Sheboygan River Basin
Conservation Mapping Tool

May 2009

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Funding for this project provided by the Kohler Trust for Preservation

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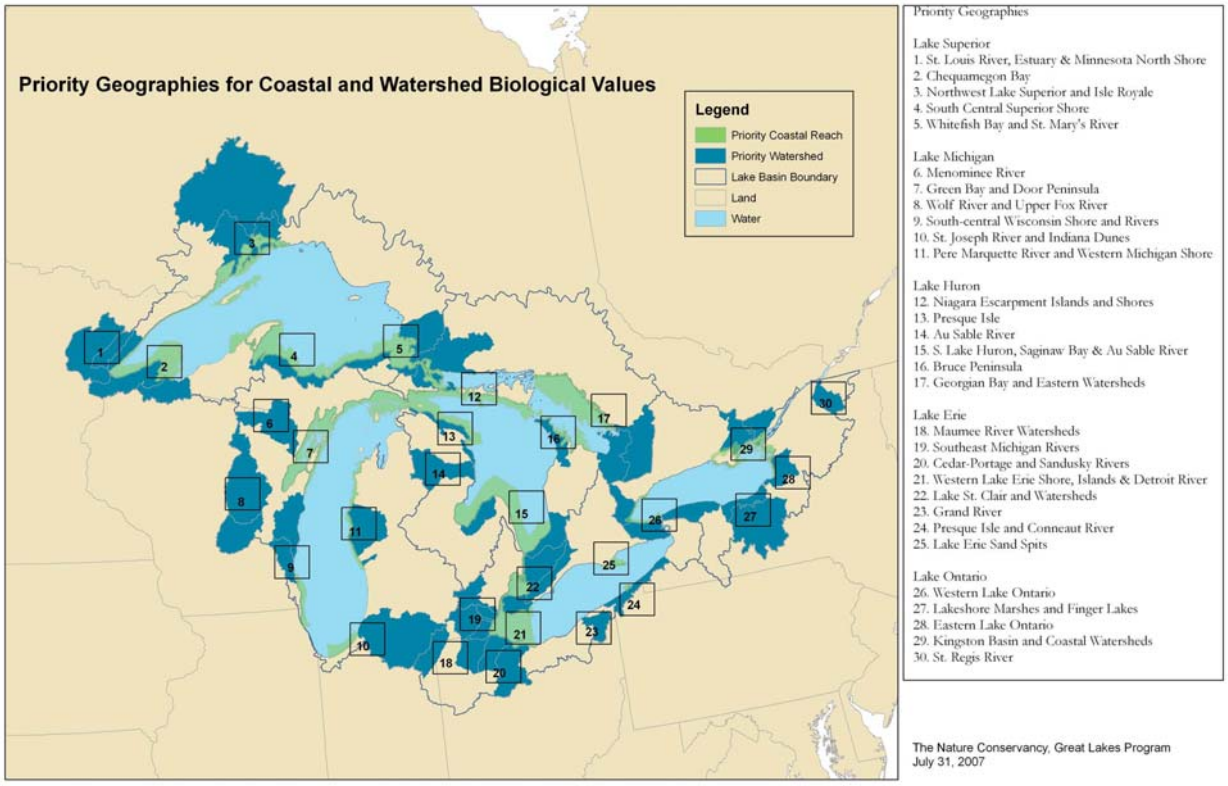
INTRODUCTION:

In 2007, The Nature Conservancy's Great Lakes Project completed a conservation planning exercise that identified priority geographies (watersheds and coastal reaches) around the Great Lakes Basin (Figure 1). The analysis considered factors such as fish diversity and rarity, mussel diversity and rarity, and other indicators of the health and functionality of freshwater systems. Out of this analysis, a number of priority geographies were identified for each lake basin. The Manitowoc-Sheboygan River Basin, along with its associated coastal reach, was recognized as a conservation priority for Lake Michigan. This prioritization enables TNC and conservation partners to focus efforts in those places that have the most ecological potential. Maintaining and restoring the quality of these coastal areas will contribute to the integrity of the Great Lakes system as a whole.

FIG. 1.: Great Lakes Priority Geographies



To achieve conservation, planning at such a coarse scale—watersheds around the Great Lakes—must be complemented by finer-scale planning *within* these watersheds. The mapping tool presented here provides this finer-scale planning. Through the input of partners, including meetings and sharing documents the mapping tool identifies areas of the Basin (sub-watersheds) where we are most likely to achieve the greatest conservation yield. The goals of this mapping tool are to tie specific conservation strategies such as restoration and protection to the areas where they are likely to be most effective, and to focus the collective efforts of conservation practitioners in the Basin. The natural resources of the Basin are considered in this tool, as are threats to those resources.

It is our hope and intent that conservation planning and implementation at the broad scale of the Great Lakes Basin can positively influence conditions on-the-ground (e.g., in the Sheboygan River Basin). At the same time, conservation projects at individual sites—if coordinated via broader-scale planning—can cumulatively contribute to the functioning and integrity of the entire Great Lakes Basin.

A group of Sheboygan River Basin conservation practitioners first met in January of 2009 to identify key targets and threats that impact the conservation goals of groups in the Basin. Attendees at the meeting included representatives from Wisconsin DNR, Ozaukee County, Sheboygan County, Glacial Lakes Conservancy, Kohler Trust for Preservation, and Sheboygan River Basin Partnership. Bay-Lake Regional Planning Commission also provided input. At the meeting, a mapping tool was outlined.

The goal of the mapping tool is to identify priority areas for protection and restoration in the Sheboygan River Basin based on the primary goals of the conservation practitioners working in the Basin. Some of these goals include: protect natural areas, maintain or improve water quality, inform local land use decisions, and integrate protection and restoration of terrestrial and aquatic resources. The tool maps key criteria that identify where protection and restoration could be most effective in achieving these goals.

This package contains a number of maps that comprise the final tool. At the meeting on April 6th, a number of partners provided information and feedback to improve a draft version of the mapping tool. A number of suggestions are represented in these maps.

METHODS/APPROACH:

A brief explanation of the maps in this package will help define the potential of this tool.

The Mapping Tool consists of a collection of maps that combine existing and new data, with the goal of identifying the most promising conservation opportunities within the Basin. In each of the maps, the Basin has been subdivided into 24 different sub-watersheds using US Environmental Protection Agency's 12-digit Hydrologic Unit Code (HUC) (http://dnr.wi.gov/org/water/swims/datasets/HUC/HUC_overview.htm). The Sheboygan River Basin is nearly 400,000 acres and the average area of each sub-watershed is roughly 16,600 acres. This stratification of the Basin enables us to compare and prioritize these 24 sub-watersheds, according to conservation goals and the distribution of natural resources and threats throughout the Basin.

Each map consists of either one criterion (e.g., percent natural landcover) or several criteria (e.g., percent existing wetland, percent river floodplain and percent potentially restorable wetland). Based on the levels of these criteria within each sub-watershed, a score was generated and used to rank each sub-watershed relative to the others. The rankings are quartile (i.e., each sub-watershed was assigned to one of four groups, based on its score). Therefore, there are four possible ranks (1-4) and 6 sub-watersheds were assigned to each rank. Due to some tied scores, either greater or fewer than 6 sub-watersheds may have been assigned to a rank.

A note about Lake Michigan Coastal Areas. All partners agreed that coastal areas along Lake Michigan are a priority for protection and restoration. The mapping tool was developed to compare and prioritize sub-watersheds. We recommend that, for conservation planning purposes, the coastal zone be considered high priority for protection and restoration efforts, similar to sub-watersheds identified as high-priority in the mapping tool. Two maps are included with this report that provide some general information about coastal land use and development pressure.

Description of Maps:

OVERVIEW MAP:

Map 1. Overview of the Sheboygan River Basin. Includes conservation ownership and easements as available from various state data layers, and Sheboygan County GIS. The sub-watersheds used as assessment units (12 digit HUCs as defined by US EPA) are introduced in this map.

TERRESTRIAL MAPS:

Map 2. Species and Communities Rank. Species and natural community occurrence data are from the Natural Heritage Inventory dataset, obtained from the Bureau of Endangered Resources, WI DNR. The ranking is based on the number of different rare species or communities in the database that occur within the sub-watershed. Species and communities that have not been observed since 1970 were omitted from the analysis.

Map 3. The Migratory Bird Habitat Model Rank is based on output from Eichhorst et al. (2007). This model ranks the landscape according to habitat suitability for migratory birds by three species assemblages, land birds, shorebirds, and waterfowl. The ranking is based on the all-bird model, which is a sum of the scores of the three groups, and averages that score by sub-watershed.

Map 4. The Natural Landcover Rank was calculated by identifying all the lands not cropped or developed as classified by the National Agriculture Statistics Service (NASS) 2007 Wisconsin Cropland Data Layer. The percentage of non-converted land per sub-watershed was calculated and each sub-watershed was ranked 1-4 with 4 having the largest percent natural cover.

Map 5. Terrestrial Features and Habitat Composite Score consists of the sum of the rankings for Species and Communities, Migratory Bird Habitat Model, and Natural Landcover.

WETLAND MAPS:

Map 6. Percent of Sub-watershed that is Wetland, where wetland is defined as wetlands larger than 2 acres identified by the Wisconsin Wetland Inventory (dates

vary by county; ca. 1990 to 2005), WI DNR. Updates for Sheboygan County's wetlands data are expected to be completed in 2009.

Map 7. Percent Sub-watershed that is River Floodplain. The floodplain is modeled using the 30 meter Digital Elevation Model (DEM) available from WI DNR and the 24k hydrology data, also from WI DNR. A process was run using Environmental Systems Research Institute (ESRI) ArcInfo software that calculates a cost for moving away from a river or stream based on distance, elevation and slope. The low flat areas around a stream have little cost until a change in elevation is encountered. This represents the boundary of the floodplain or terrace. The modeled data were compared to the floodplains included in the Bay-Lake Regional Planning Commission (RPC) Environmental Corridors layer and were found to correlate quite well. The approach used here based on the Active River Area concept (Smith et al., 2008).

Map 8. Percent Sub-watershed with Potentially Restorable Wetlands. Potentially restorable wetlands are defined as soils with a hydric rating of D, A/D, B/D OR C/D (as classified in each county's USDA electronic soils database) that are currently not classified by WI DNR as wetland and occur on cropped lands as classified by the National Agriculture Statistics Service (NASS) 2007 Wisconsin Cropland Data Layer. This concept, and some of the methodology, was borrowed from WI DNR Milwaukee River Basin Wetland Assessment Project (Kline et al., 2006).

Map 9. The Wetland Metric Composite Score is the sum of the ranks of Percent Wetland, Percent River Floodplain, and Percent Potentially Restorable Wetlands.

AQUATIC MAPS:

Map 10. Aquatic Habitat Diversity Rank is based on the work of Wisconsin DNR and the USGS Aquatic Gap Analysis Program (Lyons, J., pers. communication, April 2009). Stream minimum flows and water temperature are major factors that determine which fish species can live in a given body of flowing water in Wisconsin. A wide number of landscape variables, including geology, topography, channel connectivity, climate, and land cover/use have been applied to the flowing waters of the state at varying scales, from individual streams to entire watersheds. From these variables, newly developed computer models have been used to predict stream water temperature and flow for each reach in the state. This information, paired with the knowledge of the relationship between fish species and minimum flows and temperature, has enabled the creation of a stream classification for the State of Wisconsin that identifies 11 unique aquatic natural communities. This map ranks sub-watersheds by the number of different aquatic natural communities they contain. Thus, sub-watersheds with the greatest diversity of habitats (and therefore the greatest potential diversity of species) have been identified.

Map 11. Fish Species Richness Rank is based on the number of different species of native fishes that have been identified through sampling conducted by WI DNR since 1970. The sample data come from the USGS Great Lakes Gap Analysis Program and Wisconsin DNR Fish Mapping Application.

Map 12. Water Resources Rank is based on the number of Exceptional or Outstanding Resource Waters in the sub-watershed along with reference waters in the sub-watershed, as identified by John Masterson, WI DNR Water Quality Biologist (pers. communication, March 2009). Included in the map are waters listed with the Environmental Protection Agency as not attaining their potential use; however, these did not influence the ranking.

Map 13. Aquatic Composite Ranking is the sum of the Aquatic Habitat, Fish Richness, and Water Resources ranks.

SUMMARY MAP:

Map 14. The All Ecological Rankings Composite Score consists of the sum of the rankings for Terrestrial Features Composite, Wetland Composite, and Aquatic Composite Ranks.

STRESSOR OR OPPORTUNITY MAPS:

Map 15. Projected Housing Density Change Rank is calculated from the work of Hammer, et al. 2004. This rank assesses the change in housing densities between 2000 and 2030, averaged within each sub-watershed.

Map 16. Modeled Potential Ground-water Recharge Rank was calculated using methods in Westenbroek et al. (in review). Ranking is an average of the model output across each sub-watershed.

Map 17. Modeled Soil Runoff Rank is a ranking of the sub-watersheds based on an un-calibrated run of the Soil and Water Assessment Tool (SWAT). SWAT is a river basin scale model developed to quantify the impact of land management practices in large, complex watersheds (Arnold et al., 1998). SWAT incorporates landuse, climate, soils, and topographic information to model water infiltration and runoff at a watershed scale. The landuse layer for this model was National Agriculture Statistics Service (NASS) 2007 Wisconsin Cropland Data Layer. The rank is based on the modeled annual average soil yield from a 10 year model run.

Map 18. Projected Housing Density Change Rank with The All Ecological Rankings Composite Score. This map shows sub-watersheds with the highest projected housing density growth rates layered on top of the all ecological rankings composite. This visualization can help identify the areas with the

highest ecological composite that may be most threatened by development in the near future.

Map 19. Modeled Potential Ground-water Recharge Rank with The All Ecological Rankings Composite Score. This map shows sub-watersheds with the highest modeled potential ground-water recharge layered on top of the all ecological rankings composite. This visualization can help identify the areas with the highest ecological composite that may be most likely to contribute to the recharge of ground-water.

Map 20. Modeled Soil Runoff Rank with The All Ecological Rankings Composite Score. This map shows sub-watersheds with the highest modeled soil runoff layered on top of the all ecological rankings composite. This visualization can help identify the areas with the highest ecological composite that may be most threatened by soil and sediment entering the waterways.

COASTAL MAPS:

Map 21. Coastal Landcover/Landuse. This map shows a simplified classification of the USDA National Agriculture Statistics Service (NASS) 2007 Wisconsin Cropland Data Layer. This helps identify possible areas for protection and restoration in a 1 mile buffer zone from the shore of Lake Michigan.

Map 22. Coastal Housing Density 2000. This map highlights housing density from 2000 which identifies less developed areas for protection and restoration in a 1 mile buffer zone from the shore of Lake Michigan.

MAPPING TOOL USES AND APPLICATIONS

The twenty-two static maps produced as part of this tool can be used in many ways. Users can also access interactive versions of the maps to combine them in different ways or turn on additional data layers. The raw spatial data can be used or analyzed by those with more advanced GIS skills.

The mapping tool can be used or applied in these ways:

Identify the best places to aggregate land protection strategies. How?
If the goal is to target land protection efforts in areas with the greatest terrestrial, wetland and aquatic natural features, the mapping tool's "Map 14 – All Ecological Rankings Composite Score" shows these areas of greatest natural features in dark and light green. These areas are the headwaters of the Sheboygan River down to Johnsonville; Upper and Middle Mullet River; Black River and Barr Creek area, and the area near the City of Belgium.

Next step: If the goal is to target protection activities in the sub-watersheds that are richest in natural features but also most threatened by development, practitioners could use "Map 15 - Projected Housing Density Change" to further prioritize sub-watersheds. This is shown in "Map 18." Of the most biologically rich sub-watersheds identified, Black River

and Barr Creek sub-watersheds have the highest projected rate of increase for housing. Kiel Marsh, Middle Mullet River and City of Belgium sub-watersheds are also projected to have high development pressures.

Alternatives: Practitioners interested in protecting floodplain habitat could use the mapping tool's "Map 7 - Percent sub-watershed that is River Floodplain" to identify the sub-watersheds with the most river floodplain. These areas are Feldner's Creek, Sheboygan Lake, Lower Onion River, Black River, Barr Creek and City of Belgium sub-watersheds. The CD also contains the modeled floodplain data layer. Though the model is meant to be used at a sub-watershed scale, practitioners could use the "River Floodplain" GIS layer to view the general distribution of floodplain within a sub-watershed. Finer scale floodplain data or ground-truthing would be needed to identify particular floodplain parcels to protect. The "Protected Lands" layer shows land that is already under conservation ownership or protection.

Identify the best places to implement wetland restoration activities. How?

If the goal is to target wetland restoration in areas with the greatest terrestrial, wetland and aquatic features, the mapping tool's "Map 14 – All Ecological Rankings Composite Score" shows these areas in dark and light green. There are nine high ranked sub-watersheds. The mapping tool's "Map 8 - Percent Sub-watershed with Potentially Restorable Wetlands" shows that of those nine sub-watersheds with high natural feature components, the sub-watersheds with the highest percent of potentially restorable wetlands are the Headwaters of the Sheboygan River, Feldner's Creek, Upper Mullet River, Barr Creek and City of Belgium areas.

Next step: The CD contains the "Potentially Restorable Wetlands" data layer. Though the data are meant to be used at a sub-watershed scale, practitioners could use the "Potentially Restorable Wetlands" GIS layer to view the general distribution of restoration opportunities within a sub-watershed. This could be used as a start to further refine specific on the ground restoration prioritization.

Identify the best places to aggregate soil run-off strategies. How?

If the goal is to target agricultural run-off strategies in areas with the greatest percent of soil run-off, the mapping tool's "Map 17 - Modeled Soil Runoff" shows these areas in red and yellow. There are thirteen sub-watersheds with medium or high modeled soil runoff.

Next step: If the goal is to target activities to reduce soil run-off in the sub-watersheds that are richest in natural features but also most threatened by soil-run off, practitioners could use "Map 14 – All Ecological Rankings Composite Score" to further prioritize sub-watersheds. This ranking combination is shown in "Map 20." Of the most biologically rich sub-watersheds identified, Otter Creek, Headwaters of Sheboygan River and City of Belgium sub-watersheds have the highest soil loss.

Identify place-based opportunities for collaboration. How?

"Map 14 – All Ecological Rankings Composite Score" identifies the areas with the most terrestrial, wetland and aquatic features. Collaboration in these sub-watersheds could leverage the greatest conservation outcome.

Next step: The map(s) are a starting point for discussions about collaborative efforts. How could partners leverage additional resources for the highest priority areas?

Other suggested or possible uses for the mapping tool:

- Justify current priority areas for conservation work
- Identify new areas for conservation work, or areas that merit additional field reconnaissance
- With some GIS expertise, there are numerous data combinations and score "weighting" that could be done with the mapping tool to customize the prioritization of sub-watersheds. For example, practitioners could give more "weight" to the ranks from the "Migratory Bird Habitat Model (Map 3)" and less weight to the "Species and Communities (Map 2)" and "Natural Landcover (Map 4)" ranks when coming up with a Terrestrial Features and Habitat Composite Rank.
- Decision making tool for where to implement (or not implement) conservation strategies on the ground (on a sub-watershed scale or even a site-level scale if data integrity is maintained at that scale)
- A new way to think about the Basin holistically
- Combining stressors (threats) with biological data to determine where to implement a threat abatement strategy to have the greatest impact (e.g., influencing land use planning, such as the adoption of overlay districts, in areas that are richest in natural features and also most threatened by development)
- Galvanize support (financial, public, etc.) for conservation work in a particular sub-watershed

ACKNOWLEDGEMENTS

The authors thank the following people for their input to this project:

The Kohler Trust for Preservation

Wisconsin Department of Natural Resources: Tim Beyer, Owen Boyle, Dale Katsma, John Lyons, John Masterson, Kelly L. Raleigh Moses, Vic Pappas

Glacial Lakes Conservancy: Shirley Griffin, Vickie Hall

Ozaukee County: Andrew Holschbach

Sheboygan River Basin Partnership: Stacy Hron, Pete Pittner

Sheboygan County: Patrick Miles, Shawn Wesener, Brett Zemba

Bay-Lake Regional Planning Commission: Tony Bellovary, Angela Pierce

U.S. Geological Survey: Jana Stewart, Stephen Westenbroek

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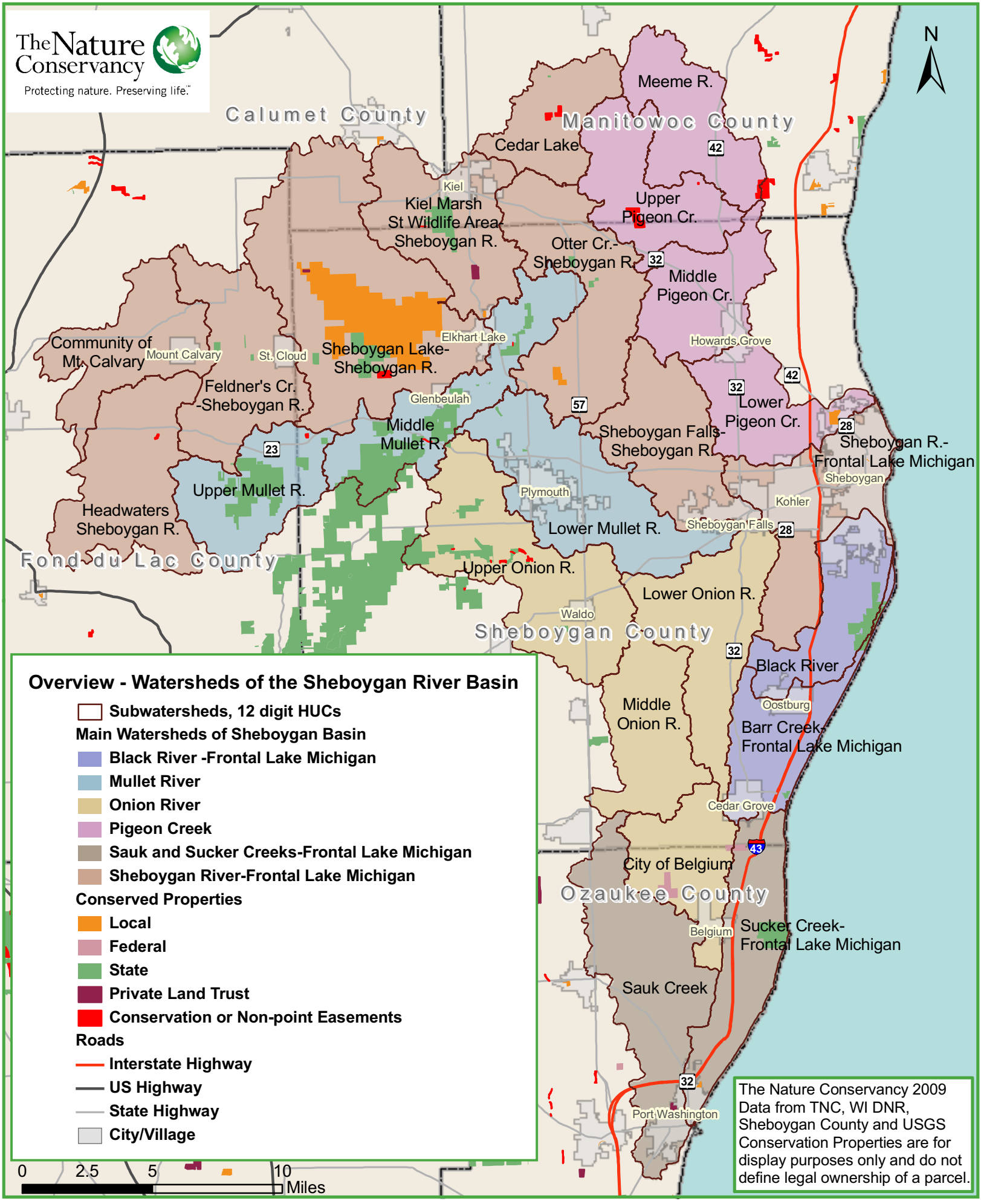
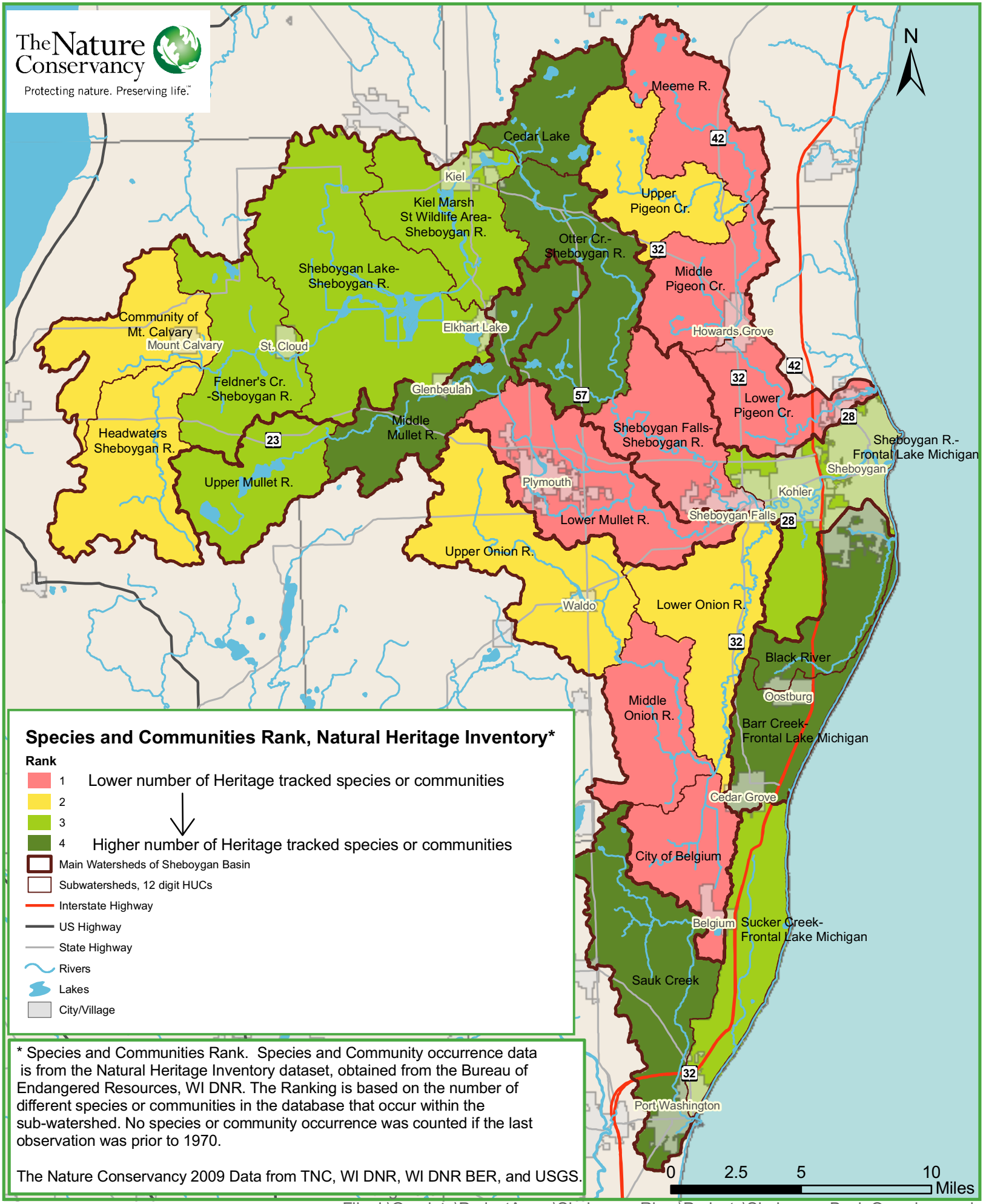
MAPS

Twenty-two maps produced with the Sheboygan River Basin Conservation Mapping Tool are included.

Overview - Watersheds of the Sheboygan River Basin Map 1



Species and Communities Rank, Natural Heritage Inventory Map 2



Species and Communities Rank, Natural Heritage Inventory*

Rank

- 1 Lower number of Heritage tracked species or communities
- 2
- 3
- 4 Higher number of Heritage tracked species or communities

- Main Watersheds of Sheboygan Basin
- Subwatersheds, 12 digit HUCs
- Interstate Highway
- US Highway
- State Highway
- Rivers
- Lakes
- City/Village

* Species and Communities Rank. Species and Community occurrence data is from the Natural Heritage Inventory dataset, obtained from the Bureau of Endangered Resources, WI DNR. The Ranking is based on the number of different species or communities in the database that occur within the sub-watershed. No species or community occurrence was counted if the last observation was prior to 1970.

The Nature Conservancy 2009 Data from TNC, WI DNR, WI DNR BER, and USGS.

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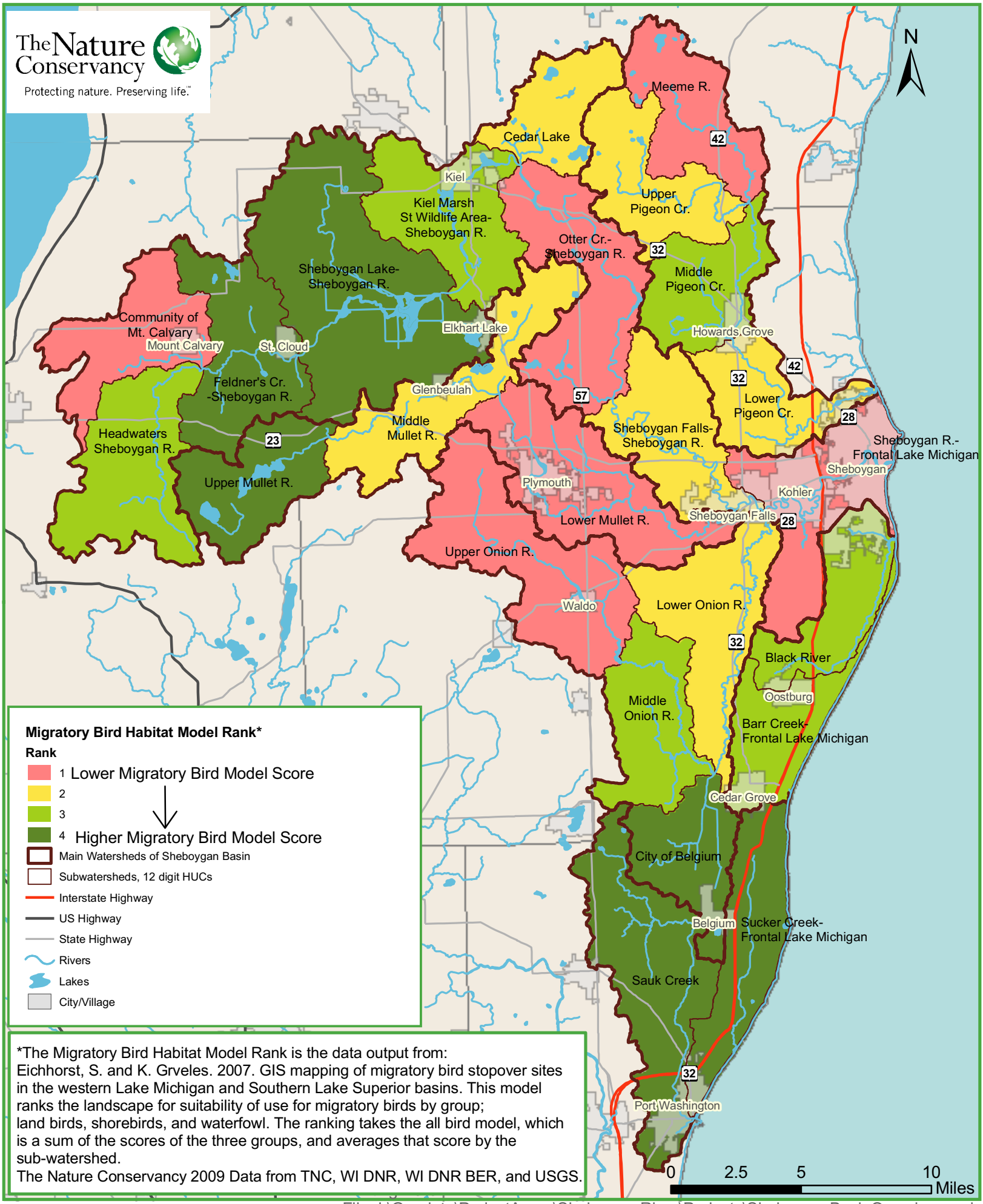
Migratory Bird Habitat Model Rank

Map 3



Migratory Bird Habitat Model Rank*

Rank

- 1 Lower Migratory Bird Model Score
- 2
- 3
- 4 Higher Migratory Bird Model Score
- Main Watersheds of Sheboygan Basin
- Subwatersheds, 12 digit HUCs
- Interstate Highway
- US Highway
- State Highway
- Rivers
- Lakes
- City/Village

*The Migratory Bird Habitat Model Rank is the data output from:
Eichhorst, S. and K. Grveles. 2007. GIS mapping of migratory bird stopover sites in the western Lake Michigan and Southern Lake Superior basins. This model ranks the landscape for suitability of use for migratory birds by group; land birds, shorebirds, and waterfowl. The ranking takes the all bird model, which is a sum of the scores of the three groups, and averages that score by the sub-watershed.
The Nature Conservancy 2009 Data from TNC, WI DNR, WI DNR BER, and USGS.

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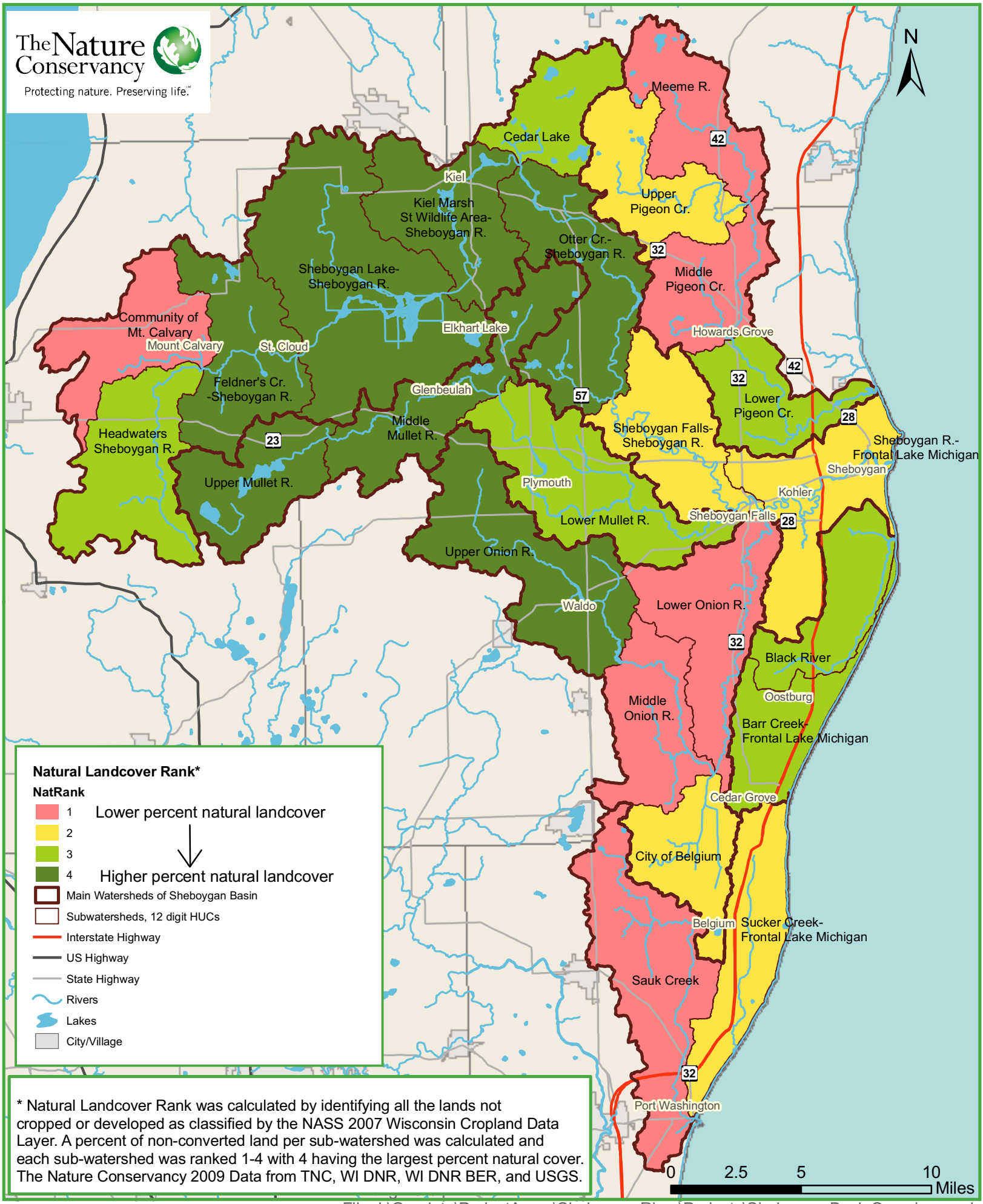
Natural Landcover Rank

Map 4



* Natural Landcover Rank was calculated by identifying all the lands not cropped or developed as classified by the NASS 2007 Wisconsin Cropland Data Layer. A percent of non-converted land per sub-watershed was calculated and each sub-watershed was ranked 1-4 with 4 having the largest percent natural cover. The Nature Conservancy 2009 Data from TNC, WI DNR, WI DNR BER, and USGS.

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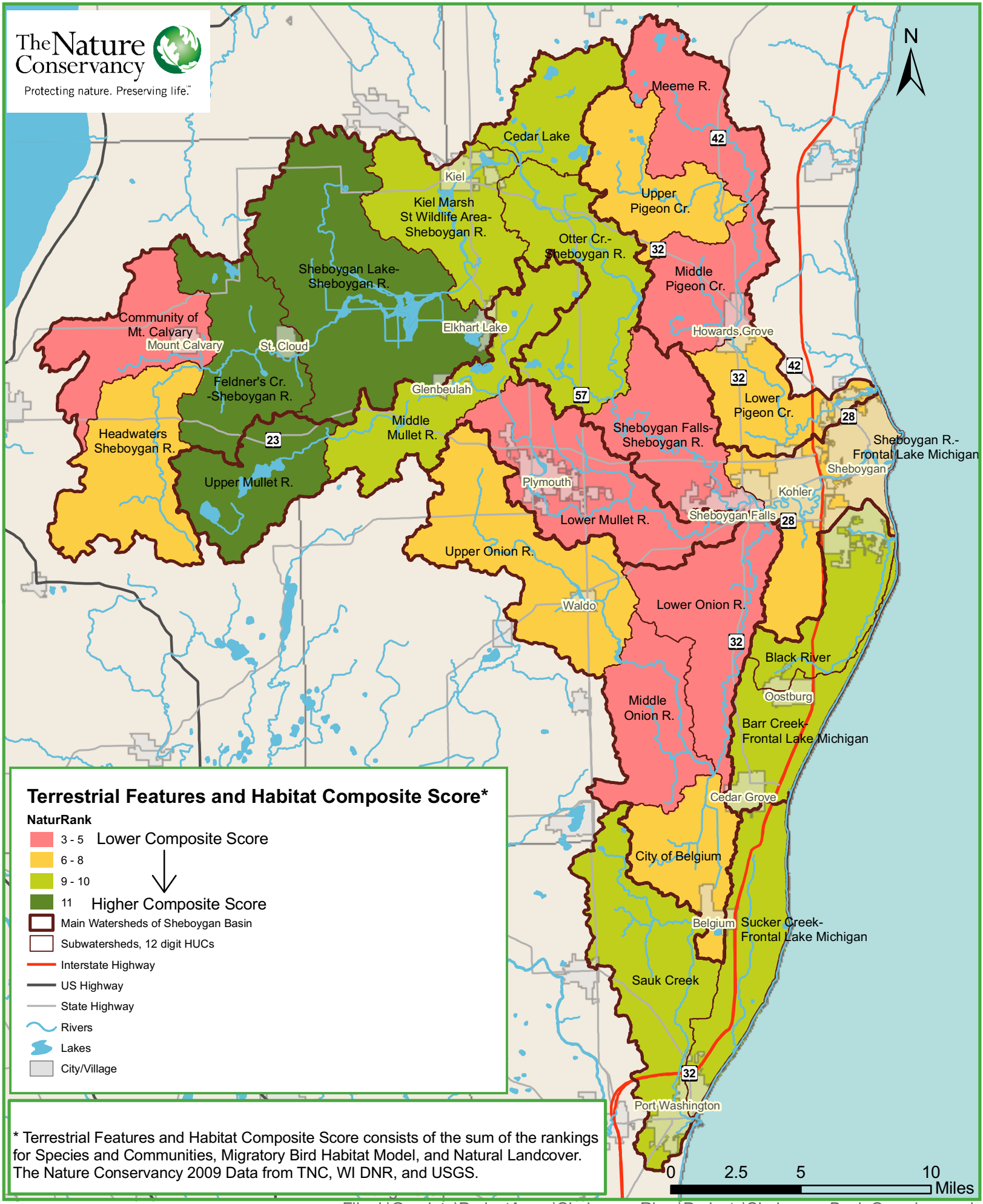
Terrestrial Features and Habitat Composite Score Map 5



Terrestrial Features and Habitat Composite Score*

NaturRank

- 3 - 5 Lower Composite Score
- 6 - 8
- 9 - 10
- 11 Higher Composite Score
- Main Watersheds of Sheboygan Basin
- Subwatersheds, 12 digit HUCs
- Interstate Highway
- US Highway
- State Highway
- Rivers
- Lakes
- City/Village

* Terrestrial Features and Habitat Composite Score consists of the sum of the rankings for Species and Communities, Migratory Bird Habitat Model, and Natural Landcover. The Nature Conservancy 2009 Data from TNC, WI DNR, and USGS.

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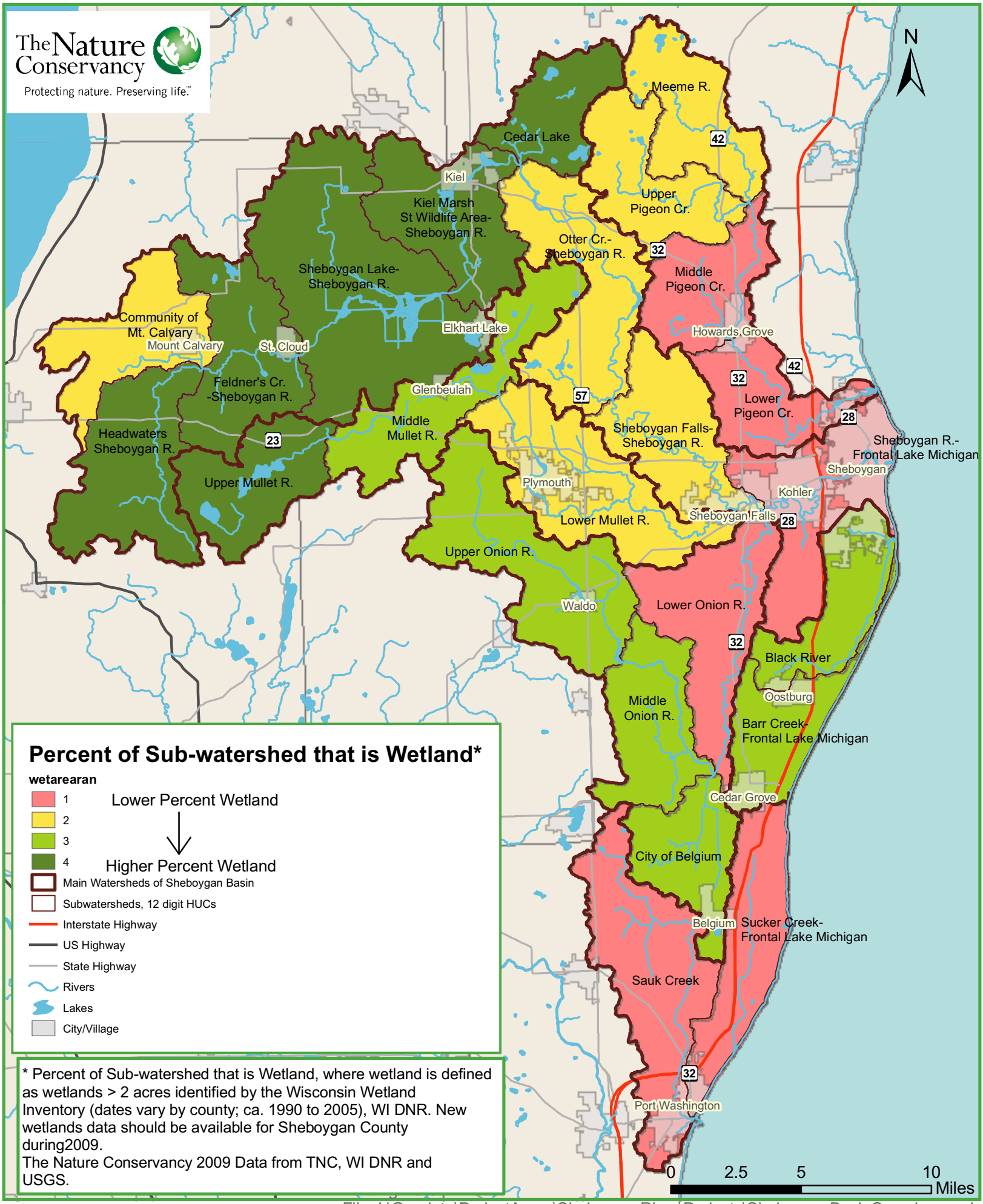
Percent of Sub-watershed that is Wetland

Map 6



Percent of Sub-watershed that is Wetland*

wetarearan

- 1
- 2
- 3
- 4

Lower Percent Wetland

↓

Higher Percent Wetland

- Main Watersheds of Sheboygan Basin
- Subwatersheds, 12 digit HUCs
- Interstate Highway
- US Highway
- State Highway
- Rivers
- Lakes
- City/Village

* Percent of Sub-watershed that is Wetland, where wetland is defined as wetlands > 2 acres identified by the Wisconsin Wetland Inventory (dates vary by county; ca. 1990 to 2005), WI DNR. New wetlands data should be available for Sheboygan County during2009.
The Nature Conservancy 2009 Data from TNC, WI DNR and USGS.

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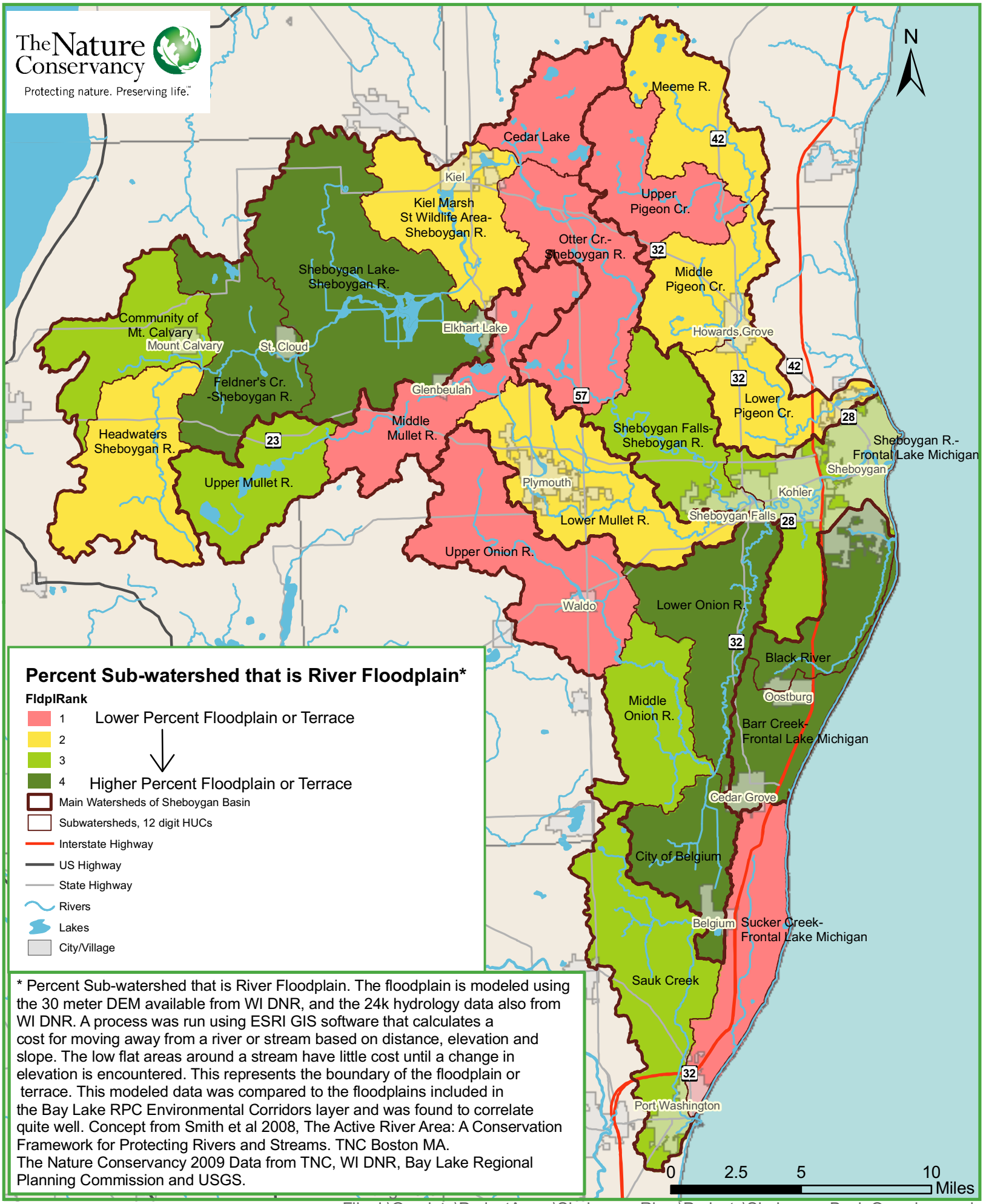
Percent Sub-watershed that is River Floodplain Map 7



Percent Sub-watershed that is River Floodplain*

FldplRank

- 1 Lower Percent Floodplain or Terrace
- 2
- 3
- 4 Higher Percent Floodplain or Terrace
- Main Watersheds of Sheboygan Basin
- Subwatersheds, 12 digit HUCs
- Interstate Highway
- US Highway
- State Highway
- Rivers
- Lakes
- City/Village

* Percent Sub-watershed that is River Floodplain. The floodplain is modeled using the 30 meter DEM available from WI DNR, and the 24k hydrology data also from WI DNR. A process was run using ESRI GIS software that calculates a cost for moving away from a river or stream based on distance, elevation and slope. The low flat areas around a stream have little cost until a change in elevation is encountered. This represents the boundary of the floodplain or terrace. This modeled data was compared to the floodplains included in the Bay Lake RPC Environmental Corridors layer and was found to correlate quite well. Concept from Smith et al 2008, The Active River Area: A Conservation Framework for Protecting Rivers and Streams. TNC Boston MA.
The Nature Conservancy 2009 Data from TNC, WI DNR, Bay Lake Regional Planning Commission and USGS.

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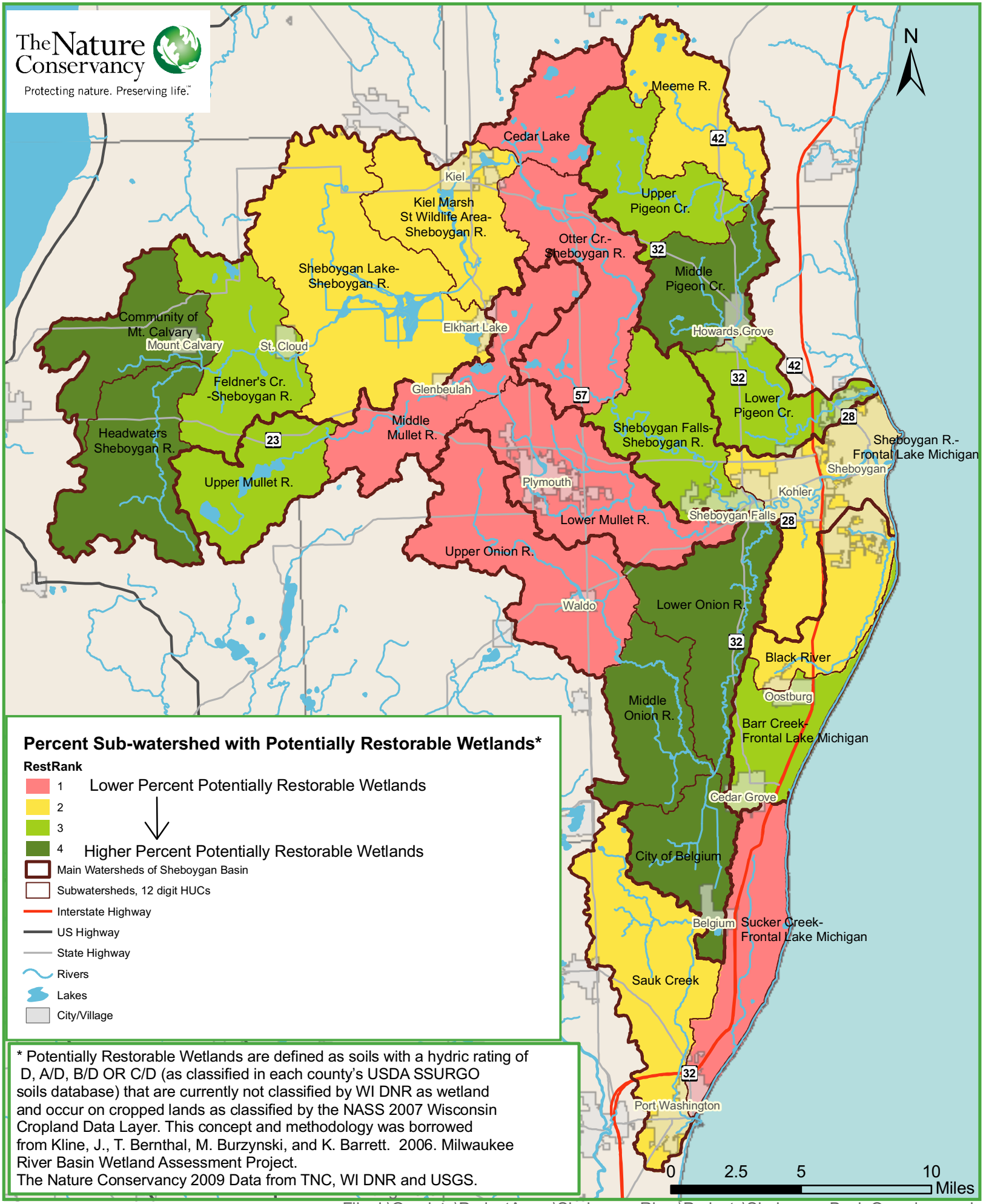
Percent Sub-watershed with Potentially Restorable Wetlands Map 8



Percent Sub-watershed with Potentially Restorable Wetlands*

RestRank

- 1 Lower Percent Potentially Restorable Wetlands
- 2
- 3
- 4 Higher Percent Potentially Restorable Wetlands

Main Watersheds of Sheboygan Basin
Subwatersheds, 12 digit HUCs
Interstate Highway
US Highway
State Highway
Rivers
Lakes
City/Village

* Potentially Restorable Wetlands are defined as soils with a hydric rating of D, A/D, B/D OR C/D (as classified in each county's USDA SSURGO soils database) that are currently not classified by WI DNR as wetland and occur on cropped lands as classified by the NASS 2007 Wisconsin Cropland Data Layer. This concept and methodology was borrowed from Kline, J., T. Bernthal, M. Burzynski, and K. Barrett. 2006. Milwaukee River Basin Wetland Assessment Project.
The Nature Conservancy 2009 Data from TNC, WI DNR and USGS.

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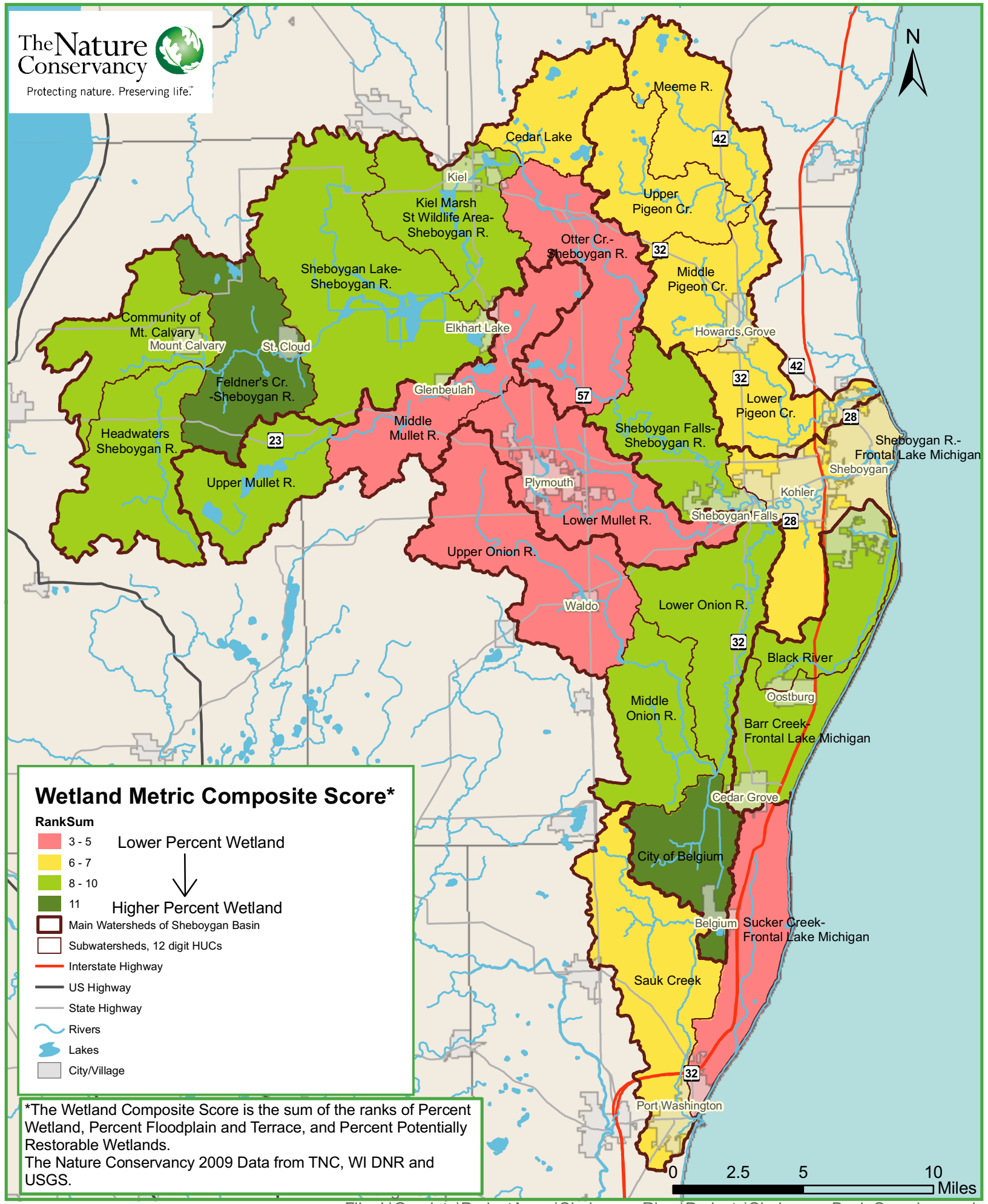
Wetland Metric Composite Score

Map 9



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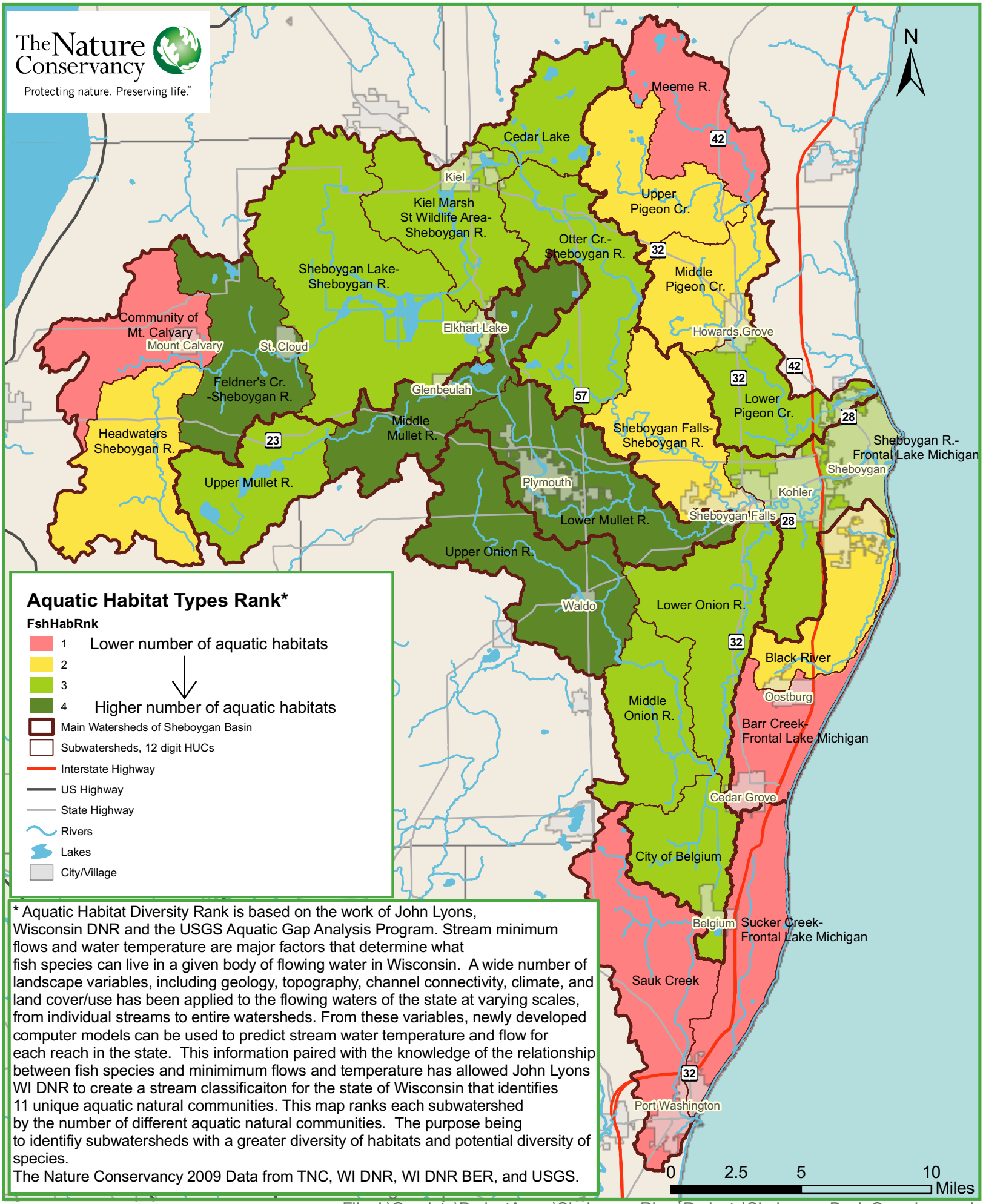
Aquatic Habitat Diversity Rank

Map 10



Aquatic Habitat Types Rank*

FshHabRnk

- 1 Lower number of aquatic habitats
- 2
- 3
- 4 Higher number of aquatic habitats
- Main Watersheds of Sheboygan Basin
- Subwatersheds, 12 digit HUCs
- Interstate Highway
- US Highway
- State Highway
- Rivers
- Lakes
- City/Village

* Aquatic Habitat Diversity Rank is based on the work of John Lyons, Wisconsin DNR and the USGS Aquatic Gap Analysis Program. Stream minimum flows and water temperature are major factors that determine what fish species can live in a given body of flowing water in Wisconsin. A wide number of landscape variables, including geology, topography, channel connectivity, climate, and land cover/use has been applied to the flowing waters of the state at varying scales, from individual streams to entire watersheds. From these variables, newly developed computer models can be used to predict stream water temperature and flow for each reach in the state. This information paired with the knowledge of the relationship between fish species and minimimum flows and temperature has allowed John Lyons WI DNR to create a stream classificaiton for the state of Wisconsin that identifies 11 unique aquatic natural communities. This map ranks each subwatershed by the number of different aquatic natural communities. The purpose being to identifiy subwatersheds with a greater diversity of habitats and potential diversity of species.

The Nature Conservancy 2009 Data from TNC, WI DNR, WI DNR BER, and USGS.

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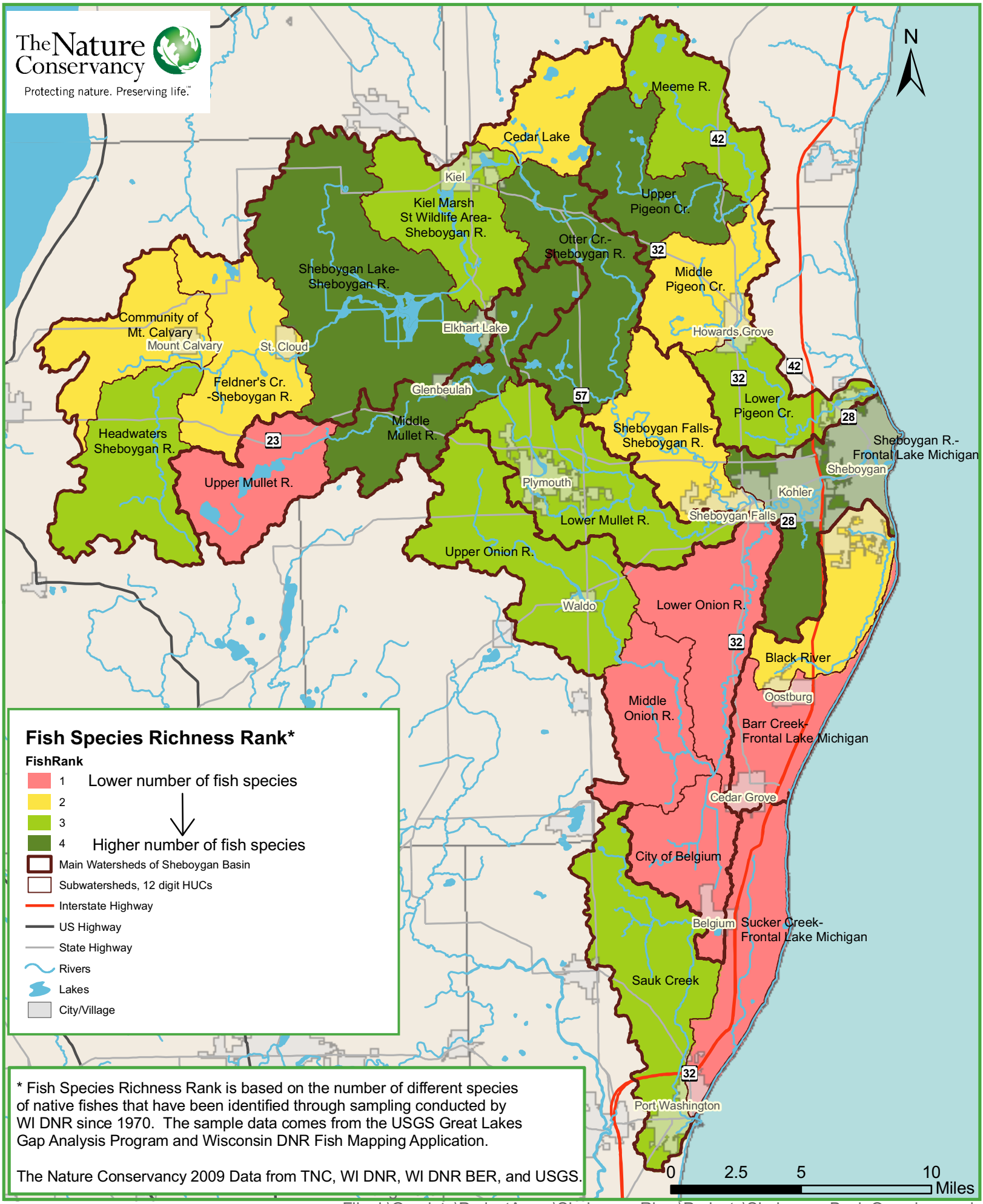
Fish Species Richness Rank

Map 11



* Fish Species Richness Rank is based on the number of different species of native fishes that have been identified through sampling conducted by WI DNR since 1970. The sample data comes from the USGS Great Lakes Gap Analysis Program and Wisconsin DNR Fish Mapping Application.

The Nature Conservancy 2009 Data from TNC, WI DNR, WI DNR BER, and USGS.

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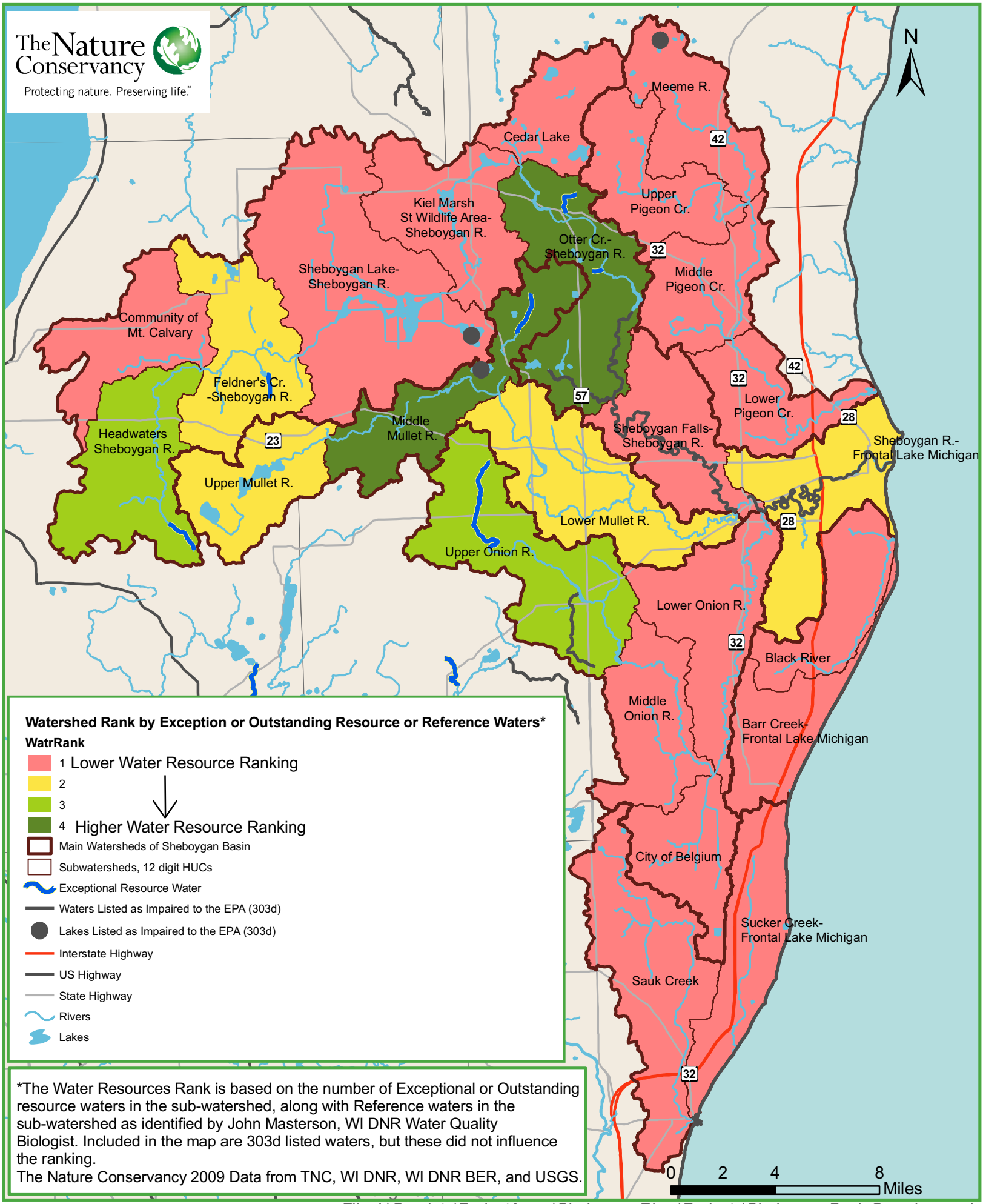
Watershed Rank by Water Resources

Map 12



Watershed Rank by Exception or Outstanding Resource or Reference Waters*

WatrRank

- 1 Lower Water Resource Ranking
- 2
- 3
- 4 Higher Water Resource Ranking

Main Watersheds of Sheboygan Basin
Subwatersheds, 12 digit HUCs
Exceptional Resource Water
Waters Listed as Impaired to the EPA (303d)
Lakes Listed as Impaired to the EPA (303d)
Interstate Highway
US Highway
State Highway
Rivers
Lakes

*The Water Resources Rank is based on the number of Exceptional or Outstanding resource waters in the sub-watershed, along with Reference waters in the sub-watershed as identified by John Masterson, WI DNR Water Quality Biologist. Included in the map are 303d listed waters, but these did not influence the ranking.

The Nature Conservancy 2009 Data from TNC, WI DNR, WI DNR BER, and USGS.

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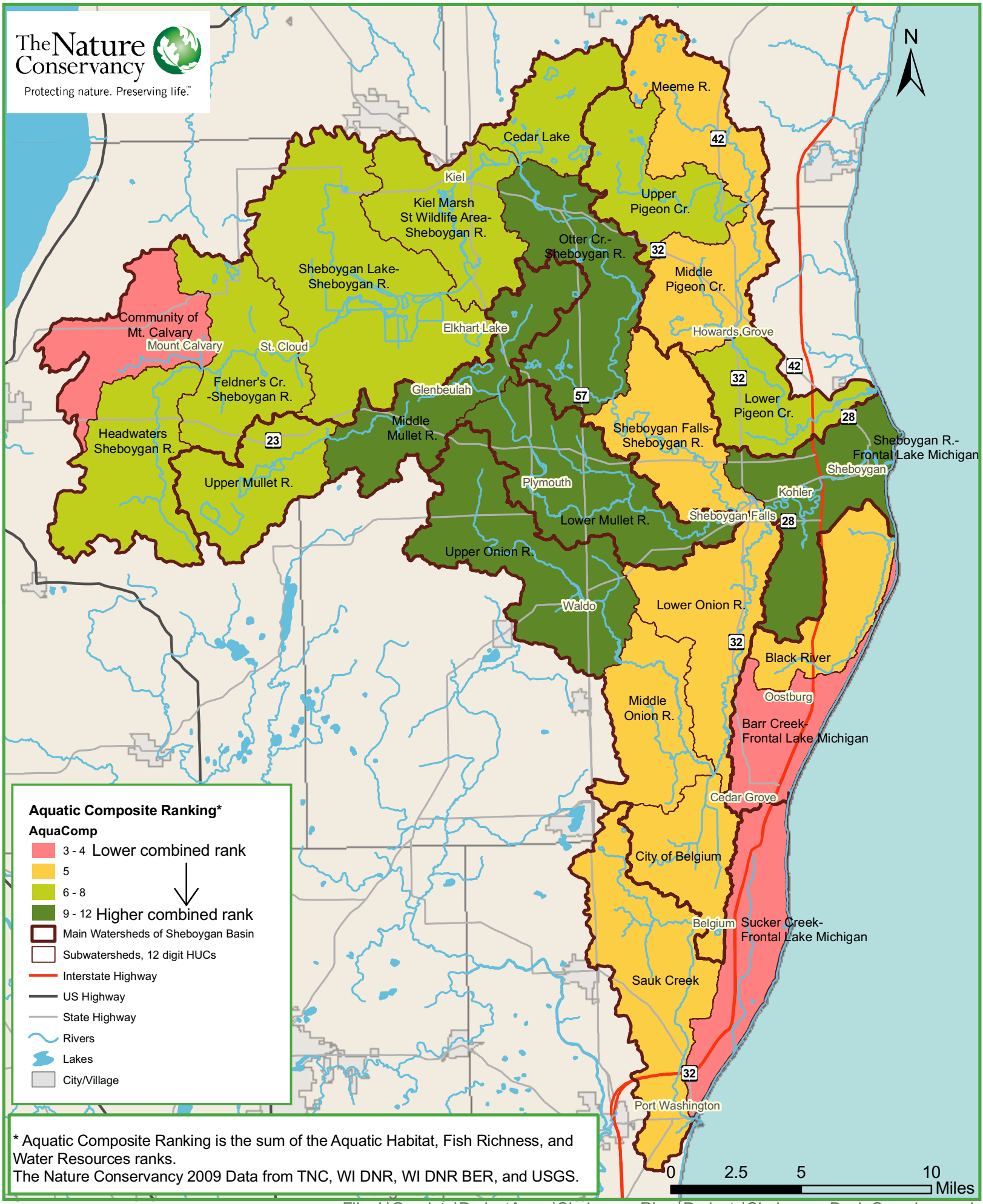
Aquatic Composite Rank

Map 13



* Aquatic Composite Ranking is the sum of the Aquatic Habitat, Fish Richness, and Water Resources ranks.
The Nature Conservancy 2009 Data from TNC, WI DNR, WI DNR BER, and USGS.

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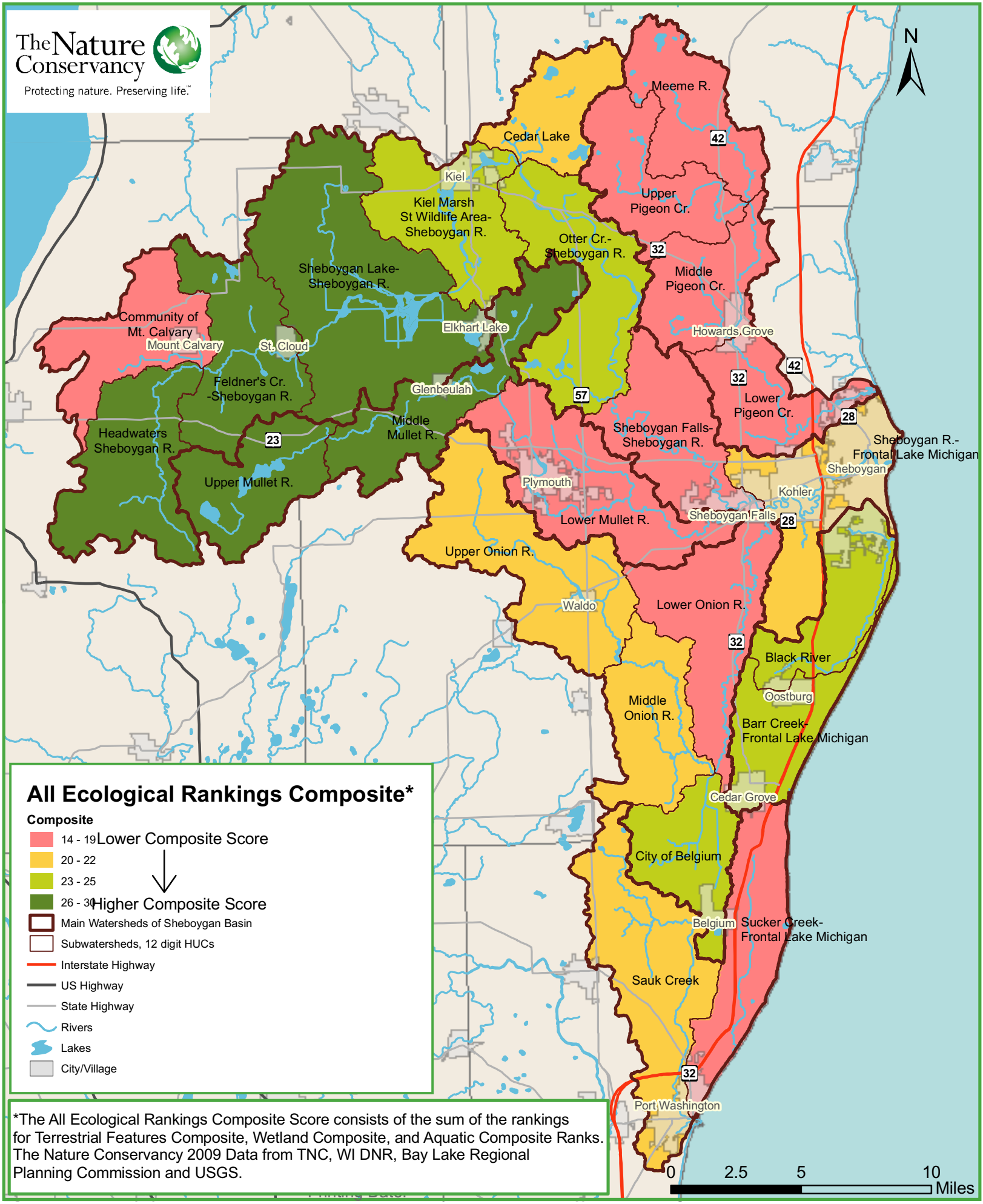
All Ecological Rankings Composite Score Map 14



All Ecological Rankings Composite*

Composite

- 14 - 19 Lower Composite Score
- 20 - 22
- 23 - 25
- 26 - 30 Higher Composite Score
- Main Watersheds of Sheboygan Basin
- Subwatersheds, 12 digit HUCs
- Interstate Highway
- US Highway
- State Highway
- Rivers
- Lakes
- City/Village

*The All Ecological Rankings Composite Score consists of the sum of the rankings for Terrestrial Features Composite, Wetland Composite, and Aquatic Composite Ranks. The Nature Conservancy 2009 Data from TNC, WI DNR, Bay Lake Regional Planning Commission and USGS.

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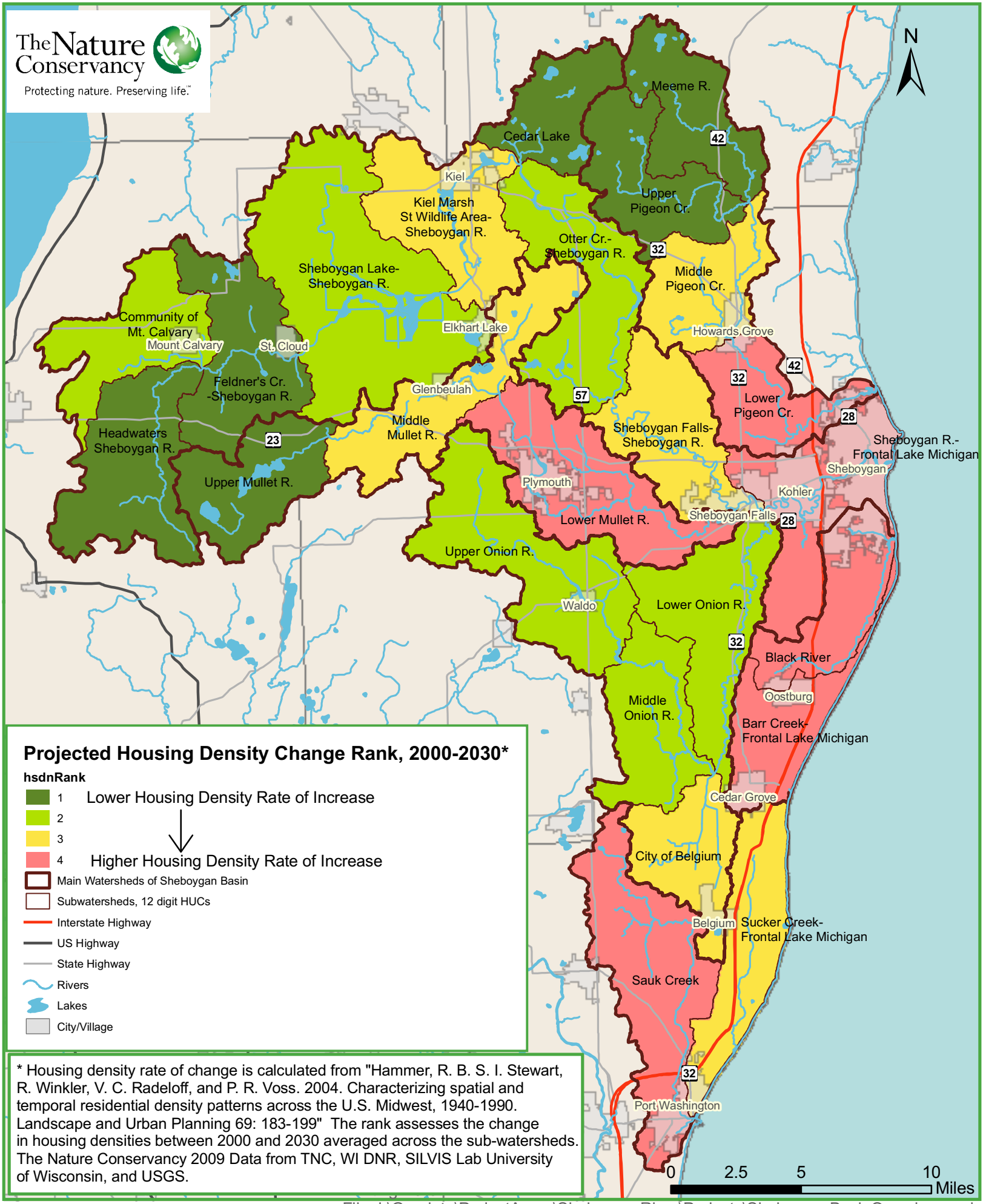
Projected Housing Density Change Rank, 2000-2030 Map 15



Projected Housing Density Change Rank, 2000-2030*

hsdnRank

- 1 Lower Housing Density Rate of Increase
- 2
- 3
- 4 Higher Housing Density Rate of Increase

- Main Watersheds of Sheboygan Basin
- Subwatersheds, 12 digit HUCs
- Interstate Highway
- US Highway
- State Highway
- Rivers
- Lakes
- City/Village

* Housing density rate of change is calculated from "Hammer, R. B. S. I. Stewart, R. Winkler, V. C. Radeloff, and P. R. Voss. 2004. Characterizing spatial and temporal residential density patterns across the U.S. Midwest, 1940-1990. Landscape and Urban Planning 69: 183-199" The rank assesses the change in housing densities between 2000 and 2030 averaged across the sub-watersheds. The Nature Conservancy 2009 Data from TNC, WI DNR, SILVIS Lab University of Wisconsin, and USGS.

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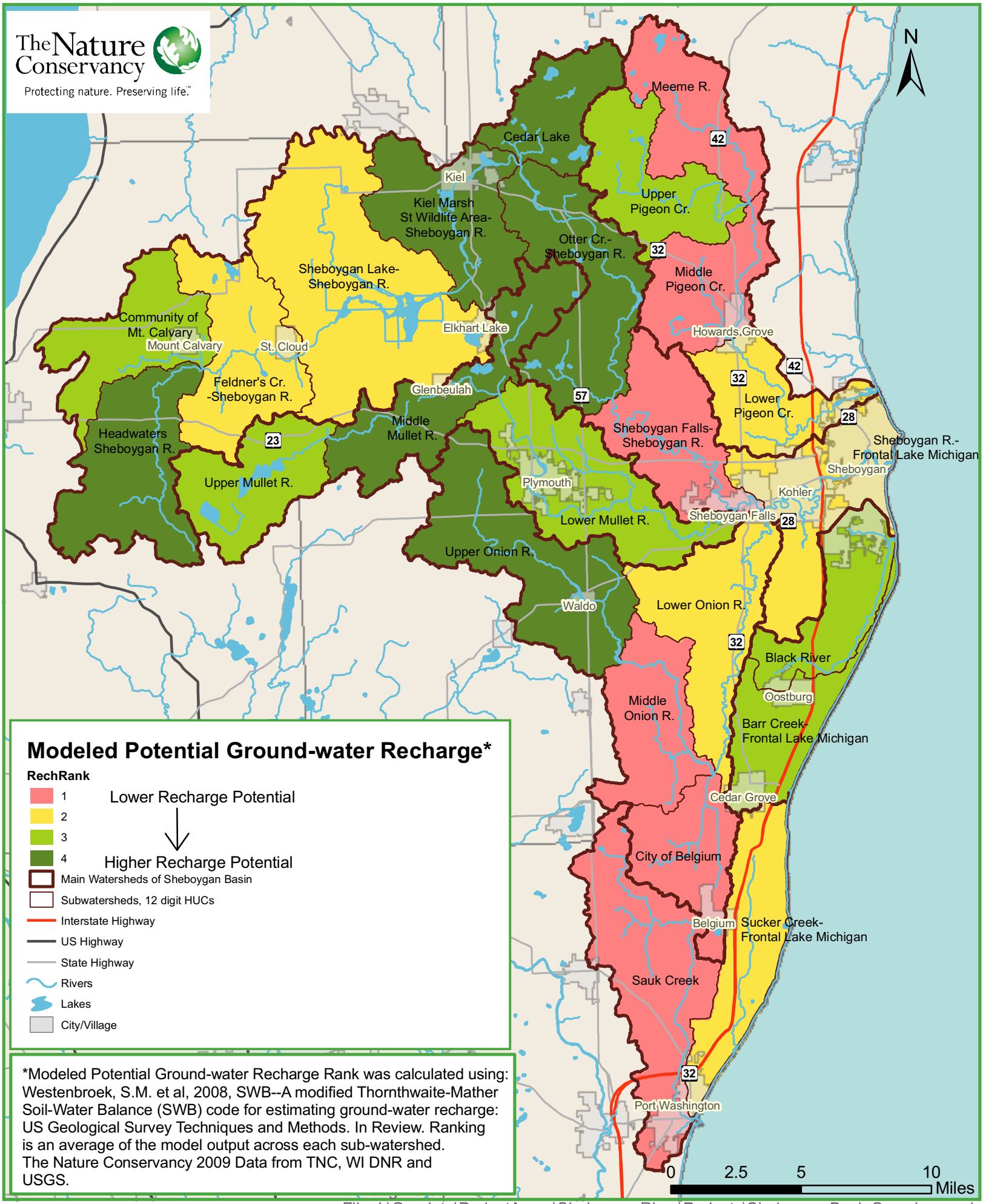
Modeled Potential Ground-water Recharge

Map 16



*Modeled Potential Ground-water Recharge Rank was calculated using: Westenbroek, S.M. et al, 2008, SWB--A modified Thornthwaite-Mather Soil-Water Balance (SWB) code for estimating ground-water recharge: US Geological Survey Techniques and Methods. In Review. Ranking is an average of the model output across each sub-watershed. The Nature Conservancy 2009 Data from TNC, WI DNR and USGS.

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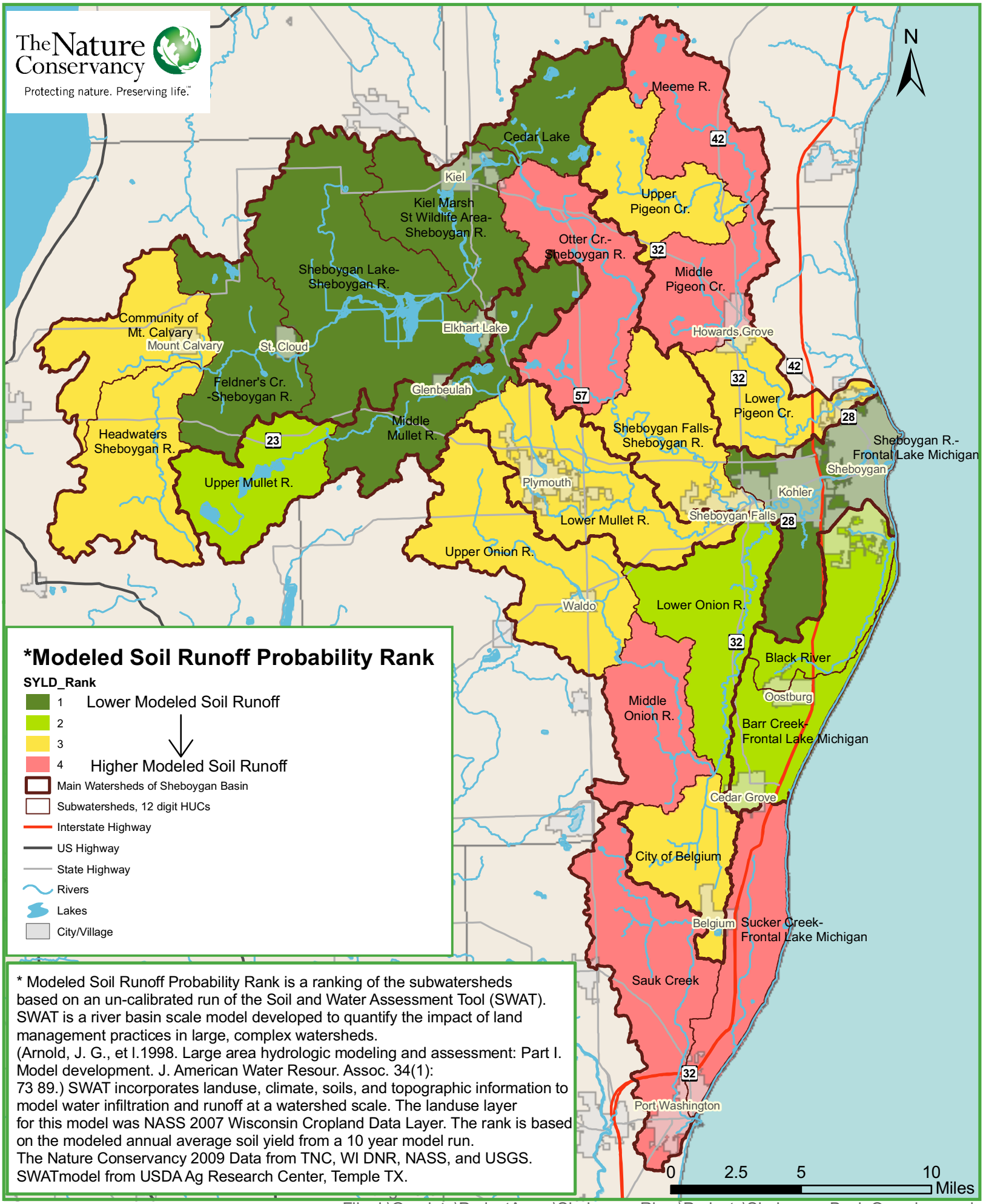
Modeled Soil Runoff Rank

Map 17



*Modeled Soil Runoff Probability Rank

SYLD_Rank

- 1 Lower Modeled Soil Runoff
- 2
- 3
- 4 Higher Modeled Soil Runoff
- Main Watersheds of Sheboygan Basin
- Subwatersheds, 12 digit HUCs
- Interstate Highway
- US Highway
- State Highway
- Rivers
- Lakes
- City/Village

* Modeled Soil Runoff Probability Rank is a ranking of the subwatersheds based on an un-calibrated run of the Soil and Water Assessment Tool (SWAT). SWAT is a river basin scale model developed to quantify the impact of land management practices in large, complex watersheds.
(Arnold, J. G., et l.1998. Large area hydrologic modeling and assessment: Part I. Model development. J. American Water Resour. Assoc. 34(1):
73 89.) SWAT incorporates landuse, climate, soils, and topographic information to model water infiltration and runoff at a watershed scale. The landuse layer for this model was NASS 2007 Wisconsin Cropland Data Layer. The rank is based on the modeled annual average soil yield from a 10 year model run.
The Nature Conservancy 2009 Data from TNC, WI DNR, NASS, and USGS.
SWATmodel from USDA Ag Research Center, Temple TX.

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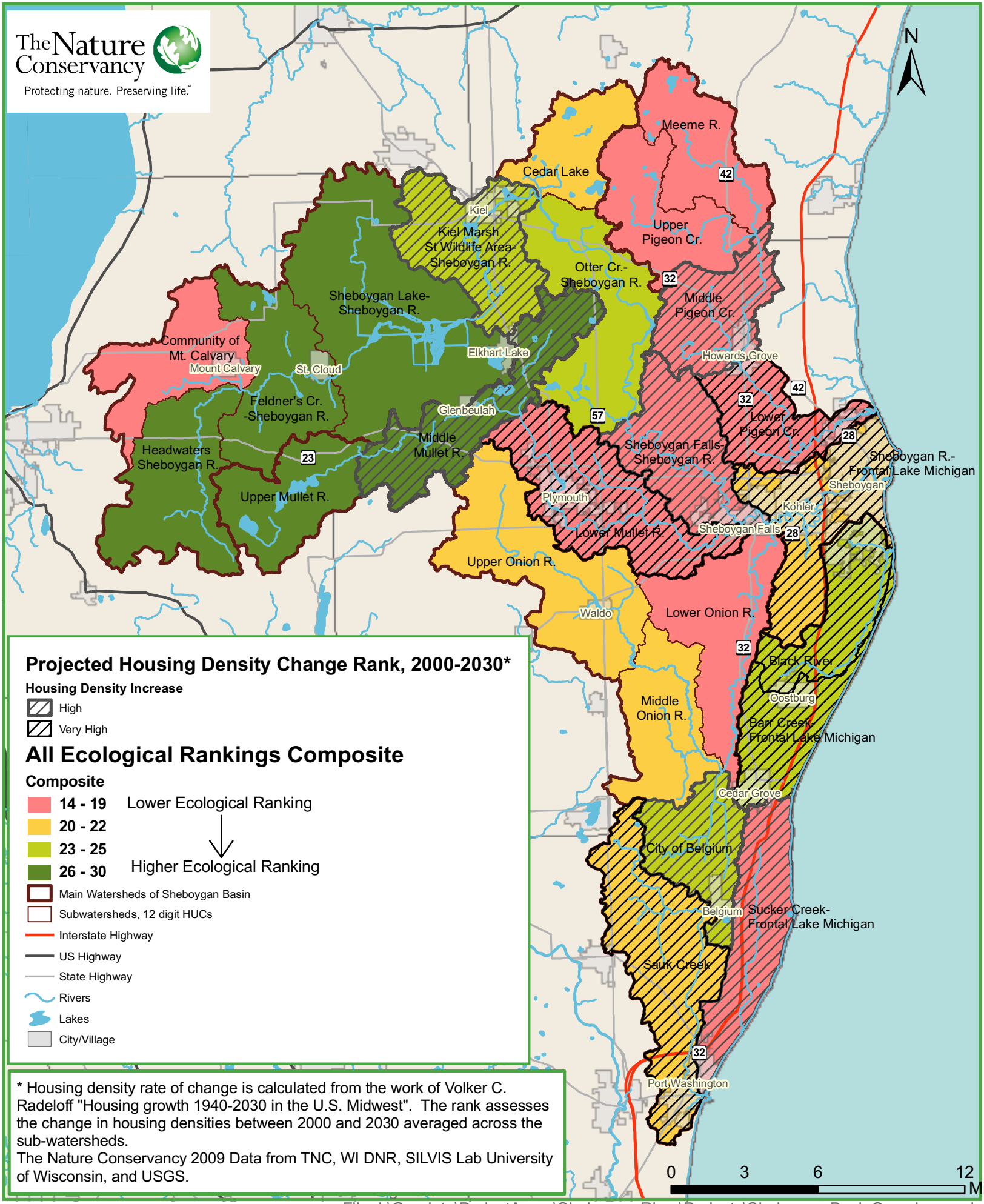
Projected Housing Density Change Rank, 2000-2030 Map 18



Projected Housing Density Change Rank, 2000-2030*

Housing Density Increase

- High
- Very High

All Ecological Rankings Composite

Composite

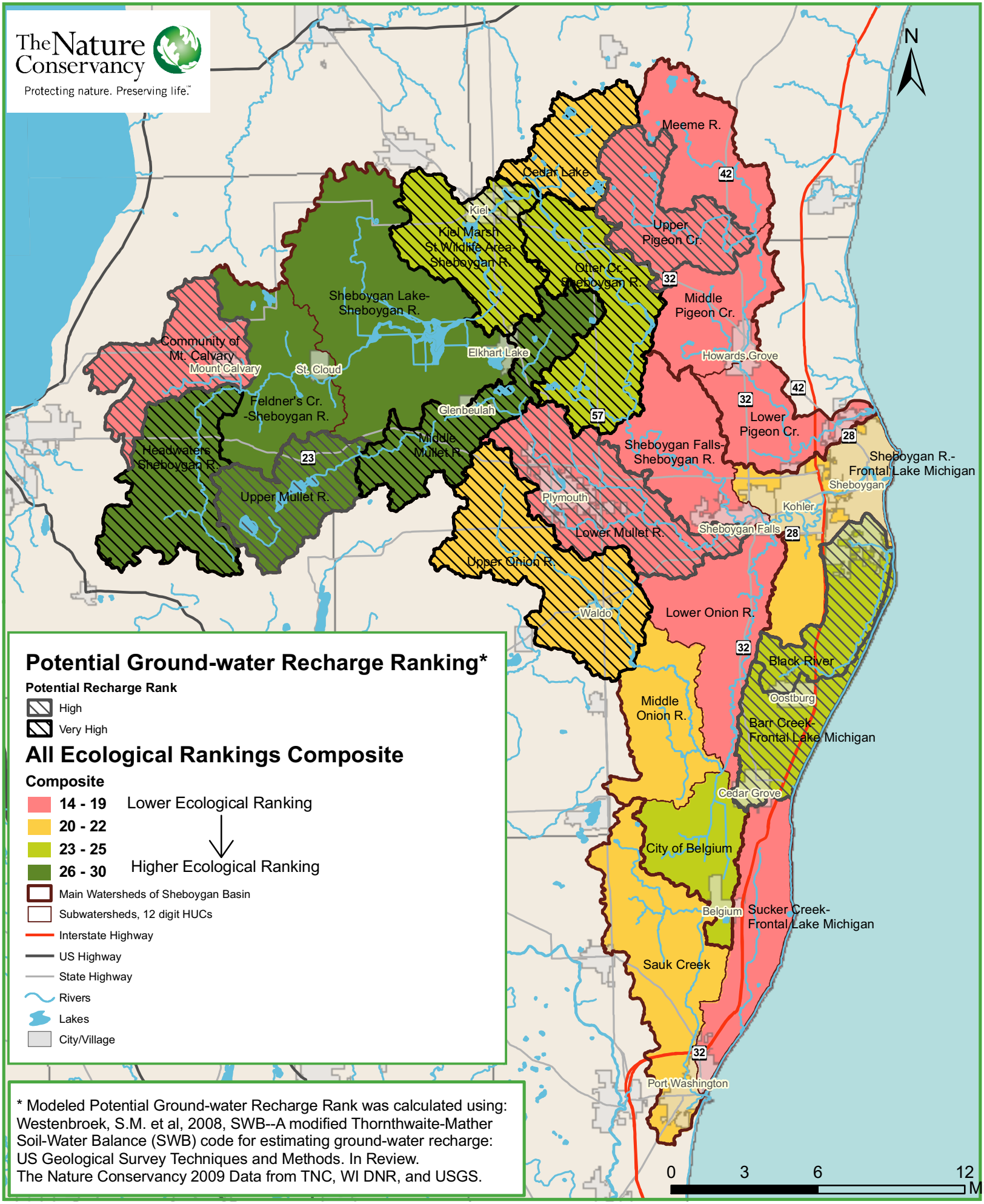
- 14 - 19 Lower Ecological Ranking
- 20 - 22
- 23 - 25
- 26 - 30 Higher Ecological Ranking
- Main Watersheds of Sheboygan Basin
- Subwatersheds, 12 digit HUCs
- Interstate Highway
- US Highway
- State Highway
- Rivers
- Lakes
- City/Village

* Housing density rate of change is calculated from the work of Volker C. Radeloff "Housing growth 1940-2030 in the U.S. Midwest". The rank assesses the change in housing densities between 2000 and 2030 averaged across the sub-watersheds.

The Nature Conservancy 2009 Data from TNC, WI DNR, SILVIS Lab University of Wisconsin, and USGS.

File: I:\Geodata\ProjectAreas\SheboyganRiver\Projects\SheboyganBasinOverview.mxd

Modeled Potential Ground-water Recharge Ranking Map 19



Potential Ground-water Recharge Ranking*

Potential Recharge Rank

- High
- Very High

All Ecological Rankings Composite

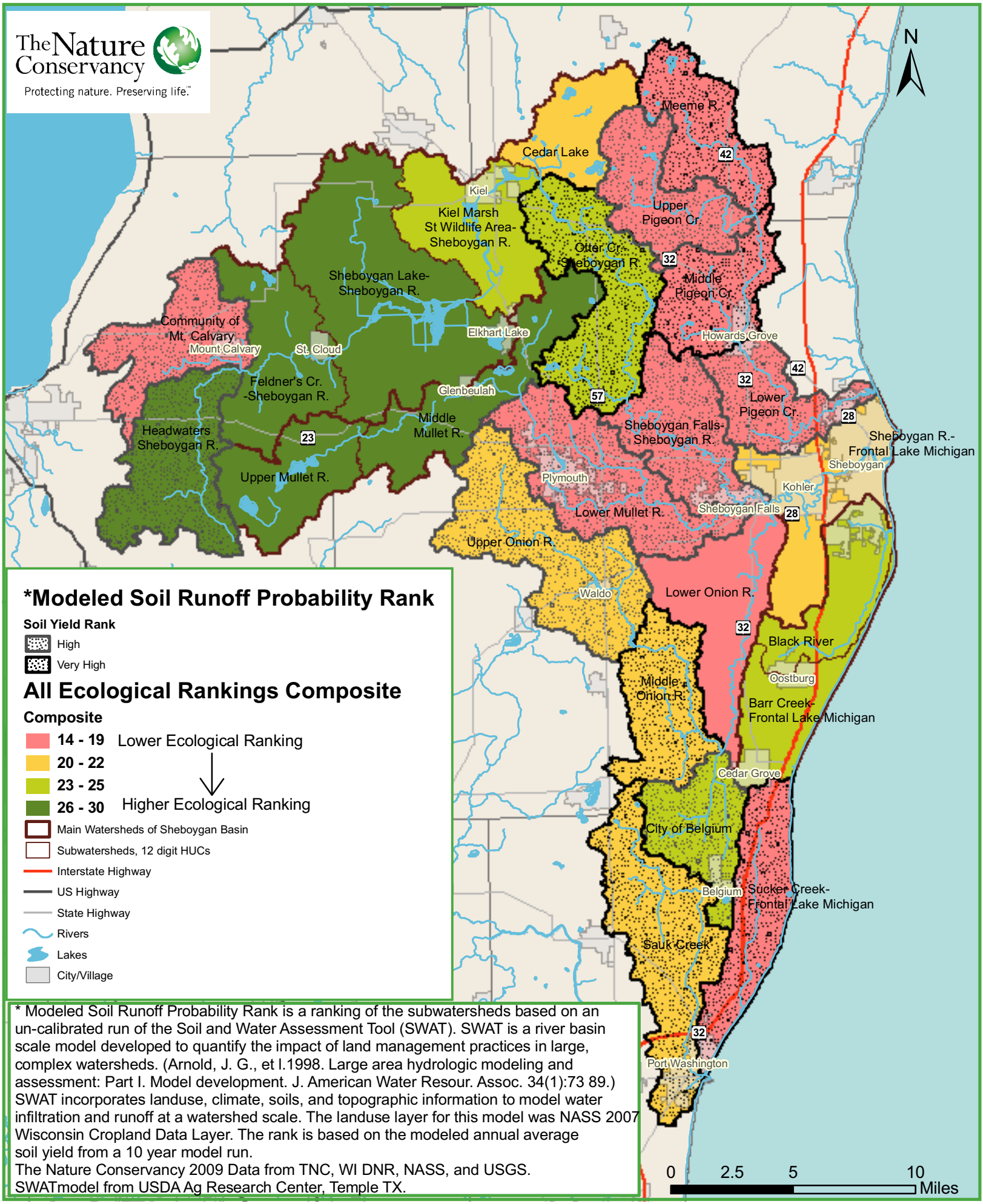
Composite

- **14 - 19** Lower Ecological Ranking
- **20 - 22**
- **23 - 25**
- **26 - 30** Higher Ecological Ranking
- Main Watersheds of Sheboygan Basin
- Subwatersheds, 12 digit HUCs
- Interstate Highway
- US Highway
- State Highway
- Rivers
- Lakes
- City/Village

* Modeled Potential Ground-water Recharge Rank was calculated using: Westenbroek, S.M. et al, 2008, SWB--A modified Thornthwaite-Mather Soil-Water Balance (SWB) code for estimating ground-water recharge: US Geological Survey Techniques and Methods. In Review.
The Nature Conservancy 2009 Data from TNC, WI DNR, and USGS.

Modeled Soil Runoff Ranking

Map 20



*Modeled Soil Runoff Probability Rank

Soil Yield Rank

- High
- Very High

All Ecological Rankings Composite

Composite

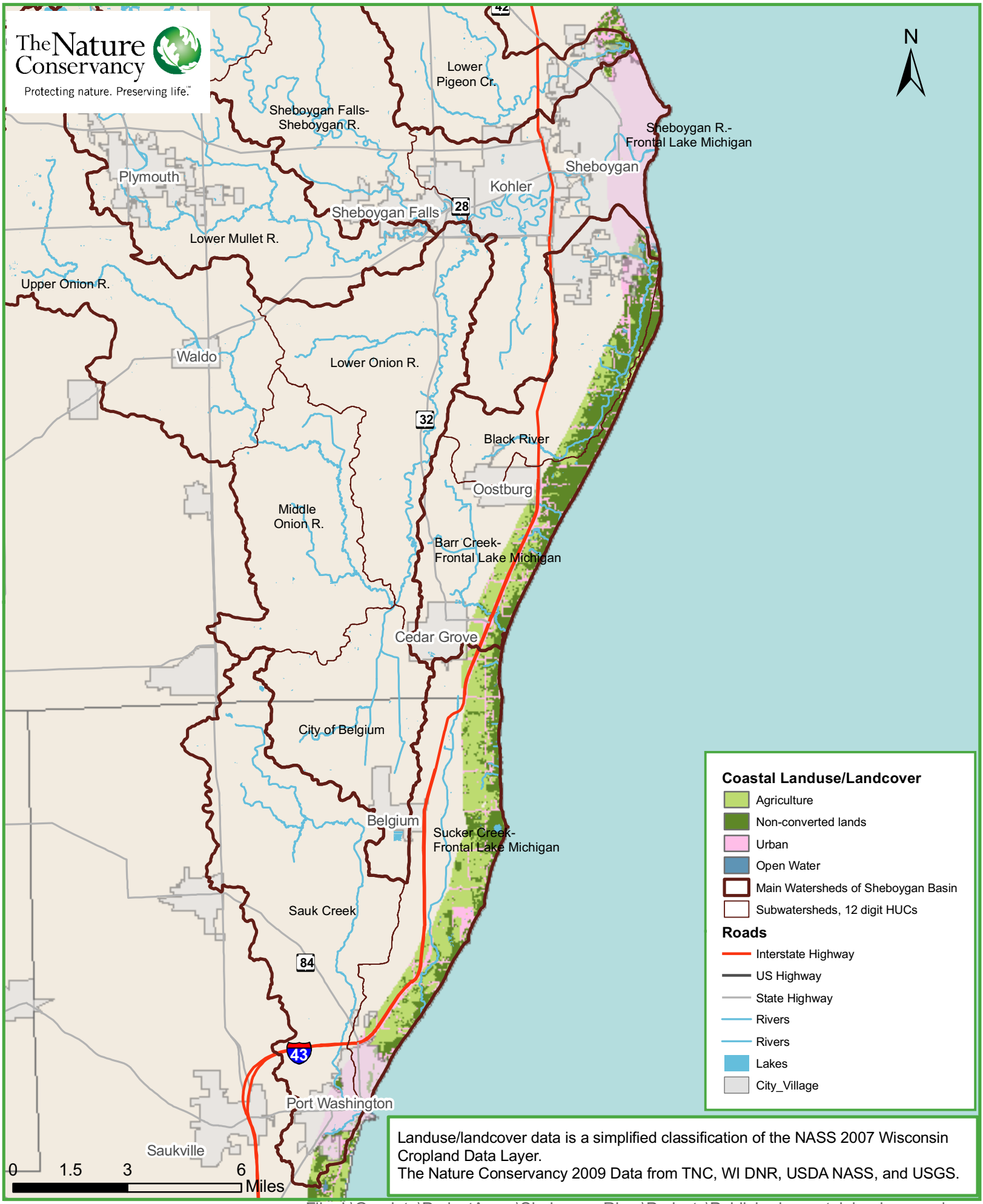
- 14 - 19 Lower Ecological Ranking
- 20 - 22
- 23 - 25
- 26 - 30 Higher Ecological Ranking
- Main Watersheds of Sheboygan Basin
- Subwatersheds, 12 digit HUCs
- Interstate Highway
- US Highway
- State Highway
- Rivers
- Lakes
- City/Village

* Modeled Soil Runoff Probability Rank is a ranking of the subwatersheds based on an un-calibrated run of the Soil and Water Assessment Tool (SWAT). SWAT is a river basin scale model developed to quantify the impact of land management practices in large, complex watersheds. (Arnold, J. G., et l.1998. Large area hydrologic modeling and assessment: Part I. Model development. J. American Water Resour. Assoc. 34(1):73 89.) SWAT incorporates landuse, climate, soils, and topographic information to model water infiltration and runoff at a watershed scale. The landuse layer for this model was NASS 2007 Wisconsin Cropland Data Layer. The rank is based on the modeled annual average soil yield from a 10 year model run.

The Nature Conservancy 2009 Data from TNC, WI DNR, NASS, and USGS.
SWATmodel from USDA Ag Research Center, Temple TX.

Coastal Landcover

Map 21



Landuse/landcover data is a simplified classification of the NASS 2007 Wisconsin Cropland Data Layer.
The Nature Conservancy 2009 Data from TNC, WI DNR, USDA NASS, and USGS.

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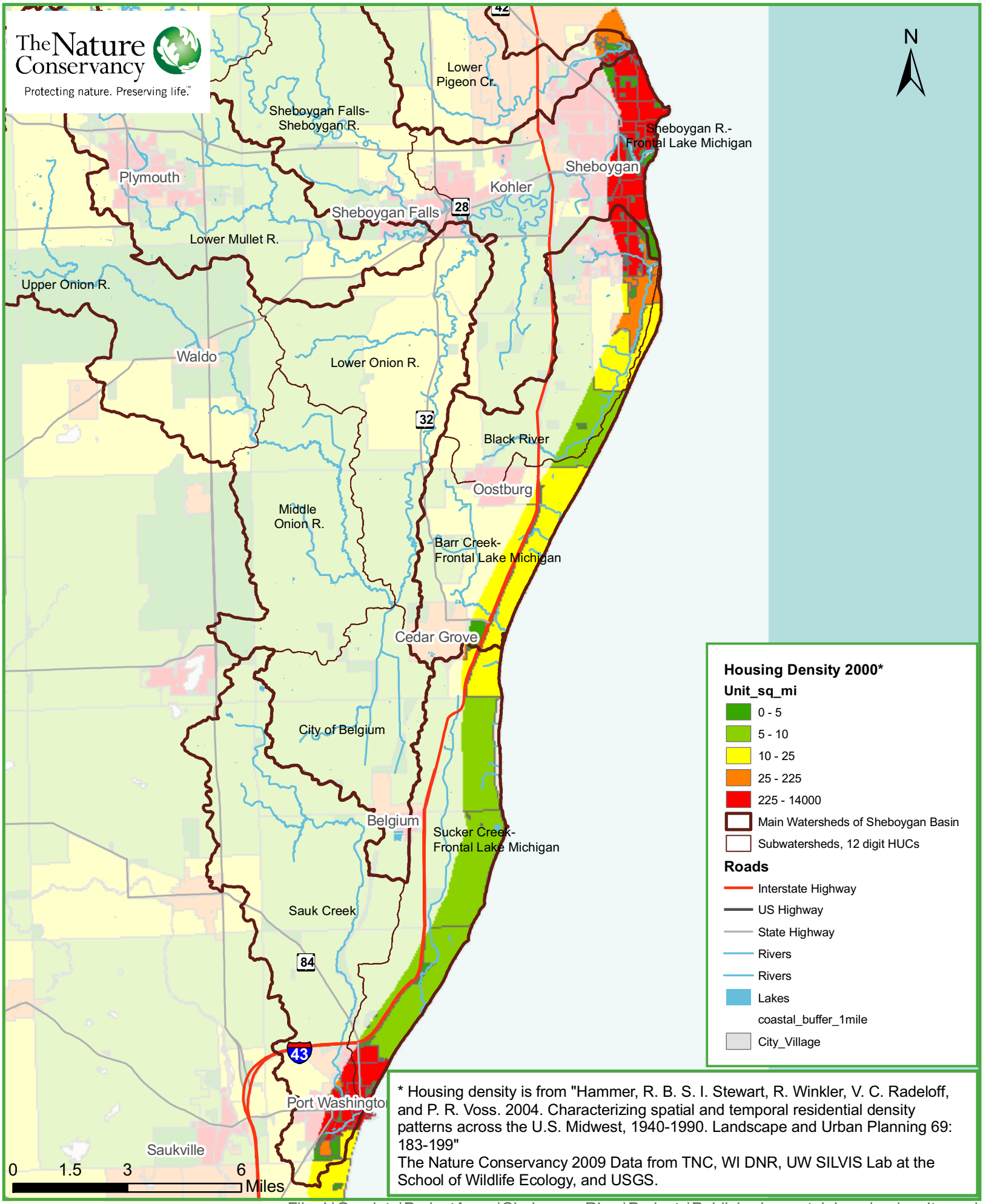
Coastal Housing Density 2000

Map 22



* Housing density is from "Hammer, R. B. S. I. Stewart, R. Winkler, V. C. Radeloff, and P. R. Voss. 2004. Characterizing spatial and temporal residential density patterns across the U.S. Midwest, 1940-1990. Landscape and Urban Planning 69: 183-199"

The Nature Conservancy 2009 Data from TNC, WI DNR, UW SILVIS Lab at the School of Wildlife Ecology, and USGS.

File: I:\Geodata\ProjectAreas\SheboyganRiver\Projects\Published_coastal_housingdensity.mxd

APPENDIX: GIS Data and ArcReader documents on CD

Included on the CD of this report are the spatial data used to create the maps. Also, the underlying data used to create the sub-watershed rankings were included for those datasets for which The Nature Conservancy had the rights to distribute the data.

All of these data reside in the Spatial Data folder. The following is a description of each folder in that folder. All data layers include metadata files readable by ArcCatalog, or many of the files include "xxxxx.html" files that are html format metadata files.

_ArcReaderDocuments: Includes all the published ArcReader maps. These are interactive maps of the data presented in the static maps of the Mapping Tool. This will allow you to turn layers on and off, and see how the different layers related to one another. ArcReader is a free software available for download at:
http://www.esri.com/software/arcgis/arcreader/download.html
You will need to download the appropriate version for your operating system and install it if you do not already have it on your computer. You will also see a link to download a nice tutorial on this page to get to know ArcReader.

Aquatic: Includes the aquatic criteria sub-watershed ranking shapefiles.

BaseData: Includes all the background spatial layers, most of which come from Wisconsin DNR. Included in this folder is an "all rankings.xls" excel spreadsheet that has all the rankings from all the criteria associated with the sub-watersheds. It would be possible to create a custom sub-watershed prioritization using this file.

Stress_Opportunity: Includes sub-watershed ranking shapefiles, the housing density base data shapefile, and the recharge raster dataset used to create that file. The landuse base data is in the Terrestrial folder.

Subwatershed Data.gdb: This is the file geodatabase of the 12 digit huc's used in the mapping tool. It includes the "SheboyganBasinSubwatersheds" Feature Dataset which contains file geodatabase tables of all the rankings for the different targets and stressors/opportunities and the subwatersheds feature data class,and relationships from the subwatershed features to all of the rankings for the different targets and stressors/opportunities.

Terrestrial: Includes the terrestrial criteria sub-watershed ranking shapefiles and the landcover and migratory bird habitat model base datasets.

Wetland: Includes the wetland criteria sub-watershed ranking shapefiles and the modeled floodplain and potentially restorable wetlands base datasets.

Once you have ArcReader installed on your machine, you will be able to open and manipulate the display of any of the "xxxxx.pmf" files in the ArcReaderDocuments folder. All of the data are compatible with ESRI products and many other GIS software programs that can read ESRI format data.