESULTS

The wetland spatial data produced as a result of this effort can be used for a multitude of purposes. The addition of the LLWW information to the original NWI database facilitates a greater ability to subset the data. This gives the end user the ability to craft the data to the specific needs of the organization, and produce maps that highlight wetlands of significance for one specific function or multiple. Because of the scalability of the final datasets, watershed-scale maps can be produced as quickly and easily as maps showing sub-watersheds or local communities.

Final deliverables for this effort include hard-copy maps illustrating wetland extent during presettlement and 1998 eras, predicted wetlands of significance for 9 functions, wetlands separated by LLWW type, and wetlands separated by NWI type. Due to scale issues, only a subset of these maps were included in this report. However, further information and additional maps can be obtained by contacting the MDEQ, Land and Water Management Division using the information included at the beginning of this report.

Wetland Extent Comparison

Trends by Generalized NWI Types: The Paw Paw River watershed has undergone major changes in wetland extent and type since presettlement times. Prior to European settlement, vegetated wetlands occupied an estimated 65,254 acres of the watershed, or approximately 23% of the total watershed area. Of this, nearly 96% of the wetlands were forested, with a much smaller percentage comprised of emergent (1%) and scrub-shrub (3%) wetlands. The predominant forested wetland types (based on original GLO surveys) were mixed hardwood swamps, black ash swamp, and tamarack swamp. Mixed hardwood swamp and Black ash swamp were characteristic of the Paw Paw River and Dowagiac River floodplains. Tamarack swamp was more common on poorly drained outwash areas and ground moraine (Comer, 1996). Emergent and scrub-shrub areas are most likely under-represented in the presettlement analysis, due to surveyor methodology and sporadic natural disturbance, such as fire.

By 1998, wetland extent in the watershed had fallen to 37,425 acres, or 13% of the total watershed area. This represents a decrease in total wetland acreage of 43%. Of this total, 67% of the wetland area was comprised of forested areas. Emergent wetlands showed a large increase from 1% climbing to 15% by 1998. Scrub-shrub wetlands exhibited a similar increase in area, changing from 2% in presettlement time to 13%. The reasons for the increase in non-forested palustrine wetlands could be due to multiple factors. Assuredly, some of the marked increase is due to advancements in mapping methods in the 1998 coverage versus the relatively inaccurate methods employed by GLO surveyors. However, agricultural and silvicultural operations inevitably played a large role in this increase as well. Large areas of forested wetlands cut over for timber, or ineffectively drained for agricultural use were converted to emergent wetlands and through succession, some acreage eventually to a scrub-shrub condition. Table 1 presents a more detailed accounting of this wetland change over time by generalized NWI wetland type, while Table 2 breaks NWI classes down further for the 1998 NWI data.

Table 1: Generalized NWI type comparison

WETLAND TYPE	PRESETTLEMENT AREA	1998 AREA OF WETLANDS	NET AREA REMAINING
Palustrine Emergent	516	5751*	1115%
Palustrine Forested	62538	25145**	40%
Palustrine Shrub-Scrub	1604***	4885****	305%
Other Palustrine			
Farmed	0	607	NA
Ponds	596	1037	174%
TOTAL	65254	37425	57%

* Includes mixed emergent wetland classes and mixed communities where subclasses include Forested and Shrub-Scrub areas
**Includes mixed forested wetland classes and mixed communities where subclasses include Emergent and Shrub-Scrub areas
***Includes mixed Shrub-Scrub/Emergent communities
****Includes mixed shrub-scrub wetland classes and mixed communities where subclasses include Emergent, Forested and Shrub-Scrub

Table 2: 1998 NWI Classes

NWI WETLAND TYPE	ACREAGE
Aquatic Bed	92.9
Aquatic Bed/Emergent	13.6
Aquatic Bed/Shrub-Scrub	25.6
Aquatic Bed/Unconsolidated Bottom	117.7
Emergent	5465.8
Mixed Emergent/Scrub-Shrub (Deciduous)	311.4
Mixed Emergent/Scrub-Shrub (Evergreen)	14.9
Needle-leaved Deciduous Forest	155.6
Deciduous Forest	7.96
Evergreen Forested	27.6
Scrub-Shrub/Emergent	542.1
Broad-leaved Deciduous Forested	22953
Forested Dead	561.9
Forested Dead Mix	71.6
Mixed Forested	115.5
Deciduous Forested/Emergent	71
Forested Scrub-Shrub	1439.8
Deciduous Scrub-Shrub	3795.9
Evergreen Scrub-Shrub	79.84
Mixed Scrub-Shrub	212
Unconsolidated Bottom/Vegetated	212.9
Unconsolidated Bottom	5694.1
Unconsolidated Shore	3.23
TOTAL	41985.9
Riverine-Unconsolidated Bottom	1689.5

Trends by LLWW Type: At presettlement, an estimated 3161 wetlands covered approximately 64,657.5 acres (Table 4). Nearly 60% of the wetland area was represented by terrene wetlands, while 34% of the wetlands were comprised of lotic systems; 7% of total wetland areas were comprised of lentic wetlands. Approximately 77% of the wetlands were basin landforms. Wetlands considered as flat landforms comprised around 12% of the total wetland area. Only around 1% of wetlands were considered fringe landforms in presettlement times. Floodplain wetlands comprised 10% of total wetland area. Landforms recorded in negligible amounts included slope and island landforms, mostly due to lack of information on these types in presettlement times. Recorded water flow paths were as follows; nearly half (49%) of presettlement wetlands experienced outflow, 35% throughflow, 3% bidirectional-nontidal flow, and 12% were isolated (completely surrounded by upland).

By 1998, the Paw Paw's wetland area had been reduced by 43%, while the number of wetlands (excluding ponds) had increased 187% to 5903 due mostly to fragmentation caused by road construction and agriculture. The most striking change was in total wetland acreage, however wetland LLWW type also showed some changes over time. Terrene wetlands now represent about 48% of the total wetland area (excluding ponds), while Lotic wetlands comprise 47%, and Lentic wetlands making up about 5%. From a landform standpoint, Basin type wetlands represent 71% of the total, followed by Flats at 12% and Floodplain wetlands at 13%. Less-frequent landforms included Fringe wetlands that comprised 4% of total wetland area, with Island and Slope landforms comprising around ½%. A significant change was noted in this analysis when it came to water flow path. Outflow wetlands fell to 34% of total area, while Throughflow wetlands became the dominant type at 47%. Other Water Flow situations included Isolated at 13%, and Bidirectional wetlands filling out the last 5%. One possible explanation for the increase in Throughflow wetlands is the extensive agricultural ditching that took place in the watershed in the era between presettlement and 1998. Wetlands that were once isolated or in an outflow position, were connected with newly created stream channels and agricultural drains creating a hydrologic connection that did not exist originally in the watersheds natural state. See Appendix 3 for maps illustrating differences in hydrology over the two time periods.

Since presettlement, Terrene wetlands have experienced the biggest loss of total acreage at 56%, with Terrene Basins and Flats being the most negatively affected. Habitat fragmentation was significant, with the mean size of basin wetland dropping from 20.2 acres in size to 5.5 acres in size. By 1998, the mean size of the most abundant wetland type, terrene outflow wetlands, dropped from 33.9 to 7.6 acres while the number of wetlands increased from 887 to 1601. Only 76% of lotic stream wetlands remained from presettlement to 1998, and 70% of lotic river wetlands. Lentic wetlands experienced a 55% total loss over this time period.

The proportion of wetland acreage represented by different landforms changed slightly, with a drop in basin wetlands (77% to 71%) and an increase in Fringe and Floodplain types (1% to 4% and 10% to 13% respectively). Flat wetlands held steady at 12% of total wetland area. When factored against total area of all wetlands (including open water wetlands included in NWI) the percent of outflow area fell from 47% to 29%. All other waterflow path types increased with Throughflow wetlands going from 35% to 47% of total area, Isolated wetlands going from 12% to 14%, and Bidirectional wetlands going from 7% to 10%. See Table 3 for a full accounting of changes by HGM type.

Table 3: HGM Code Comparison (HGM Code represents concatenation of LLWW descriptors)

LANDSCAPE POSITION	LANDFORM	WATER FLOW PATH	PRESETTLEMENT #	PRESETTLEMENT ACREAGE	1998 #	1998 ACREAGE	% CHANGE IN ACREAGE
Lentic	Basin	BI	128	1240.3	162	774.3	-38
		OU	88	1668.8	5	22.3	-99
		TH	16	381.4	24	196.5	-48
	Flat	BI	23	589.5	70	432.4	-27
		OU	7	95.6	10	53.2	-44
		TH	3	50.9	2	12.4	-76
	Fringe	BI	12	154	80	470.1	305*
		OU	5	136	<NULL>	<NULL>	NA*
		TH	<NULL>	<NULL>	2	4.3	NA*
	Island	BI	<NULL>	<NULL>	18	51.7	NA**
Lotic River	Floodplain	TH	217	6559.6	156	4615.2	-30
	Fringe	TH	8	557.3	69	344.2	-38
Lotic Stream	Basin	TH	401	13039.4	899	9805.5	-25
	Flat	TH	65	2020.7	190	1272.5	-37
	Fringe	TH	7	119.5	125	515.3	431*
Terrene	Basin	IS	1058	6141.3	2082	3864.6	-37
		OU	766	27039.9	1360	10442.9	-61
	Flat	IS	236	1813.6	375	778	-57
		OU	112	2970.5	202	1570.8	-47
	Fringe	IS	<NULL>	<NULL>	31	103.2	NA*
		OU	<NULL>	<NULL>	2	2.1	NA*
		TH	<NULL>	<NULL>	1	0.2	NA*
	Slope	IS	<NULL>	<NULL>	1	0.7	NA***
		OU	9	79.3	37	147.6	186***
TOTAL			3161	64657.5	5903	35480	-45

* This increase is an artifact (including <NULL>), since the presettlement extent of Fringe wetlands could not be accurately established

**Extent of presettlement Island wetlands could not be accurately established

***This increase is an artifact, since the presettlement extent of Slope wetlands could not be accurately established

Causes of Wetland Trends

With European settlement and the resulting population boom, drainage and conversion of the watershed's wetlands occurred for the better part of 200 years, rapidly increasing in the last century. The majority of the agricultural drainage occurred in the upper reaches of the Paw Paw River Basin. The increase in linear stream miles played a large part in conversion from one wetland type to another, connecting wetlands that were once isolated and adding inflows to wetlands that previously only had outflows. Pond construction also played a role in conversion of both upland and wetland, seeing a 174% increase since presettlement times. Pond acreage increased from 596 acres in presettlement times to 1037 acres in 1998. The presettlement ponds were natural features, such as in-stream ponds and beaver ponds while the increase in 1998 was largely due to the creation of ornamental ponds on private property.

Loss of lentic wetlands may be due to the placement of water control structures on many waterways, and/or the armoring of lake edges. Water control structures placed on an lake inflow, for example, could cause the flooding and eventual loss of lakeside emergent/aquatic bed wetlands. Lake armoring speeds erosional processes, while hampering depositional processes resulting in the loss of substrate on lake edges, and eventually the wetland vegetation that could persist there.

Trends by Wetland Function

Two comparisons of changes in functions were made, one showing changes in wetland area providing functions at significant level (Table 4) and the other illustrating changes in functional units (Table 5). From the standpoint of total area, functional loss ranged from 62% (Conservation of Biodiversity) to 27% (Waterfowl and Waterbird Habitat). Wetlands that served as sources of streams (streamflow maintenance) experienced an overall decrease of 44%. Ditching of these headwater wetlands resulted in lost wetland hydrology either completely or to a point at which they could no longer effectively contribute to downstream flow. The ability of the watershed's wetlands to retain sediment was decreased by half, and nutrient transformation could only be performed at 55% of the wetlands original capacity, contributing to worsening surface water quality. Habitat for fish, shellfish, waterfowl, invertebrates, and any other wetland wildlife was reduced anywhere from 27% of original capacity (waterfowl habitat) to 61% (Fish/Shellfish habitat). To incorporate a real-world perspective on the cumulative effect of these losses, there is evidence based on historical accounts, that some of the tributaries to the Paw Paw River once held waters cool enough to support an active trout fishery. Though this subject represents a societal value as opposed to a wetland function (not the intent of this type of study), some inference can be made between the two. Possible explanations for the loss of the fishery could be the decline in total habitat area in the form of forested floodplain wetlands or the reduced streamflow coming from increasingly fragmented headwater areas that originally contributed to cold water baseflows.

Table 4: Detailed functional comparisons

FUNCTION	POTENTIAL SIGNIFICANCE	PRESETTLEMENT ACREAGE	1998 ACREAGE	% CHANGE IN AREA
Surface Water Detention	High	24,652.70	14,696.50	-40
	Moderate	36,459.40	16,173.60	-56
	Total	61,112.10	30,870.10	-49
Streamflow Maintenance	High	34,822.80	17,517.20	-50
	Moderate	21,074.70	13,947.20	-34
	Total	55,897.50	31,464.40	-44
Nutrient Transformation	High	55,259.70	33,015.20	-40
	Moderate	9,994	2,879.70	-71
	Total	65,253.70	35,894.90	-45
Retention of Sediment and Other Particulates	High	23,901.50	14,204.70	-41
	Moderate	36,849.90	15,704.70	-57
	Total	60,751.40	29,909.40	-51
Shoreline Stabilization	High	26,612.80	18,537.20	-30
	Moderate	23,660.60	12,001.10	-49
	Total	50,273.40	30,538.30	-39
Fish/Shellfish Habitat	High	38,463.40	13,952.10	-64
	Moderate	161.00	187.90	117
	Shading	15,121.70	6,861.40	-55
	Total	53,746.10	21,001.40	-61

Waterfowl/Waterbird Habitat	High	27,111	19,689.30	-27
	Moderate	161	351.80	219
	Total	27,272	20,041.10	-27
Other Wildlife Habitat	High	59,783.50	28,345.90	-53
	Moderate	4,874	7,927.70	163
	Total	64,657.50	36,273.60	-44
Conservation of Biodiversity	High	1,426	545.7	-62
	Moderate	<NULL>	<NULL>	
	Total	1,426	545.7	-62

Functional units (Table 5) may give a more accurate look at the loss of functional capacity in the watershed, as this approach gave more weight to wetlands performing functions at a high level of significance versus a moderate level of significance. For the wetland functions evaluated for the Paw Paw River Watershed, there was a cumulative loss ranging from 27% (Waterfowl and Waterbird Habitat) to 62% (Conservation of Biodiversity). The streamflow maintenance function is operating at a net loss of 46% of original capacity. Wetlands detaining surface water are operating at 47% of original capacity. Wetlands stabilizing shorelines are operating at 36% of original capacity. The other 4 functions (nutrient transformation, sediment retention, other wildlife habitat, fish and shellfish habitat) were performing at most, 43% or their original functional capacity. Not one of the functions showed an increase in capacity.

Table 5: Functional unit comparison

FUNCTION	PRESETTLEMENT FUNCTIONAL UNITS	1998 FUNCTIONAL UNITS	PREDICTED % OF ORIGINAL CAPACITY LEFT	PREDICTED % CHANGE IN FUNCTIONAL CAPACITY
Surface Water Detention	85,764.80	45,566.60	53	47
Streamflow Maintenance	90,720.30	48,981.60	54	46
Nutrient Transformation	120,513.40	68,910.10	57	43
Sediment and Other Particulate Retention	84,652.90	44,114.10	52	48
Shoreline Stabilization	76,886.20	49,075.50	64	36
Fish and Shellfish Habitat	92,209.50	34,953.50	38	62
Waterfowl and Waterbird Habitat	54,383	39,730.40	73	27
Other Wildlife Habitat	124,441	64,619.50	52	48
Conservation of Biodiversity	2,852	1,090.00	38	62

General Limitations of the Study

Historical wetland data produced from existing soils surveys, are obvious approximations of wetland extent and condition. NWI Coding for presettlement wetland polygons was derived from soil characteristics, and checked against presettlement vegetation maps produced by interpreting GLO Surveys from the early 1800's. This required an approximation of flooding and ponding frequency, as well as vegetative cover. Given that landform information in this analysis was derived from NWI water regime, certain types of landform (fringe, slope, etc) may be underrepresented in the presettlement coverage. Presettlement hydrology was approximated using current surface water data, and only those streams that appeared to have a natural channel or were denoted as undisturbed in the attribution were included in the presettlement analysis.

The 1998 NWI data should be an accurate reflection of wetland extent and condition within the watershed. However, given the inherent limitations of using a data source that is mainly derived from aerial photo interpretation, care should be exercised when using the results of this analysis. Issues with photo quality, scale, and variable environmental conditions should be taken into consideration when interpreting this information (Tiner, 1997 and 1999). Also, errors of omission and commission are possible. Drier-end wetlands tend to be difficult to interpret on aerial photos, as are forested wetlands where canopy can obscure hydrology below. Because water regime information was interpreted from one snapshot in time, it may not always be reliable in determining seasonal saturation. Many times, the seasonal saturation of wetlands can vary widely over long time periods which can be difficult to account for in this type of mapping effort.

This analysis produces a planning tool that can assist in identifying potential wetlands of significance for certain functions. However, no effort was made to compare the relative significance of two wetlands predicted to perform the same function. The W-PAWF also does not consider the condition of adjacent upland or the relative water quality of adjacent waterbodies, which may be considered important factors in determining the overall health and condition of a wetland (Tiner, 2005).

No assessment technique on wetland function is likely to be robust enough to first evaluate the level of a particular function and then further distinguish whether the function is part of a human-based value system (Brinson, 1993). Also, it should be noted, that this type of analysis is not intended for a user to take it to the field for the purpose of matching indicators with functions. Rather, this type of analysis is intended to show how some fundamental knowledge about water flows and sources and geomorphic setting can be interpreted to illustrate ecological functioning (Brinson, 1993).

Appropriate Use of this Type of Analysis

At the watershed or regional level, an understanding of the status and trends of wetland ecosystems is essential for the establishment of policies, strategies, and priorities for action (Ramsar Convention on Wetlands 2005).

The U.S. EPA considers the development of a State comprehensive wetland monitoring and assessment program as a top priority to determine the causes, effects and extent of pollution to wetland resources, and to improve pollution prevention, reduction and elimination strategies (Fennessy et. al. 2004). This pilot project has no long-term monitoring component, however, it is a first-cut approach to enhancing wetland inventory and assessment techniques at a watershed scale and should assist local planners in a monitoring strategy if that goal is identified at a local level. Also, wetland assessment is the identification of the status of, and threats to, wetlands as a basis for the collection of more specific monitoring activities (Apfelbeck, 2006).

Wetland inventories can be carried out at different levels of detail and a sequential inventory, starting simple and subsequently undertaking more detailed work, should be undertaken (Ramsar Convention on Wetlands 2005). With the development of the Michigan Rapid Assessment Method (MiRAM), a field-based method, opportunities exist to enhance landscape level wetland inventory and assessment. Really, this type of rapid assessment method should be paired with landscape level assessment to ensure proper management decisions. For example, degree of landscape-level stress and wetland functions are best determined by also considering landscape-level information (Apfelbeck, 2006). Field-based assessments are necessary to accurately assess wetland functions. However, remote assessments are important when evaluating wetland functions at the watershed scale since it is often necessary to have some way to screen wetlands to target for further assessment (Apfelbeck, 2006).

This type of analysis is meant to be an initial screening of the overall status and trends of the wetland resource base within a watershed. When paired with presettlement information, cumulative impacts of wetland functional degradation can be evaluated. Given limited public understanding of the functions and values of wetlands, this analysis can serve as an effective illustration of the role of wetlands within the larger landscape and the role that wetland destruction and degradation has played in reduced surface-water quality, habitat, and flood control over time.

The overall results of this effort provide many possibilities and unlimited potential for future use of these datasets within Michigan's 404 Program. LWMD staff involved in this project envision myriad applications of this assessment within not only the non-regulatory arena, but also regulatory applications. Given the use of “best professional judgment” as a basis for permitting and enforcement/compliance decisions, data that can speak to wetland functions and values within a watershed will be extremely useful to regulatory staff. In a non-regulatory sense, this analysis can help to pinpoint potential restoration, enhancement, and protection activities to appropriate areas of the watershed that are most in need of a particular wetland function. From a regulatory perspective, wetlands should be inventoried, assessed, monitored, and managed in the context of the entire watershed to supplement the site-by-site regulatory-based assessments which are often necessary for addressing direct impacts such as dredging, filling, and draining. A watershed approach can also integrate indirect wetland impacts that are caused by land use practices that require a broader understanding of how wetlands function on the landscape and the benefits that they provide. For this reason, watershed planning allows communities to make better choices on preserving the highest quality wetlands by protecting the most vulnerable wetlands and for prioritizing sites for restoration (Cappiella et al. 2006).

The usefulness of this data will also depend on the goals of the partnering watershed management authority. For example; in a watershed undergoing problems with excessive sedimentation in waterways, this data could be used to pinpoint wetlands which are currently performing that function at a significant rate. In a highly urbanized watershed, this analysis can be used to pinpoint wetlands of significance for flood control AND sediment retention. The high level of scalability of this analysis is what makes it so versatile for use in a Wetland Management Program. Watershed groups and local governments should consider using landscape assessments to identify priority areas, probable stressors, and wetland restoration and conservation opportunities (Apfelbeck, 2006).

When taken a step further, a set of profiles and reference wetlands could be developed based on this approach. By studying in detail the functioning of various reference wetland types, one should be able to extrapolate to other similar wetlands on the assumption that wetlands with similar landscape position and landform, similar location with respect to water sources, and similar slope and catchment area will also have similar functions (Brinson, 1993). The array of key wetland types that emerge as reference wetlands can be used not only for the purposes of characterizing and quantifying various aspects of wetland function, but also as standards to evaluate wetland construction and restoration projects. In this sense they become the standards of success in contrast to relying on endless lists of design criteria and performance standards. One of the most valuable uses may be in the training of wetland scientists who will be involved in work on permit review, assessment of functions, construction of new wetlands, and restoration of degraded ones (Brinson, 1993).

In Michigan, wetlands are just beginning to be considered in the context of watershed management planning and the creation of municipal master plans. Wetland restoration and enhancement are increasingly becoming popular tools, in lieu of traditional best management practices, to enhance the overall ecological health and surface water quality of a watershed. Understanding the overall historic impact of wetland loss and degradation can assist local planners and resource managers in siting future development as it lends new importance to the wetlands that remain.

FUTURE DIRECTIONS

There are countless elements of wetland inventory, assessment, and monitoring that could be added to a landscape level assessment of wetlands in a watershed. This pilot project presented a piece of a larger monitoring and assessment strategy, and the basis for expanding the information in the future. Next steps would include the development of wetland profiles and reference wetlands for use in evaluating proposed project wetlands. In the 404 review process, an applicant for a dredge and fill permit could be required to identify the functional type of wetland in the application, and within reason, identify which reference wetland it most resembles in the same physiographic region (Brinson, 1993). The regulatory team, having been trained locally or regionally in the functioning of each wetland class, will be prepared to assess the similarity between the one described in the permit application and the reference wetland population for which a body of knowledge exists (Brinson, 1993). This type of application could speed the regulatory review process as a whole, and improve the quality of wetland management in a watershed context.

Estimating the effects of future land use changes on wetlands through analyzing patterns in future land use to identify potential wetland loss and prioritize wetlands for conservation could be another useful analysis in the future (Apfelbeck, 2006). Existing data sources could be employed in this type of effort to better predict build-out and its effect on wetland quantity and function.

CONCLUSIONS

The wetland resource base in the Paw Paw River Watershed has undergone significant disruption in the 200 years since Michigan was settled, losing approximately 50% of its total wetland area, and in some cases up to 62% of its wetland function. There is evidence to suggest that the result of these losses is reduced surface water quality and total loss of some fisheries. The watershed itself has been extensively ditched since presettlement, and this has resulted in the destruction, degradation, and vegetative conversion of many of the wetlands and waterways that originally existed. Forested wetlands have been the most affected, with silviculture and drainage for agriculture responsible for most of the impact. Because of ineffective drainage and/or forestry practices, there has been a sharp increase in the amount of emergent and scrub-shrub wetland acreage over time. Several wetland functions were reduced in capacity by 50% or more in the watershed as a whole; Retention of Sediment and Other Particulates lost 51% capacity, Fish and Shellfish Habitat was reduced by 61%, and Conservation of Biodiversity by 62%. Others fell just below that mark, with streamflow maintenance, nutrient transformation, and other wildlife habitat all estimated to have lost 44-45% of their original capacity.

The findings of this analysis provide an estimate of the extent of wetland area and associated functionality since presettlement times. Given that any landscape level analysis is a ‘first-cut’ approach to understanding wetland loss and its impacts, this study should be used as one piece to a larger wetland restoration/management plan and field work should be done to verify specific wetland functions predicted as part of this effort. However, understanding at a small scale the changes in wetland extent and functionality that have occurred in this watershed over time should be a valuable tool to resource managers on the ground.

This study demonstrates that techniques employed in the Northeast to produce landscape level wetland functional assessments, can also be applied to watersheds in the Midwest. Some tweaking in the functional correlations used may be necessary to predict accurately the extent of wetlands performing specific functions. Overall, the correlations created in the Northeast fit well into the ecology of Michigan, with minor modifications being needed specifically for fish and shellfish habitat.

With the recent release of the FGDC Draft Wetland Mapping Standard, it is expected that all Federal efforts to map wetlands in the future will include the LLWW attribution explained in this report. This development ensures that information collected on wetlands at a landscape level will include the data necessary to produce a functional assessment for large geographic areas. The methodology employed in this study provides a consistent approach to assessing wetland function, which as a concept is being incorporated more and more into resource management of all kinds in Michigan. There are currently several other efforts ongoing in the State to assess wetland function at a small scale, with the assistance of MDEQ staff. In the future, perhaps this information can be obtained at a statewide level, and give the first glimpse into the status and trends of Michigan’s wetlands from a functional qualitative perspective.

ACKNOWLEDGEMENTS

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Appendix 1: Simplified Keys for LLWW Classification

Simplified Keys for Classifying Inland (Nontidal) Wetlands by Landscape Position, Landform, and Water Flow Path
(Adapted from Tiner 2003)

Landscape Position

1. Wetland borders a river, stream, lake, reservoir, or in-stream pond………..…………....2
1. Wetland does not border one of these waterbodies; it is surrounded by upland or borders a pond that is surrounded by upland……………………………..…………..Terrene
2. Wetland lies along a lake or reservoir or within its basin (i.e., the relatively flat plain contiguous to the lake or reservoir)…………………………. ………………………..Lentic
2. Wetland lies along a river or stream, or in-stream pond…………………….…………...3
3. Wetland is the source of a river or stream and this watercourse does not flow through the wetland………...………………………………………………………………Terrene
3. A river or stream flows through or alongside the wetland ……………………….……...4
4. Wetland is periodically flooded by river or stream ………..……………………………Lotic[1]
4. Wetland is not periodically flooded by the river or stream ………..…………………....Terrene

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Landform

1. Wetland occurs on a slope >2%...Slope
1. Wetland does not occur on a slope >2%...2
2. Wetland forms an island completely surrounded by water………………………….……..Island
2. Wetland does not form an island…….……………………………………………….…….3
3. Wetland occurs in the shallow water zone of a permanent waterbody...………………..Fringe
3. Wetland does not occur in this zone….………………………………………..……..4
4. Wetland forms a nonvegetated bank or is within the banks of a river or stream…….….Fringe
4. Wetland is a vegetated river or stream bank or is not within the banks……..….………5
5. Wetland occurs on an active alluvial plain along a river (polygonal feature) [2]…….Floodplain*
5. Wetland does not occur on an active floodplain…………………………………….…..6
6. Wetland occurs on a broad interstream divide (including headwater positions) associated with coastal or glaciolacustrine plains or similar plains………………....Interfluve*
6. Wetland does not occur on such a landform...…………………………………………….…7
7. Wetland occurs in a distinct depression………...………………………………….…...Basin
7. Wetland occurs on a nearly level landform………………………………………..Flat

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*Basin and Flat sub-landforms can be identified within these landforms when desirable.

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[1] Lotic wetlands are separated into river and stream sections (based on watercourse width - polygon = Lotic River vs. linear = Lotic Stream at a scale of 1:24,000) and then divided into one of five gradients: 1) high (e.g., shallow mountain streams on steep slopes), 2) middle (e.g., streams with moderate slopes), 3) low (e.g., mainstem rivers with considerable floodplain development and slow-moving streams), 4) intermittent (periodic flows), and 5) tidal (hydrology under the influence of the tides).
[2] For practical purposes, floodplain is restricted to rivers (i.e., polygonal watercourses); similar areas along streams (linear features) are designated as basins or flats.

Water Flow Path[3]

1. Wetland is typically surrounded by upland (nonhydric soil); receives precipitation and runoff from adjacent areas with no apparent outflow[4]…..……………………....Isolated**
1. Wetland is not geographically isolated……………….………………………………2
2. Wetland is a sink receiving water from a river, stream, or other surface water source, lacking surface-water outflow…………………………………………….Inflow
2. Wetland is not a sink; surface water flows through or out of the wetland………..…..3
3. Water flows out of the wetland, but does not flow into this wetland from another source……………………………………………………………….Outflow
3. Water flows in and out of the wetland or water table fluctuates due to presence of a lake or reservoir………………………………..……………………..….4
4. Water flows through the wetland, often coming from upstream or uphill sources (typically wetlands along rivers and streams) ……………..……………..Throughflow
4. Wetland is along a lake or reservoir and not along a river or stream entering this type of waterbody; its water levels are subjected to the rise and fall of lake or reservoir levels…………………………..……………………………Bidirectional-Nontidal

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**Wetland is geographically isolated; hydrological relationship to other wetlands and watercourses may be more complex than can be determined by simple visual assessment of surface water conditions. If groundwater relationships are known can apply other water flow paths as appropriate, but add “groundwater” to the term (e.g., outflow-groundwater).

Source: Tiner, R.W. 2003. Dichotomous Keys and Mapping Codes for Wetland Landscape Position, Landform, Water Flow Path, and Waterbody Type Descriptors. U.S. Fish and Wildlife Service, National Wetlands Inventory Program, Northeast Region, Hadley, MA. 44 pp.

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[3]Surface water connections are emphasized because they are more readily identified than groundwater linkages (see footnote below for paludified landscapes).

[4] Water flow path for some bogs and similar wetlands may be paludified; paludification processes occur in areas of low evapotranspiration and high rainfall, peat moss moves uphill creating wetlands on hillslopes (i.e., wetland develops upslope of primary water source).

Appendix 2: Functional Correlations

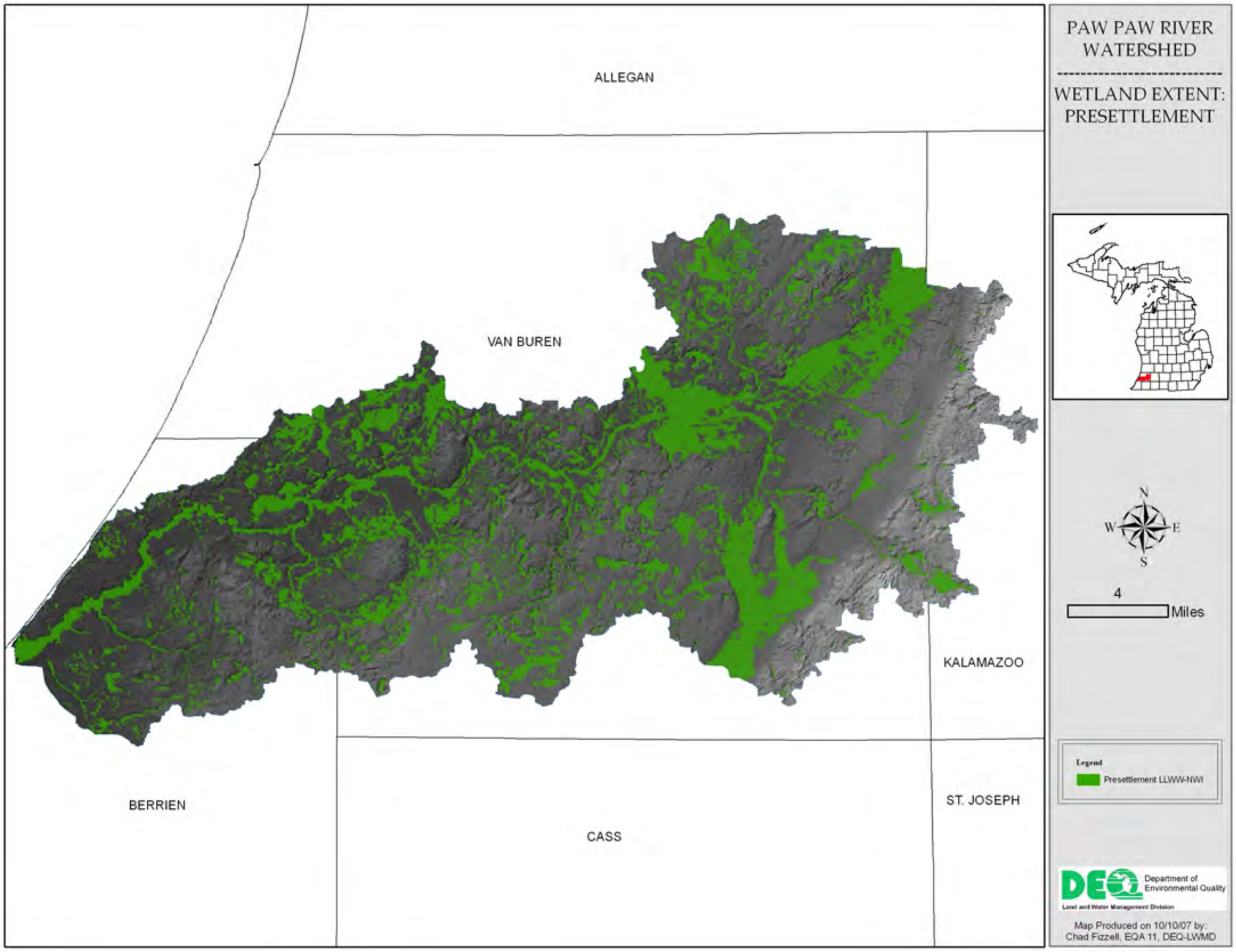
CORRELATION BETWEEN FUNCTIONS AND WETLAND TYPES FOR INLAND (NONTIDAL) WETLANDS - REVISED 9/22/05

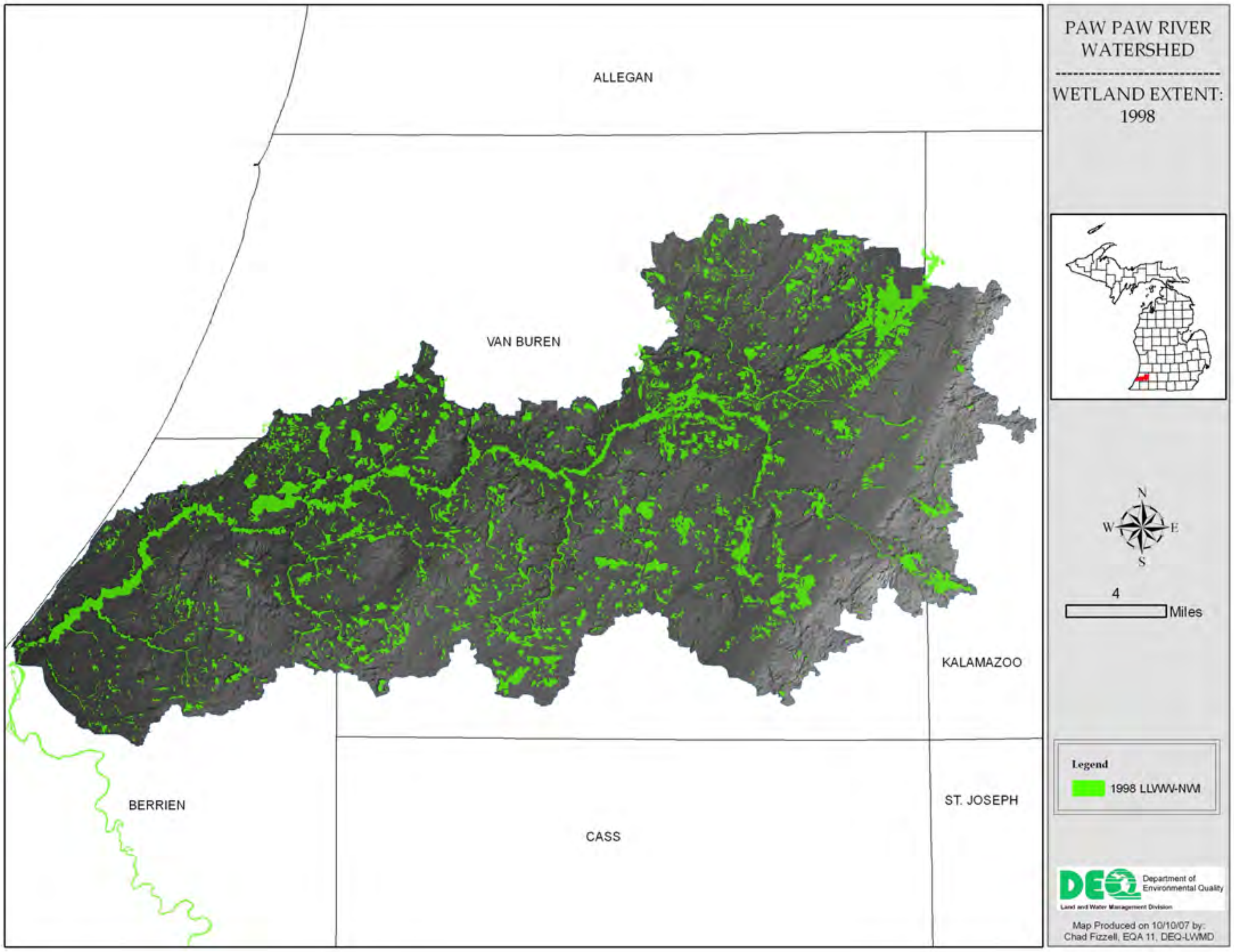
Function	Level of Function	Wetland Types
Surface Water Detention	High	LEBA, LEFR, LEFL (in reservoir and dammed areas only), LEIL, LSBA, LRBA, LSFP, LRFP, LSFR, LRFR, LRIL, PDTH, TEFRpdTH, TEBApdTH, PDBI, PDBT, TEBApdBT, TEBATH. TEBATI
	Moderate	LRFL, LSFL, LEFL, TEIF, TEBA (other than above), PD (other except PD2f), TE__pd (other), TEFP__
Streamflow Maintenance	High	hw (not dr = not ditched)
	Moderate	hwdr, LR1FP, LS1FP, LS_BA, PDTH, TE__pdTH, PDOU, TE__pdOU, TEOU (not hw but associated with streams not rivers), LE wetlands associated with throughflow lakes (LK__TH)
Nutrient Transformation	High	P__(AB, EM, SS, FO and mixes)C, P__(AB, EM, SS, FO and mixes)E, P__(AB, EM, SS, FO and mixes)F, P__(AB, EM, SS, FO and mixes)H, P__(AB, EM, SS, FO and mixes)B (not on coastal plain or glaciolacustrine plain)
	Moderate	P__(AB, EM, SS, FO and mixes)B (on coastal plain or glaciolacustrine plain), P__(AB, EM, SS, FO)A
Sediment and Other Particulate Retention	High	LEBA, LEFR(vegetated), LEIL(veg), LSBA, LRBA, LSFP, LRFP, LRFR(veg), LSFR(veg), LRIL (veg), PDTH, TE__pdTH (including __pq), PDBI, TE__pdBI (including __pq), PDBT, TE__pdBT, TEBATH, TEBATI, TEIFbaTH, TEIFbaTI
	Moderate	LSFL(not PSS_Ba or PFO_Ba), LRIL (nonveg), LRFR(nonveg), LSFR (nonveg), TEBA(not PSS_Ba or PFO_Ba), PD (not c, d, e, f, g, j types), TE__pd(not PSS_Ba or FO_Ba), TEFP__

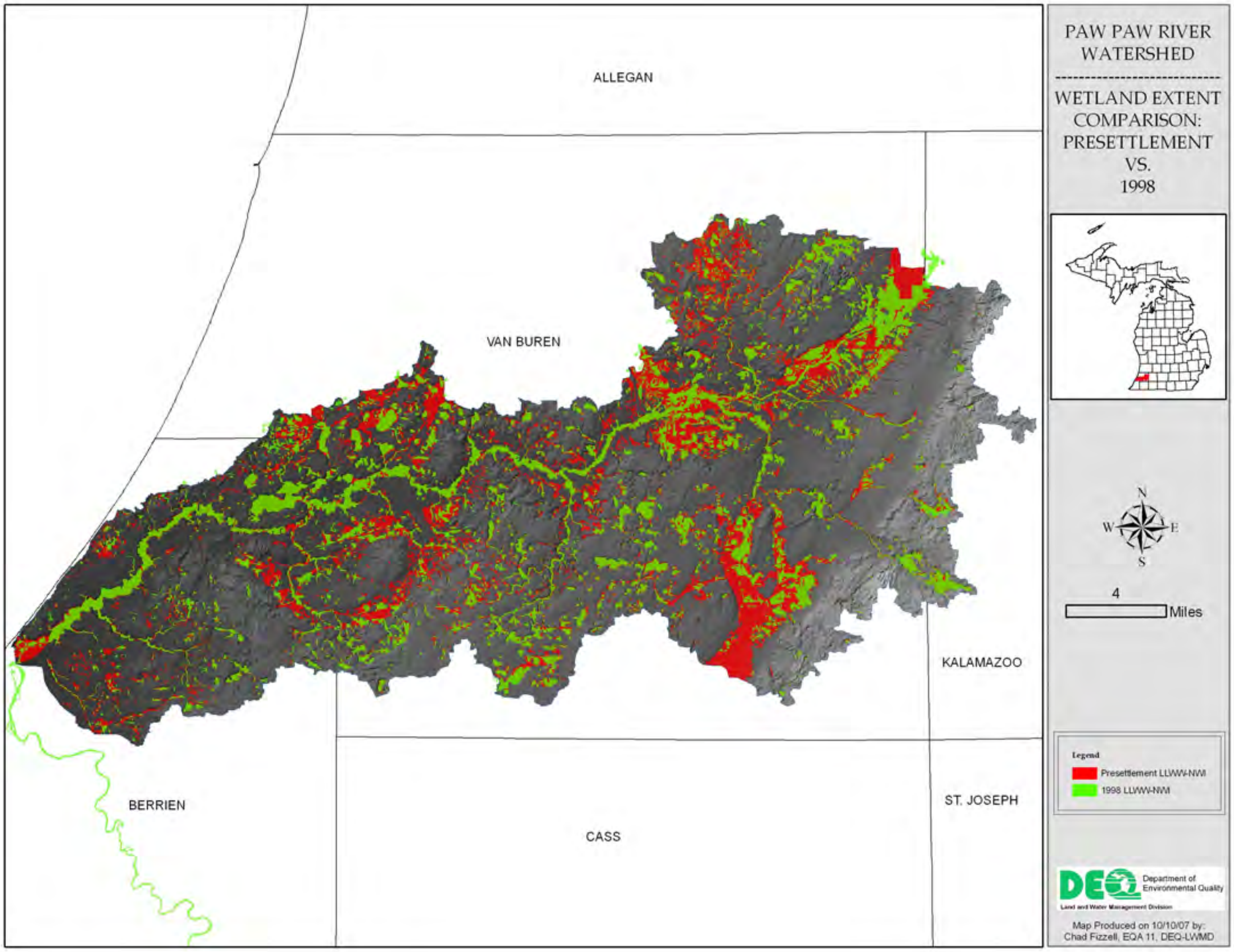
Shoreline Stabilization	High	LR_(AB, EM, SS, FO and mixes; not LRIL), LS_(AB, EM, SS, FO and mixes), LE__(AB, EM, SS, FO and mixes; not LEIL)
	Moderate	TE__pd (AB, EM, SS, FO and mixes), TE__OUhw (AB, EM, SS, FO and mixes)
Fish and Shellfish Habitat	High	L2__F, L2AB, L2UB/__(AB, EM, SS, FO), LE__ (vegetated; AB, EM, SS, FO) and NWI water regime = H (permanently flooded), P__F <u>and</u> adjacent to PD, LK, RV (all except RV4), or ST (all except ST4) waters, PAB, PUB/__(AB, EM, SS, FO), P__(EM, SS, FO)H, PD <u>associated with</u> P__(AB, EM, SS, FO)F
	Moderate	LE__ <u>and</u> PEM1E, LR__ <u>and</u> PEM1E (and mixes), LS__ <u>and</u> PEM1E (and mixes), PEM5F <u>and</u> adjacent to LK, RV (except RV4), or ST(except ST4), and PD (except c, d, e, f, g, j types); PD (except c, d, e, f, g, j types); TEFRpd (along these ponds)
	Stream Shading	LS (not LS4) <u>and</u> PFO, LS (not LS4) <u>and</u> PSS (not PSS_Ba)
	Locally Significant	Example: Lake Champlain - seasonally flooded LE__ wetlands (important for spring spawning); *possibly add LR__ and LS__wetlands with an E or C (water regime – spawning)*
Waterfowl and Waterbird Habitat	High	L2_F (vegetated, AB, EM, SS, FO and mixes with nonvegetated), L2AB (and mixes with nonvegetated), L2US_(F,E, or C), L2_H (vegetated, AB, EM, SS, FO and mixes with nonvegetated), P__F (excluding EM5-dominated wetlands) <u>and</u> adjacent to PD, LK, RV(not RV4), or ST(not ST4) waters; PAB, P__H (vegetated, EM, SS, FO including mixes with UB), P__Eh, P__Eb; LS__ <u>and</u> PEM1E (including mixes), LR__ and PEM1E (including mixes), TE__ hw and PEM1E,LE__ and PEM1E (including mixes), PD <u>associated with</u> P__(AB, EM, SS, FO)F, PUB__b

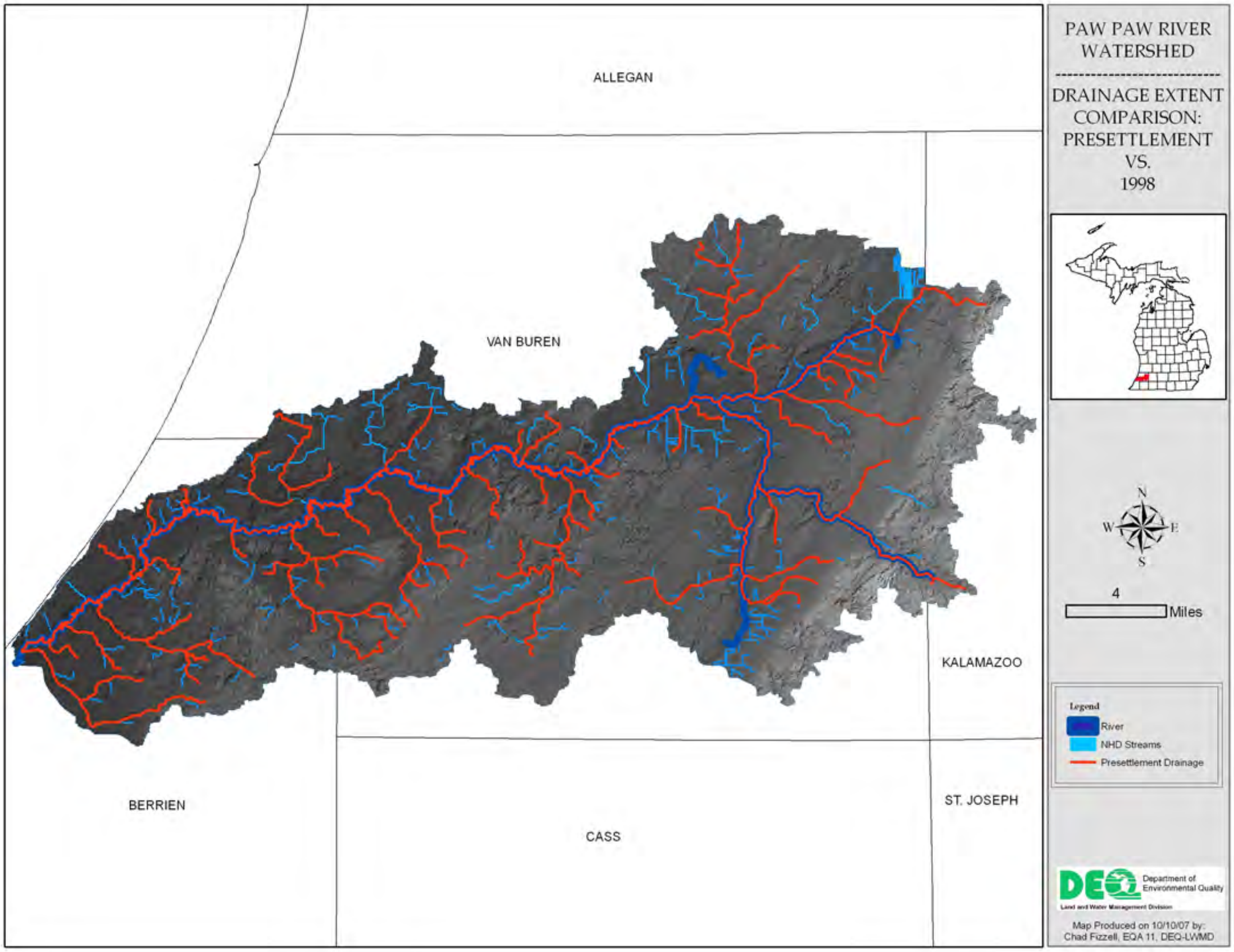
	Moderate	PEM5__E or F and adjacent to PD, LK, RV(not RV4), or ST(not ST4), other L2UB (not listed as high), Other PD (except c, d, e, f, g, j types), PEM1E__ (including mixes) and associated with PD, LK, RV(not RV4), or ST(not ST4)
	Wood Duck	LS(1 or 2)BA and P__ (FO or SS and mixes), LS(1 or 2)FR and P__ (FO or SS and mixes), LR(1 or 2)FPba and P__(FO or SS and mixes), LR(1 or 2)BA and P__(FO or SS and mixes), LRFPba and PFO/EM, LRFPba and PUB/FO
Other Wildlife Habitat	High	Any wetland complex ≥ 20 acres, wetlands 10-20 acres with 2 or more classes (excluding EM5), small isolated wetlands in dense cluster in a forest matrix (restrict to forest regions of U.S. with woodland vernal pools)
	Moderate	Other vegetated wetlands
Conservation of Biodiversity	Regional significant (Northeast U.S.)	PFO4__g (Atlantic white cedar), PEM__i (herbaceous fen), PSS__i (shrub fen), PFO__i (treed fen), PFO2__ (bald cypress), LS__FR, LR__FR, PD1m (woodland vernal pool), forested wetlands within >7410-acre forest
	Locally significant (Northeast U.S.)	PFO2__ (larch), urban wetlands, PSS3Ba (and mixes; shrub bog), northern white cedar swamps, hemlock swamps, LEFR with EM/AB and AB/EM vegetation, Other uncommon types in watershed

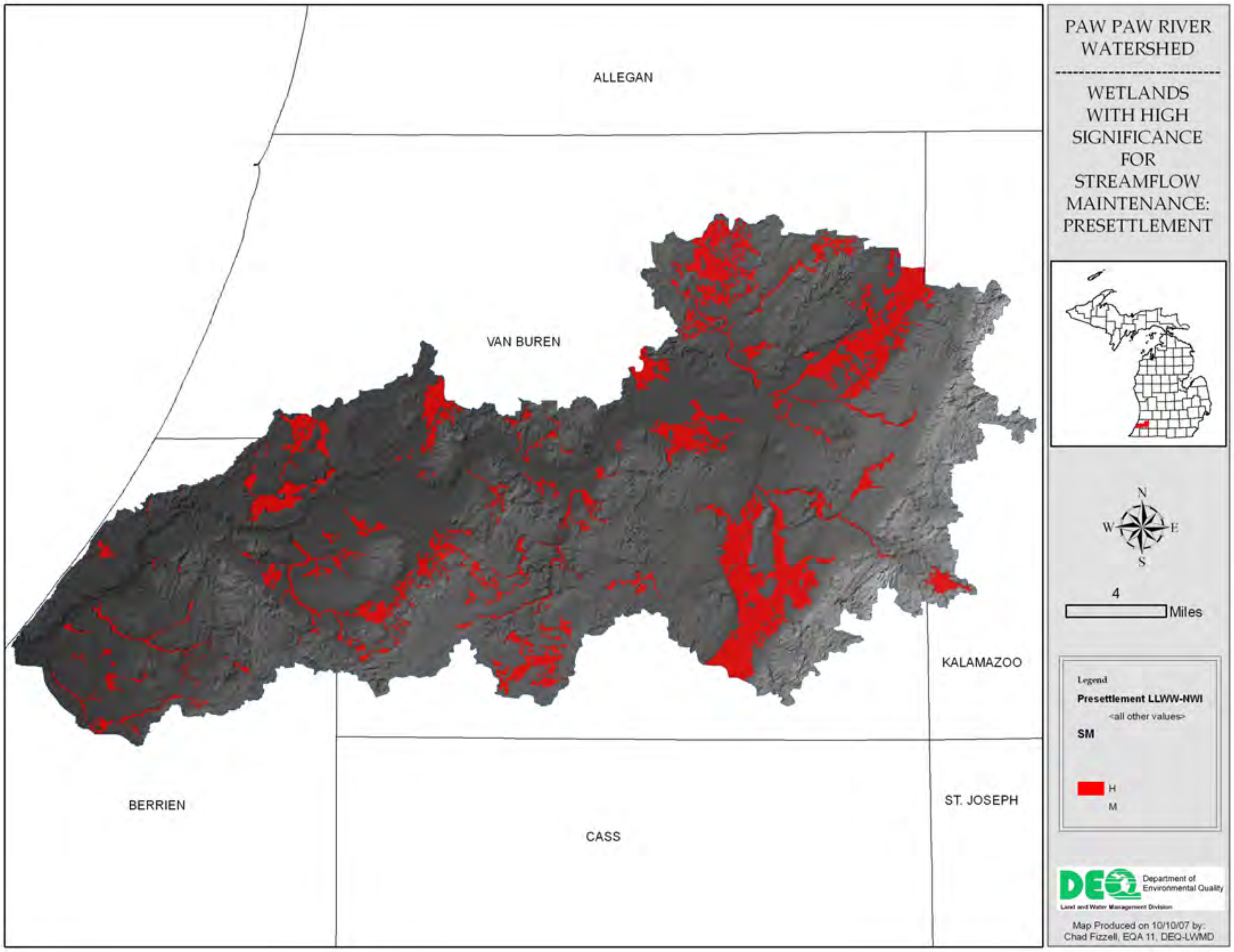
Appendix 3: Sample maps for Paw Paw River Watershed wetland functional assessment

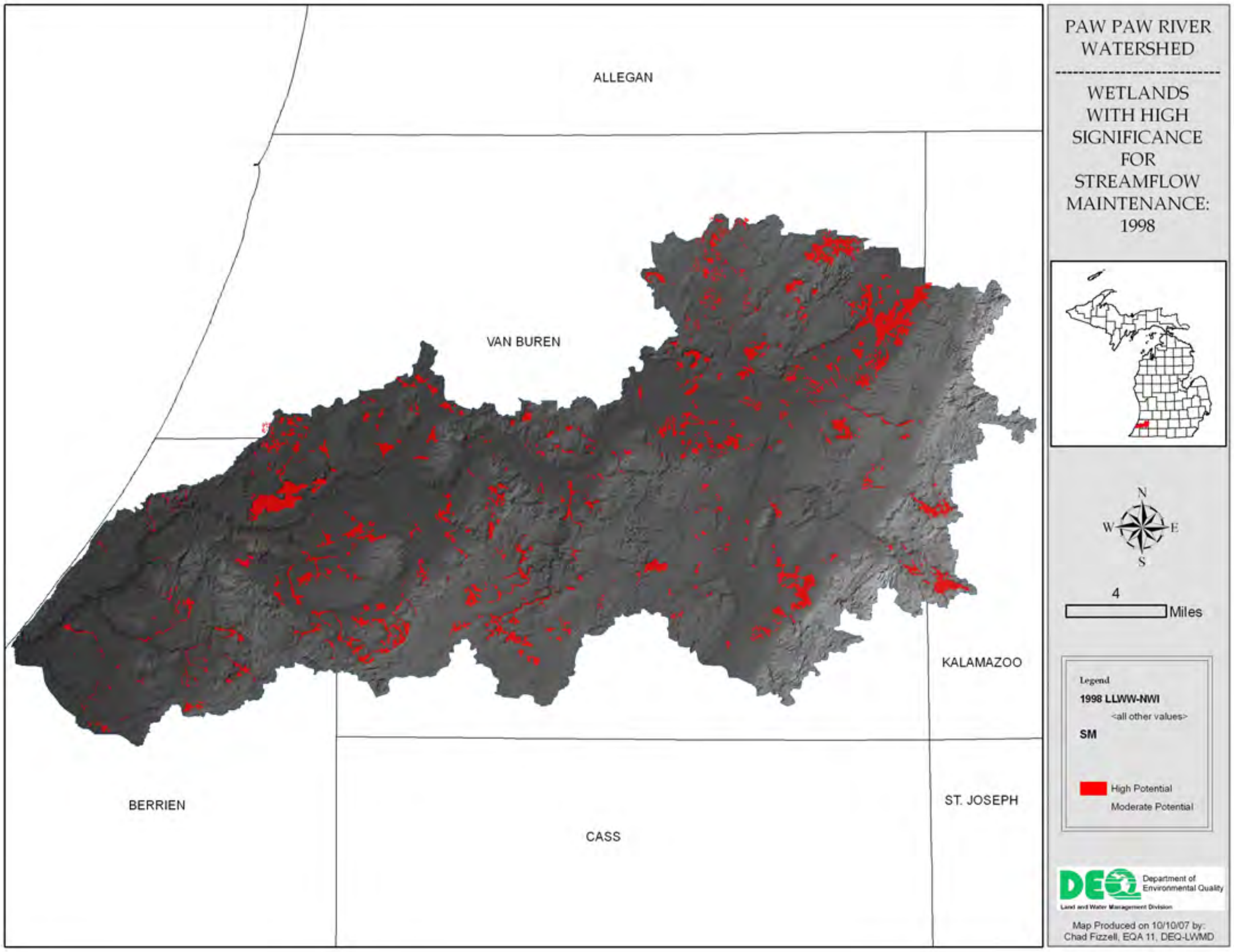


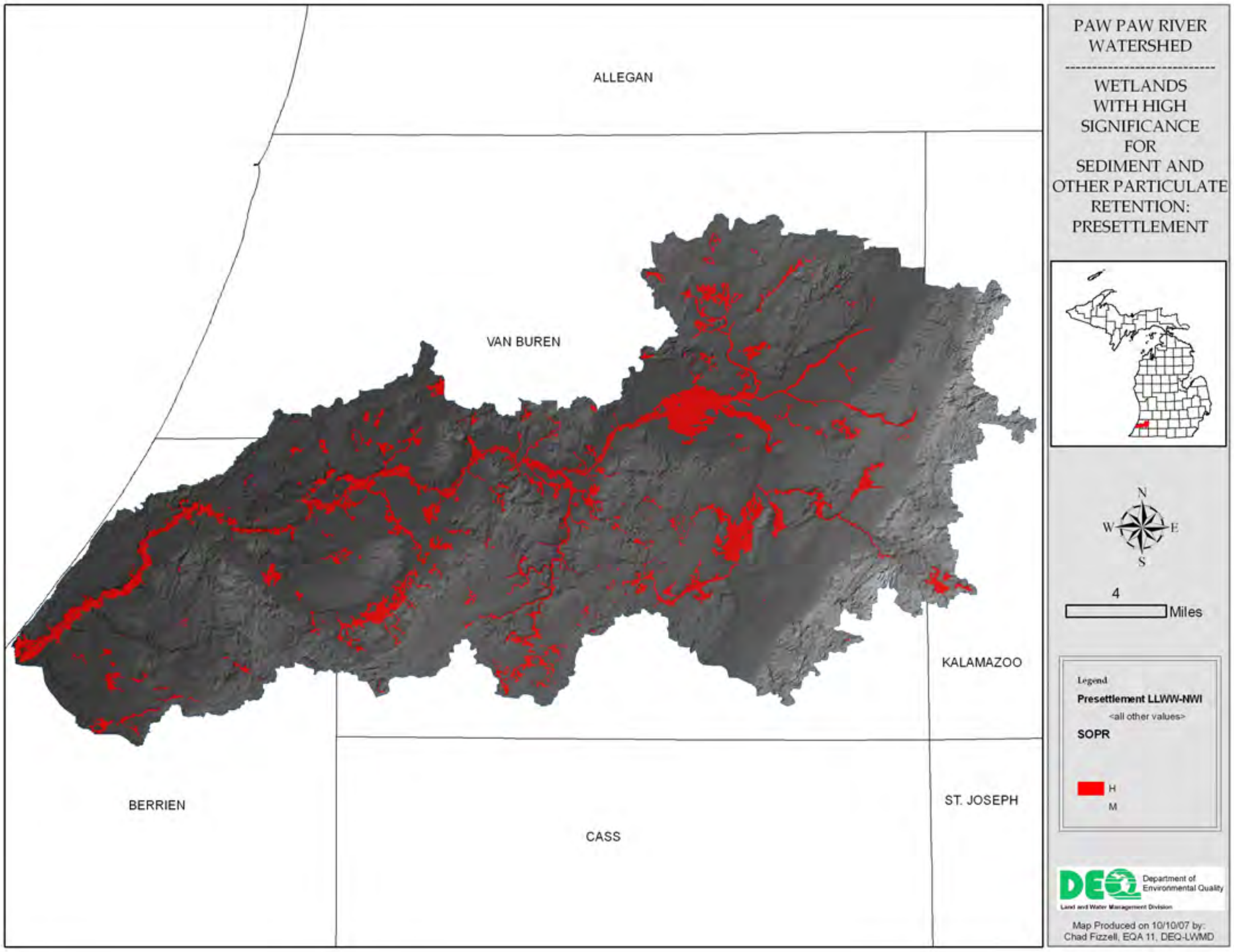

PAW PAW RIVER WATERSHED
WETLAND EXTENT: 1998
ALLEGAN
VAN BUREN
KALAMAZOO
BERRIEN
CASS
ST. JOSEPH
N
W
E
S
4
Miles
Legend
1998 LLWW-NWI
DEQ Department of Environmental Quality
Land and Water Management Division
Map Produced on 10/10/07 by:
Chad Fizzell, EQA 11, DEQ-LWMD


PAW PAW RIVER WATERSHED
WETLAND EXTENT COMPARISON: PRESETTLEMENT VS. 1998
ALLEGAN
VAN BUREN
KALAMAZOO
BERRIEN
CASS
ST. JOSEPH
N
W
E
S
4
Miles
Legend
Presettlement LLWW-NWI
1998 LLWW-NWI
Department of Environmental Quality
Land and Water Management Division
Map Produced on 10/10/07 by:
Chad Fizzell, EQA 11, DEQ-LWMD

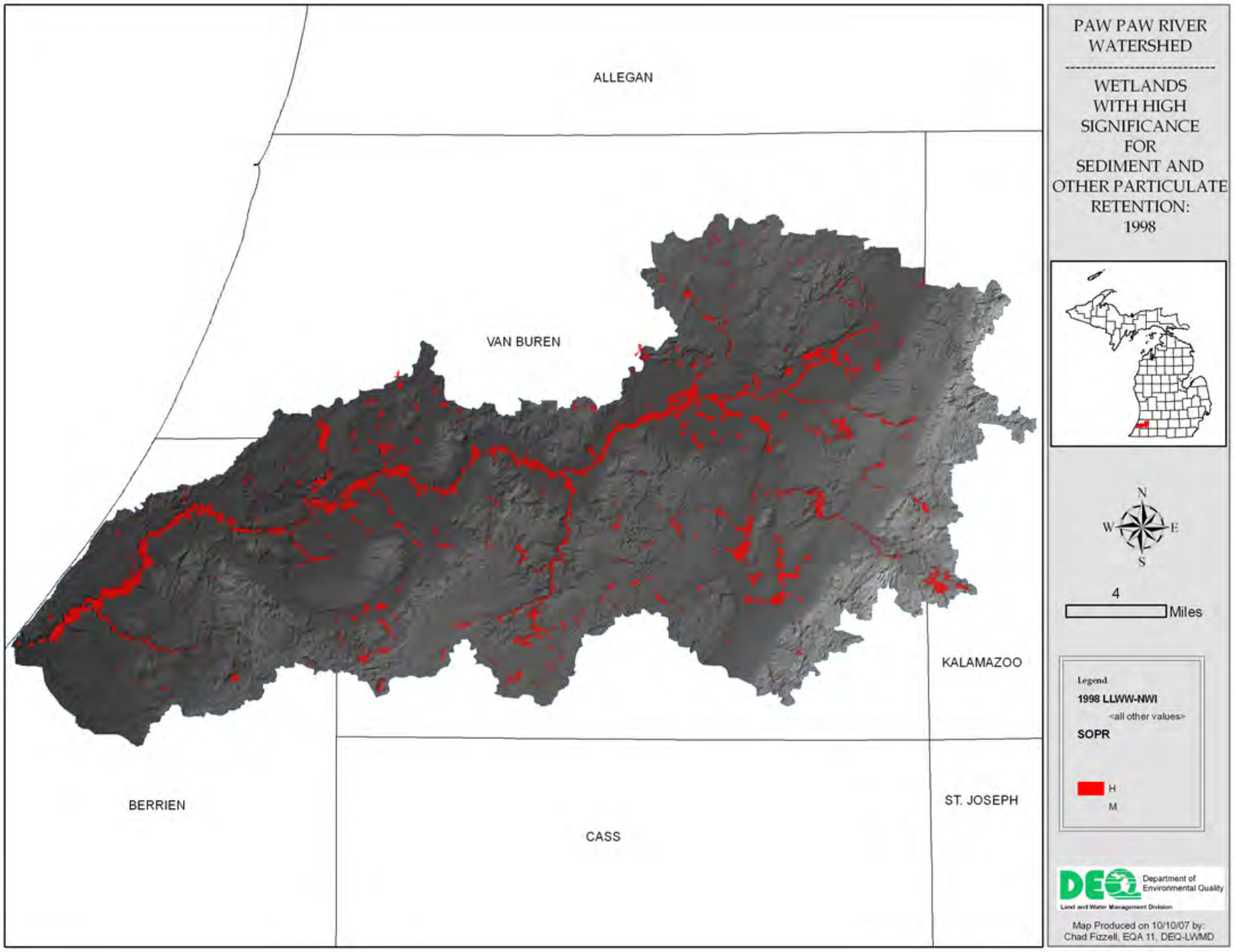

PAW PAW RIVER WATERSHED
DRAINAGE EXTENT COMPARISON: PRESETTLEMENT VS. 1998
ALLEGAN
VAN BUREN
KALAMAZOO
BERRIEN
ST. JOSEPH
CASS
N
W
E
S
4
Miles
Legend
River
NHD Streams
Presettlement Drainage
DEQ
Department of Environmental Quality
Land and Water Management Division
Map Produced on 10/10/07 by:
Chad Fizzell, EQA 11, DEQ-LWMD


PAW PAW RIVER WATERSHED
WETLANDS WITH HIGH SIGNIFICANCE FOR STREAMFLOW MAINTENANCE: PRESETTLEMENT
ALLEGAN
VAN BUREN
KALAMAZOO
BERRIEN
CASS
ST. JOSEPH
N
W
E
S
4
Miles
Legend
Presettlement LLWW-NWI
<all other values>
SM
H
M
Department of Environmental Quality
Land and Water Management Division
Map Produced on 10/10/07 by:
Chad Fizzell, EQA 11, DEQ-LWMD


PAW PAW RIVER WATERSHED
WETLANDS WITH HIGH SIGNIFICANCE FOR STREAMFLOW MAINTENANCE: 1998
ALLEGAN
VAN BUREN
KALAMAZOO
BERRIEN
CASS
ST. JOSEPH
N
W
E
S
4
Miles
Legend
1998 LLWW-NWI
<all other values>
SM
High Potential
Moderate Potential
DEQ
Department of Environmental Quality
Land and Water Management Division
Map Produced on 10/10/07 by:
Chad Fizzell, EQA 11, DEQ-LWMD



PAW PAW RIVER WATERSHED
WETLANDS WITH HIGH SIGNIFICANCE FOR SEDIMENT AND OTHER PARTICULATE RETENTION: PRESETTLEMENT
ALLEGAN
VAN BUREN
KALAMAZOO
BERRIEN
CASS
ST. JOSEPH
N
W
E
S
4
Miles
Legend
Presettlement LLWW-NWI
<all other values>
SOPR
H
M
Department of Environmental Quality
Land and Water Management Division
Map Produced on 10/10/07 by:
Chad Fizzell, EQA 11, DEQ-LWMD


PAW PAW RIVER WATERSHED
WETLANDS WITH HIGH SIGNIFICANCE FOR SEDIMENT AND OTHER PARTICULATE RETENTION: 1998
ALLEGAN
VAN BUREN
KALAMAZOO
BERRIEN
CASS
ST. JOSEPH
N
W
E
S
4
Miles
Legend
1998 LLWW-NWI
<all other values>
SOPR
H
M
DEQ Department of Environmental Quality
Land and Water Management Division
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