Identification of Priority Forests in the Upper Mississippi River System

U.S. Department of the Interior
U.S. Geological Survey

Identification of Priority Forests in the Upper Mississippi River System

by

Jason J. Rohweder
U.S. Geological Survey
Upper Midwest Environmental Sciences Center
2630 Fanta Reed Road
La Crosse, Wisconsin 54603

and

Theresa M. Heyer
Northeastern Area, S&PF
USDA Forest Service
1992 Folwell Ave
St. Paul, MN 55108

Samuel Osinde
Upper Mississippi Forest Partnership
Wisconsin Dept. of Natural Resources
3550 Mormon Coulee Road
La Crosse WI 54601

Darrell Zastrow
Wisconsin Dept. of Natural Resources
PO Box 7921
Madison WI 53707-7921

Steve Westin
MO Department of Conservation
Division of Forestry
PO Box 180
Jefferson City, MO 65102

Kirk Lohman
U.S. Geological Survey
Upper Midwest Environmental Sciences Center
2630 Fanta Reed Road
La Crosse, Wisconsin 54603

Prepared for

Upper Mississippi Forest Partnership
November 2006

Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Department of Interior, U.S. Geological Survey.

Identification of Priority Forests in the Upper Mississippi River System

Core team:

Mike Dosskey
USDA Forest Service
National Agroforestry Center

Theresa Heyer
USDA Forest Service
Northeastern Area

Eileen Kirsch
US Geological Survey
Midwest Environmental Sciences Center

Tom Luther
USDA Forest Service
Northeastern Area

Samuel Osinde
Wisconsin Department of Natural Resources
Upper Mississippi Forest Partnership

Jason Rohweder
US Geological Survey
Midwest Environmental Sciences Center

Al Todd
USDA Forest Service
Northeastern Area

Barb Tormoehlen
USDA Forest Service
Northeastern Area

Steve Westin
Missouri Department of Conservation

Darrell Zastrow
Wisconsin Department of Natural Resources

Partners in providing key data layers:

Tim Aunan
Minnesota Department of Natural Resources

Todd Bishop
Iowa Department of Natural Resources

Chris Ensminger
Iowa Department of Natural Resources

Brett Martin
Indiana Department of Natural Resources

John C. Nelson
US Geological Survey
Environmental Sciences Center

Andy Paulious
Wisconsin Department of Natural Resources

Janel Pike
Wisconsin Department of Natural Resources

Contents

Introduction 1

Spatial Datasets Used in Analyses 2
Data Parameters 2
Forested Wetlands 4
Land Cover 6
Slope 7
Public Lands 8
Change in Housing Density 10
Nitrogen Yield 12
Public Water Supply 13
Soils 15
Natural Floodplain Boundary 18
Hydrography 19
Natural Heritage Inventory 22

Existing Bottomland Forests and Priority Areas for Bottomland Afforestation 23
Introduction 23
Methods and Results 23
Conclusions 28

Preservation of Riparian Corridor Water Quality and Aquatic Habitat 28
Introduction 28
Methods and Results 29
Conclusions 45

Important Migratory Bird Habitat 45
Introduction 45
Methods and Results 45
Bottomland Forest Birds LINK Output 49
Upland Forest Birds LINK Output 51
Grassland Birds LINK Output 52
Shrubland Birds LINK Output 54
Conclusions 62

Priority Forests for Conservation 62
Introduction 62
Methods and Results 62
Conclusions 67

Next Steps 68

Acknowledgments 68

References Cited 68

Tables

Table 1. State Soil Geographic (STATSGO) Database map unit aggregate sample calculation 16
Table 2. Priority areas for bottomland afforestation model parameters 25
Table 3. Priority areas for bottomland afforestation model area summary 28
Table 4. Soil Survey Geographic (SSURGO) Database land capability class erodible soils calculations 32
Table 5. Riparian corridor afforestation priority model parameters 33
Table 6. Riparian corridor forest conservation priority model parameters 36
Table 7. Important migratory birds used in the analyses 47
Table 8. Priority forest model parameters 63

Figures

Figure 1. Study area 3
Figure 2. Forested wetlands 4
Figure 3. Wisconsin wetland data composition 5
Figure 4. National Land Cover Dataset (NLCD; 1992) 6
Figure 5. Slope (Percent Rise) 7
Figure 6. Public lands 8
Figure 7. Proximity to public lands 9
Figure 8. Predicted change in housing density 11
Figure 9. Nitrogen yield 12
Figure 10. Adjusted population of water consumers 14
Figure 11. Soil erodibility 15
Figure 12. Average soil capability class for non-irrigated soils 16
Figure 13. Average percent of soils classified as hydric 17
Figure 14. Average depth to water table 18
Figure 15. Natural floodplain boundary 19
Figure 16. National Hydrography Dataset 20
Figure 17. Proximity to hydrography 21
Figure 18. Hydrography 300 foot corridor 22
Figure 19. Existing bottomland forests and priority areas for bottomland afforestation 24
Figure 20. Diagram depicting how weighted overlay functions 26
Figure 21. Priority areas for bottomland afforestation model diagram 27
Figure 22. Percent agriculture by watershed 30
Figure 23. High resolution hydrographic and soil data availability 30
Figure 24. Locations of Watonwan River and South Fork of the Salt River watersheds 31
Figure 25. Riparian corridor afforestation priority model diagram 33
Figure 26. Watonwan River riparian corridor afforestation priority model output 34
Figure 27. Sample subwatershed depicting high riparian corridor afforestation priority 35
Figure 28. Riparian corridor forest conservation priority model diagram 36
Figure 29. Riparian corridor forest conservation priority model output 37
Figure 30. Sample subwatershed depicting high riparian corridor forest conservation priority 38
Figure 31. Summary of agricultural classes surrounding perennial and intermittent water bodies 39
Figure 32. Summary of forested classes surrounding perennial and intermittent water bodies 40
Figure 33. South Fork of the Salt River riparian corridor afforestation priority model output 41
Figure 34. Sample subwatershed depicting high riparian corridor afforestation priority 42

Figure 35. Riparian corridor forest conservation priority model output 43
Figure 36. Sample subwatershed depicting high riparian corridor forest conservation priority 44
Figure 37. Example of NatureServe range maps 48
Figure 38. Bottomland forest birds matrix 49
Figure 39. Bottomland forest birds LINK output 50
Figure 40. Upland forest birds matrix 51
Figure 41. Upland forest birds LINK output 52
Figure 42. Grassland birds matrix 53
Figure 43. Grassland birds LINK output 54
Figure 44. Shrubland birds matrix 55
Figure 45. Shrubland birds LINK output 55
Figure 46. Area-weighted mean potential species occurrence by bird guild 56
Figure 47. Area-weighted mean potential species occurrence by bird species 56
Figure 48. Bird guild mean potential species occurrence scores separated by area percentage 57
Figure 49. Mean potential species occurrence averaged by county 59
Figure 50. Potential species richness averaged by county 60
Figure 51. Simpson's diversity index averaged by county 61
Figure 52. Priority forest model diagram 65
Figure 53. Priority forest model output 66
Figure 54. Priority forest model scores and percent forest summarized by watershed 67

Introduction

The Upper Mississippi River System (UMRS) is a valuable natural, historic, cultural, and economic resource. The river supports a tremendous diversity and abundance of wildlife. Use of the land and the river over time has often come at the expense of wildlife, natural function of the river and its watershed, and a clean environment (Wiener et al. 1998). Steady progress has been made on a number of pollution problems; however, the river is still faced with some difficult and complex management challenges. Urban and industrial growth, habitat loss, sediment and nutrient loading, and the effects of river regulation and modification have all disrupted the ecological health of the watershed and the river system. Downstream, recent studies of hypoxia problems in the Gulf of Mexico have further pointed out the need for extensive efforts in the UMRS watershed to reduce nutrient pollution from agricultural and urban lands and restore critical habitats, like forests that provide both biological benefits and the ability to protect water quality.

The United States Department of Agriculture (USDA) Forest Service's Northeastern Area and state foresters from Wisconsin, Minnesota, Iowa, Illinois, Missouri, and Indiana have joined in partnership to study and manage forests in the UMRS. The Upper Mississippi Forest Partnership (UMFP) focuses activities, demonstration projects, and cooperative programs on key watershed forestry issues. The UMFP was formed to focus efforts on the positive contribution that the region's forests can make in addressing these water quality and habitat loss issues (Knutson et al 1996).

The Upper Mississippi Forest Partnership has developed and adopted an action plan that focuses on four primary management themes:

1. Restoration of bottomland hardwoods;
2. Establishment of riparian forest buffers;
3. Providing critical migratory bird habitat; and
4. Conservation of priority forest areas.

In an effort to guide the implementation of the UMFP action plan, the partnership conducted a Geographic Information System (GIS) study. The goal of the study was to generate products that will help UMFP focus its activities and limited resources.

The three main tasks included:

1. Assemble GIS data layers for conservation planning within the geographic boundaries of the UMRS.
2. Organize the data layers.
3. Create and execute GIS models to identify geographical areas conducive to each management theme.

The GIS software used for this analysis was ArcGIS 9.0 (Environmental Systems Research Institute ([ESRI] Redlands, California). This software allows for organized storage, manipulation, and publishing of the various relevant data layers used. Also packaged within this platform is a visual modeling extension called ModelBuilder 9.1. This extension provides the

framework and necessary tools to build and execute the models used to create the outputs for the selected primary management themes. Within ModelBuilder, the user uses a flowchart format to add GIS data and then the user alters this input data with the use of existing or user-developed tools to create new output.

The overriding objective of this analysis is to identify where investments of time and resources can be best applied to resolve water quality and wildlife habitat issues in the UMRS. It is not intended to be a site level planning tool. That is the next step beyond this analysis.

Identification of high priority areas was accomplished in much of the analysis using a system of weighted overlays. The help documentation within ArcGIS 9.0 defines weighted overlay as "a technique for applying a common measurement scale of values to diverse and dissimilar inputs to create an integrated analysis." The values or weights that were given to each of the data layers were chosen based upon the knowledge of the members of the GIS advisory committee that was created by the UMFP steering committee.

This analysis was completed by the United States Geological Survey (USGS) Upper Midwest Environmental Sciences Center through an interagency agreement among UMFP participating agencies. We used the best available data to develop output products. The following sections describe the relevant data sources and methodologies used to produce the output products.

Spatial Datasets Used in Analyses

Many spatial datasets were used to complete the analyses. In the following sections, a sample figure is given depicting the areal extent and relevant attributes of each dataset. Each figure will display the data layer within the context of the entire UMRS and also give a close-up of an area (highlighted within UMRS with a dark black square) to emphasize the data at a scale commensurate with the chosen 30-meter cell size. Also, text describing the data source, data processing steps, and data provider(s) follow. Data were given preference if they were the most current available, most accurate, had the highest spatial and thematic detail, were regionally available, and were relevant to the questions being asked. It is important to note that not all datasets used in each analysis were of the same spatial resolution as the outputs created using the models. Some datasets, such as those based upon the State Soil Geographic (STATSGO) database map unit and the 8-digit hydrologic code (HUC) are of a lower spatial resolution than many of the other datasets, such as the National Land Cover Dataset or slope.

Data Parameters

All datasets were clipped by the study area defined as those areas within the Upper Mississippi River System that intersect the states of Minnesota, Wisconsin, Iowa, Illinois, Indiana, and Missouri (Figure 1). This accounts for an area in excess of 188,000 square miles.

Figure 1. Study area

Data used in the analysis and subsequent output datasets are in the following coordinate system:

Projection	ALBERS
Datum	North American Datum of 1983 (NAD83)
Spheroid	Geodetic Reference System 1980 (GRS80)
Units	METERS
Zunits	NO
Xshift	0.0
Yshift	0.0
Parameters:	
1st standard parallel	29 30 0.0
2nd standard parallel	45 30 0.0
Central meridian	-96 0 0.0
Latitude of projection's origin	23 0 0.0
False easting (meters)	0.0
False northing (meters)	0.0

Forested Wetlands

The primary source for wetland data (Figure 2), specifically forested and scrub-shrub wetlands, were provided by the United States Fish and Wildlife Service (USFWS) National Wetland Inventory (NWI). These data delineate the areal extent of wetlands and surface waters as defined by Cowardin et al. (1979). NWI data are available for all of the states within the study area but is only available for a small portion of the state of Wisconsin. The small areas of Wisconsin that were mapped by the NWI were not used in this analysis and other data sources were used to fill this data gap. Only those polygons labeled with the NWI attribute "FO" (Forested) or "SS" (Scrub/Shrub) were included in the analysis.

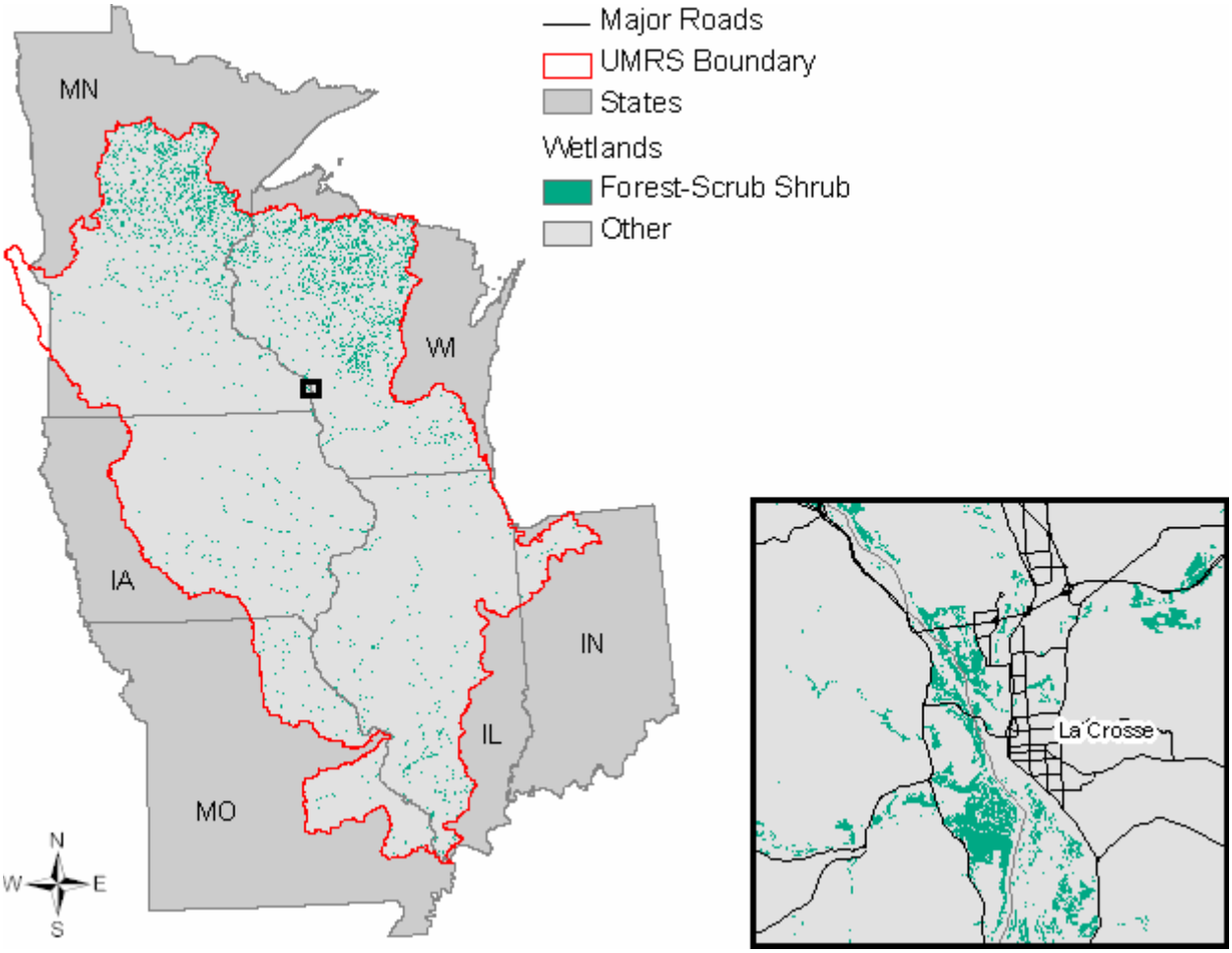

Figure 2. Forested wetlands

To create a seamless data layer, additional forested wetland data were compiled for the state of Wisconsin. Two data sources were used to accomplish this task. The first source was the Wisconsin Wetlands Inventory. For this dataset, wetland delineations were created from rectified photographic base maps. Polygons labeled with the classes "Forested" or "Scrub/Shrub" were used in the analysis. Some areas in Wisconsin lacked robust attribute delineations and consequently these polygons couldn't be classified as to their wetland type (e.g., Forested). For these areas, representing several townships (Figure 3), the Wiscland Land Cover raster dataset was used as a surrogate. This dataset is based on Landsat satellite imagery

acquired from the Multi-Resolution Land Characteristics Consortium acquired in 1992. Polygons labeled with the classes “FORESTED WETLAND: broad-leaved deciduous”, “FORESTED WETLAND: coniferous”, “FORESTED WETLAND: mixed deciduous/coniferous”, “WETLAND: lowland shrub”, “WETLAND: lowland shrub: broad-leaved deciduous”, “WETLAND: lowland shrub: broad-leaved evergreen”, or “WETLAND: lowland shrub: needle-leaved” were used in the analysis.

Forested wetlands are important for their contribution to the UMRS in the form of water quality improvement and wildlife habitat. Being able to locate these areas spatially is important when prioritizing forests for conservation.

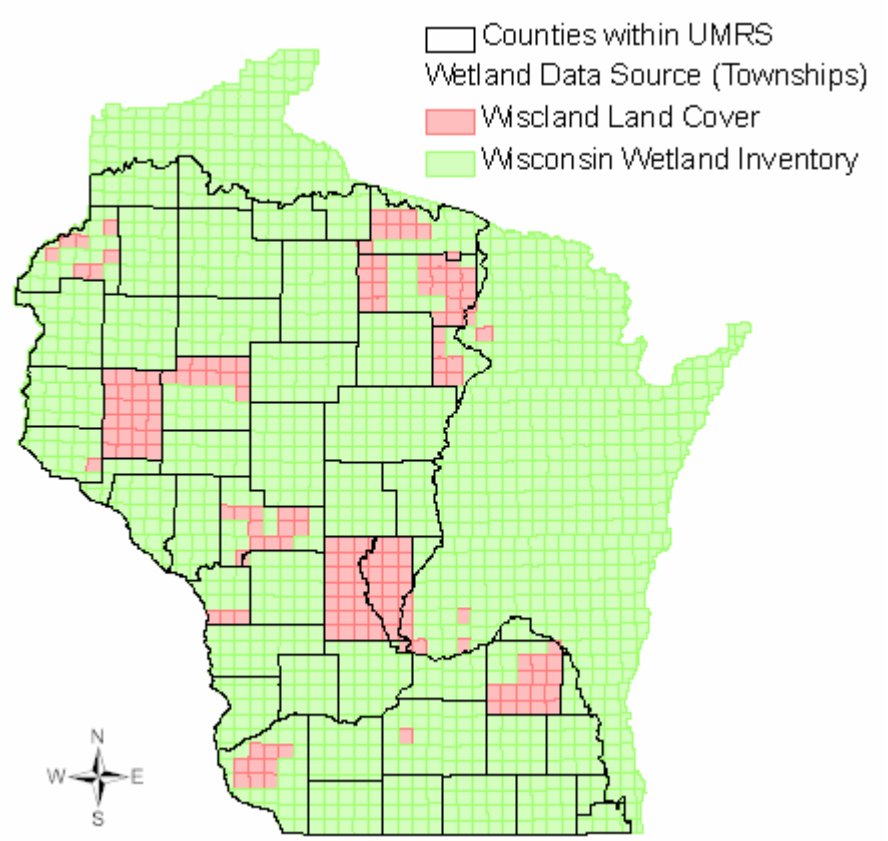

Figure 3. Wisconsin wetland data composition

More information on the National Wetland Inventory can be found at the following web address: http://www.fws.gov/nwi/.
More information on the Wisconsin Wetland Inventory can be found at the following web address:
http://dnr.wi.gov/org/water/fhp/wetlands/mapping.shtml.
More information on the Wiscland Land Cover Dataset can be found at the following web address:
http://www.dnr.state.wi.us/maps/gis/datalandcover.html.

Land Cover

Land cover data were acquired from the National Land Cover Dataset (NLCD; 1992). The USGS, in cooperation with the U.S. Environmental Protection Agency (USEPA), has produced a land cover dataset for the conterminous United States on the basis of 1992 Landsat thematic mapper imagery and supplemental data. The NLCD is a component of the USGS Land Cover Characterization Program. The seamless NLCD contains 21 categories of land cover information suitable for a variety of state and regional applications, including landscape analysis, land management, and modeling nutrient and pesticide runoff (Figure 4). The NLCD is distributed by state as 30-meter resolution raster images in an Albers Equal-Area map projection.

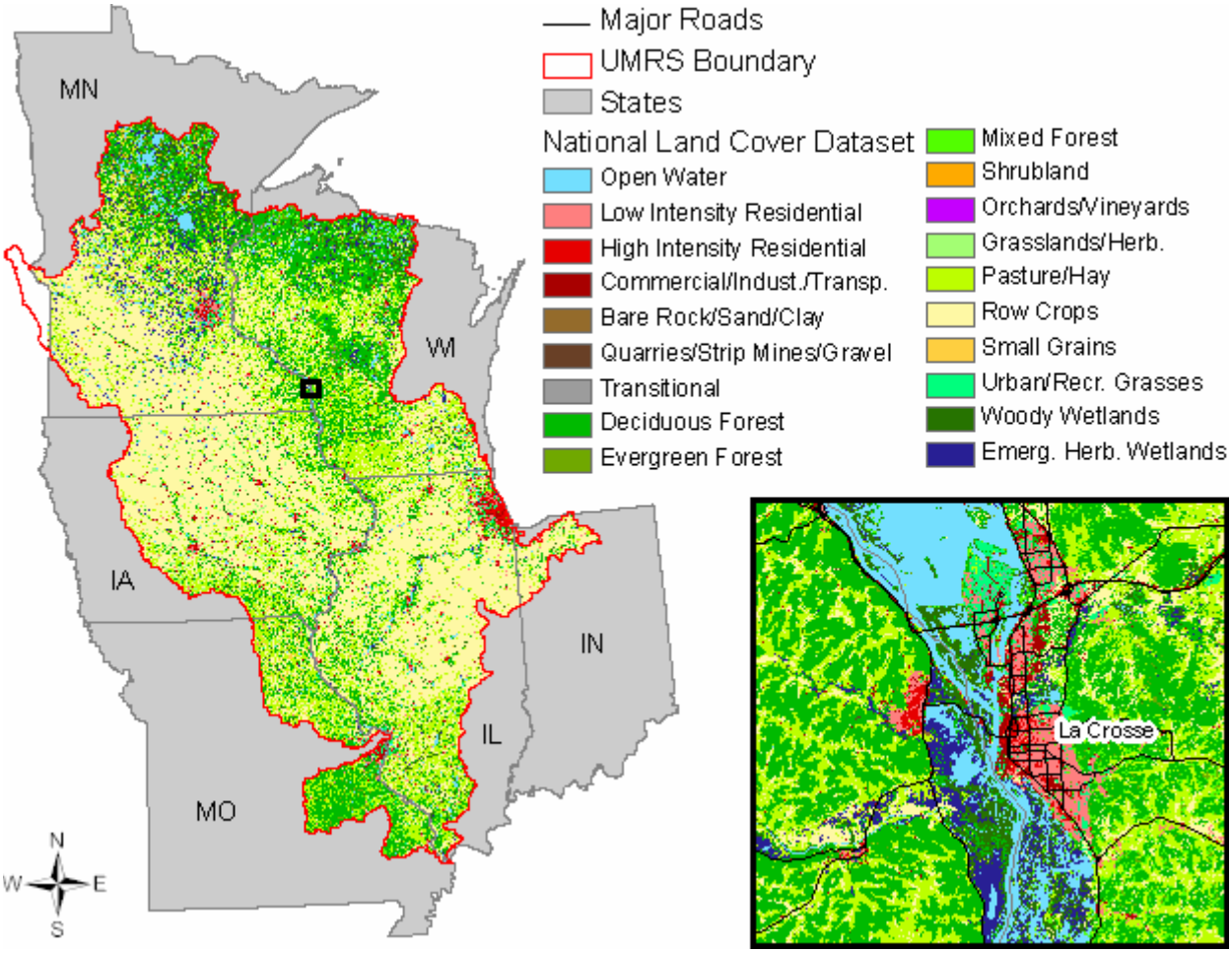

Figure 4. National Land Cover Dataset (NLCD; 1992)

This data layer is important because of the ability to separate areas of the landscape according to their land cover type down to a very manageable level.

More information on the National Land Cover Dataset can be found at the following web address:
http://landcover.usgs.gov/natllandcover.php.

Slope

Slope data were derived from 7.5-minute digital elevation model (DEM) data collected from the USGS (Figure 5). The DEMs consist of an array of elevations for ground positions at regularly spaced intervals. The DEM data for 7.5-minute units correspond to the USGS 7.5-minute topographic quadrangle map series for all of the United States and its territories except Alaska.

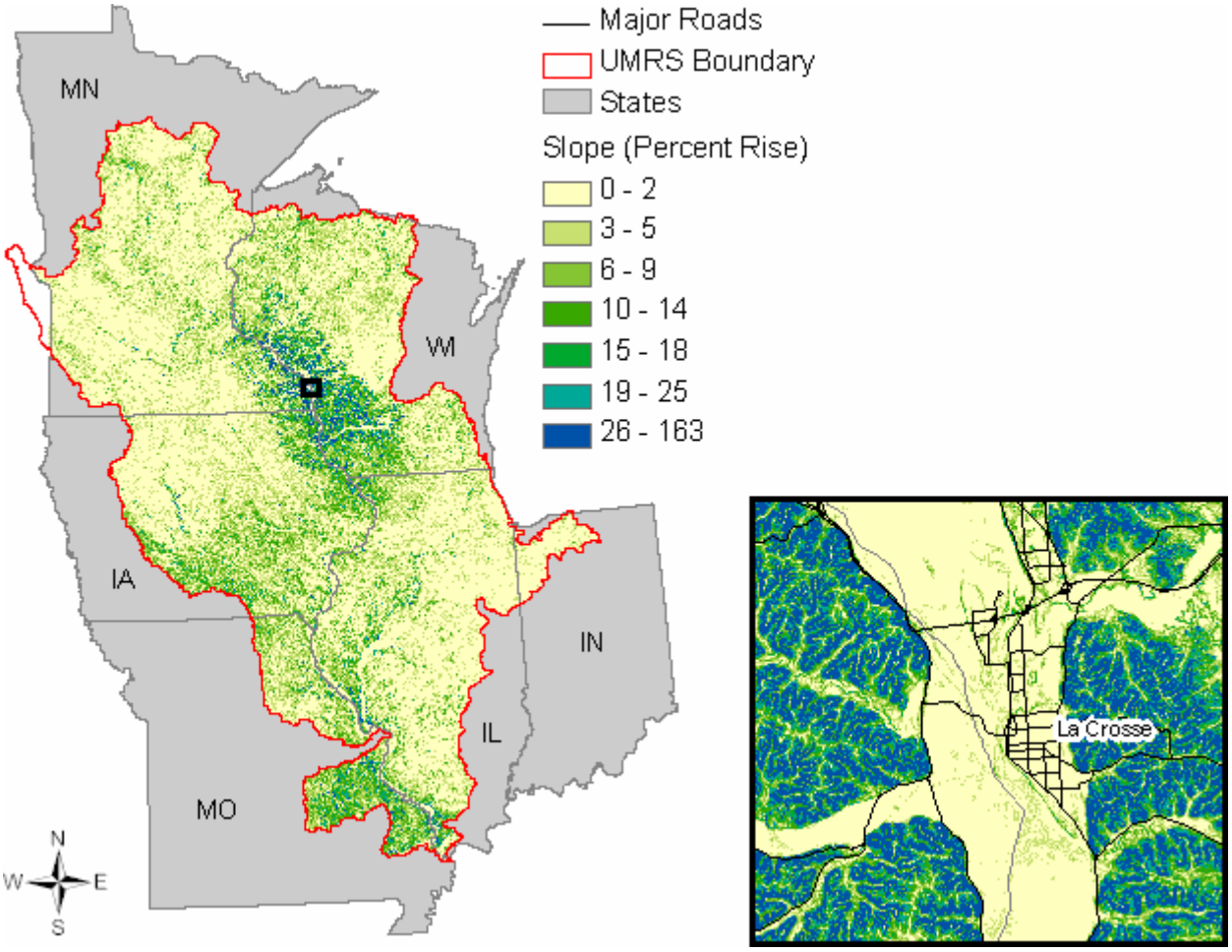

Figure 5. Slope (Percent Rise)

Slope identifies the maximum rate of change in value from each cell to its neighbors. Slope can be calculated as percent rise or degree of slope. For these analyses, we calculated slope as percent rise. Conceptually, the slope function fits a plane to the z-values of a 3 x 3 cell neighborhood around the processing or center cell (Burrough and McDonell 1998). As the slope angle approaches vertical (90 degrees) the percent rise approaches infinity. Slope percent rise groupings (e.g., 0-2, 3-5, etc.) were based upon common separations used in soil surveys (T.M. Heyer, USDA, Forest Service, personal communication, August 2006).

Slope becomes important in prioritizing areas of forest due to the effect of increased surface run-off on steep slopes and the increased ability for soils to be saturated on level slopes.

More information on USGS digital elevation models can be found at the following web address: http://edc.usgs.gov/products/elevation/dem.html.

Public Lands

Public lands data were acquired from the Conservation Biology Institute's (CBI) Protected Areas Database (PAD), Version 4 (Figure 6). This dataset was originally a product of collaboration between CBI and the World Wildlife Fund. It is updated as more current/accurate data become available. UMFP participants from the Wisconsin Department of Natural Resources (WIDNR) were concerned about the consistency of PAD data within the state of Wisconsin. They felt that federal and county lands were under-represented within the state. They suggested the substitution of stewardship data collected as part of the Wisconsin GAP project. This was accomplished to create a seamless public lands data layer.

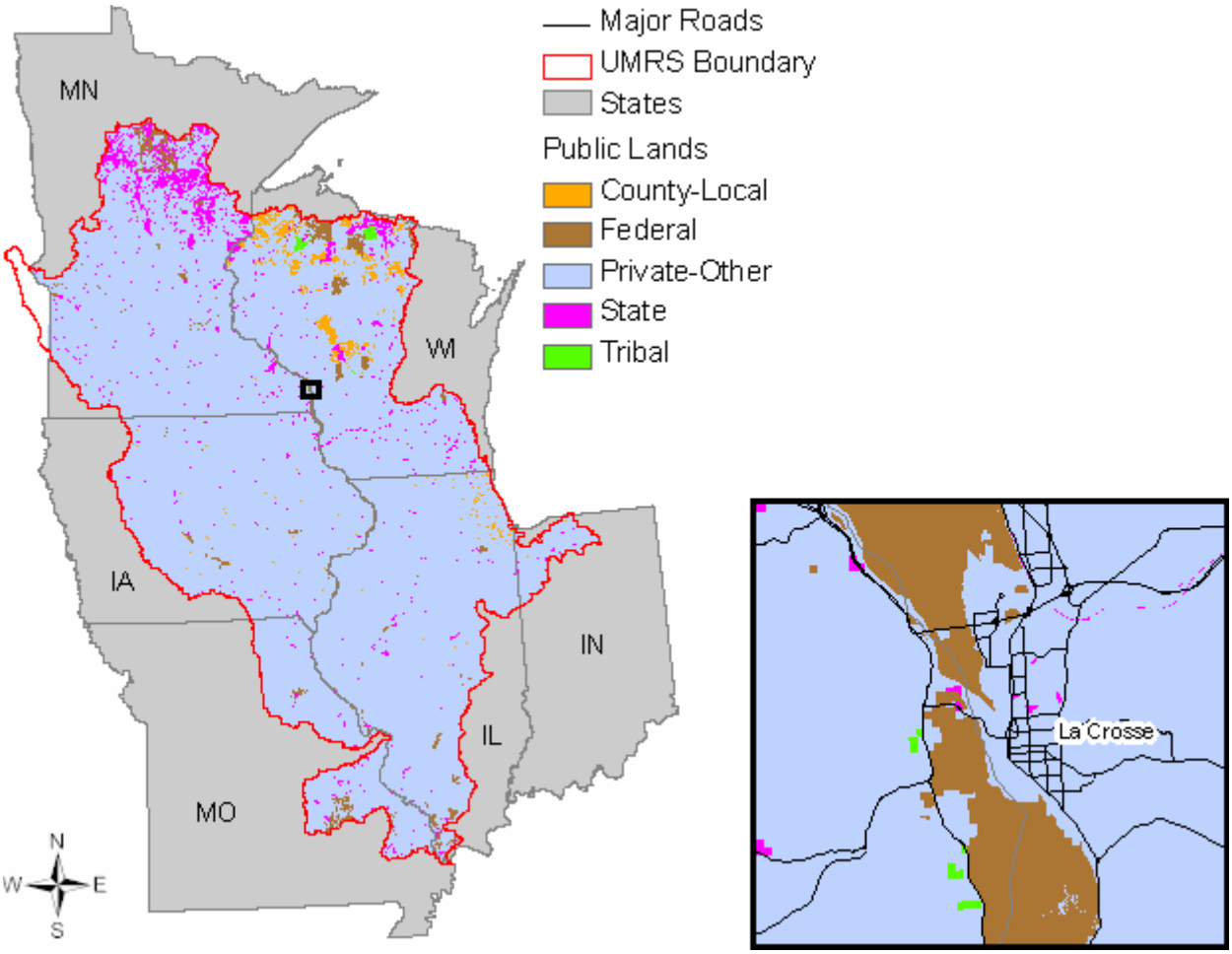

Figure 6. Public lands

Proximity to public lands was calculated by assigning values to cells in the data layer based on their Euclidian distance to all classes of public lands (Figure 7). Output data were aggregated

into ½ mile increments. Proximity to public lands is important in forest management due to the desire to create large contiguous blocks of forest.

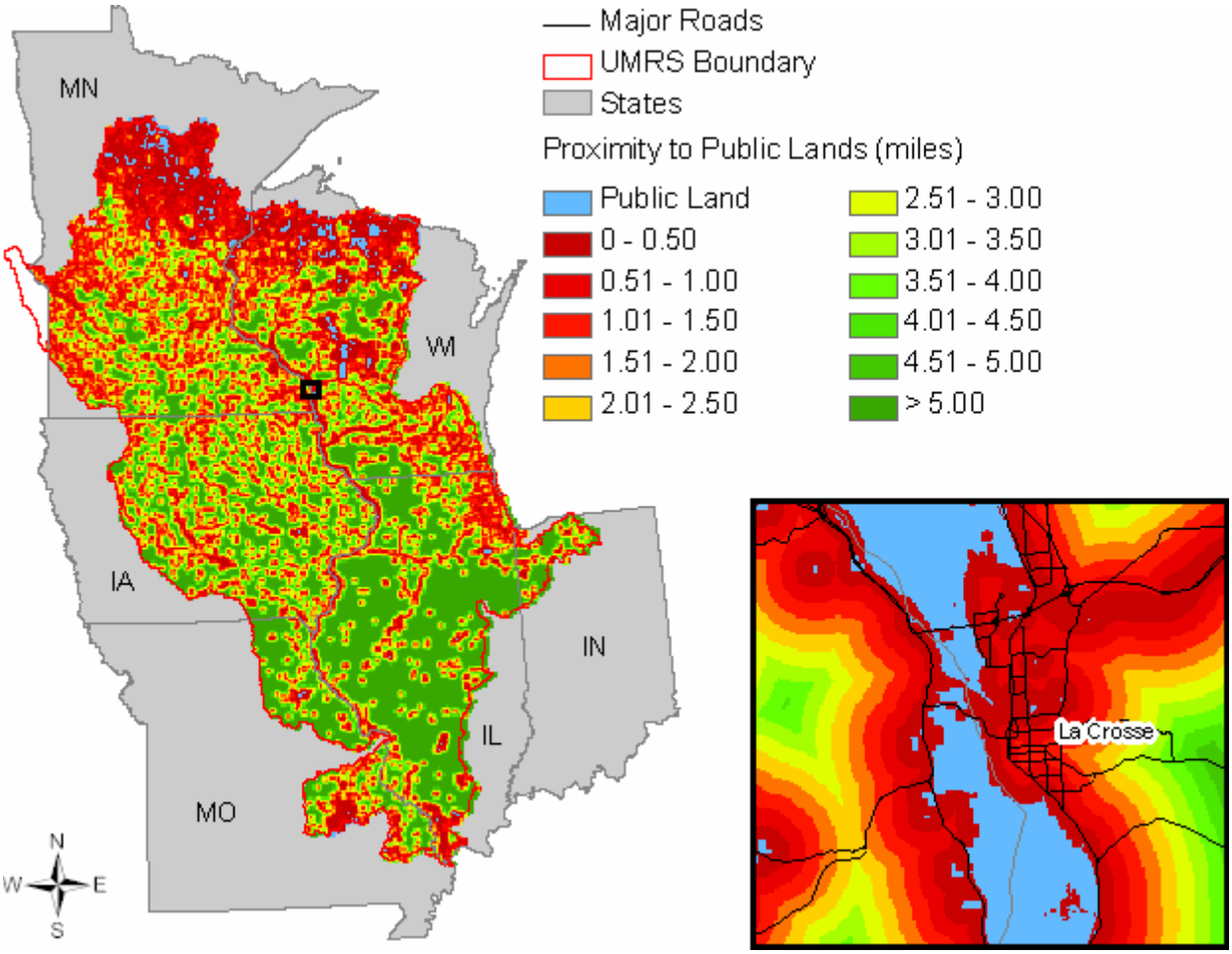

Figure 7. Proximity to public lands

More information on the Protected Areas Database can be found at the following web address: http://www.consbio.org/cbi/projects/PAD/index.htm.

Change in Housing Density

Change in housing density was used as an input data layer to represent a potential threat to currently forested areas. Those areas with a predicted increase in housing density may have a negative effect on current forest stands due to the difficulties involved with planning and managing small scale forest ownerships. The dataset used to depict change in housing density was acquired from Colorado State University (Theobald 2005). Two initial data layers were used to create a final data layer to be used in the analyses. The first depicted housing density in the year 2000 and the second depicted housing density in the year 2030. To reduce the overall file size, the continuous housing data values (in units per hectare * 1000) were aggregated into the following classes:

1: (<=1 – 2)	2: (2 – 8)	3: (9 – 15)	4: (16 – 31)
5: (32 – 49)	6: (50 – 62)	7: (63 – 82)	8: (83 – 124)
9: (125 – 247)	10: (248 – 494)	11: (495 – 1454)	12: (1455 – 4118)
13: (4119 – 9884)	14: (9885 – 24711)	15: (24712 – 9,999,999)	

Areas were excluded from the data layer if they fell under the categories: public/protected lands, open water, dominated by commercial/industrial/transportation land use (Theobald 2005). The SERGOM v2 model was used to forecast housing density growth using county-level population forecasts for 2030.

To create a change in housing density layer, the class value from 2030 was subtracted from the class value from 2000 for each cell. So if a cell in 2030 had a value of 8 and in 2000 the value was 5 then we know that there was an increase of three housing density classes from 2000 to 2030 (Figure 8).

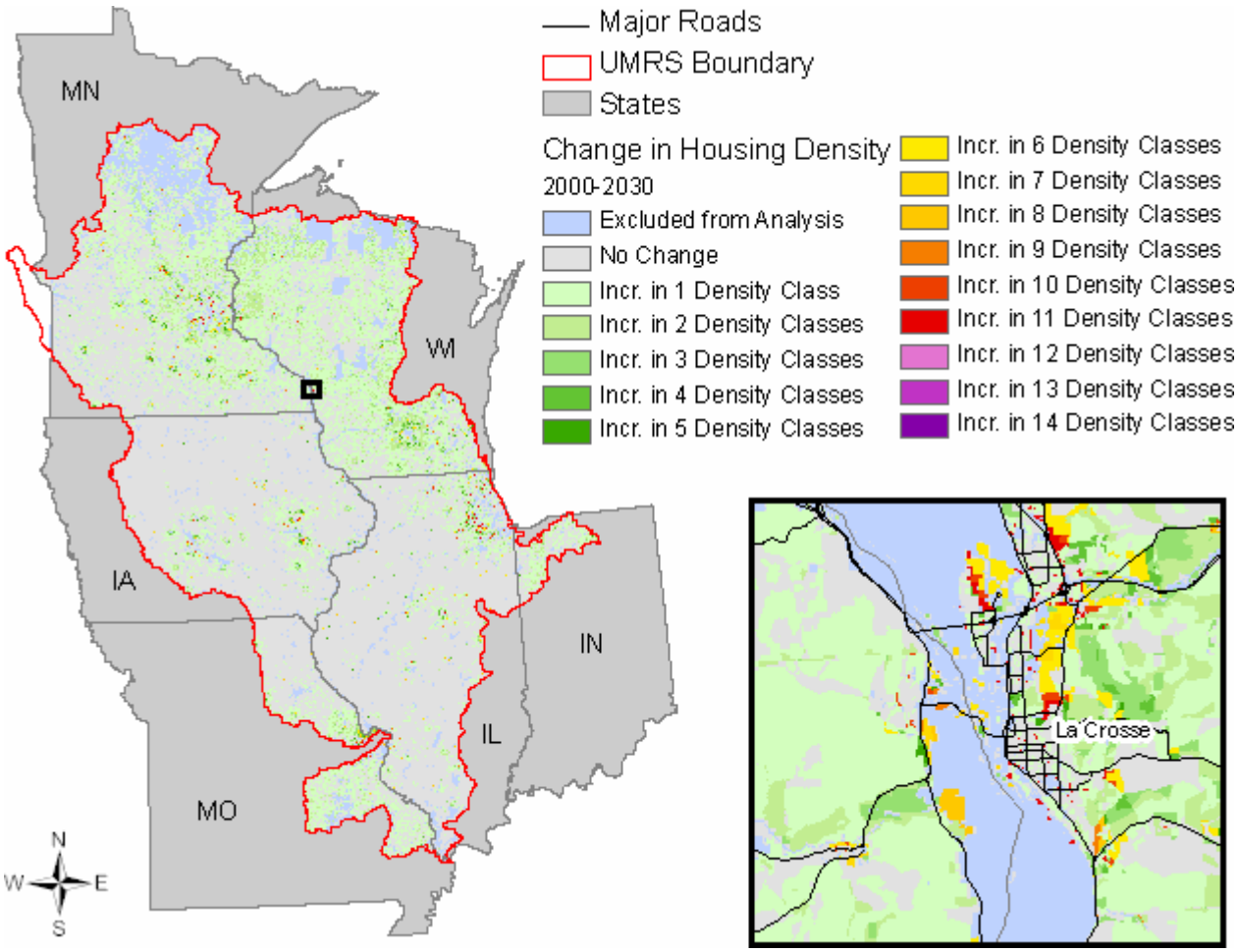

Figure 8. Predicted change in housing density

Increasing housing density is perceived as a threat to existing and potential forest cover. These areas are included within the analysis to denote where pressure may be put on the resource by human encroachment.

More information on the change in housing density dataset can be found at the following web address:
http://www.ecologyandsociety.org/vol10/iss1/art32/.

Nitrogen Yield

Nitrogen yield data were obtained from the USGS Water Resources Division. The Spatially Referenced Regressions On Watershed (SPARROW) relates in-stream water-quality measurements to spatially referenced characteristics of watersheds, including contaminant sources and factors influencing terrestrial and stream transport (Smith et. al. 1997). SPARROW provides an empirical estimate of the origin and fate of contaminants in streams. For these particular data layers we looked specifically at Total Nitrogen yield (kg/sq km/yr) by 8-digit HUC (Figure 9). Nitrogen yield classifications were grouped by 250 kg/sq km/yr increments.

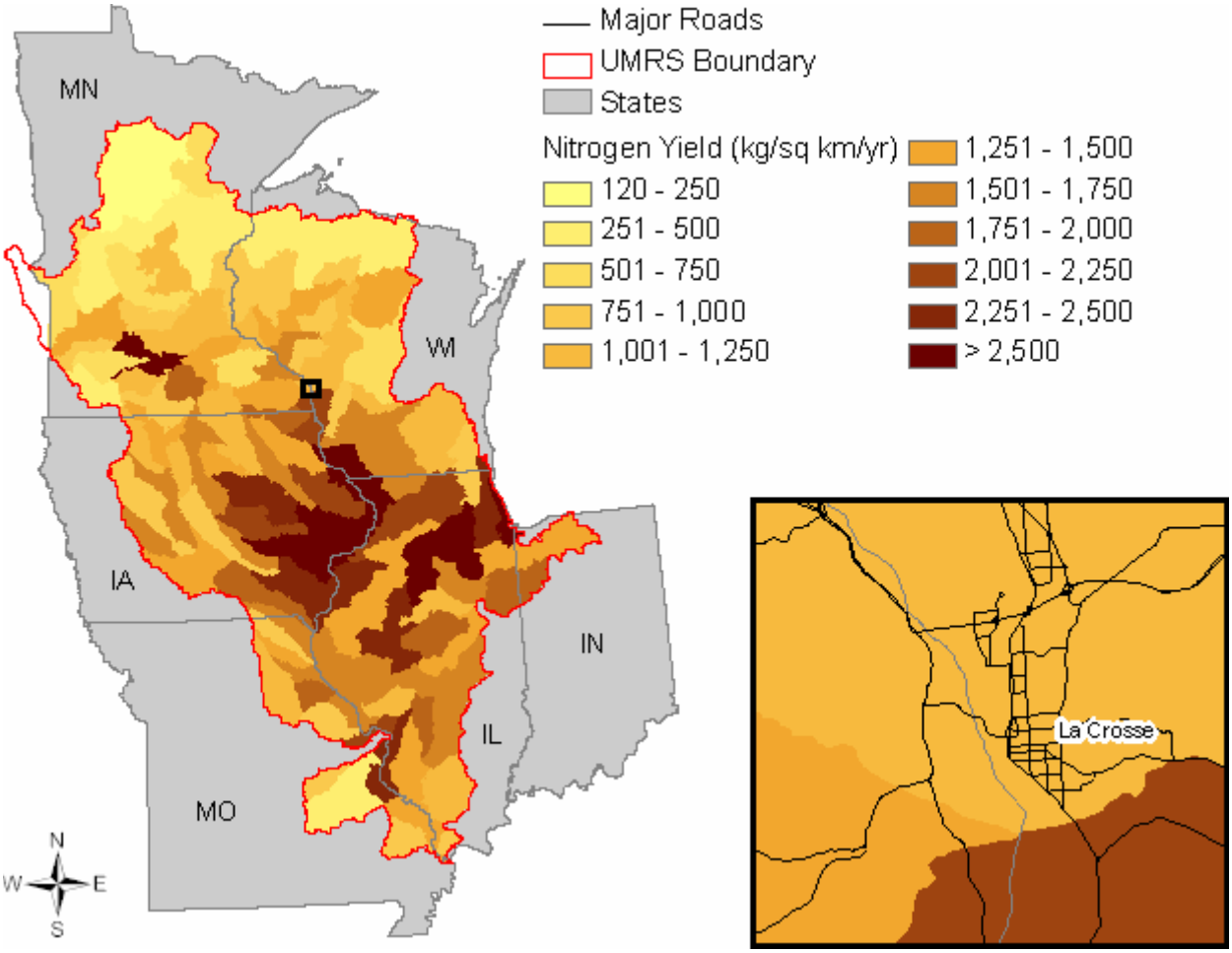

Figure 9. Nitrogen yield

This data layer makes it possible to denote those watersheds within the UMRS that are exporting large amounts of nitrogen.

More information on SPARROW can be found at the following web address: http://water.usgs.gov/nawqa/sparrow/wrr97/results.html.

Public Water Supply

Public Water Supplies (wells, wellhead protection areas) are important areas for protection from contamination of water quality. Healthy forests can help protect these areas. Sources of this dataset may include state GIS offices (Department of Natural Resources [DNR], Departments of Environmental Protection), and/or universities. The raw water intake data have largely been withdrawn from web sites by the USEPA due to homeland security concerns. This dataset was created to summarize public water supply data by individual 8-digit HUC. The attribute used for these coverages are adjusted by the population of water consumers by HUC. The values are adjusted by size (Figure 10).

The process used to calculate the adjusted population of water consumers by HUC is described below: Taken from R.L. Whitney, USDA Forest Service, personal communication, August 8, 2006.

1. The raw Public Water Supply (PWS) Consumers by HUC data table had several repetitive entries for consumers. For example, if PWS #1 had 4 intakes, and a total consumer base of 1,000 people, each of the 4 intakes would have 1,000 entered in the *consumers* column of the data table, which if summed would total 4,000 customers. To resolve this "double counting," the number of consumers was divided by the number of intakes in the PWS. This was done for each PWS. In PWSs that had intakes in more than one HUC, the area of the HUCs that made up the PWS were summed and a watershed area fraction was calculated for each HUC. This was the proportion PWS each watershed makes up. The number of water consumers was multiplied by this watershed fraction then divided by the number of PWS intakes in that HUC. This achieved the adjusted population of water consumers.

2. Once the adjusted population was determined for each intake, the adjusted population was summed by HUC to determine the total consumers by watershed.

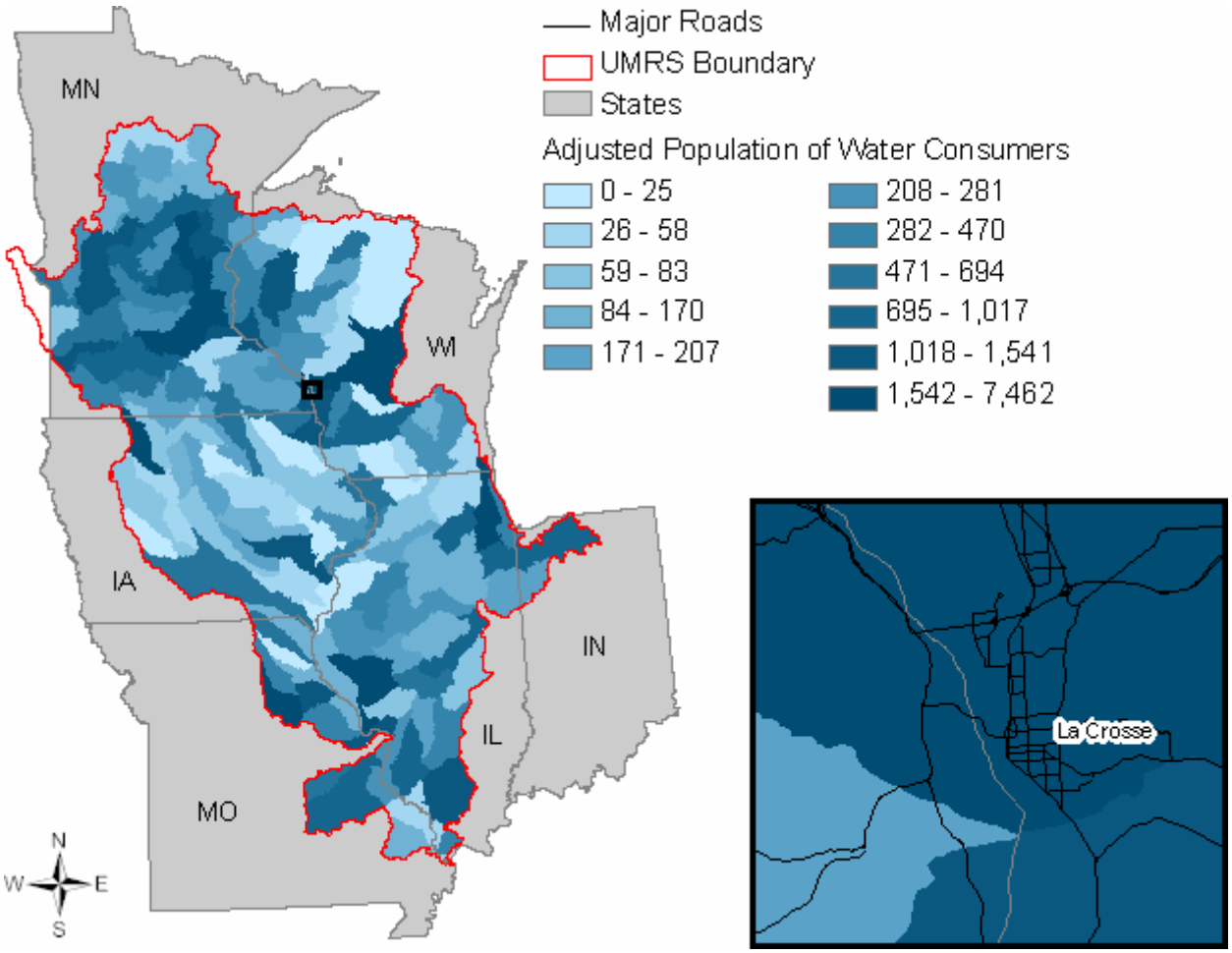

Figure 10. Adjusted population of water consumers

More information on public water system data can be found at the following web address: http://www.epa.gov/safewater/pws/index.html.

Soils

Soils data were acquired from the STATSGO database. STATSGO soil maps are created by generalizing the more detailed SSURGO soils maps. This is accomplished by sampling areas on the more detailed maps and applying these data statistically to the entire STATSGO map unit.

KFFACT is an erodibility factor that quantifies the susceptibility of soil particles to detachment and movement by water (Figure 11). This factor is used in the Universal Soil Loss Equation to calculate soil loss by water.

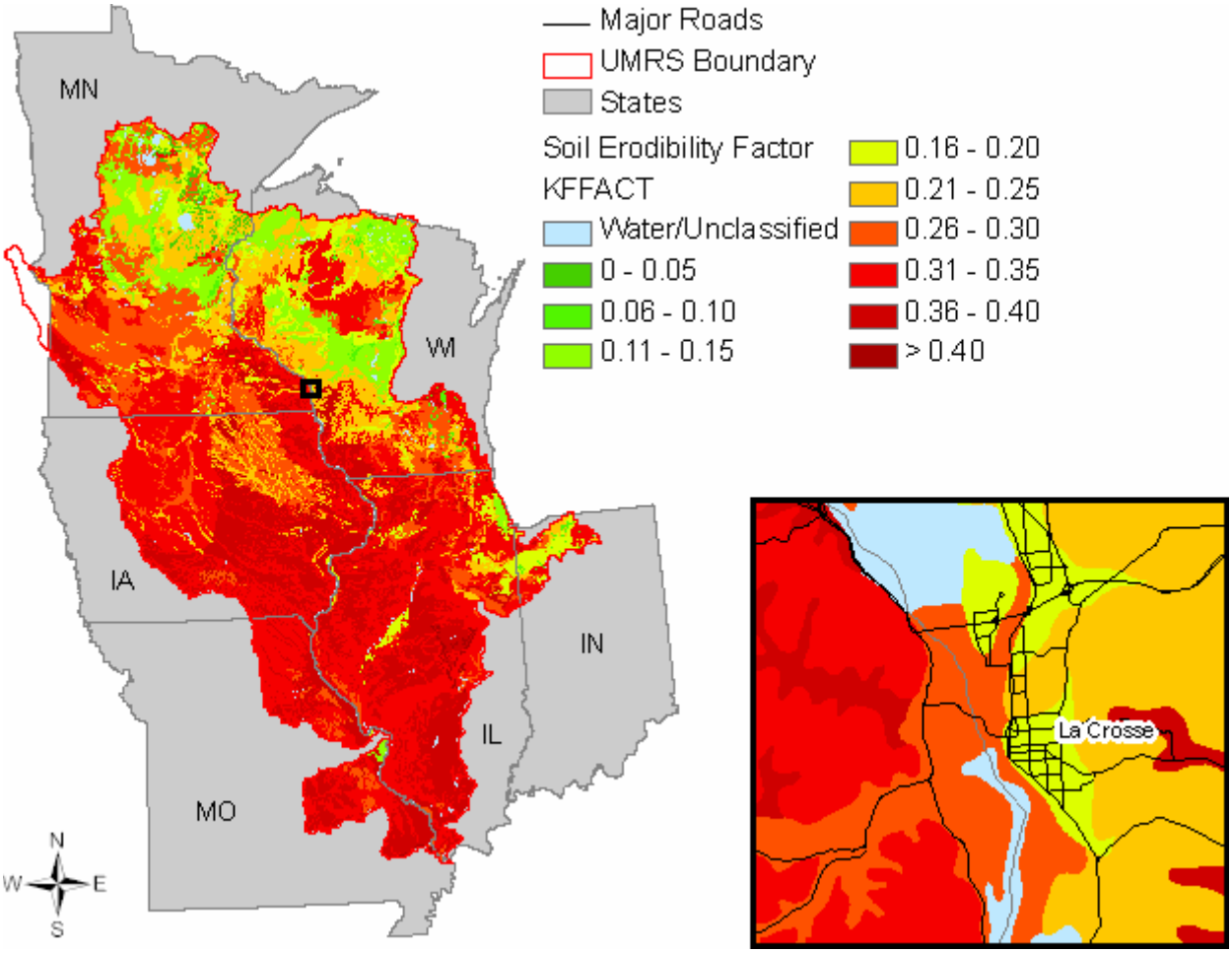

Figure 11. Soil erodibility

Non-irrigated capability class (CLNIRR) is a rating for soil units that indicate a soil's relative capability to supported non-irrigated agricultural use (Figure 12). As the number increases towards 8 the soil has more limitations and is less likely to be useable for non-irrigated agricultural use. Things that cause a soil unit to get a high ranking are related to erodibility, wetness, climate, and soil depth. Each STATSGO map unit is made up of several individual detailed soil components. Each of these components has a percentage applied to it that determines that components presence within the map unit. To calculate a unique value for each map unit, the CLNIRR for each respective component was multiplied by the components relative

percentage within the map unit. These values were summed to create the "Average Capability Class" value for the entire map unit (Table 1).

Table 1. State Soil Geographic (STATSGO) Database map unit aggregate sample calculation

Map Unit	Soil Component	Component Percent	CLNIRR	CLNIRR * Pct	WTDEPL	WTDEPL * Pct	HYDRIC	HYDRIC Pct
MN291	MOUNDPRAIRIE	33%	2	0.66	1	0.33	Y	33%
	MOUNDPRAIRIE	31%	7	2.17	0	0	Y	31%
	RAWLES	9%	2	0.18	4	0.36	N	
	KALMARVILLE	14%	2	0.28	0	0	Y	14%
	ABSCOTA VARIANT	2%	3	0.06	3	0.06	N	
	MINNEISKA VARIANT	4%	2	0.08	3	0.12	N	
	BOOTS	7%	6	0.42	0	0	Y	7%
TOTAL		100		3.85		0.87		85%

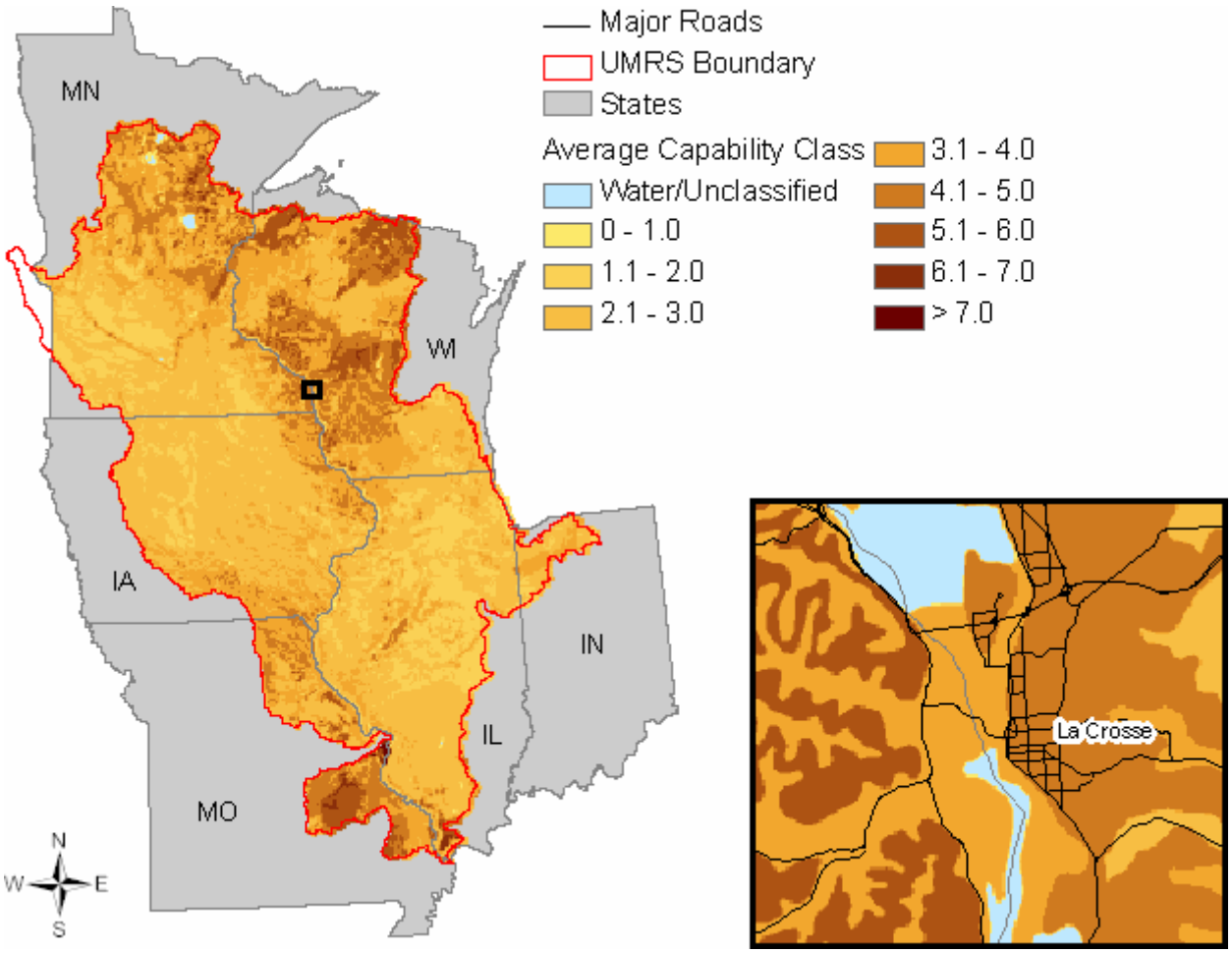

Figure 12. Average soil capability class for non-irrigated soils

Hydric soil rating (HYDRIC) is a classification given to each map unit's individual soil component (Figure 13). A soil is designated either yes (Y) or no (N) as to whether that soil component is considered hydric or not. The definition of a hydric soil is a soil that formed under conditions of saturation, flooding or ponding long enough during the growing season to develop anaerobic conditions in the upper soil horizon. The concept of hydric soils includes soils developed under sufficiently wet conditions to support the growth and regeneration of hydrophytic vegetation (USDA NRCS n.d.*a*). To calculate how much of the entire map unit was rated as hydric, each of the separate map components percentages were summed that were labeled as being hydric (Table 1).

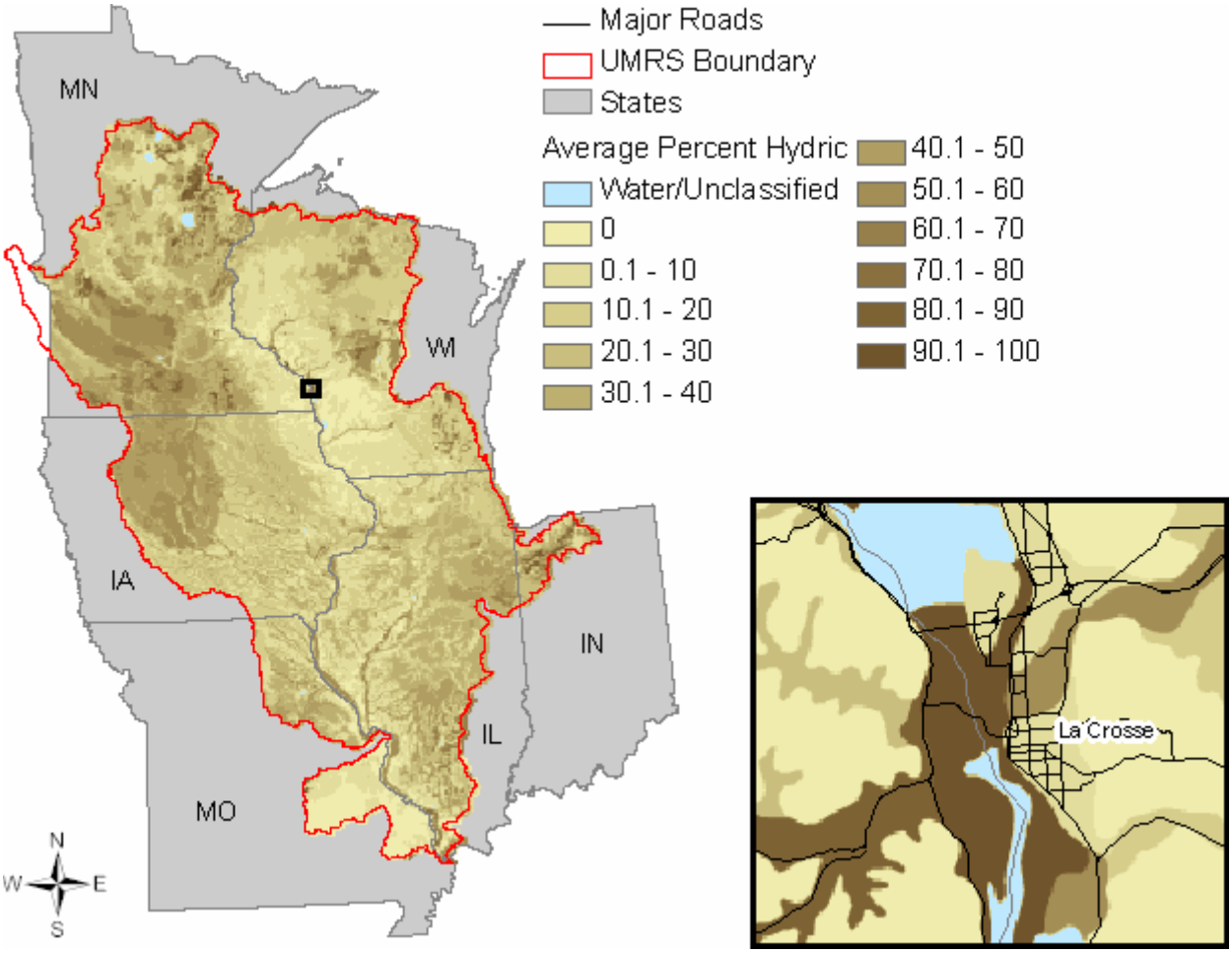

Figure 13. Average percent of soils classified as hydric

The minimum value for the range in depth to the seasonally high water table (WTDEPL) is measured in feet. To calculate a unique value for each entire map unit the WTDEPL for each respective component was multiplied by the components relative percentage within the map unit (Figure 14). These values were summed to create the "Average Depth to Water Table" value for the entire map unit (Table 1).

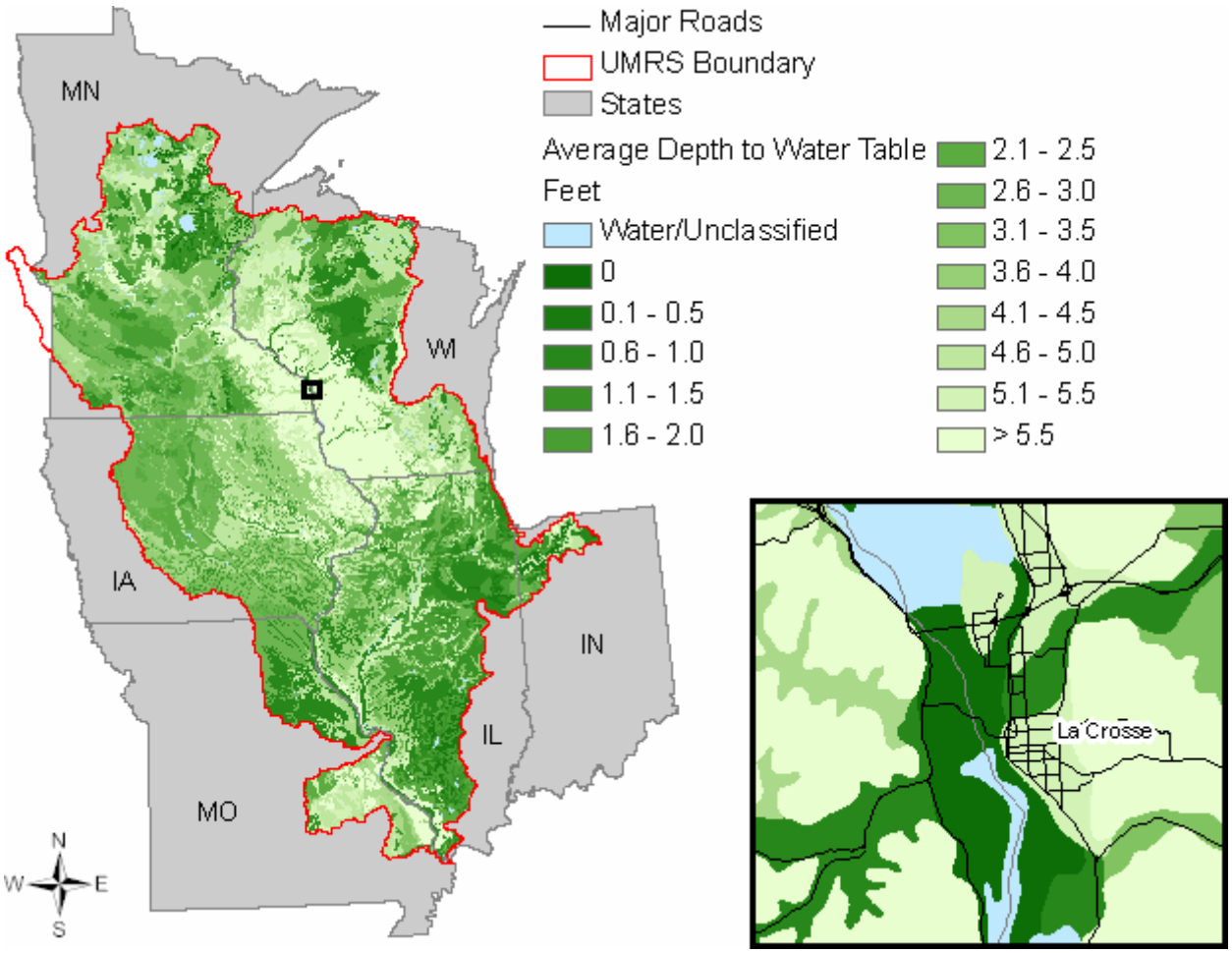

Figure 14. Average depth to water table

More information on STATSGO can be found at the following web address: http://www.ncgc.nrcs.usda.gov/products/datasets/statsgo/.

Natural Floodplain Boundary

The extent of natural floodplains was created by the Scientific Assessment and Strategy Team (SAST) to help provide an assessment of the 1993 Mississippi River flood and to aid in evaluating management alternatives in the event of a similar flooding event. The floodplain edge was delineated for all riverways extending from the main stem of the Mississippi, Missouri, Kansas, and Illinois Rivers greater than 1 km wide.

For these analyses, leveed and unleveed areas were intersected into the SAST floodplain boundary to provide an extra dimension for evaluation of the floodplain (Figure 15). The leveed areas polygon was acquired from the Army Corps of Engineers (COE), Rock Island District.

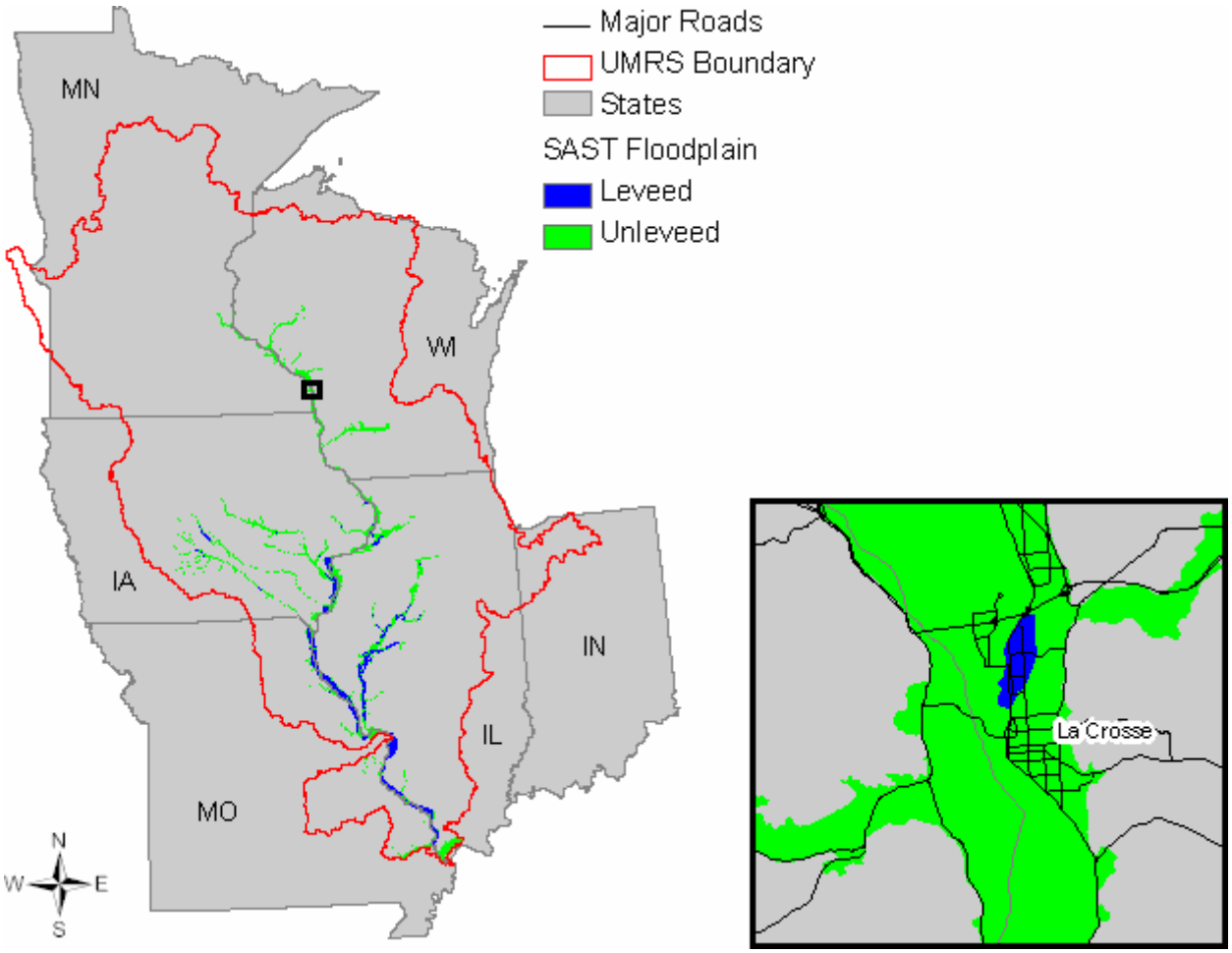

Figure 15. Natural floodplain boundary

More information on SAST data can be found at the following web address: http://edc.usgs.gov/sast/meta/fnl/fldpln.html.

Hydrography

The National Hydrography Dataset (NHD) is a comprehensive set of digital spatial data that contains information about surface water features such as lakes, ponds, streams, rivers, springs and wells. Only medium-resolution, 1:100,000 scale data are available for the entire UMRS (Figure 16). Classes deemed relevant for these analyses were selected from the overall list of hydrographic classes. Linear features were limited to perennial and intermittent streams, canals, and ditches. Polygonal features were limited to lakes, ponds, reservoirs, canals, ditches, swamps, marshes, and large rivers/streams.

The NHD is the culmination of recent cooperative efforts of the USEPA and the USGS. It combines elements of USGS digital line graph hydrography files and the USEPA Reach File (RF3).

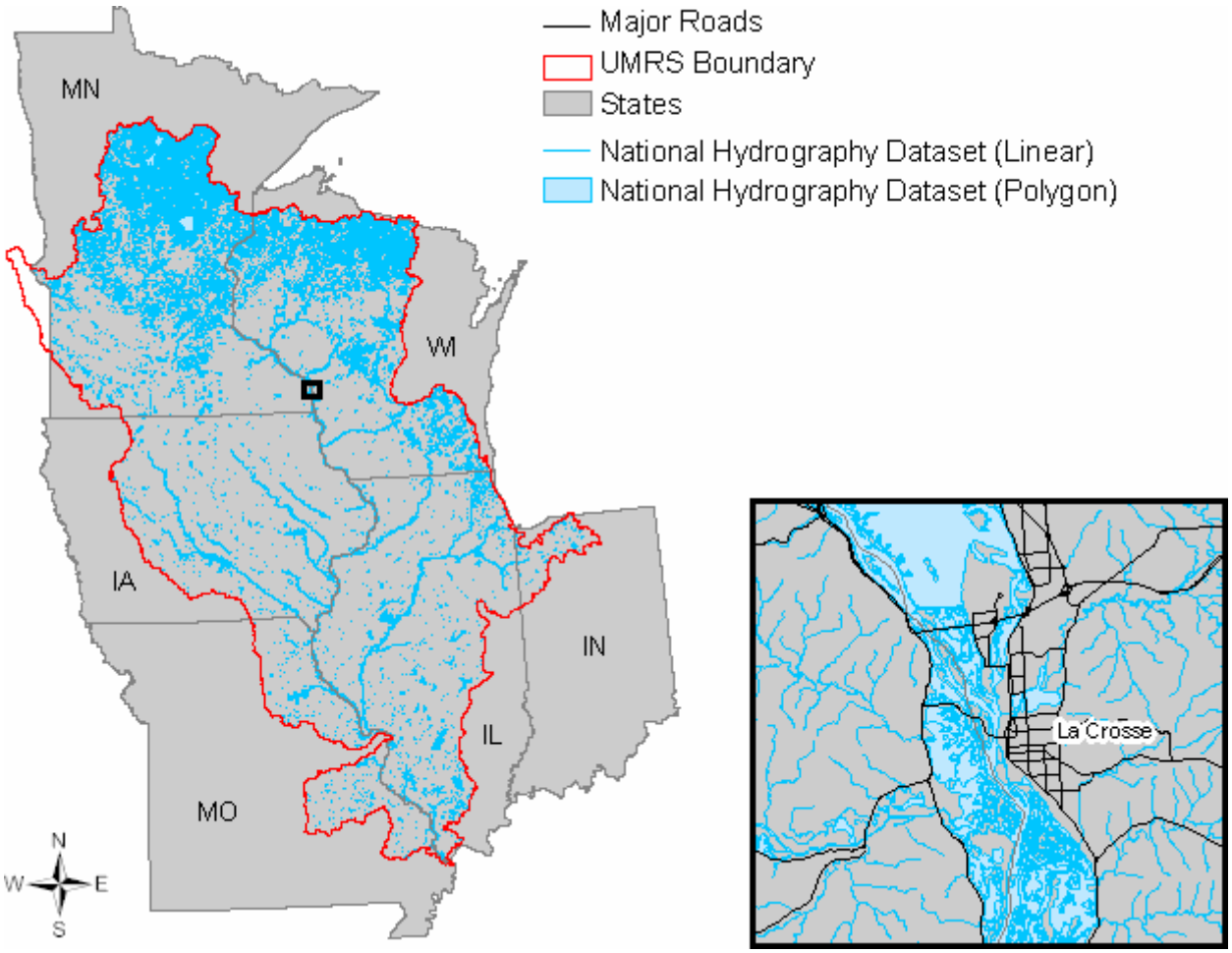

Figure 16. National Hydrography Dataset

Proximity to hydrography was calculated by assigning values to cells in the data layer based on their Euclidian distance to all classes of hydrography (Figure 17). Output data were aggregated into ½ mile increments.

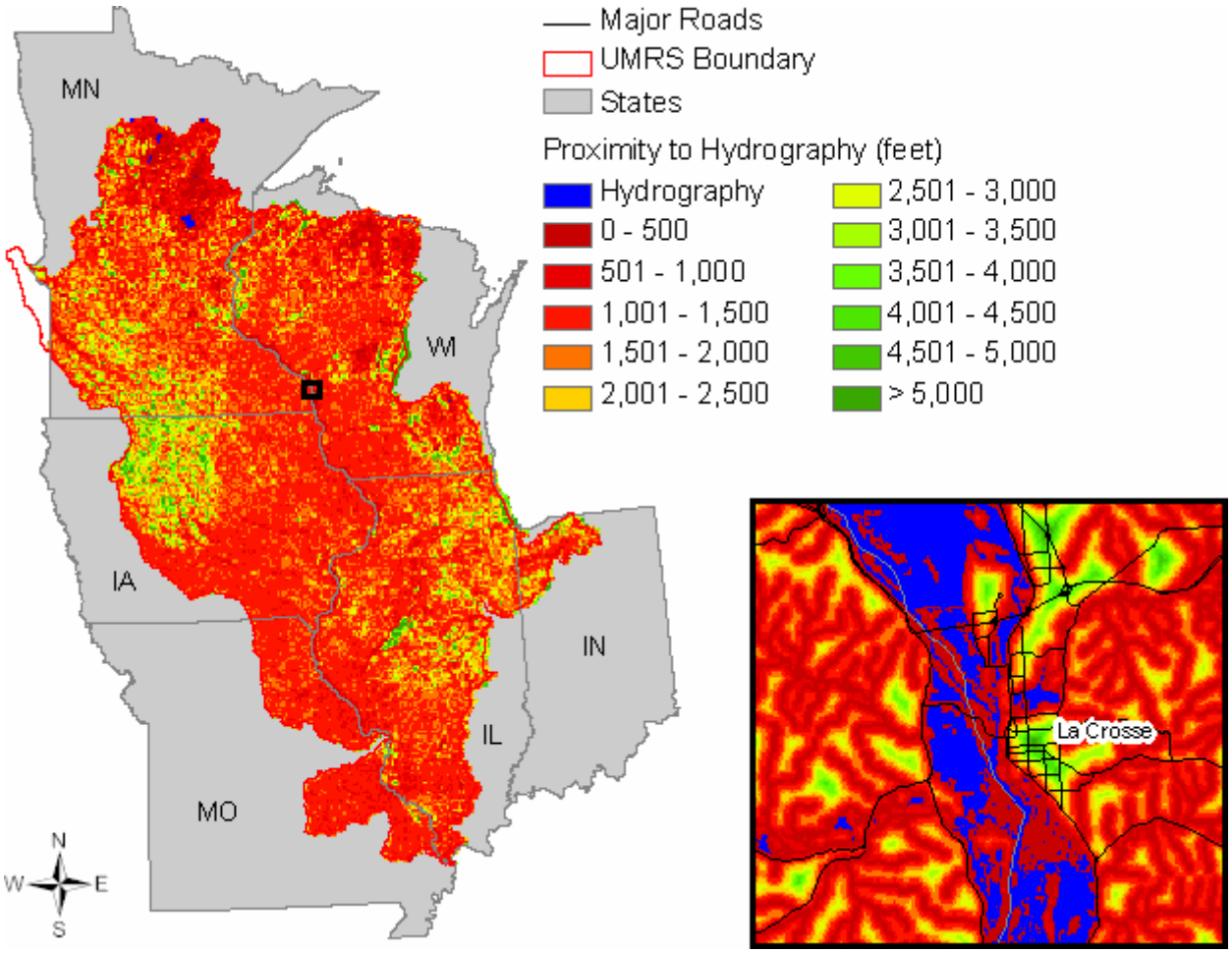

Figure 17. Proximity to hydrography

Existing hydrography was buffered 300 feet to create a dataset that would depict a 300 foot corridor around water bodies (Figure 18).

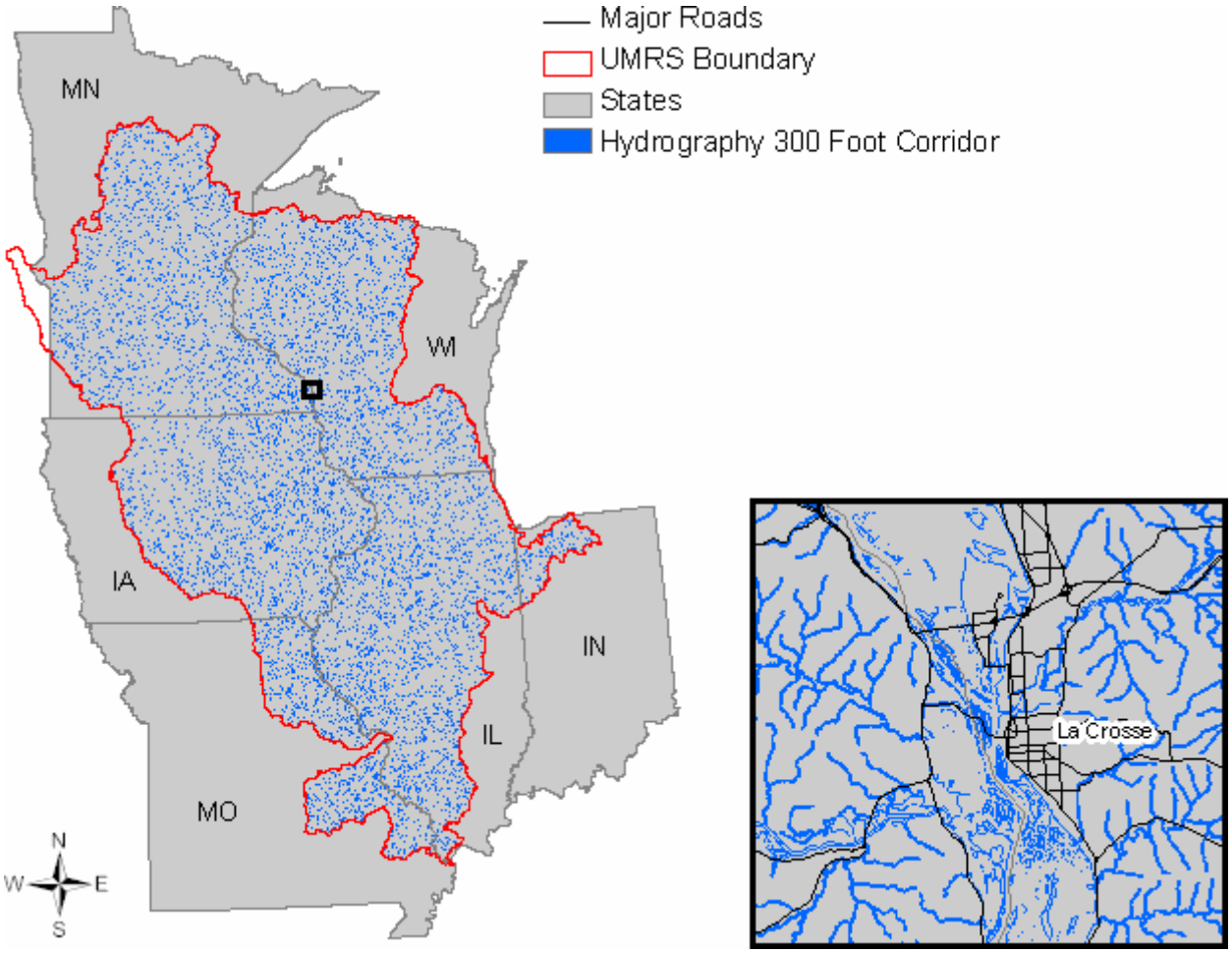

Figure 18. Hydrography 300 foot corridor

More information on the National Hydrography Dataset can be found at the following web addresses:
http://nhd.usgs.gov/
and
http://erg.usgs.gov/isb/pubs/factsheets/fs10699.html.

Natural Heritage Inventory

Natural Heritage Inventory (NHI) data were collected for the six states used in this study. The collected data exist in various data formats (raster/polygon/point) and spatial and thematic resolutions.

Wisconsin NHI data were supplied by the WIDNR. Per recommendations by the data supplier, only data collected from 1970 and more recent were used. Any data that had an "unknown" within the *last_obs_date* field were also removed. Data with a "G" rating in the *precision* field were removed, and *precision* ratings of "S, F, Q, or MN" were buffered 2,640 feet (1/2 mile). Data with a *precision* of "M" were not buffered since the buffer was inherent.

Minnesota NHI data were supplied by the MNDNR. For this dataset all polygons with an observation date greater than or equal to 1970 were buffered 2,640 feet.

Iowa NHI data were collected from the IADNR. All of the obtained points were buffered 2,640 feet.

Missouri NHI data were obtained from the Missouri Department of Conservation. For this dataset, all polygons with *lastObs* greater than or equal to "1970" were buffered 2,640 feet.

The Illinois NHI data were collected from the ILDNR. All polygons were buffered 2,640 feet.

Indiana NHI data were collected from the INDNR. This dataset includes plant and animal species, natural communities, and animal aggregations. These points were buffered 2,640 feet.

No figure was created to depict the collected and manipulated NHI data due to its inherent sensitivity.

Existing Bottomland Forests and Priority Areas for Bottomland Afforestation

Introduction

The Upper Mississippi Basin, as a whole, benefits from bottomland forests. They provide diverse habitat for wildlife and fish. Bottomland forests also reduce soil erosion, improve water quality, enhance recreational activities, and provide a scenic landscape. Bottomland forests are not regenerating in the Mississippi and Illinois River system due to agricultural and urban developments, changes in natural river flood pulses, rising water tables, wind and wave erosion and aggressive invasion by exotic plants, such as reed canary grass and common native competitors. The remaining bottomland forests are changing in composition from shade intolerant species such as cottonwood, American elm, and silver maple to forests dominated by shade tolerant species such as hackberry and the nonnative mulberry (Urich et al. 2002).

Methods and Results

This analysis involved prioritizing areas within the UMRS floodplain based upon their location and capability to regenerate bottomland forest. For this particular analysis, any forested land cover type (deciduous, coniferous, mixed, woody wetlands) occurring within the floodplain will be designated as bottomland forest.

In addition, the analysis focuses on only the UMRS and its major tributaries because these larger river systems have a floodplain that is inundated periodically, reducing its value for agricultural production. That is not to say agriculture is to be excluded but recognizes there are areas better suited to natural vegetation that can withstand periodic flooding.

The first step in the analysis was to highlight those areas within the floodplain already classified as forest by the NLCD 1992.

In ArcMap, pixels were selected within the UMRS NLCD (Figure 4) that had a code of 41 (deciduous forest), 42 (evergreen forest), 43 (mixed forest), or 91 (woody wetlands). We then clipped these selected pixels using the SAST floodplain boundary (Figure 15). These areas are displayed in green in Figure 19 and are designated "Existing Bottomland Forest."

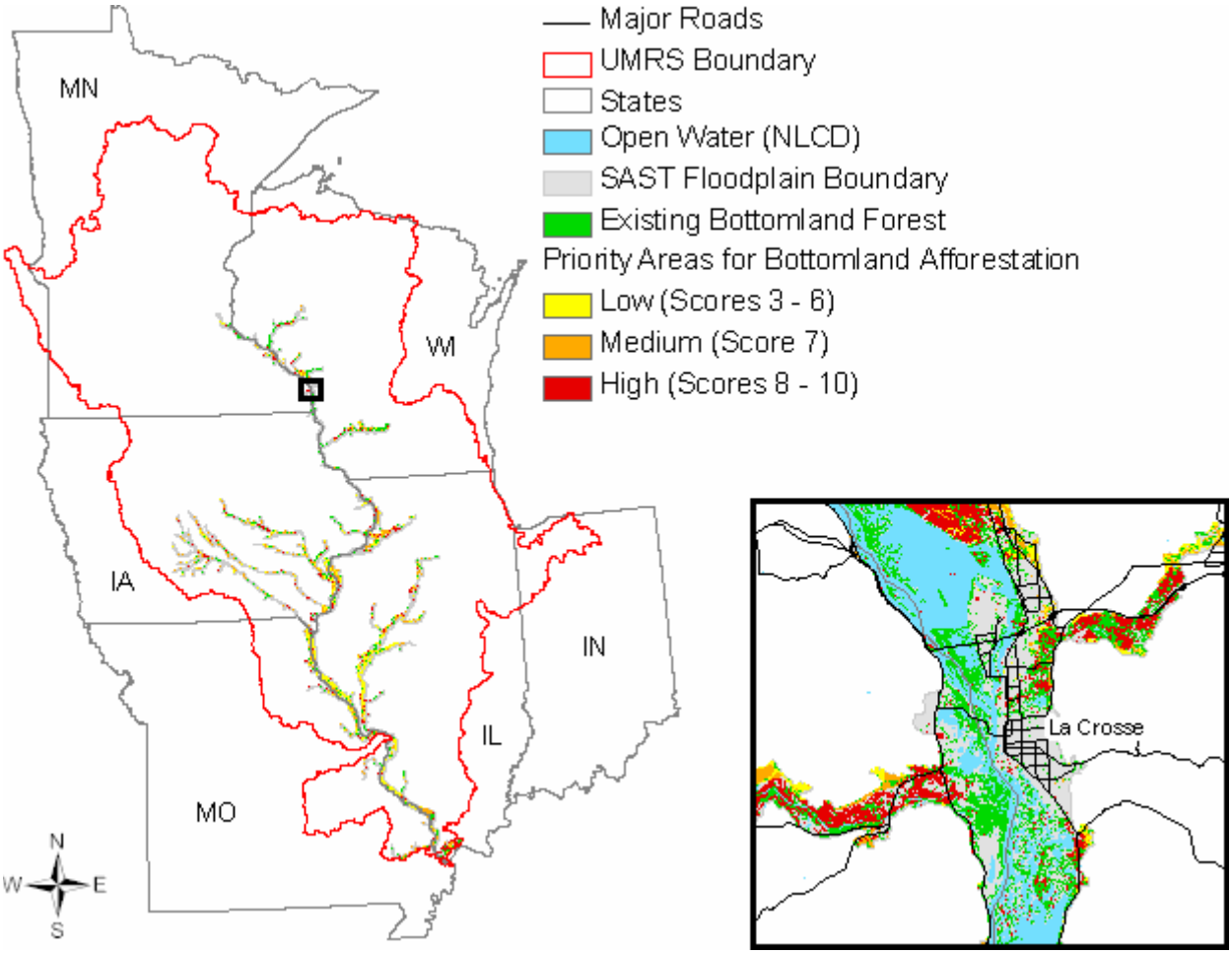

Figure 19. Existing bottomland forests and priority areas for bottomland afforestation

The next step in the analysis was to create a model using several data parameters to rank the areas within the floodplain that have the potential to be converted to bottomland forest. The model parameters displayed in Table 2 shows the scores given to each separate data layer's unique attributes and the relative influence each data layer has within the model as a whole (table continues on following page). The numbers used within the model were derived by the GIS advisory committee based upon their knowledge of bottomland afforestation needs. This model functions by reclassifying the values of each of the input data layers from the initial dissimilar class descriptions into a consistent integer score value from 0 to 10. Higher scores are given to an attribute if it is the preferred characteristic of an area to be afforested within the floodplain. These individual reclassified input data layers are then overlaid and the scores for a particular location are averaged using the designated model influences (%) as a modifier. Higher model influences were given to those data layers that were considered most important for potential afforestation.

Table 2. Priority areas for bottomland afforestation model parameters

National Land Cover Dataset (1992)	
Score	Description
NoData	Open Water
NoData	Low Intensity Residential
NoData	High Intensity Residential
NoData	Commerical/Industrial/Transp.
NoData	Bare Rock/Sand/Clay
NoData	Quarries
NoData	Transitional
NoData	Deciduous Forest
NoData	Evergreen Forest
NoData	Mixed Forest
10	Shrubland
NoData	Orchards/Vineyards
NoData	Grassland/Herbaceous
10	Pasture / Hay
10	Row Crops
5	Small Grains
NoData	Urban Recreational Grasses
NoData	Woody Wetlands
NoData	Emerg. Herbaceous Wetlands
25%	Model Influence
COE Leveed Areas	
Score	Description
2	Leveed within Floodplain
10	Unleveed within Floodplain
20%	Model Influence
Slope (Percent Rise)	
Score	Description
10	0 - 2
0	3 – 5
0	6 – 9
0	10 - 14
0	15 - 18
0	19 - 25
0	26 - 163
13%	Model Influence
STATSGO (Percent Hydric)	
Score	Description
10	Water
0	0
1	1 – 10
2	11 - 20
3	21 - 30

STATSGO (Ave. Depth to Water Table)	
Score	Description
10	Water
10	0
10	0.1 - 0.5 (feet)
9	0.6 - 1.0
8	1.1 - 1.5
7	1.6 - 2.0
6	2.1 - 2.5
5	2.6 - 3.0
4	3.1 - 3.5
3	3.6 - 4.0
2	4.1 - 4.5
1	4.6 - 5.0
0	5.1 - 5.5
0	> 5.5
10%	Model Influence
STATSGO (Ave. Capability Class)	
Score	Description
10	Water
1	0 - 1.0
3	1.1 - 2.0
5	2.1 - 3.0
6	3.1 - 4.0
7	4.1 - 5.0
8	5.1 - 6.0
9	6.1 - 7.0
10	> 7.0
10%	Model Influence
Proximity to Public (Including Tribal)	
Score	Description
10	0 - 0.5
5	0.5 - 1.0
0	1.0 - 1.5
0	1.5 - 2.0
0	2.0 - 2.5
0	2.5 - 3.0
0	3.0 - 3.5
0	3.5 - 4.0
0	4.0 - 4.5
0	4.5 - 5.0
0	> 5.0
5	Public Lands
10%	Model Influence

4	31 - 40
5	41 - 50
6	51 - 60
7	61 - 70
8	71 - 80
9	81 - 90
10	91 - 100
12%	Model Influence

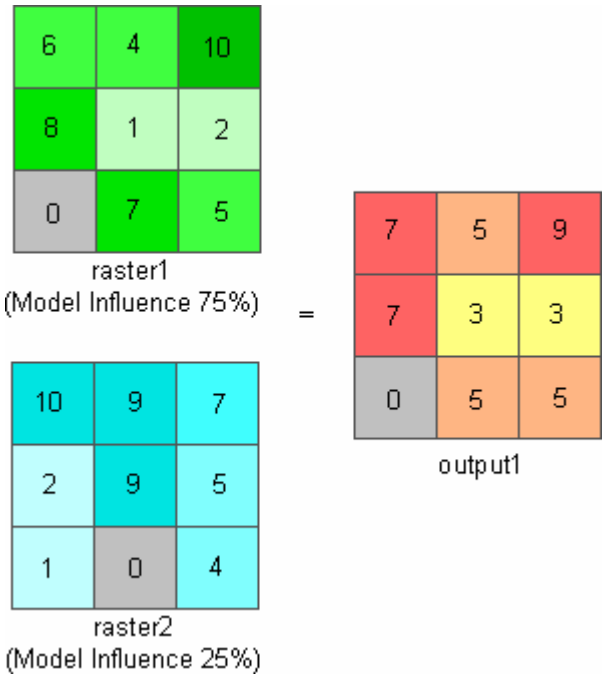

Figure 20. Diagram depicting how weighted overlay functions

Figure 20 illustrates how the weighted overlay tool operates. Each cell value in raster1 is multiplied by its model influence (0.75), and each cell in raster2 is similarly multiplied by its model influence (0.25). Next, these values are added together and rounded to the nearest integer. For instance, in the top right cell, the value for raster1 would be (10 * 0.75) = 7.5 and the value for raster2 would be (7 * 0.25) = 1.75. These values are then summed to equal 9.25 which is then rounded to 9. For cells with a score of "NoData" within any of the inputs, no output value is calculated. The values in output1 that are shaded in red would be the highest score/priority for this particular example model.

This model was created in ModelBuilder 9.1 (Figure 21) and then run within the ArcMap GIS platform. Within the ModelBuilder platform, blue ovals designate input datasets, yellow rectangles designate ArcGIS tools, and green ovals designate derived datasets.

The SAST floodplain boundary was again used as an analysis mask for this analysis, anything outside of the floodplain is given a value of NoData. Figure 19 shows the results of the "Priority Areas for Bottomland Afforestation" model. The resultant values from the model were grouped into one of three categories: low (yellow), medium (orange), and high (red). The basis for the

groupings was each group should have as close to an equal amount of area as possible (quantile method).

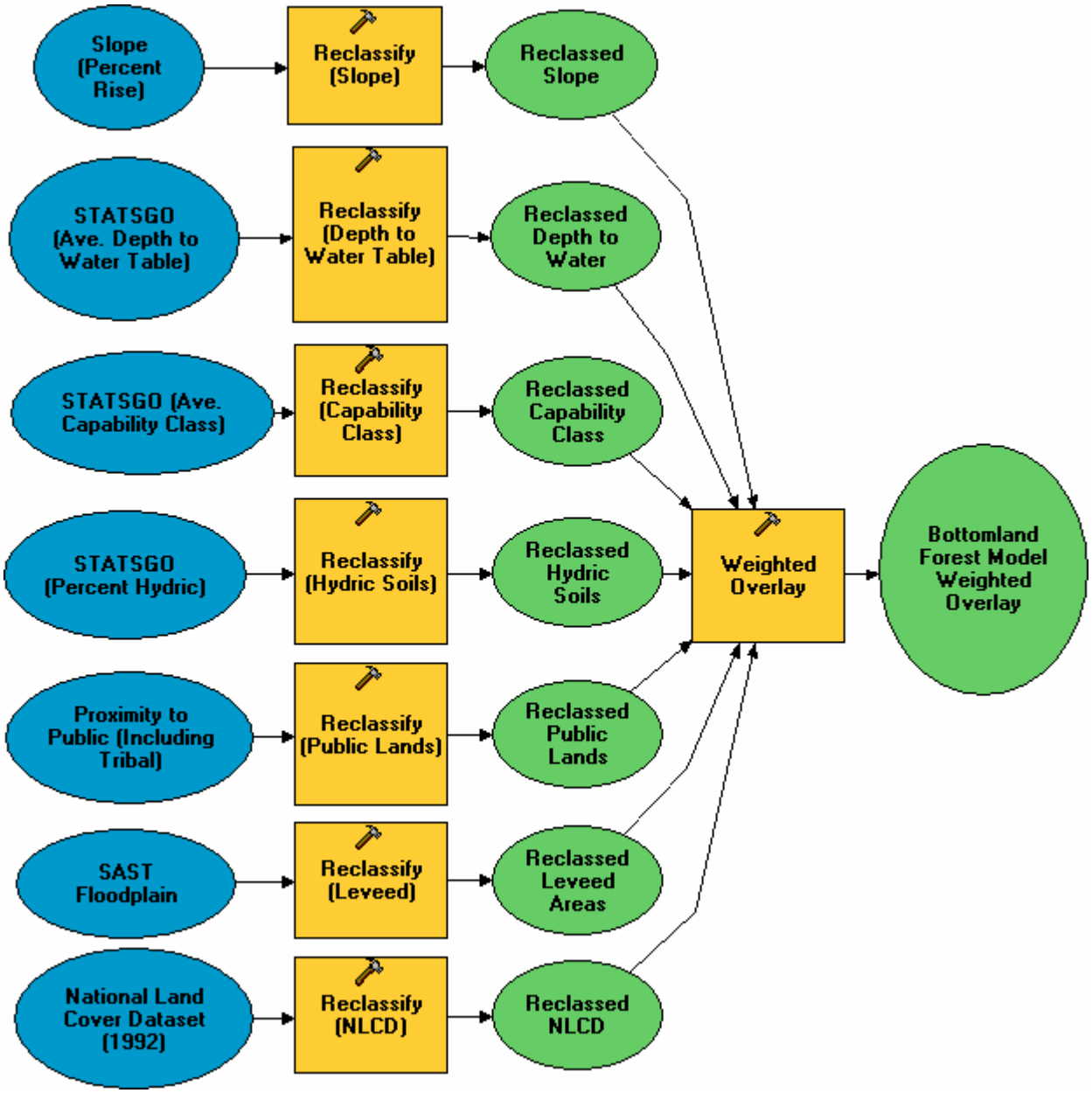

Figure 21. Priority areas for bottomland afforestation model diagram

Optimal areas within the floodplain for bottomland afforestation in this model have several distinguishing characteristics based upon the scoring by the GIS committee. They are outside of a flood control levee, have wet soils, consist of a land cover type that would be alterable, are on low slopes, and are in close proximity to existing publicly managed lands (Table 2). Close proximity to public land was given higher priority in order to create larger, more contiguous blocks of bottomland forest. Many species will benefit from this. It is well documented that decreasing parcel size correlates to lower species diversity, increased risk of predation, and infestation by exotics (USDA Forest Service n.d.).

An area summary was created to show the relative amount of acreage for each bottomland afforestation classification (low, medium, and high) and to also show the total percentage of area within the SAST floodplain designated as priority areas for bottomland afforestation, existing bottomland forest, and other land cover types not used within the model (Table 3).

Table 3. Priority areas for bottomland afforestation model area summary

	Low (Acres)	Low (Pct)	Medium (Acres)	Medium (Pct)	High (Acres)	High (Pct)	Total (Acres)	Total (Pct)
Priority Areas for Bottomland Afforestation	946166.86	41.17	809956.30	35.25	541839.22	23.58	2,297,962.38	52.97
Existing Bottomland Forest							924,871.72	21.32
Other							1,115,100.85	25.71
Total SAST Floodplain Area							4,337,934.95	100.00

Conclusions

This analysis is useful in providing a regional perspective on bottomland afforestation but is not intended to be a site planning tool. In order to document exactly where restoration should take place, more detailed land use and ownership, soils, and elevation data are needed to determine which species are the most likely to thrive and provide needed migratory bird habitat.

The major tributaries of the Mississippi River in Iowa (Des Moines, Skunk, and Iowa Rivers) and Illinois (Illinois River) have more high priority areas because they have fewer levees and proximity to existing forests. Conversely, the high percentage of low priority areas along the main stem of the Mississippi River as one moves downstream indicates leveed areas cut off from the river, good agricultural soils, and farther from existing bottomland forests. However, there are high priority areas identified along the whole system that warrant further analysis and attention.

A more detailed map in both Adobe Portable Document Format (.pdf) and Joint Photographic Experts Group (.jpg) formats is located on the Upper Mississippi Forest Partnership website at http://www.na.fs.fed.us/watershed/upper_mississippi_partnership/.

Preservation of Riparian Corridor Water Quality and Aquatic Habitat

Introduction

Land use changes in riparian areas have led to declining water quality in the Gulf of Mexico and the UMRS and its tributaries. Pollutants, including sediment, nitrogen and phosphorus are the result of poorly managed farms, urban development, surface mines, and timber harvests. Increased sediment loads have contributed to filling of the navigation pools in the UMRS and its backwaters and side-channels. These areas are critical for fish and wildlife. In addition, many

environmental contaminants are strongly attached to soil particles and deposited in the navigation pools. Aquatic organisms can be harmed by contact with these contaminated sediments.

The delivery of high amounts of nitrogen to the Gulf of Mexico causes a hypoxia zone to expand each summer (USGS 2006). About 90% of the nitrate load to the Gulf of Mexico comes from nonpoint sources, and more than 31% of that load comes from the Upper Mississippi River. The hypoxia zone has persisted and grown for the past decade. The hypoxia zone was about 5,000 square miles in 1993, and it reached its all time high in 2002 at 8,500 square miles, about the size of the state of Massachusetts.

Riparian forests can be effective in removing excess nutrients and sediment from surface runoff and shallow groundwater and can also ameliorate the effects of some pesticides, and directly provide dissolved and particulate organic food needed to maintain high biological productivity and diversity in the adjoining stream (Welsch n.d.).

Methods and Results

The riparian corridor analysis consisted of two steps. The first step located those areas with high percentages of agricultural land within a watershed. From those watersheds identified as high priority, two were selected for a more detailed analysis. The detailed analysis is an attempt to show how using the detailed hydrography and soils data, we can estimate where riparian buffers are needed most or conversely which riparian areas currently forested are highest priority to remain in forest.

For step one, agricultural areas were determined to be those areas that were classified as row crops (NLCD class 82) or small grains (NLCD class 83). The percent of these pixels that occur within each watershed was calculated. Next, 1:100,000 NHD was collected (polygons and lines) and buffered 300 feet on each side (total of 600 foot buffer around lines) (Figure 16). The percent of the area within this riparian corridor that was classified as agriculture (NLCD 82 and 83) was then calculated and this percentage was then added to the previous percent agriculture calculated within the entire watershed. The watersheds in Figure 22 that are shaded purple have a high percentage of agriculture within the entire watershed and also a high percentage of agriculture within the riparian corridor within that watershed.

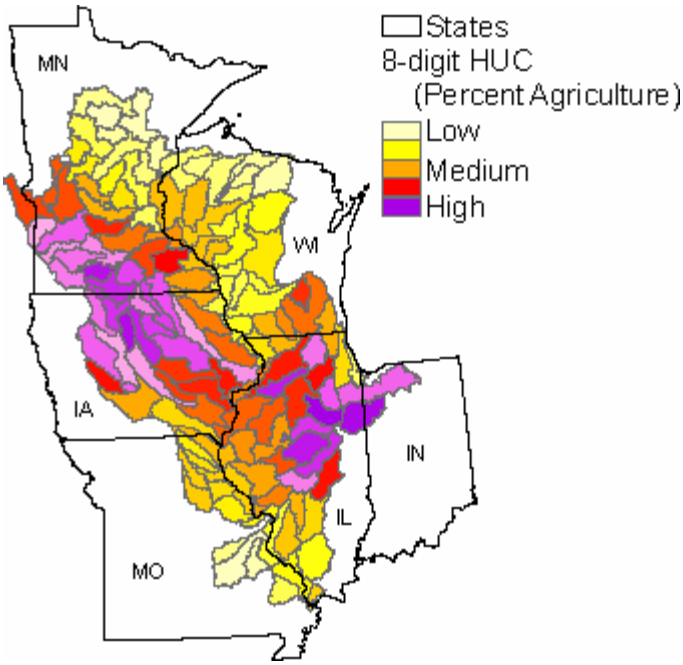

Figure 22. Percent agriculture by watershed

The other overriding factor as to where to conduct the more detailed analysis was data availability. To run the more detailed sub-watershed analysis there needed to be adequate, high-resolution data available for both hydrography (1:24,000-scale NHD) and soils (1:24,000-scale SSURGO database). Figure 23 gives a graphical representation of counties without SSURGO spatial data (left) and HUCs without high-resolution NHD (right).

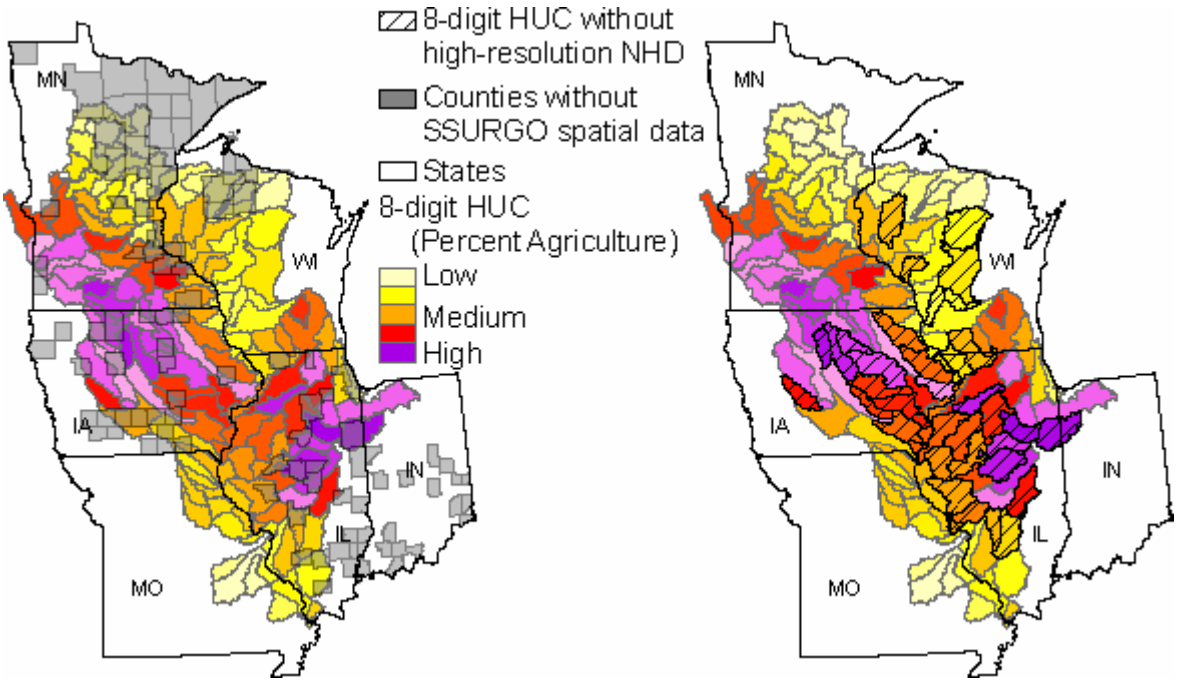

Figure 23. High resolution hydrographic and soil data availability

Watersheds that had complete coverage for both datasets were considered for the detailed sub-watershed analysis.

The watershed with the highest percentage of agriculture and also met the data requirement caveats was the Watonwan River watershed in southern Minnesota (Figure 24). This particular watershed had 85.9% agriculture within the entire watershed and 66.8% agricultural land cover within the 300 foot corridor around hydrography. For a contrasting watershed, we wanted to select an example that had steeper slopes and less dominated by agriculture. We chose the south Fork of the Salt River (Figure 24). According to M.G. Dosskey (personal communication, May 22, 2006) this watershed is heavily cropped on rolling hills famed for their claypan soils, big surface run-off and erosion problems, and water quality concerns in Mark Twain Lake.

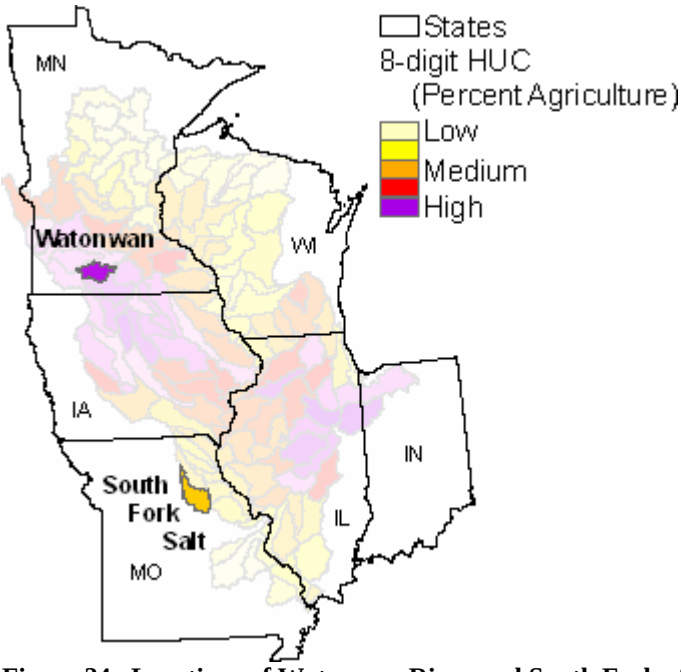

Figure 24. Locations of Watonwan River and South Fork of the Salt River watersheds

The second step of the Watonwan River riparian corridor analysis involves applying these more detailed process steps within the watershed:

1. Acquired detailed polygonal and linear NHD data for the Watonwan River watershed and selected those features that were classified as:
    a. Perennial and intermittent streams, canals, ditches, lakes, ponds, reservoirs, swamps, marshes, and large rivers/streams.
2. Clipped these selected features using a detailed Watonwan River watershed boundary acquired from the MNDNR.
3. Buffered the clipped NHD features by 300 feet (600 foot total buffer around linear features) to approximate the riparian corridor.
4. Acquired detailed SSURGO soils data for counties that intersected the Watonwan River watershed, merged together, then clipped using the MNDNR boundary file.
5. Using Microsoft Access, linked component data tables from individual counties to the merged layer's attribute table. Calculated a weighted non-irrigated land capability

classification (Nirr LCC) for each map unit key. The land capability class is a value given to soils that describes the soils on their capability to produce common cultivated plants and pasture plants without deteriorating over a period of time. The higher the number given for Nirr LCC, the less likely that soil can support these plants. Scores range from 1 to 8.

6. For each map unit key individual soil component, multiply the component percent (representative value) by the Nirr LCC, then summed these individual values for each map unit key (Table 4). Only those components with a Subclass (Nirr Subcl) of "e" were used in this analysis. Subclass "e" is made up of soils for which the susceptibility to erosion is the dominant problem or hazard affecting their use for agricultural purposes. Erosion susceptibility and past erosion damage are the major soil factors that affect soils in this subclass (USDA NRCS n.d.*b*).

Table 4. Soil Survey Geographic (SSURGO) Database land capability class erodible soils calculations

Mapunit Key	Component Name	Component Percent - Representative Value	Nirr LCC	Nirr Subcl	Nirr LCC * Pct
396313	Clarion	50	2	e	1
	Estherville	25	7	s	--
	Storden	15	2	e	0.3
TOTAL		90			**1.3**
40068	Clarion	25	4	e	1
	Estherville	20	6	e	1.2
	Storden	20	4	e	0.8
TOTAL		65			**3.0**

7. Using the data derived ran the "Riparian corridor afforestation priority model" within ArcMap based on the parameters in Table 5 and using the structure depicted in Figure 25. The NHD 300 foot buffer created above was used as a mask for the analysis. Scores for reclassifying each input layer were based on a 0 to 10 scale with 10 being the highest priority and 0 having no priority within the model. The model influence is the relative weighting that each input layer has on the model output. The model output was then averaged by subwatershed (MNDNR).

Table 5. Riparian corridor afforestation priority model parameters

SSURGO - Land Capability Classification - Subclass "E"	
Score	Description
0	Not susceptible to erosion
1	0 – 1 (LCC)
2	1 - 2
3	2 - 3
4	3 - 4
6	4 - 5
8	5 - 6
10	6 - 7
60%	Model Influence
National Land Cover Dataset (1992)	
Score	Description
2	Orchards/Vineyards
1	Grassland/Herbaceous
2	Pasture / Hay
10	Row Crops
5	Small Grains
40%	Model Influence

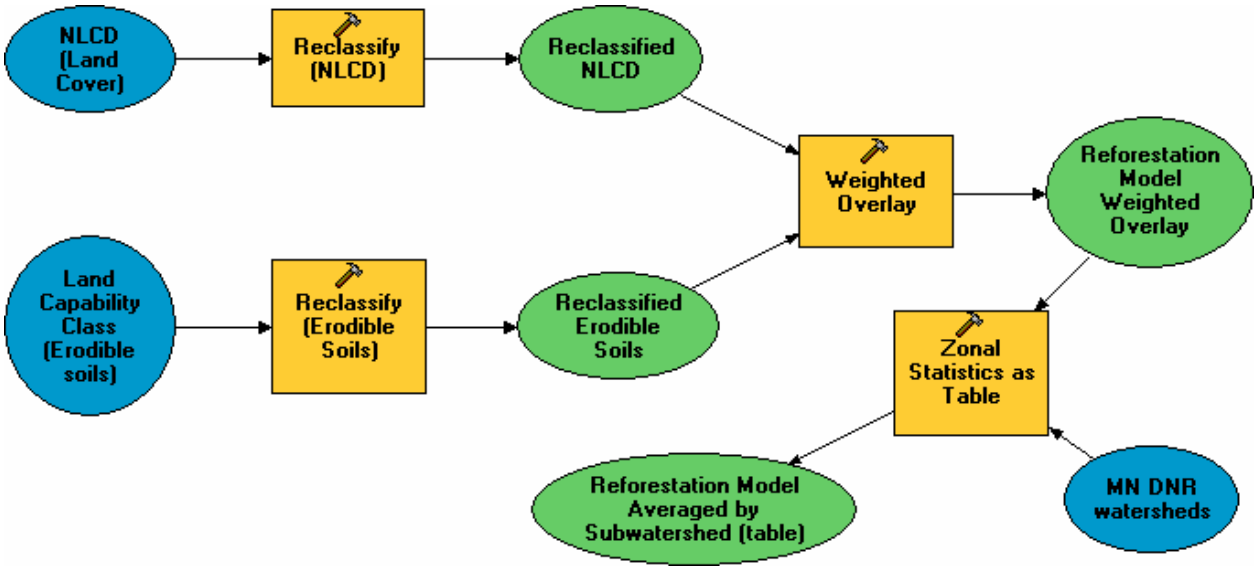

Figure 25. Riparian corridor afforestation priority model diagram

8. The final table "Reforestation Model Averaged by Subwatershed" derived with the model was then joined with the Watonwan River watershed shapefile and shaded according to average model score by subwatershed (Figure 26).

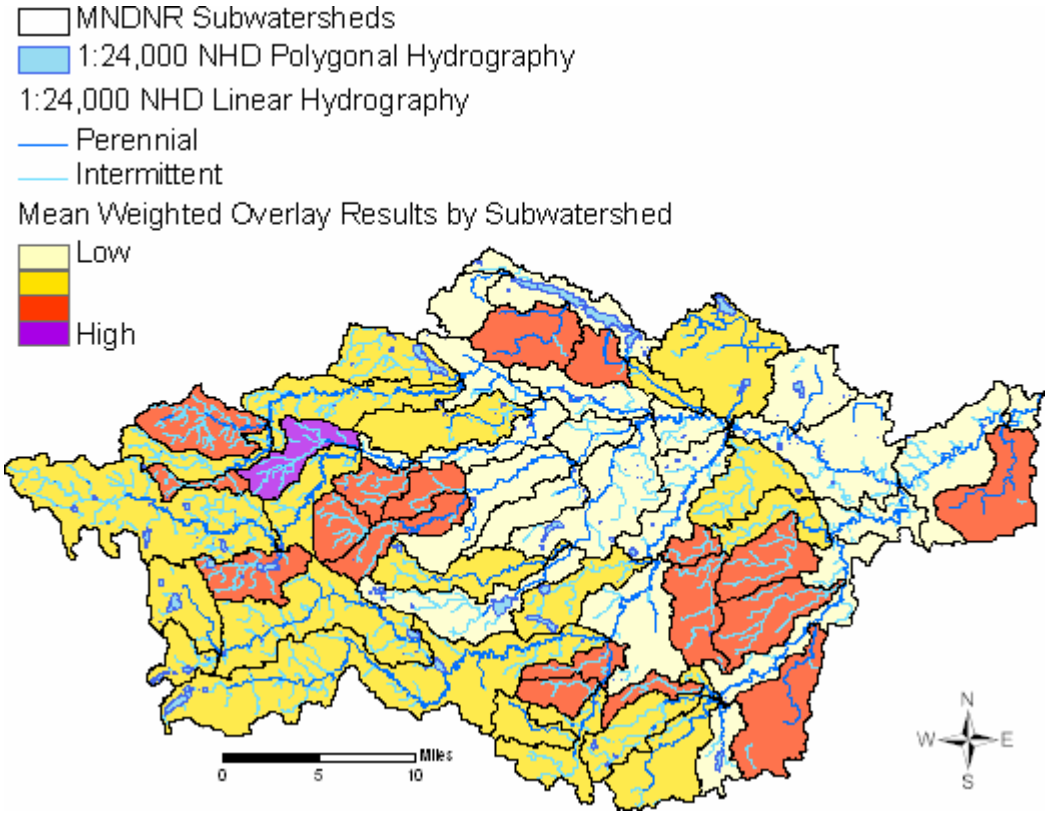

Figure 26. Watonwan River riparian corridor afforestation priority model output

9. The subwatershed with the highest mean model score is shaded purple in Figure 26. This subwatershed is displayed in detail in Figure 27 with respect to land cover, soil erodibility, and model output within the riparian corridor.

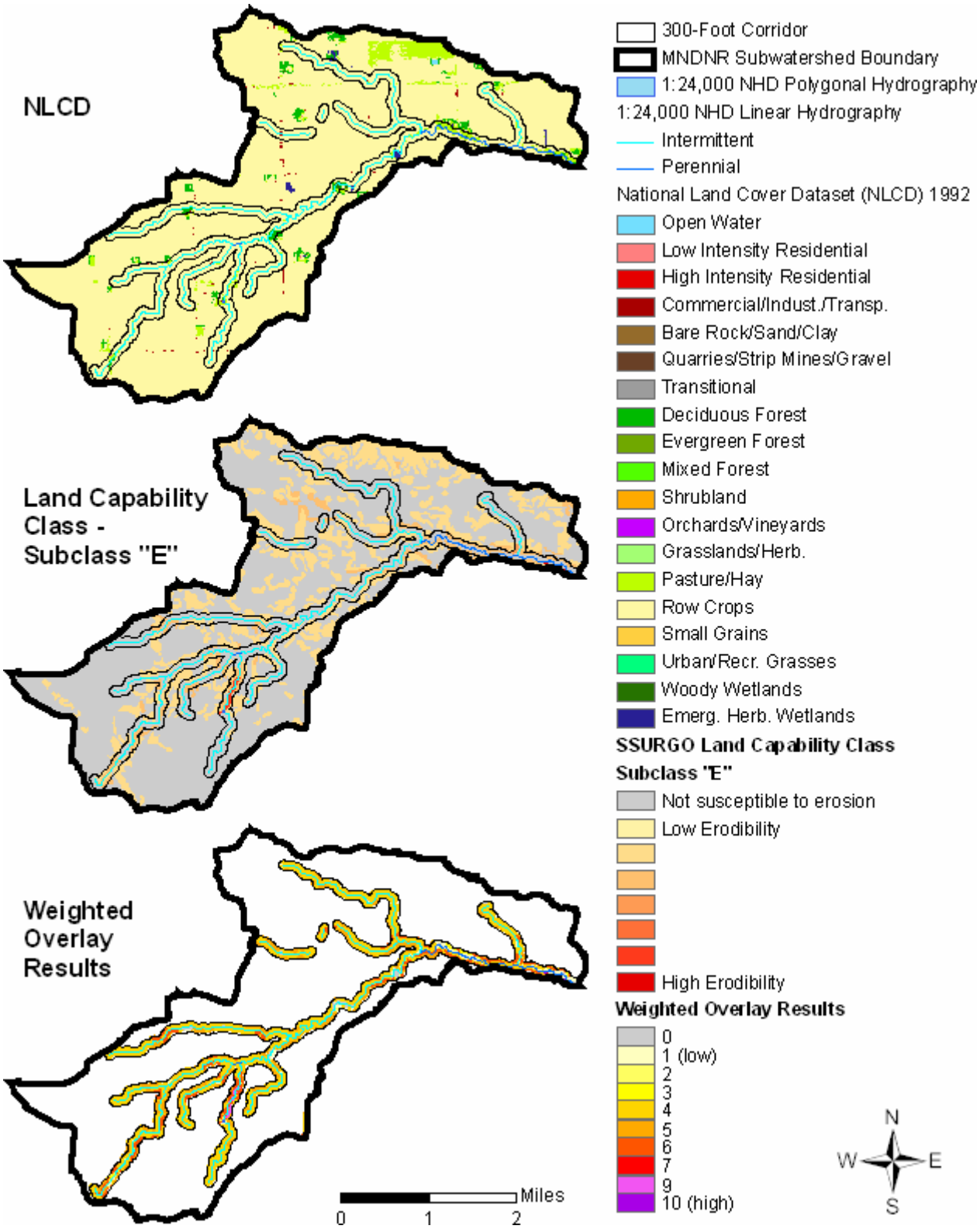

Figure 27. Sample subwatershed depicting high riparian corridor afforestation priority

10. Next, ran the "Riparian corridor forest conservation priority model" within ArcMap based on the parameters in Table 6 and using the structure depicted in Figure 28. The

NHD 300 foot buffer was again used as a mask for the analysis. Scores for reclassifying each input layer were based on a 0 to 10 scale with 10 being the highest priority and 0 having no priority within the model. The model output was then averaged by subwatershed (MNDNR).

Table 6. Riparian corridor forest conservation priority model parameters

Land Capability Classification - Subclass "E"	
Score	Description
0	Not susceptible to erosion
1	0 – 1 (LCC)
2	1 - 2
3	2 - 3
4	3 - 4
6	4 - 5
8	5 - 6
10	6 - 7
60%	Model Influence
National Land Cover Dataset (1992)	
Score	Description
10	Deciduous Forest
10	Evergreen Forest
10	Mixed Forest
5	Shrubland
10	Woody Wetlands
40%	Model Influence

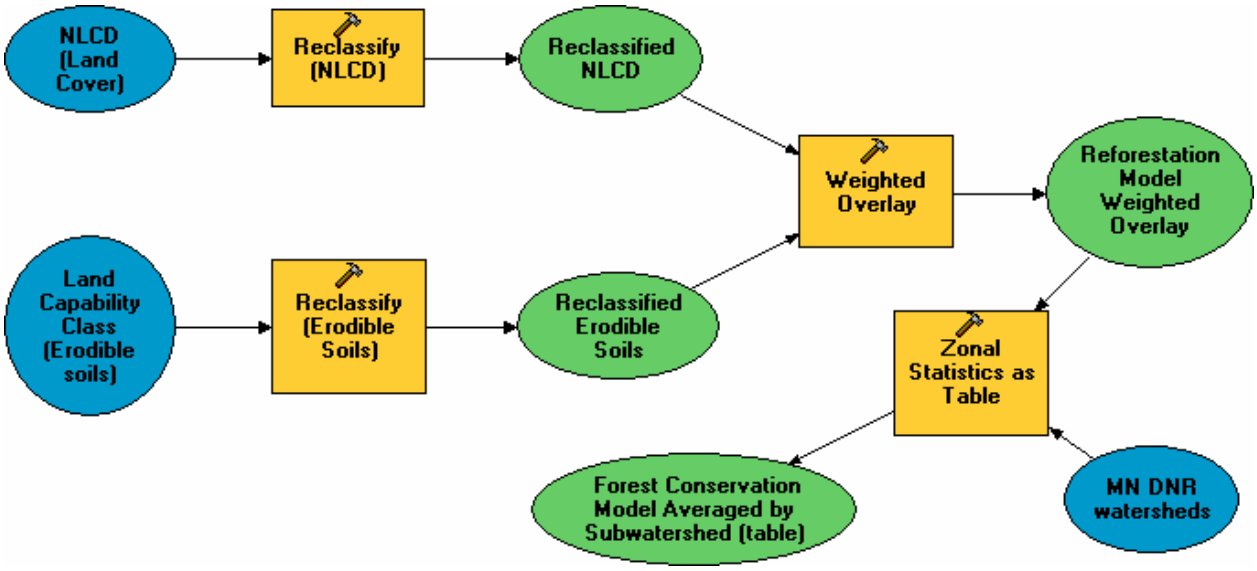

Figure 28. Riparian corridor forest conservation priority model diagram

11. The final table derived with the model was then joined with the Watonwan River watershed shapefile and shaded according to average model score by subwatershed (Figure 29).

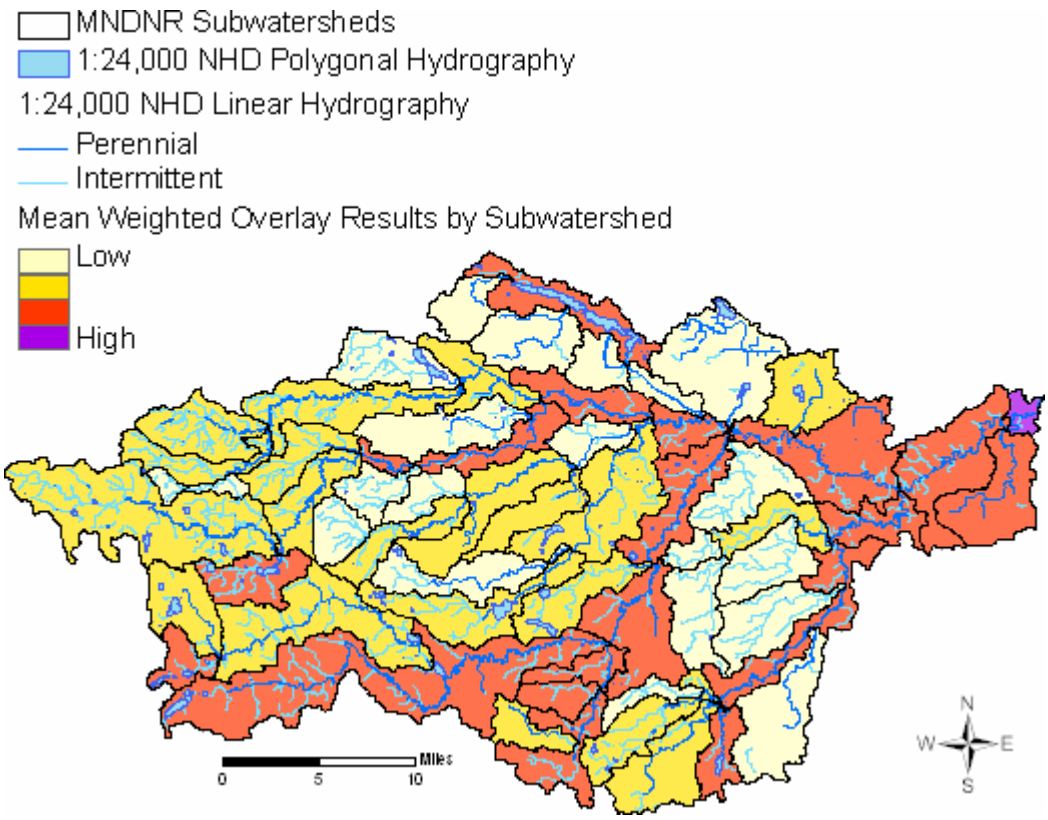

Figure 29. Riparian corridor forest conservation priority model output

12. The subwatershed with the highest mean model score is shaded purple in Figure 29. This subwatershed is displayed in detail in Figure 30 with respect to land cover, soil erodibility, and model output within the riparian corridor.

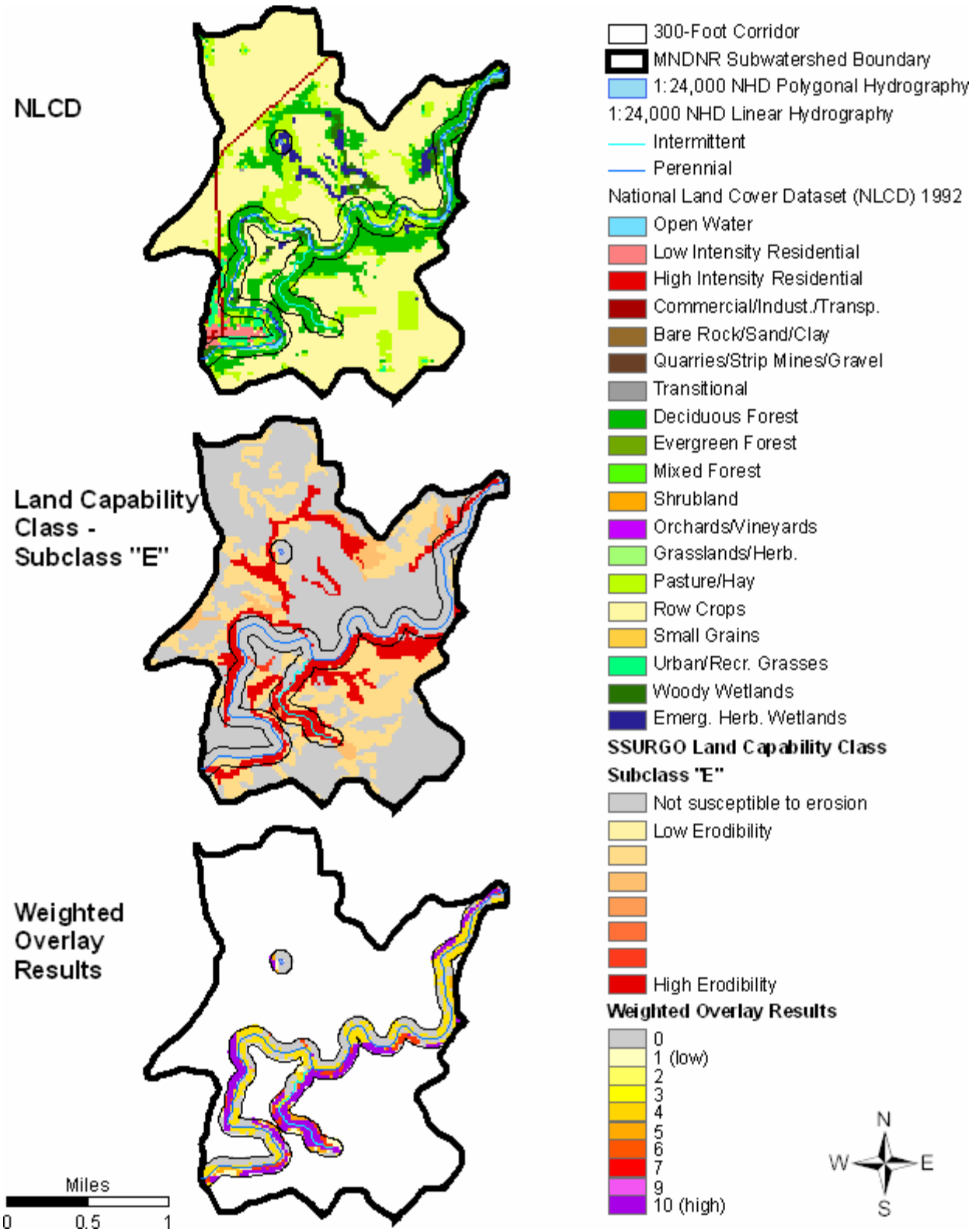

Figure 30. Sample subwatershed depicting high riparian corridor forest conservation priority

13. A separate, tabular analysis was completed to compare the land cover make-up of the riparian corridor with respect to perennial water bodies versus intermittent waterbodies.

Figure 31 shows the percentage of agriculture (row crops and small grains) within 300 feet of perennial water bodies is much lower than that within 300 feet of intermittent water bodies (NHD).

	300 foot corridor around perennial water bodies	300 foot corridor around intermittent water bodies
Acres of Ag.	20836.8	36866.7
Acres of Other	17875.1	8187.7
Total Acres	38711.9	45054.3
Pct Ag.	53.8	81.8
Pct Other	46.2	18.2

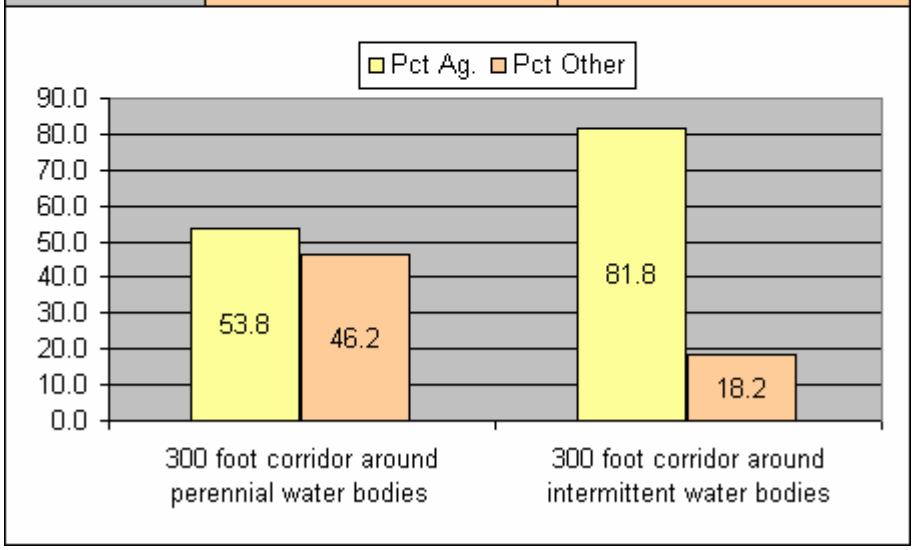

Figure 31. Summary of agricultural classes surrounding perennial and intermittent water bodies

14. Figure 32 shows the percentage of forest (deciduous, evergreen, mixed forest, woody wetlands) within 300 feet of perennial water bodies is much higher than that within 300 feet of intermittent water bodies (NHD).

	300 foot corridor around perennial water bodies	300 foot corridor around intermittent water bodies
Acres of Forest	7626.1	1629.7
Acres of Other	31085.8	43424.6
Total Acres	38711.9	45054.3
Pct Forest	19.7	3.6
Pct Other	80.3	96.4

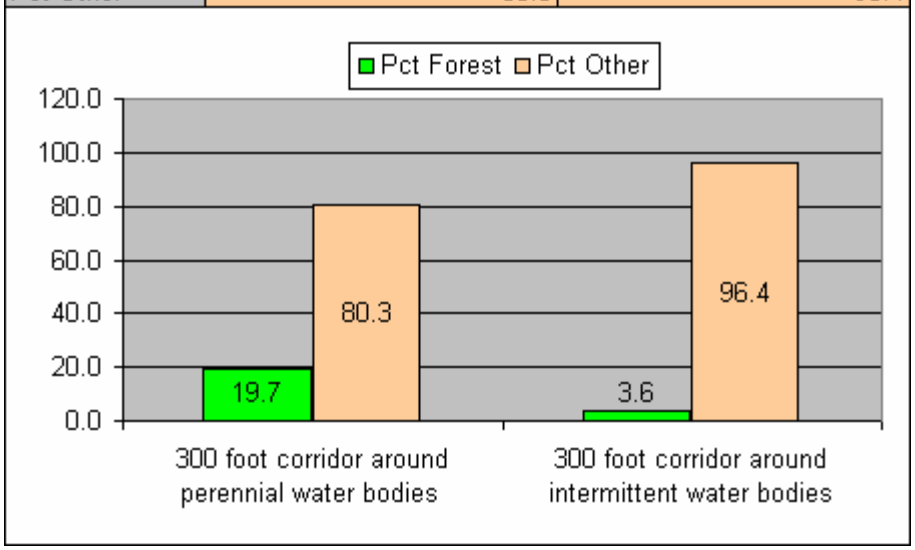

Figure 32. Summary of forested classes surrounding perennial and intermittent water bodies

South Fork of the Salt River watershed detailed riparian corridor analysis process steps:

1. Acquired detailed polygonal and linear NHD data for the South Fork of the Salt River watershed and selected those features that were classified as:
    a. Perennial and intermittent streams, canals, ditches, lakes, ponds, reservoirs, swamps, marshes, and large rivers/streams.
2. Clipped these selected features using a detailed South Fork of the Salt River watershed boundary acquired from the U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS).
3. Buffered the clipped NHD features by 300 feet (600 foot total buffer around linear features) to approximate the riparian corridor.
4. Acquired detailed SSURGO soils data for counties that intersected the South Fork of the Salt River watershed, merged together, then clipped using the NRCS boundary file.
5. Using Microsoft Access, linked component data tables from individual counties to the merged layer's attribute table. Calculated a weighted non-irrigated land capability classification (Nirr LCC) for each mapunit key. The land capability class is a value given to soils that describes the soils on their capability to produce common cultivated plants and pasture plants without deteriorating over a period of time (USDA NRCS n.d.*b*). The higher the number given for Nirr LCC, the less likely that soil can support these plants. Scores range from 1 to 8.
6. For each mapunit key individual soil component, multiply the component percent (representative value) by the Nirr LCC, then summed these individual values for each

mapunit key (Table 4). Only those components with a Subclass (Nirr Subcl) of "e" were used in this analysis. Subclass "e" is made up of soils for which the susceptibility to erosion is the dominant problem or hazard affecting their use. Erosion susceptibility and past erosion damage are the major soil factors that affect soils in this subclass (USDA NRCS n.d.*b*).

7. Using the data derived ran the "Riparian corridor afforestation priority model" within ArcMap based on the parameters in Table 5 and using the structure depicted in Figure 25. The NHD 300 foot buffer was used as a mask for the analysis. Once again, scores for reclassifying each input layer were based on a 0 to 10 scale with 10 being the highest priority and 0 having no priority within the model. The model influence is the relative weighting that each input layer has on the model output. The model output was then averaged by subwatershed supplied by the USDA NRCS.
8. The final table derived with the model was then joined with the South Fork of the Salt River watershed shapefile and shaded according to average model score by subwatershed (Figure 33).

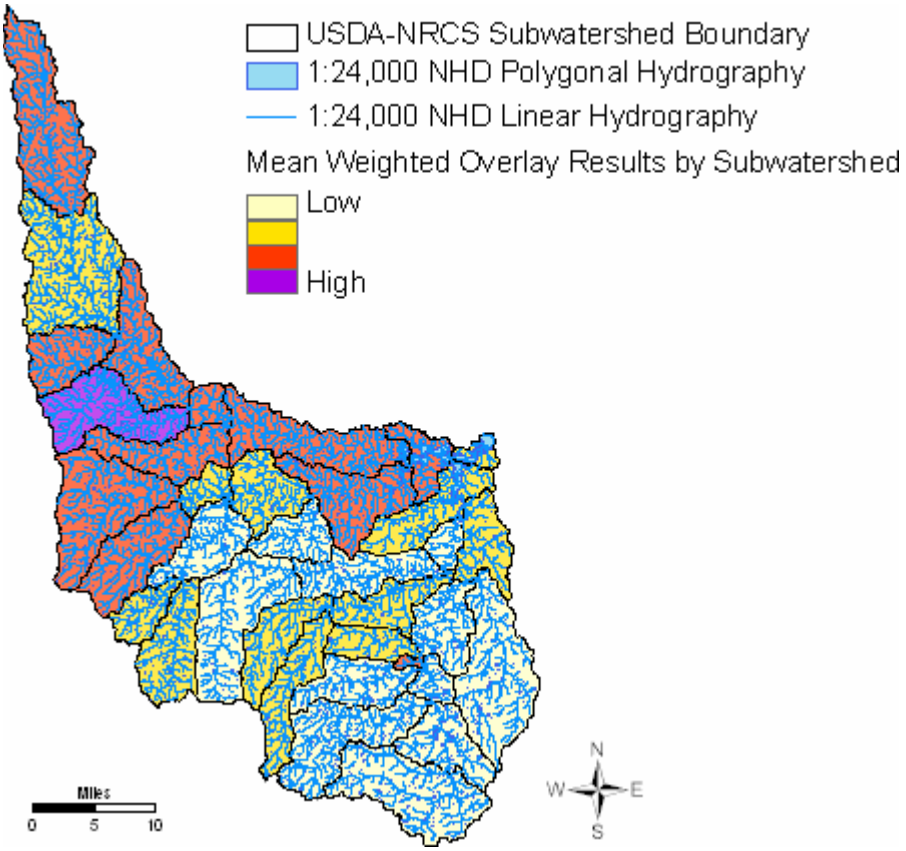

Figure 33. South Fork of the Salt River riparian corridor afforestation priority model output

9. The subwatershed with the highest mean model score is shaded purple in Figure 33. This subwatershed is displayed in detail in Figure 34 with respect to land cover, soil erodibility, and model output within the riparian corridor.

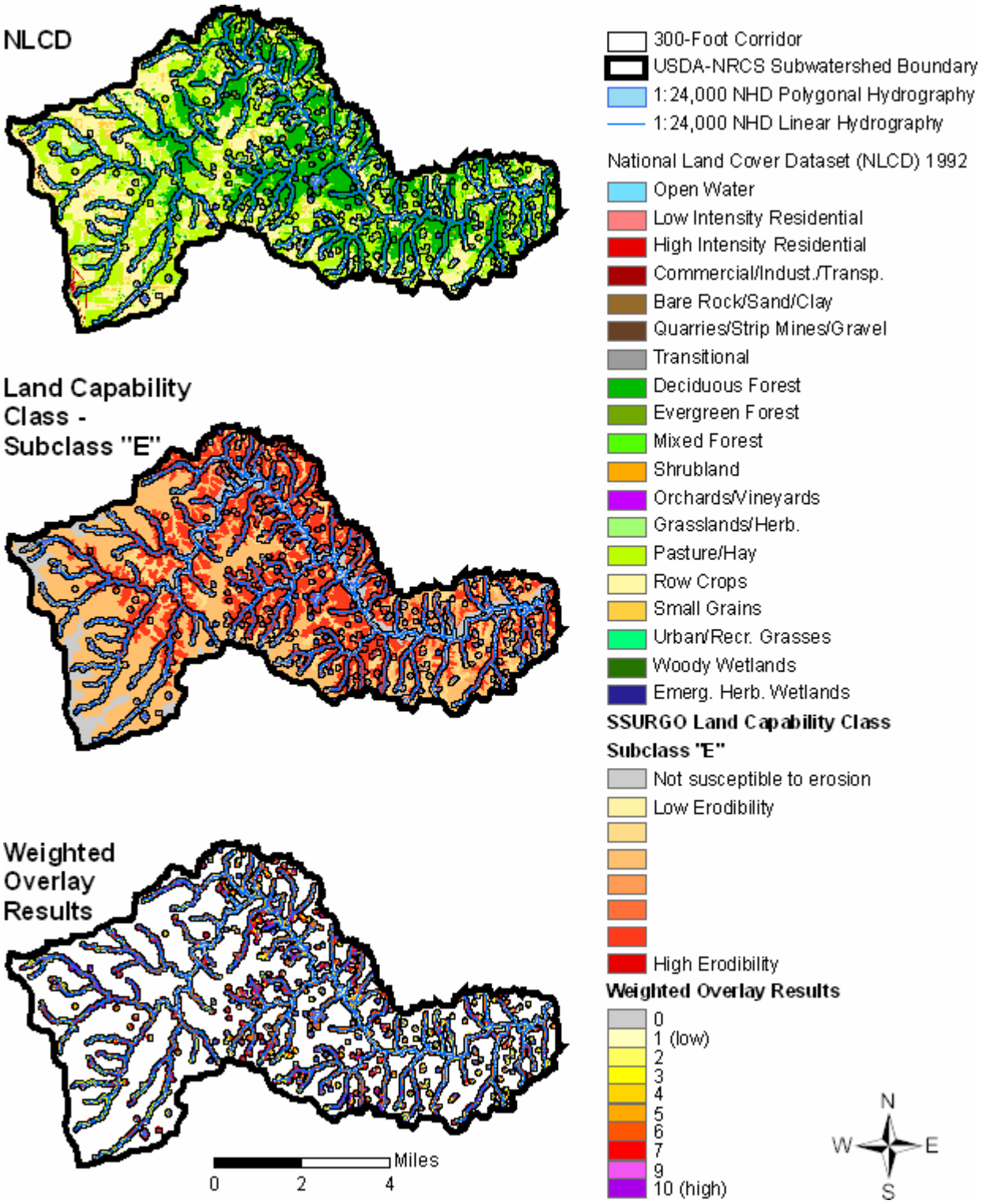

Figure 34. Sample subwatershed depicting high riparian corridor afforestation priority

10. Next, ran the "Riparian corridor forest conservation priority model" within ArcMap based on the parameters in Table 6 and using the structure depicted in Figure 28. The NHD 300 foot buffer was again used as a mask for the analysis. Scores for reclassifying each input layer were based on a 0 to 10 scale with 10 being the highest priority and 0

having no priority within the model. The model output was then averaged by subwatershed (Missouri NRCS).

11. The final table derived with the model was then joined with the South Fork of the Salt River watershed shapefile and shaded according to average model score by subwatershed (Figure 35).

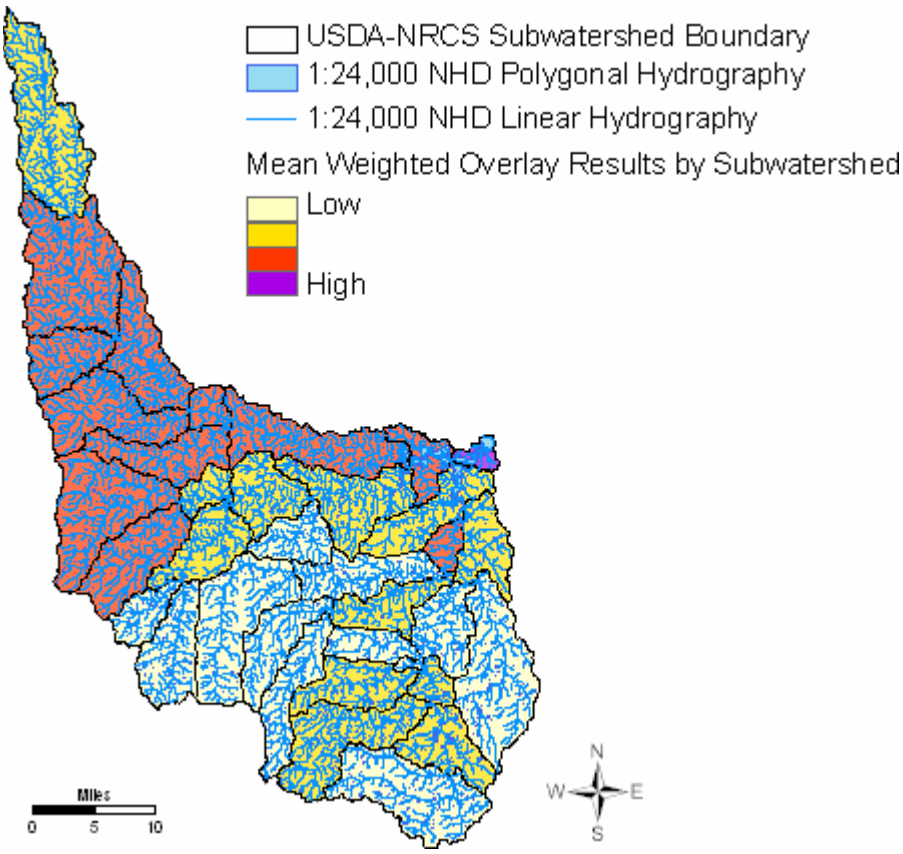

Figure 35. Riparian corridor forest conservation priority model output

12. The subwatershed with the highest mean model score is shaded purple in Figure 35. This subwatershed is displayed in detail in Figure 36 with respect to land cover, soil erodibility, and model output within the riparian corridor.

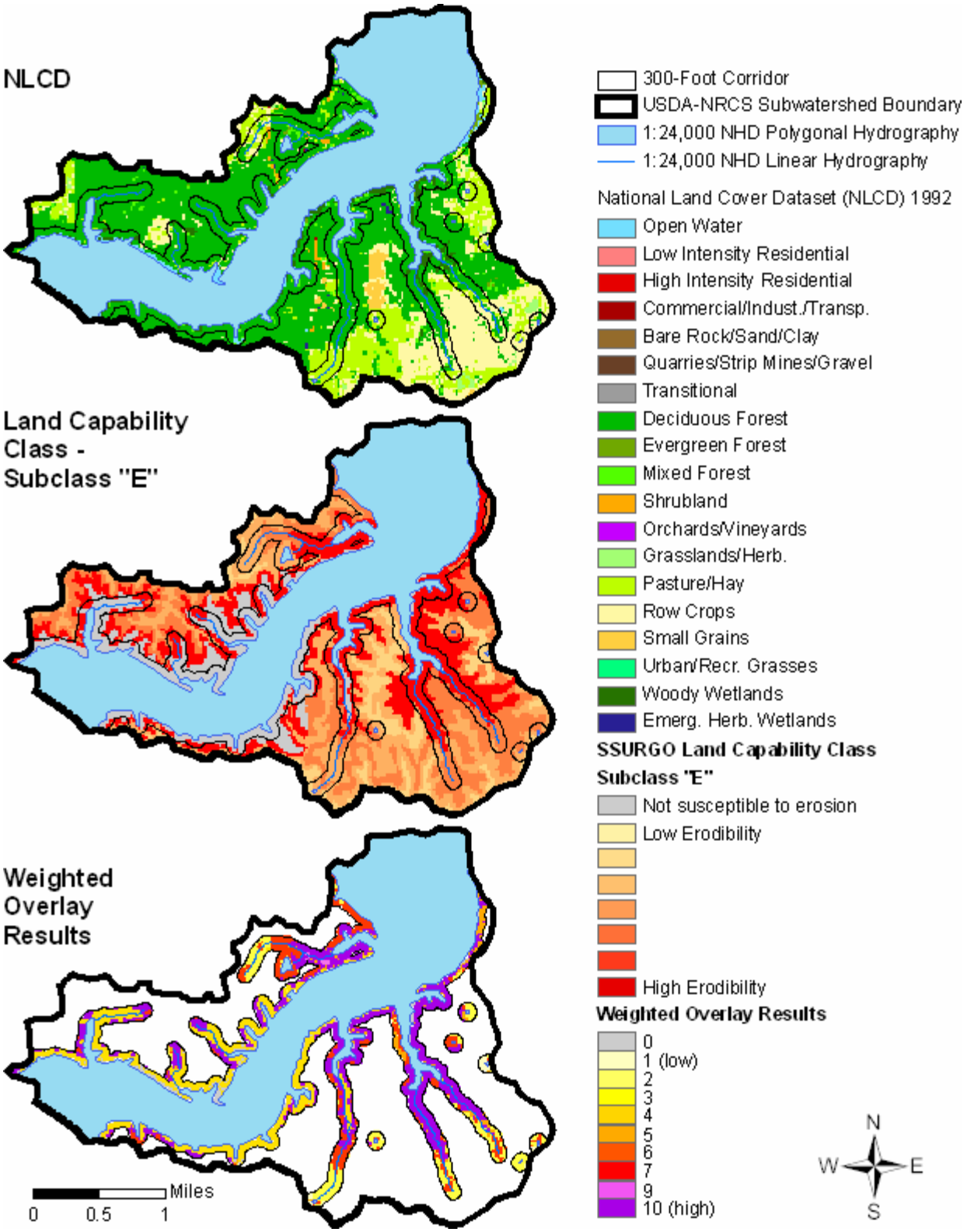

Figure 36. Sample subwatershed depicting high riparian corridor forest conservation priority

Conclusions

- Agriculture is a dominate feature of the Upper Mississippi River watershed landscape and a primary driver with respect to water quality issues.
- Detailed soils data (SSURGO) provide information on where soil erosion is a problem. These data combined with land cover can identify those areas where placing buffers to stop soil and soil nutrients from reaching a water body should be a priority. Conversely, it also indicates those areas in permanent vegetation, such as forest, close to water that should remain so.
- This model only included physical landscape parameters. It did not take into account the economics of changing land use or the social willingness to install buffers.
- Exactly what kind of buffer (grass, trees, combination) and width would depend on local site conditions. An October 2005 report published by EPA included a literature review of riparian buffer effectiveness found that 75% of the nitrogen is removed with a 25 m buffer and about 90% removal with a 100 m buffer (Mayer et. al. 2005.)
- While the landscape in the UMRS includes a range of vegetative conditions from prairie to forests, it is important to note that historically most stream systems had some type of forest cover adjacent to the water (West and Ruark 2004).

More detailed maps in both Adobe Portable Document Format (.pdf) and Joint Photographic Experts Group (.jpg) formats are located on the Upper Mississippi Forest Partnership website at http://www.na.fs.fed.us/watershed/upper_mississippi_partnership/.

Important Migratory Bird Habitat

Introduction

The UMRS is a focal point for a variety of major bird conservation efforts. The river's north-to-south orientation and contiguous habitat make it critical to the life cycle of many migratory birds. It is a globally important migratory flyway for 40% of all North American waterfowl and 60% of all the bird species in North America. However, the loss of more than 50% of historic floodplain and valley hardwood forests creates a problem for many waterfowl, raptors, songbirds, and shorebirds. The boreal transition forests of the Upper Mississippi River provide nearly the entire habitat for species such as Kirtland's and golden-winged warblers. Losses of prairie and oak savannah and transition habitats have threatened other species such as the prairie chicken, Bell's vireo and Cerulean warbler. The management of these unique and rich hardwood forest ecosystems is of particular interest to future recovery and conservation of many target species (Korschgen et al. 1998).

Methods and Results

This analysis relied upon a set of tools developed by the USGS entitled LINK (Fox et al. 2004). Portions of the following description of LINK were taken from the tool's online documentation and from Thogmartin et al. (2006).

> LINK is a set of ArcGIS tools designed to map species-habitat patterns across a landscape. LINK uses species-habitat matrices to model potential species habitat and

habitat diversity. These species-habitat matrices are user contributed and typically are created through expert opinion regarding species-habitat associations. What sets LINK apart from its predecessors is that it relates these user-contributed species/habitat matrices to raster data sources such as land cover. Raster data allows LINK to model habitat associations over a much larger spatial extent (e.g., counties, states, regions) than that of its vector-based antecedents.

Three main data sources are needed to run a LINK query: a species-habitat matrix, source layers, and (optionally) zonal layers.

A species-habitat matrix relates, for each habitat type within the raster source layer, a score representing species-habitat suitability. Species Habitat suitability ranges from 0 (little to no value as habitat) to 100 (prime habitat). The source layer is a raster spatial data layer containing landscape information for species listed in the matrix. A zonal layer is a vector (polygonal) spatial data layer used to divide the landscape into units of comparison (i.e., Counties, Management Units).

LINK relates values contained in the species-habitat matrix to the source layer to generate several indices of potential habitat. These indices include mean potential species occurrence (PSO) and potential species richness (PSR), and may be calculated for an individual species or a group of species. Mean PSO is described as the average matrix score of the species queried for each source layer class. The maximum value for Mean PSO is 100. PSR is described as the potential number of species that may be found in a given area. The maximum value for PSR is equal to the total number of species queried. The Simpson's Diversity Index measures the diversity of habitats in each zone of a zonal layer. Only source layer classes with a PSO score > 0 are used to calculate Simpson's Diversity Index (SDI). SDI values range from 0 to less than 1. The SDI is positively influenced by the number of different habitat types and the relative equality of their areas.

If the user chooses, the program can summarize these indices for each zone within a zonal layer. A zonal layer is not required to run a LINK query, but summarizing habitat information by zone helps to illustrate the distribution of habitats across a region; the use of a zonal layer provides a unit by unit evaluation of potential habitat within the area of interest.

An extension was developed to the LINK tool that incorporates bird species ranges into models of habitat suitability; in this way, species are modeled only for those areas in their range for which they are believed to exist. This range limitation emphasizes that the LINK tool models potential rather than occupied habitat. As part of this extension, we incorporated ranges for all birds in the Western Hemisphere as provided in the collection of digital distribution maps by NatureServe, and the Breeding Bird Survey. The NatureServe ranges act as a 0/1 binary mask of the predictions, allowing predicted habitat to show only for areas within the range of the species, whereas the Breeding Bird Survey ranges act as weights to the predictions, weighing predicted species occurrence by the scaled species predicted abundance.

Four separate LINK queries were run within the UMRS based upon four different bird/habitat guilds. A guild is a way to group species according to similar ecological resource requirements. The guilds used for this analysis were bottomland forest birds, upland forest birds, grassland birds, and shrubland birds. The individual species are listed in Table 7. Species were selected based on whether they were declining in numbers, or require a specific habitat type or habitat configuration that is imperiled within the UMRS (e.g., bottomland forest). Many of these species are also listed in the USFWS's "Birds of Conservation Concern, 2002" (USFWS 2002).

Table 7. Important migratory birds used in the analyses

Bottomland Forest	Upland Forest	Grassland	Shrubland
American Woodcock	Black-billed Cuckoo	Bobolink	Bell's Vireo
Canada Warbler	Brown Thrasher	Dickcissel	Blue-winged Warbler
Connecticut Warbler	Cerulean Warbler	Eastern Meadowlark	Least Flycatcher
Louisiana Waterthrush	Golden-winged Warbler	Grasshopper Sparrow	Willow Flycatcher
Prothonotary Warbler	Kentucky Warbler	Greater Prairie-Chicken	Yellow-breasted Chat
Red-shouldered Hawk	Yellow-shafted Flicker	Henslow's Sparrow	
	Ovenbird	Le Contes Sparrow	
	Red-headed Woodpecker	Loggerhead Shrike	
	Rose-breasted Grosbeak	Northern Bobwhite	
	Ruffed Grouse	Northern Harrier	
	Veery	Sedge Wren	
	Whip-poor-will	Sharp-tailed Grouse	
	Wood Thrush	Upland Sandpiper	
	Yellow throated vireo		
	Yellow-billed Cuckoo		

The source layer used in the analysis was the NLCD from 1992.

The UMRS intersects several Bird Conservation Regions (BCR) but is predominately made up of BCR 11 (prairie potholes), BCR 12 (boreal hardwood transition), BCR 22 (eastern tallgrass prairie), BCR 23 (prairie hardwood transition), and BCR 24 (central hardwoods) representing various forested to transitional forest/grassland to grassland habitats. The matrix used for the following UMRS LINK analyses was developed for use specifically within BCR 23. This matrix was scored by experts in the field of migratory bird ecology.

The zonal layer used within the analysis is counties. The range maps used for the analysis were the ones obtained from NatureServe. Figure 37 displays an example range map of one species for each of the four guilds used in the analysis. Areas in pink fall within that particular species range as derived by NatureServe. NatureServe range maps were used because they were not limited to the breeding season, but depict range throughout the year.

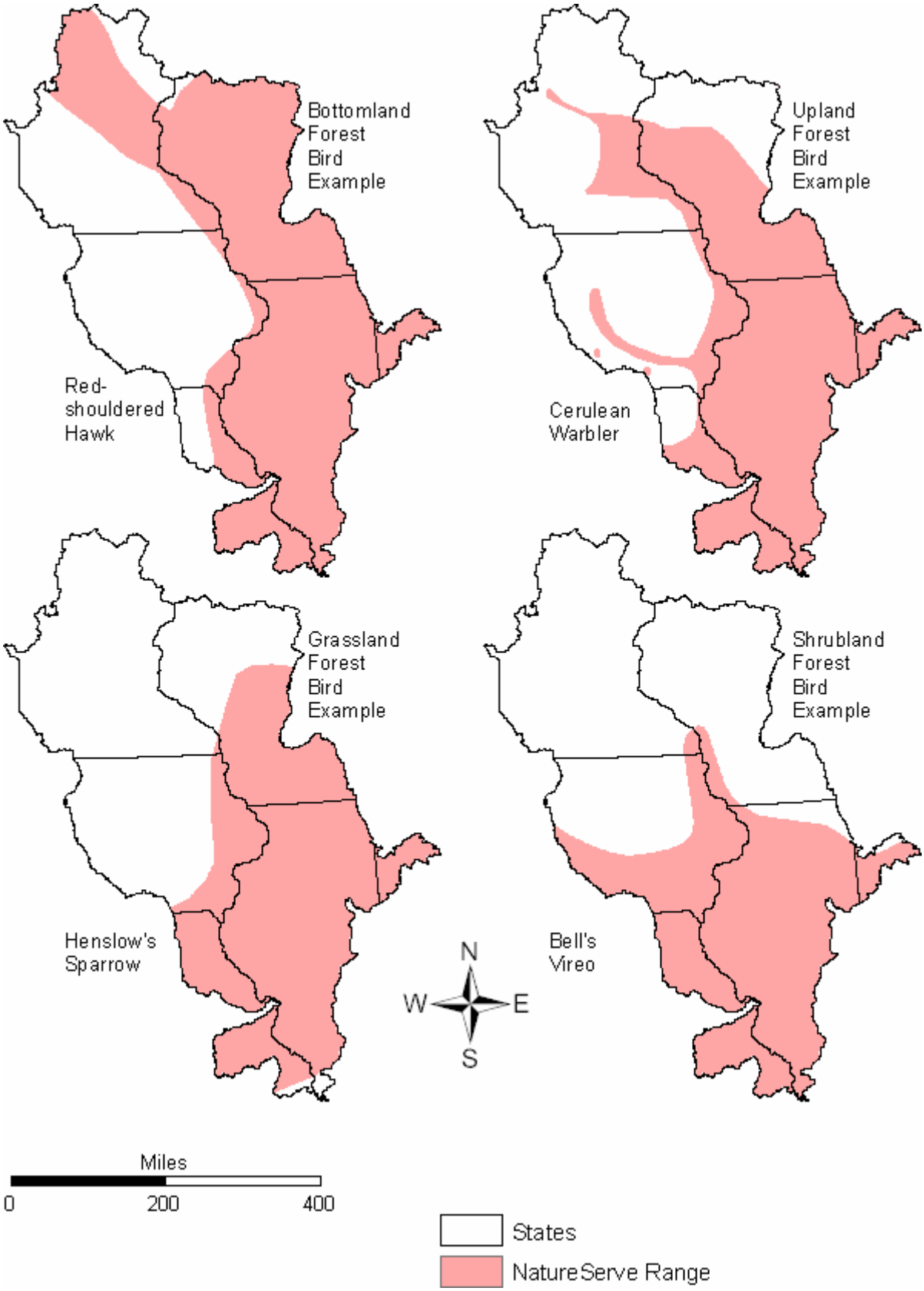

Figure 37. Example of NatureServe range maps

Bottomland Forest Birds LINK Output

The bottomland forest bird guild is made up of six representative species. These are species that are known to use the general habitat type of bottomland forests extensively. The numbers displayed in the cells in Figure 38 shows to what level each individual species was determined to use each of the NLCD habitat types.

	Open Water	Low Intensity Residential	High Intensity Residential	Commercial/Industrial/Transportation	Bare Rock/Sand/Clay	Quarries/Strip Mines/Gravel Pits	Transitional	Deciduous Forest	Evergreen Forest	Mixed Forest	Shrubland	Orchards/Vineyards/Other	Grasslands/Herbaceous	Pasture/Hay	Row Crops	Small Grains	Urban/Recreational Grasses	Woody Wetlands	Emergent Herbaceous Wetlands
Bottomland Forest Birds																			
American Woodcock	0	0	0	0	0	0	0	100	0	80	80	0	0	0	0	0	0	80	0
Canada Warbler	0	0	0	0	0	0	0	40	20	100	0	0	0	0	0	0	0	80	0
Connecticut Warbler	0	0	0	0	0	0	0	0	100	20	0	0	0	0	0	0	0	20	0
Louisiana Waterthrush	0	0	0	0	0	0	0	20	0	20	0	0	0	0	0	0	0	100	0
Prothonotary Warbler	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	100	0
Red-shouldered Hawk	0	0	0	0	0	0	0	60	0	40	20	0	0	0	0	0	0	100	20

Figure 38. Bottomland forest birds matrix

Once the analysis is completed using LINK, one of the products created is a raster dataset depicting mean potential species occurrence. Figure 39 shows this output for bottomland forest birds.

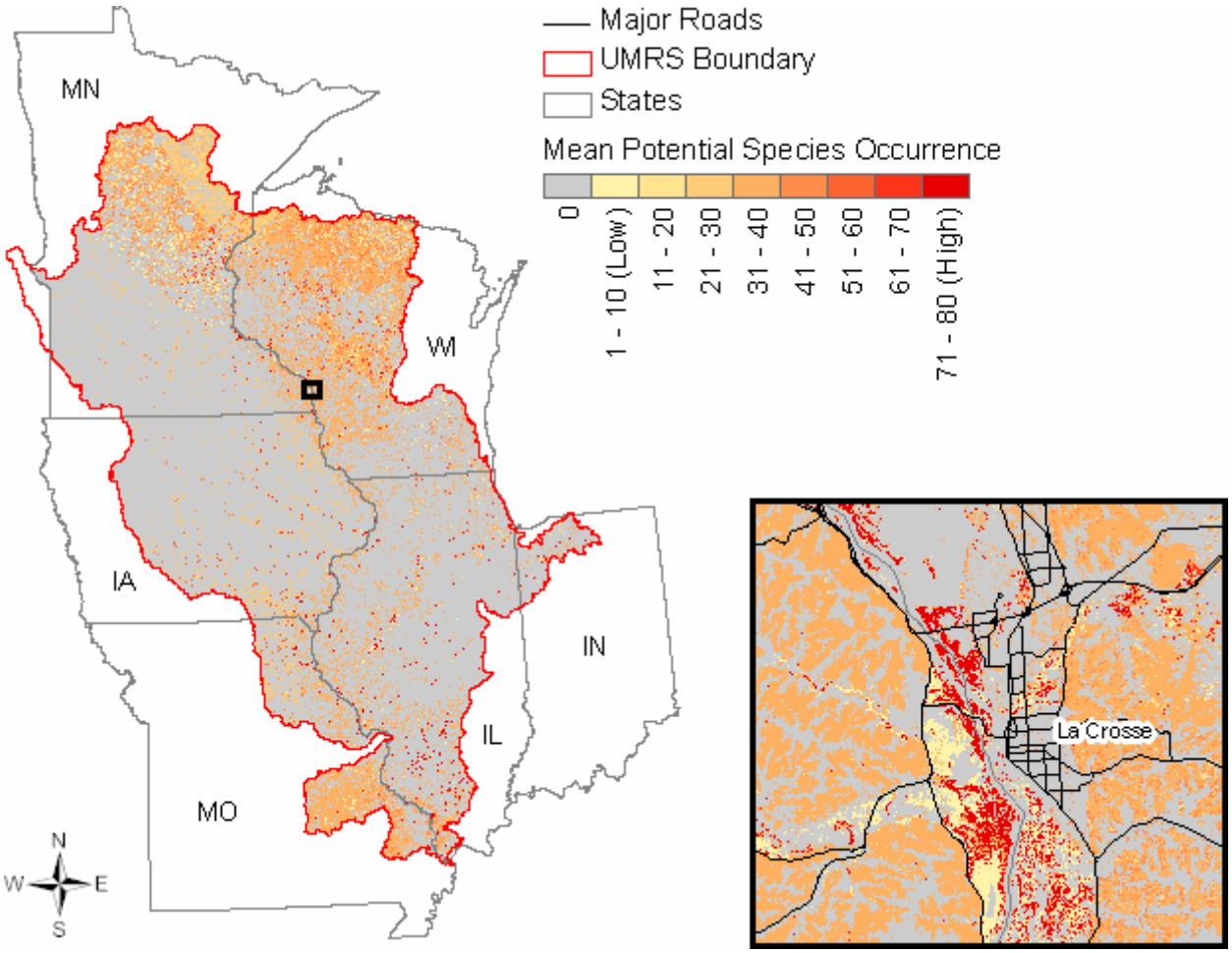

Figure 39. Bottomland forest birds LINK output

Area-weighted mean PSO score is calculated each time a LINK query is initiated. This score is created by multiplying the area of each land cover class by the average PSO value for all species using that land cover class, summing this value for all land cover types, then dividing by the total area.

(∑ (Area of each habitat type * PSO value for each habitat type)) / Total Area

The higher the area-weighted mean PSO score, the more useful that particular area of interest is for the species queried (based on the land cover used, the species selected, and the matrix used). This score does not take into account things such as edge effects, patch size or other landscape patterns. It only looks at land cover composition. The number itself doesn't reveal a lot, but comparing this score to scores calculated either on a different area or using different species allows you to make general comparisons. The area-weighted mean PSO score for bottomland forest birds was calculated to be **9.13**. The area-weighted mean PSO scores for the four bird guilds range from a low of 7.70 to a high of 19.65 (Figure 46). The low score for bottomland forest birds indicates that the UMRS provides relatively little potential bottomland forest bird habitat when compared to potential upland forest and grassland bird habitat.

Upland Forest Birds LINK Output

There were 15 species aggregated to form the upland forest birds guild in the upland forest birds LINK model. Figure 40 shows each of the species along with the individual potential species occurrence scores for each NLCD land cover type.

	Open Water	Low Intensity Residential	High Intensity Residential	Commercial/Industrial/Transportation	Bare Rock/Sand/Clay	Quarries/Strip Mines/Gravel Pits	Transitional	Deciduous Forest	Evergreen Forest	Mixed Forest	Shrubland	Orchards/Vineyards/Other	Grasslands/Herbaceous	Pasture/Hay	Row Crops	Small Grains	Urban/Recreational Grasses	Woody Wetlands	Emergent Herbaceous Wetlands
Upland Forest Birds																			
Black-billed Cuckoo	0	20	0	0	0	0	40	100	0	60	100	60	0	0	0	0	0	60	0
Brown Thrasher	0	60	0	0	0	0	40	40	0	60	100	100	20	0	0	0	20	60	0
Cerulean Warbler	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	100	0
Golden-winged Warbler	0	0	0	0	0	0	60	60	0	80	100	0	0	0	0	0	0	100	0
Kentucky Warbler	0	0	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	20	0
Ovenbird	0	0	0	0	0	0	0	100	20	80	0	0	0	0	0	0	0	40	0
Red-headed Woodpecker	0	40	0	0	0	0	0	60	0	40	20	40	20	20	0	0	20	40	0
Rose-breasted Grosbeak	0	40	0	0	0	0	20	100	0	80	60	20	0	0	0	0	0	60	0
Ruffed Grouse	0	0	0	0	0	0	20	100	40	100	0	20	0	0	0	0	0	0	0
Veery	0	0	0	0	0	0	0	80	0	100	40	0	0	0	0	0	0	100	0
Whip-poor-will	0	0	0	0	0	0	40	60	20	60	60	40	20	20	0	0	0	20	0
Wood Thrush	0	0	0	0	0	0	0	100	0	80	0	0	0	0	0	0	0	40	0
Yellow-billed Cuckoo	0	40	0	0	0	0	20	100	0	20	80	40	0	0	0	0	0	80	0
Yellow-shafted Flicker	0	60	0	0	20	20	60	100	20	60	80	80	80	80	0	0	40	80	0
Yellow-throated Vireo	0	20	0	0	0	0	0	80	0	60	0	0	0	0	0	0	0	100	0

Figure 40. Upland forest birds matrix

Figure 41 shows the mean PSO output map for upland forest birds.

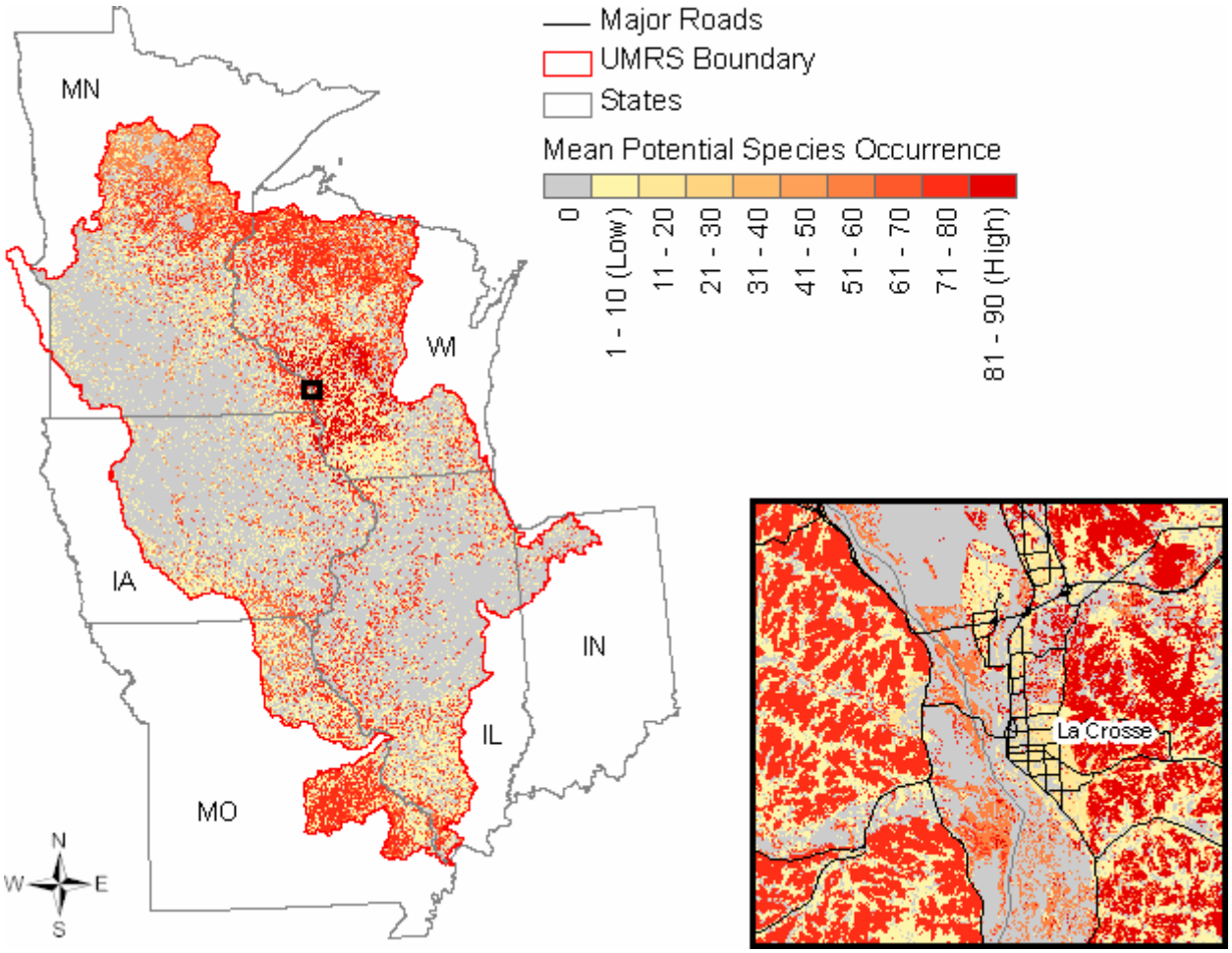

Figure 41. Upland forest birds LINK output

The area-weighted mean PSO score for upland forest birds was calculated to be **18.69**. The area-weighted mean PSO scores for the four bird guilds range from a low of 7.70 to a high of 19.65 (Figure 46). The high score for upland forest birds indicates that the UMRS provides relatively extensive potential upland forest bird habitat when compared to potential bottomland forest and shrubland bird habitat.

Grassland Birds LINK Output

There were 13 species aggregated to form the grassland birds guild. Figure 42 shows each of the species along with the individual potential species occurrence scores for each NLCD land cover type.

	Open Water	Low Intensity Residential	High Intensity Residential	Commercial/Industrial/Transportation	Bare Rock/Sand/Clay	Quarries/Strip Mines/Gravel Pits	Transitional	Deciduous Forest	Evergreen Forest	Mixed Forest	Shrubland	Orchards/Vineyards/Other	Grasslands/Herbaceous	Pasture/Hay	Row Crops	Small Grains	Urban/Recreational Grasses	Woody Wetlands	Emergent Herbaceous Wetlands
Grassland Birds																			
Bobolink	0	0	0	0	0	0	20	0	0	0	0	0	100	100	0	0	20	0	20
Dickcissel	0	0	0	0	0	0	0	0	0	0	0	0	100	80	20	0	0	0	0
Eastern Meadowlark	0	20	0	40	20	20	0	0	0	0	40	40	80	100	20	20	20	0	20
Grasshopper Sparrow	0	0	0	0	0	0	0	0	0	0	0	0	100	80	0	20	20	0	0
Greater Prairie-Chicken	0	0	0	0	0	0	20	0	0	0	20	0	100	100	0	40	0	0	0
Henslow's Sparrow	0	0	0	0	0	0	0	0	0	0	20	0	100	40	0	0	0	0	40
Le Conte's Sparrow	0	0	0	0	0	0	0	0	0	0	0	0	60	40	0	0	0	0	100
Loggerhead Shrike	0	0	0	0	0	0	20	0	0	0	40	40	100	100	0	0	0	0	0
Northern Bobwhite	0	20	0	0	0	0	60	40	0	0	60	100	100	80	100	80	0	20	0
Northern Harrier	0	0	0	0	0	0	20	0	0	0	40	0	100	100	0	0	0	40	80
Sedge Wren	0	0	0	0	0	0	0	0	0	0	0	0	60	40	0	0	0	40	100
Sharp-tailed Grouse	0	0	0	0	0	0	60	0	20	40	100	0	60	100	0	100	0	0	0
Upland Sandpiper	0	0	0	0	0	0	0	0	0	0	0	0	100	100	40	0	40	0	0

Figure 42. Grassland birds matrix

Figure 43 shows the mean PSO output map for grassland birds.

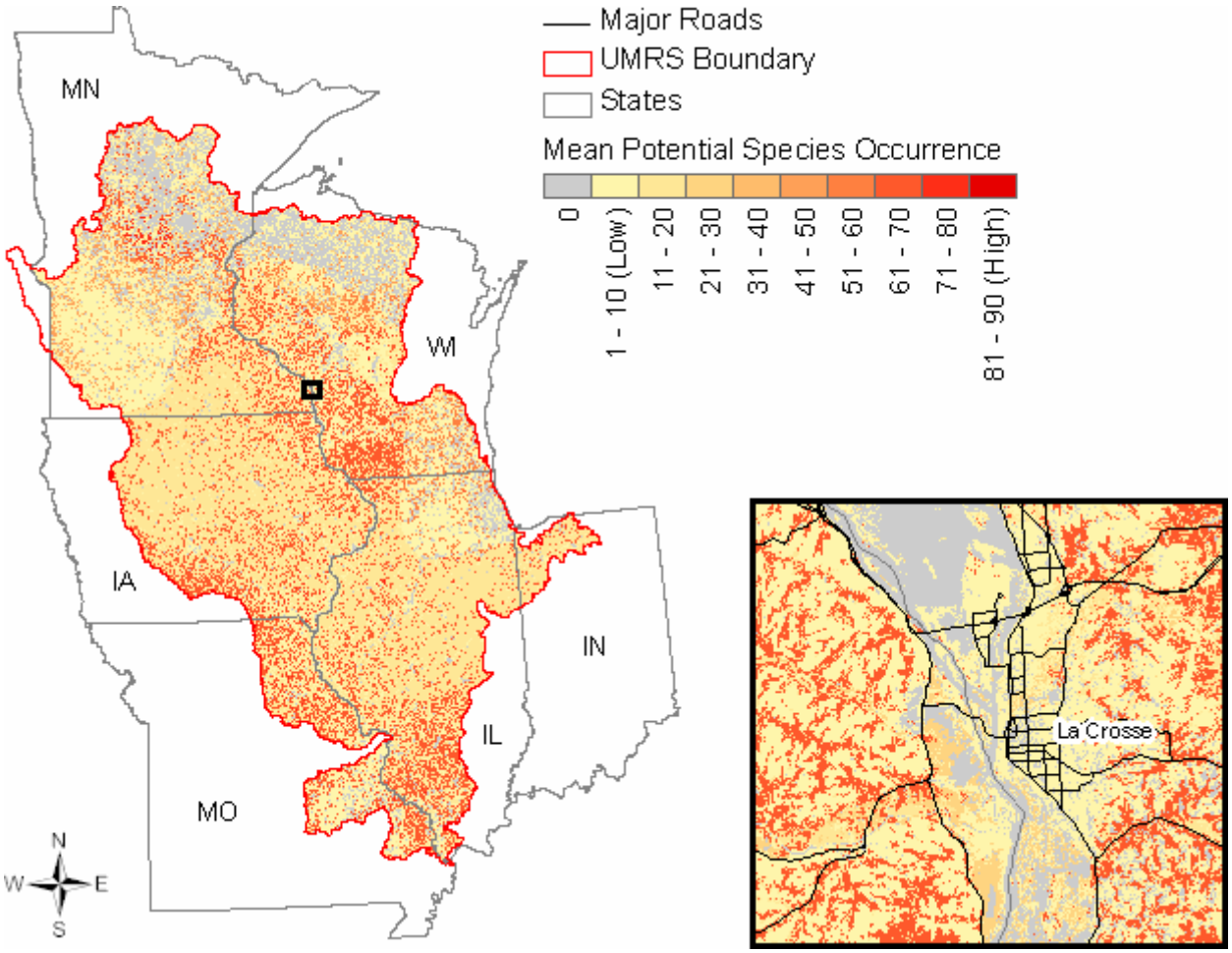

Figure 43. Grassland birds LINK output

The area-weighted mean PSO score for grassland birds was calculated to be **19.65**. The area-weighted mean PSO scores for the four bird guilds range from a low of 7.70 to a high of 19.65 (Figure 46). The high score for grassland birds indicates that the UMRS provides relatively extensive potential grassland bird habitat when compared to potential bottomland forest and shrubland bird habitat.

Shrubland Birds LINK Output

There were five species aggregated to form the shrubland birds guild. Figure 44 shows each of the species along with the individual potential species occurrence scores for each NLCD land cover type.

	Open Water	Low Intensity Residential	High Intensity Residential	Commercial/Industrial/Transportation	Bare Rock/Sand/Clay	Quarries/Strip Mines/Gravel Pits	Transitional	Deciduous Forest	Evergreen Forest	Mixed Forest	Shrubland	Orchards/Vineyards/Other	Grasslands/Herbaceous	Pasture/Hay	Row Crops	Small Grains	Urban/Recreational Grasses	Woody Wetlands	Emergent Herbaceous Wetlands
Shrubland Birds																			
Bell's Vireo	0	0	0	0	0	0	0	0	0	0	100	20	40	0	0	0	0	40	0
Blue-winged Warbler	0	0	0	0	0	0	60	100	0	20	80	0	0	0	0	0	0	60	0
Least Flycatcher	0	0	0	0	0	0	20	100	0	100	20	40	0	0	0	0	0	40	0
Willow Flycatcher	0	0	0	0	0	0	0	20	0	0	100	0	0	0	0	0	0	100	0
Yellow-breasted Chat	0	0	0	0	0	0	20	0	0	0	100	20	0	0	0	0	0	40	0

Figure 44. Shrubland birds matrix

Figure 45 shows the mean PSO output map for shrubland birds.

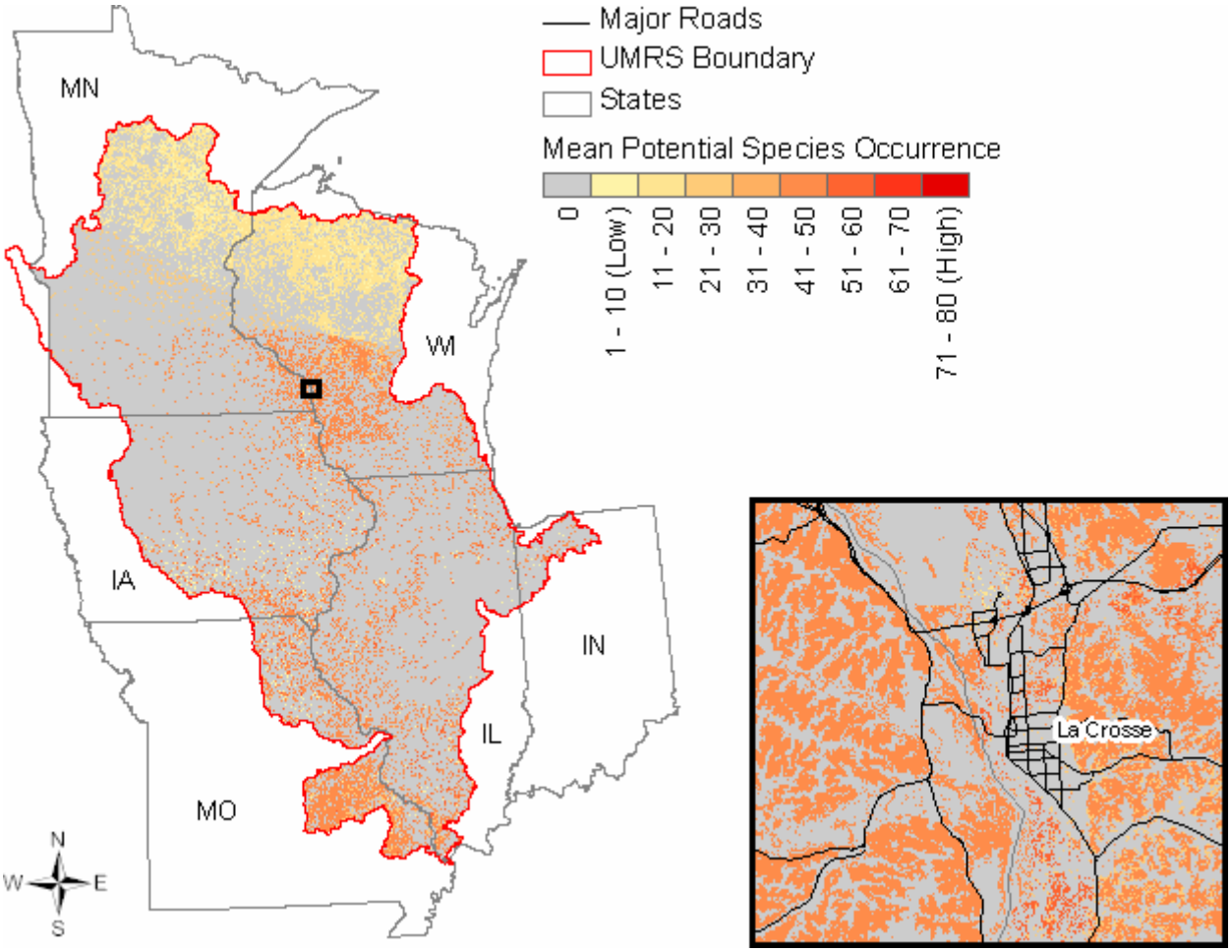

Figure 45. Shrubland birds LINK output

The area-weighted mean PSO score for shrubland birds was calculated to be **7.70**. The area-weighted mean PSO scores for the four bird guilds range from a low of 7.70 to a high of 19.65 (Figure 46). The low score for shrubland birds indicates that the UMRS provides relatively little potential shrubland bird habitat when compared to potential upland forest and grassland bird habitat.

Bird Guild	Area Weighted Mean PSO
Grassland Birds	19.65
Upland Forest Birds	18.69
Bottomland Forest Birds	9.13
Shrubland Birds	7.70

Figure 46. Area-weighted mean potential species occurrence by bird guild

The individual species area-weighted mean PSO values are displayed in Figure 47. The values are sorted (in descending order) for each guild by area-weighted mean PSO. This figure identifies the individual species from each guild with the highest area-weighted mean PSO value.

Bottomland Forest Birds	Area Weighted Mean PSO	Upland Forest Birds	Area Weighted Mean PSO
American Woodcock	22.83	Yellow-shafted Flicker	40.10
Red-shouldered Hawk	12.42	Rose-breasted Grosbeak	22.46
Canada Warbler	12.37	Black-billed Cuckoo	21.98
Louisiana Waterthrush	3.93	Ovenbird	20.58
Connecticut Warbler	2.07	Yellow-billed Cuckoo	20.29
Prothonotary Warbler	1.16	Veery	20.26
Grassland Birds		Wood Thrush	19.90
Northern Bobwhite	51.51	Yellow-throated Vireo	19.62
Upland Sandpiper	38.82	Red-headed Woodpecker	17.87
Eastern Meadowlark	27.76	Whip-poor-will	17.20
Dickcissel	24.64	Golden-winged Warbler	16.39
Northern Harrier	23.98	Ruffed Grouse	12.78
Bobolink	21.13	Brown Thrasher	11.84
Loggerhead Shrike	19.14	Cerulean Warbler	11.62
Grasshopper Sparrow	16.93	Kentucky Warbler	7.44
Sedge Wren	12.36	Shrubland Birds	
Le Conte's Sparrow	10.72	Least Flycatcher	21.57
Henslow's Sparrow	5.16	Blue-winged Warbler	12.00
Sharp-tailed Grouse	2.91	Willow Flycatcher	3.82
Greater Prairie-Chicken	0.40	Bell's Vireo	0.70
		Yellow-breasted Chat	0.43

Figure 47. Area-weighted mean potential species occurrence by bird species

Mean PSO can be broken down for each bird guild according to area percentages. In Figure 48 mean PSO is categorized in groupings of 10 and each bird guild is labeled according to the percentage of the landscape's area that had a mean PSO value in each particular grouping (numbers in bold represent the three groupings with the highest percent). A large percentage of the UMRS had a mean PSO score greater than 50 for the upland forest bird and grassland bird

guilds. This means there was a significant juxtaposition of species ranges with land cover types within the UMRS that had a score greater than 50 according to the matrix. Thus, higher rated habitat is easier to find when looking for upland forest birds and grassland birds within the UMRS. Also, grassland bird areas of potential species occurrence are much more widespread than the other guilds. Only 11.22% of the UMRS is considered "non-habitat" according to the LINK model for the grassland bird species selected.

meanPSO	Bottomland Forest Birds	Upland Forest Birds	Grassland Birds	Shrubland Birds
0 (non-habitat)	**73.49**	**52.48**	11.22	**75.11**
1 - 10	1.46	**22.40**	**32.42**	3.40
11 - 20	1.17	1.15	**33.56**	**7.73**
21 - 30	**4.22**	0.00	2.28	1.37
31 - 40	**15.81**	0.09	0.00	0.34
41 - 50	2.49	1.11	2.00	**11.15**
51 - 60	0.16	5.48	2.49	0.90
61 - 70	0.48	2.11	**15.24**	0.00
71 - 80	0.72	**13.02**	0.78	0.00
81 - 90	0.00	2.15	0.01	0.00
91 - 100	0.00	0.00	0.00	0.00

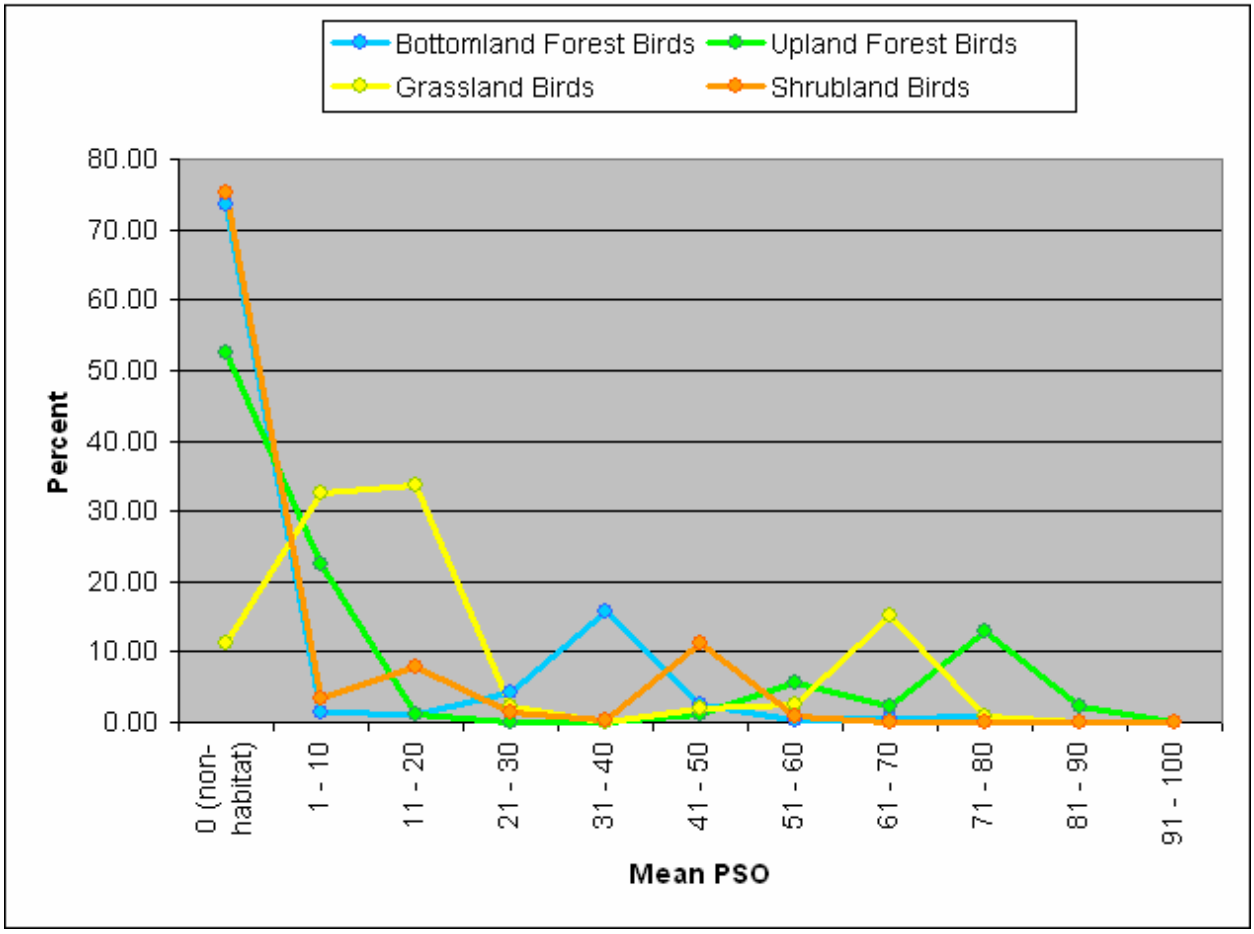

Figure 48. Bird guild mean potential species occurrence scores separated by area percentage

Next, a zonal analysis was completed for each bird guild according to mean PSO, PSR, and SDI. Figure 49 displays mean PSO averaged by county, Figure 50 displays PSR averaged by county, and Figure 51 displays SDI averaged by county. The color range values for the separate guilds within the maps are unrelated guild-to-guild but only show the general low to high value progression (i.e., colors are unrelated map-to-map).

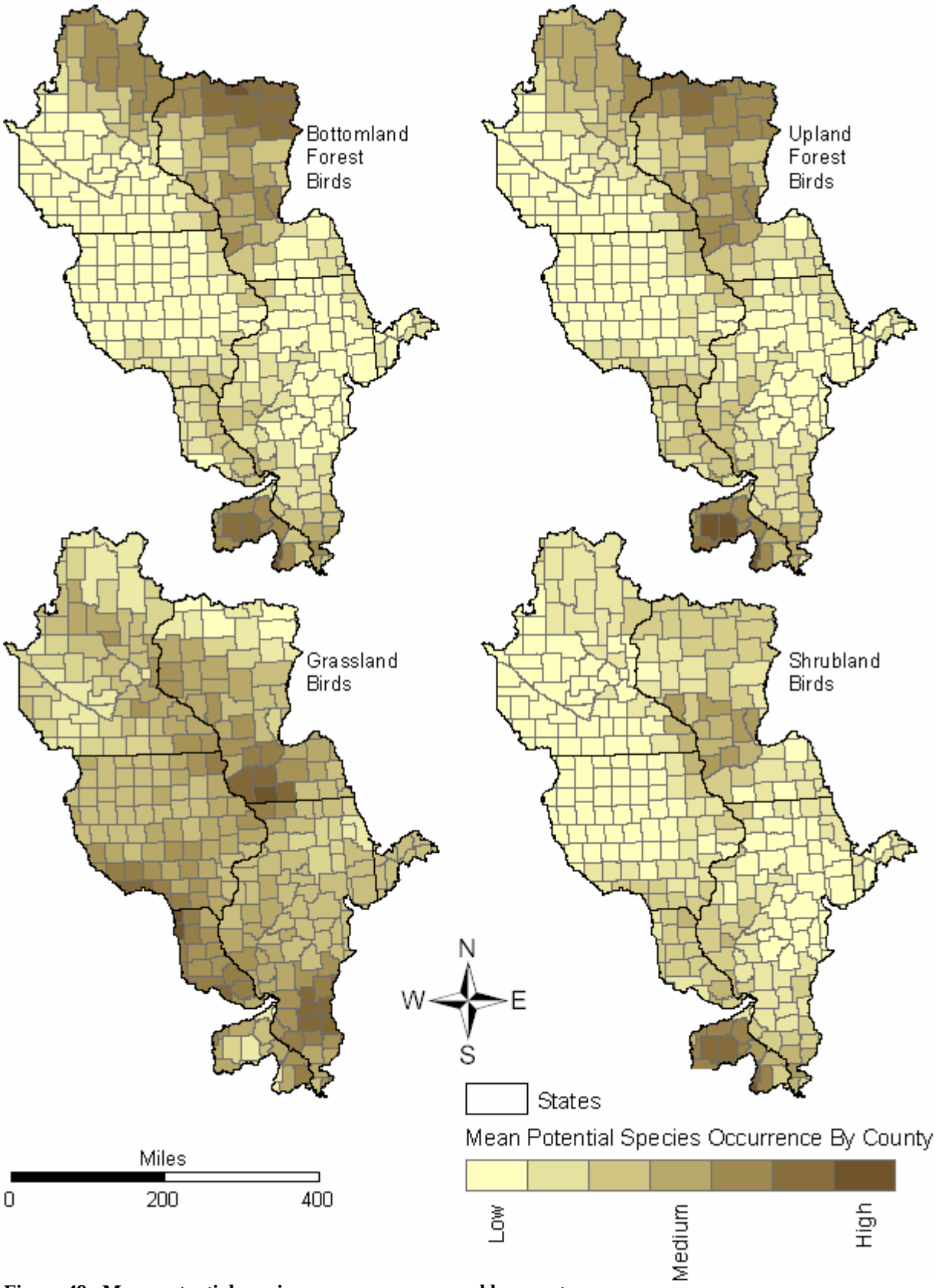

Figure 49. Mean potential species occurrence averaged by county

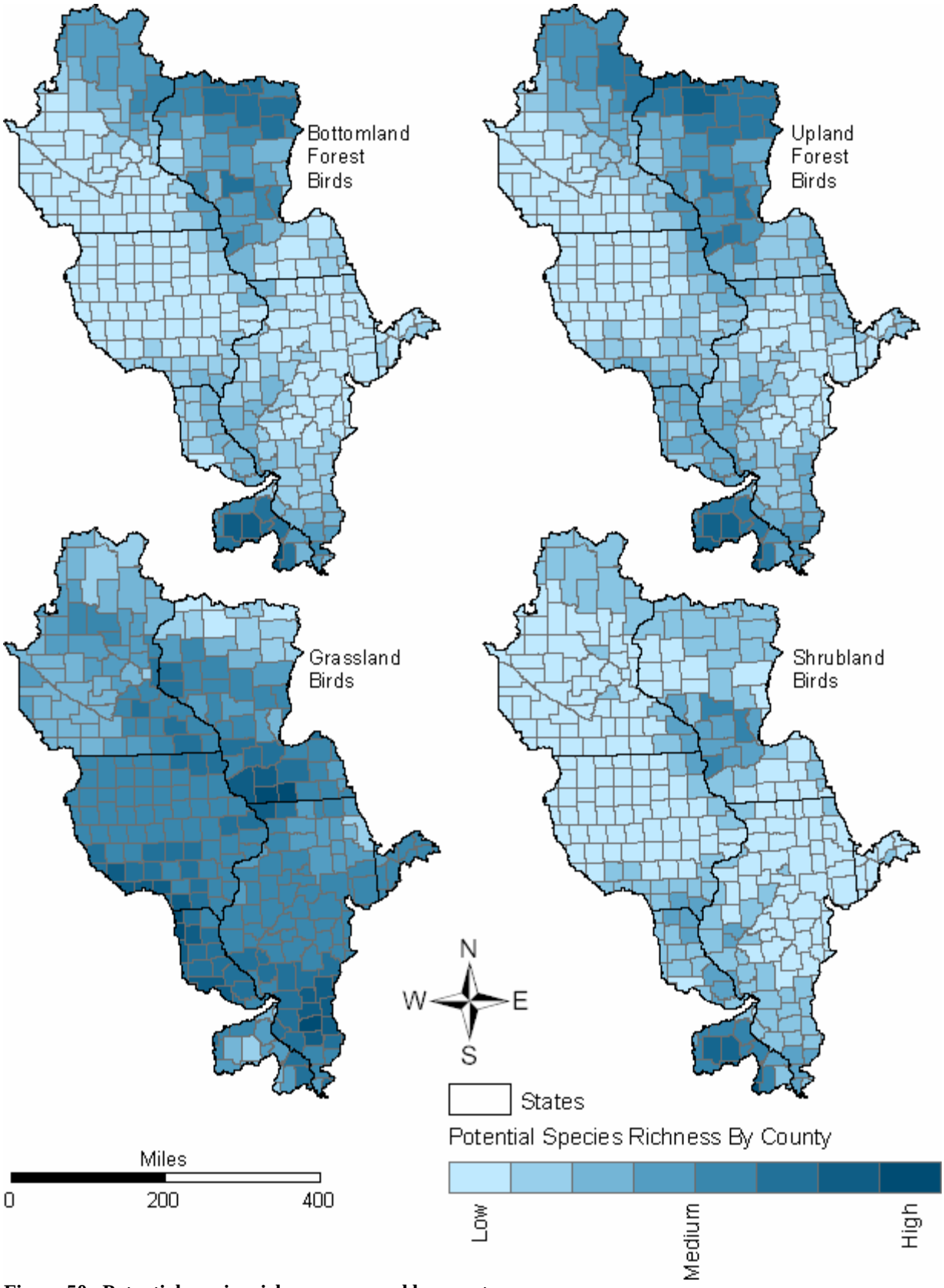

Figure 50. Potential species richness averaged by county

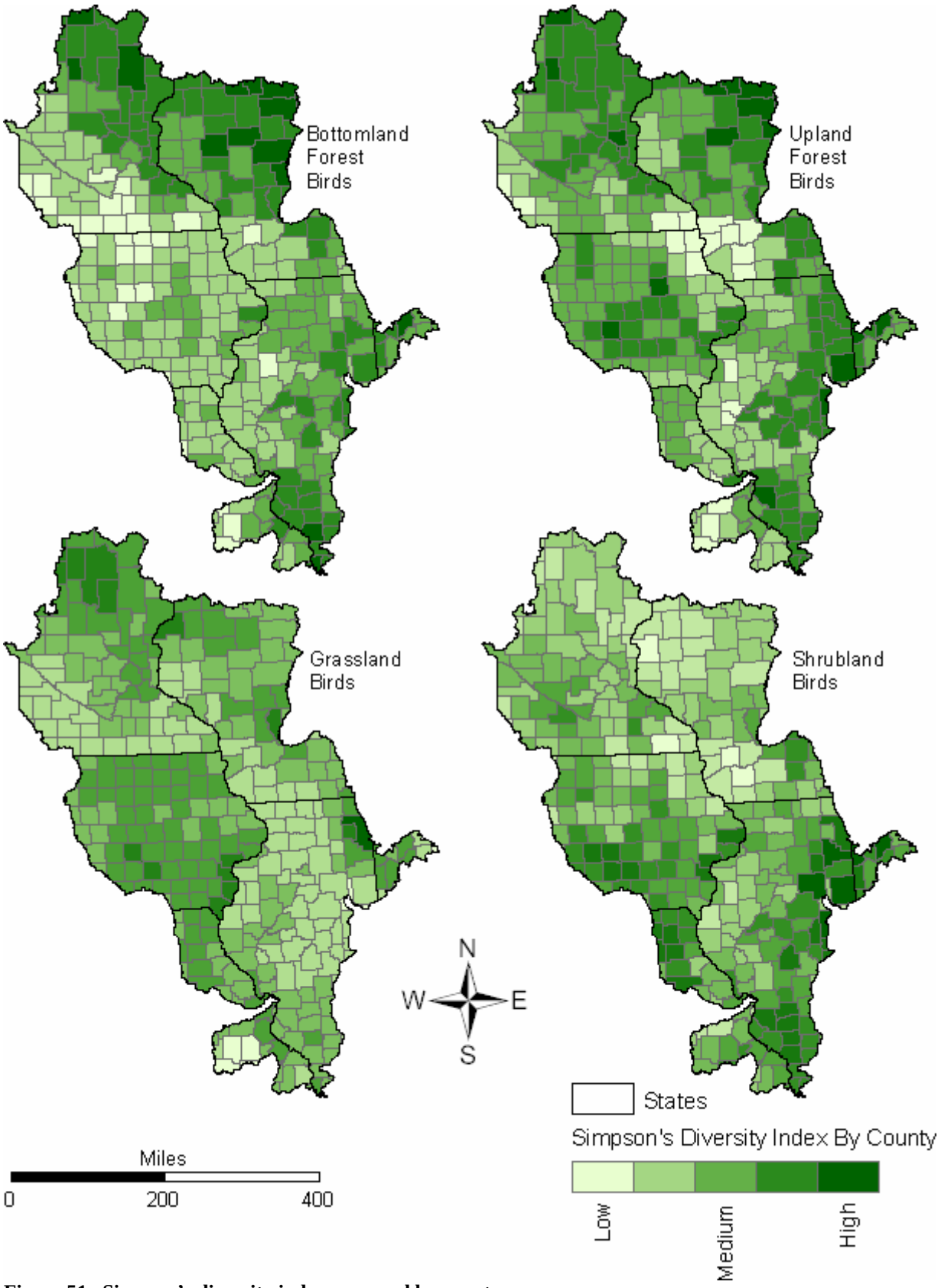

Figure 51. Simpson's diversity index averaged by county

Conclusions

This information will be important to forest managers and private forest landowners in assessing the potential of forested and transitional forested areas in providing migratory bird habitat. The large scale analysis helps to point out areas important in terms of habitat connectivity. The potential species richness data help to point out areas where restoration effects might have a better outcome in terms of providing habitat to a variety of species.

More detailed maps in both Adobe Portable Document Format (.pdf) and Joint Photographic Experts Group (.jpg) formats are located on the Upper Mississippi Forest Partnership website at http://www.na.fs.fed.us/watershed/upper_mississippi_partnership/.

Priority Forests for Conservation

Introduction

Forest, and in particular, bottomland forest land continues to decrease in the UMRS. This loss was driven by conversion to agricultural land in the 19th and early 20th century. More recently this loss is due to encroachment by invasive species (e.g., reed canary grass), urbanization and suburbanization (Lohman et al. 2006) In the Midwest, the majority of this forest land is owned by private individuals and the number of forest landowners, each owning smaller chunks of forest land, increases each year. Also, historical harvesting of the northern pine forests and conversion of prairies and forests to agriculture has altered the hydrology of the watershed.

There is no exception to the areas affected. Public water supply recharge areas, steep slopes, habitat for threatened and endangered species, riparian areas and wetlands are being impacted. A mosaic of agricultural, suburban, and urban land uses has replaced the native prairie, oak savannah, forest, and wetland in the Upper Mississippi River Basin. This change has affected natural ecosystems.

Methods and Results

This analysis involved prioritizing existing forests within the UMRS for conservation. Several different input data layers were used in this prioritization process. Specifically, forests were considered higher priority if they were

- Within watersheds (8-digit HUC) with low nitrogen yield
- Had a high relative density of water consumers
- Had a high value for bottomland forest bird species (LINK)
- Had a high value for upland forest bird species (LINK)
- High percent slope
- Resided on erodible soils
- Were close to water
- Was delineated as a forested or scrub/shrub wetland
- In close proximity to publicly managed lands
- Were feeling pressure from projected housing development
- Were in close proximity to a threatened or endangered species

For this particular analysis, NLCD land cover types 41, 42, 43, and 91 (deciduous forest, coniferous forest, mixed, and woody wetlands, respectively) occurring within the UMRS were considered forest.

The first step in the analysis was to create a model using several data parameters to rank the forests within the UMRS that have the highest conservation priority. The model parameters displayed in Table 8 shows the scores given to each separate data layer's unique attributes and the relative influence each data layer has within the model as a whole (table continues on following page). Higher scores are given to an attribute if it is the preferred characteristic. Higher model percent influences were given to those data layers that were considered most important in prioritizing areas for forest conservation.

Table 8. Priority forest model parameters

SPARROW Nitrogen Yield		**Distance to Hydrography**	
Score	Kg/sq km/year	Score	Distance (feet)
10	120 – 250	10	0 – 500
9	251 – 500	9	501 – 1000
8	501 – 750	8	1001 – 1500
7	751 – 1000	7	1501 – 2000
6	1001 – 1250	6	2001 – 2500
5	1251 – 1500	5	2501 – 3000
4	1501 – 1750	4	3001 – 3500
3	1751 – 2000	3	3501 – 4000
2	2001 – 2250	2	4001 – 4500
1	2251 – 2500	1	4501 – 5000
0	> 2500	0	> 5000
15%	Model Influence	0	Hydrography (Water)
EPA drinking Water Intakes		9%	Model Influence
Score	Adjusted popn. of water consumers	**Wetlands**	
0	0 – 25	Score	Description
1	26 – 58	0	Other Wetland
2	59 – 83	10	Forest/Scrub Shrub
3	84 – 170	0	Unclassified
4	171 – 207	7%	Model Influence
5	208 – 281	**Proximity to Public Lands (Including**	
6	282 – 470	Score	Distance (miles)
7	471 – 694	10	0 – 0.5
8	695 – 1017	7	0.5 – 1.0
9	1018 – 1541	6	1.0 – 1.5
10	> 1541	5	1.5 – 2.0
13%	Model Influence	4	2.0 – 2.5
LINK Bottomland Forest Model Results		3	2.5 – 3.0
Score	Mean Potential Species Occurrence Score	2	3.0 – 3.5
0	0	1	3.5 – 4.0
1	1	0	4.0 – 4.5

3	2
5	3
7	4
8	5
9	6
10	7
12%	Model Influence
LINK Upland Forest Model Results	
Score	Mean Potential Species Occurrence Score
0	0
1	1
2	2 – 4
3	5 – 6
4	7
5	8 – 9
6	10
7	11
8	12 – 13
9	14 – 15
10	16 - 18
12%	Model Influence
Slope (Percent Rise)	
Score	Description
0	0 - 2
2	3 - 5
6	6 - 10
7	11 - 14
8	15 - 18
9	19 - 25
10	26 - 163
10%	Model Influence
STATSGO Soils Data	
Score	KFFACT (Soil Erodibility Factor)
0	Unclassified/Water
2	0 – 0.5
3	0.06 – 0.10
4	0.11 – 0.15
5	0.16 – 0.20
6	0.21 – 0.25
7	0.26 – 0.30
8	0.30 – 0.35
9	0.36 – 0.40
10	0.41 – 0.45
10%	Model Influence

0	4.5 – 5.0
0	> 5.0
0	Public Lands
5%	Model Influence
Theobald Change in Housing Density	
Score	Description
8	No Change
10	Increase of 1 Density Class
5	Increase of 2 Density Classes
0	Increase of 3 Density Classes
0	Increase of 4 Density Classes
0	Increase of 5 Density Classes
0	Increase of 6 Density Classes
0	Increase of 7 Density Classes
0	Increase of 8 Density Classes
0	Increase of 9 Density Classes
0	Increase of 10 Density Classes
0	Increase of 11 Density Classes
0	Increase of 12 Density Classes
0	Increase of 13 Density Classes
0	Increase of 14 Density Classes
0	Area Removed from Analysis
5%	Model Influence
Threatened and Endangered Species	
Score	Description
10	Within ½ mile buffer
0	Outside ½ mile buffer
2%	Model Influence

The priority forest conservation model was created in ModelBuilder 9.1 (Figure 52) and then run within the ArcMap GIS platform. NLCD forest class types (41, 42, 43, and 91) were used as an analysis mask for this analysis, meaning anything non-forested is given a value of NoData. Figure 53 shows the results of the "Priority Forests for Conservation" model.

Figure 52. Priority forest model diagram

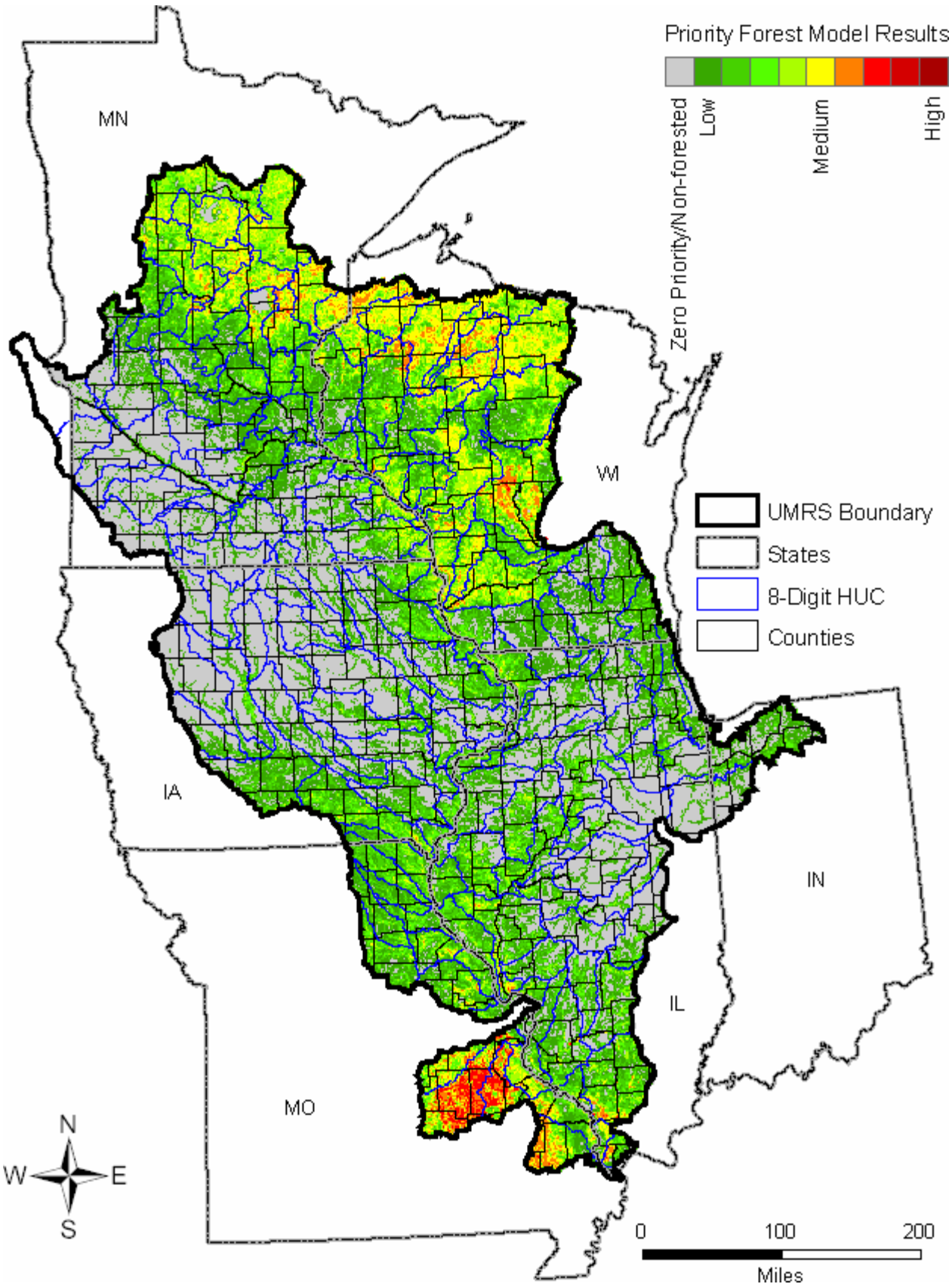

Figure 53. Priority forest model output

The model output was then averaged by 8-digit HUC (Figure 54 left). The HUCs shaded darkest red are those that have the highest mean priority forests for conservation score. Percent forest was then calculated by 8-digit HUC (Figure 54 right).

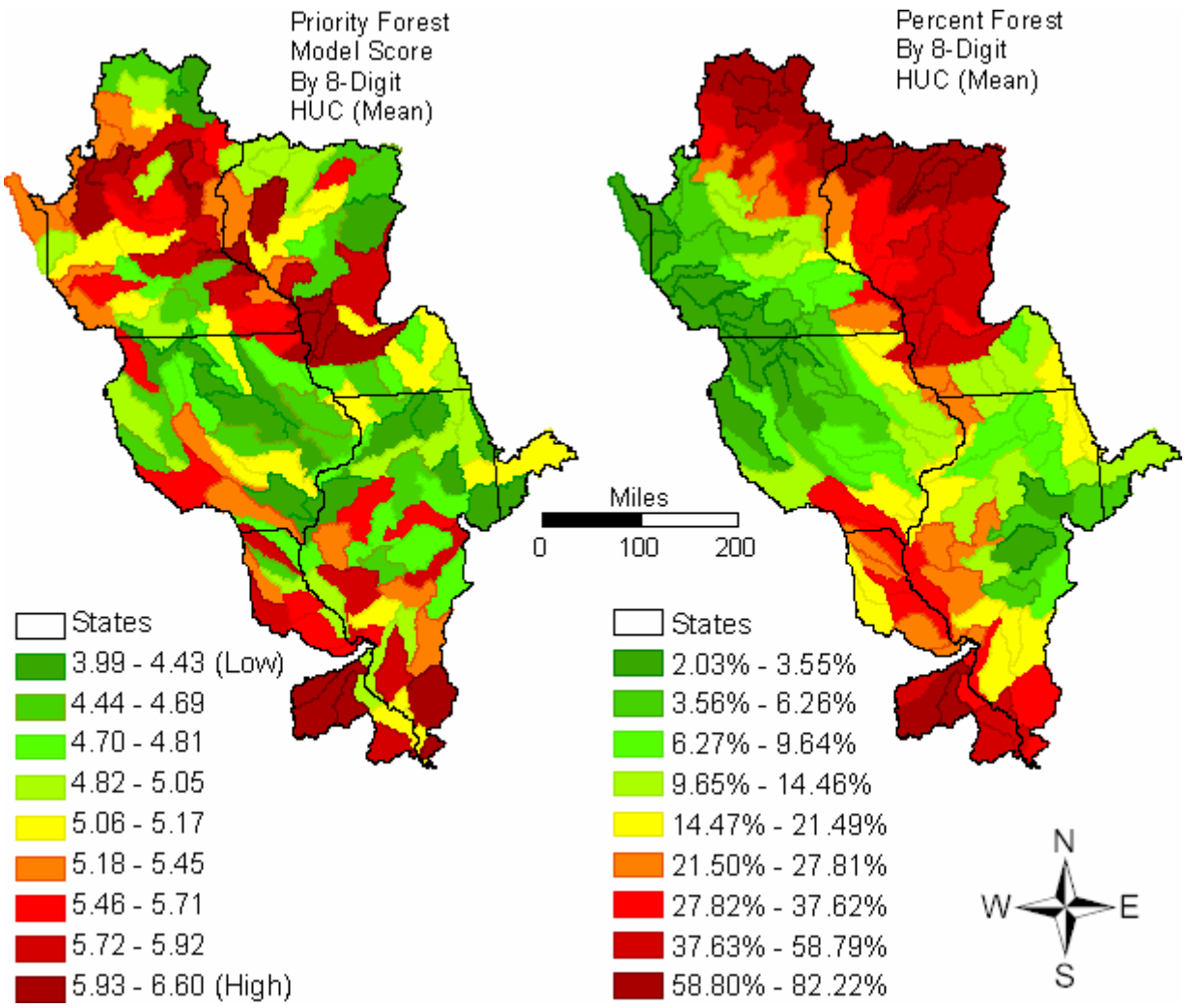

Figure 54. Priority forest model scores and percent forest summarized by watershed

Conclusions

In analyzing the Priority Forest Model map it is also important to take into account where forests do or do not exist today. Those red areas on the Priority Forest Model map that are currently forested (red in the Percent Forest map) are areas of existing forest land that should be conserved. Conversely, those red areas on the Priority Forest Model map that are low percentage forested (green in the Percent Forest map) are areas where reestablishing forests should be a priority.

A more detailed map in both Adobe Portable Document Format (.pdf) and Joint Photographic Experts Group (.jpg) formats is located on the Upper Mississippi Forest Partnership website at http://www.na.fs.fed.us/watershed/upper_mississippi_partnership/.

Next Steps

The Upper Mississippi Forest Partnership will share this information with key partners and discuss how this can influence their decision making. It will also be used in evaluating proposals submitted to the National Fish and Wildlife Foundation to the Upper Mississippi River Watershed Fund. Some analysis will be rerun by the Northeastern Area as the updated National Land Cover becomes available and as the Forest Health and Forest Fire risk maps are completed. Also, state partners have requested that some of the analyses be rerun for an individual state rather than the whole basin level. The existing data and the analysis process developed by the Upper Midwest Environmental Sciences Center will make these refinements relatively easy.

Acknowledgments

We thank Eileen Kirsch and John C. Nelson (USGS Upper Midwest Environmental Sciences Center), Tom Luther and Barb Tormoehlen (USDA Forest Service), Mike Dosskey (USDA-National Agroforestry Center), Andy Paulios and Janel Pike (WIDNR), Todd Bishop and Chris Ensminger (IADNR), Brett Martin (INDNR), and Tim Aunan (MNDNR) for their assistance with this project.

References Cited

Burrough, P. A., and R. A. McDonnell. 1998. Principals of Geographical Information Systems. Oxford University Press.

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Department of the Interior, Fish and Wildlife Service, Washington, D.C. 131 pp.

Fox, T. J. 2004. LINK: ArcGIS Tools for Conservation Planning. Computer software program produced by the author at the U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin. Available online at http://www.umesc.usgs.gov/management/dss/bird_conservation_tools_link.html.

Knutson, M. G., J. P. Hoover, and E. E. Klaas. 1996. The importance of floodplain forests in the conservation and management of neotropical migratory birds in the Midwest. Pages 168-188 *in* F. R. Thompson, editor. Management of midwestern landscapes for the conservation of neotropical migratory birds. U.S. Forest Service, North Central Forest Experiment Station, St. Paul, Minnesota. General Technical Report NC-187.

Korschgen, C., K. Kirsch, and K. Kenow. 1998. Chapter 13 Birds. Pages 13-1 to 13-13 *in* Ecological Status and Trends of the Upper Mississippi River System, 1998. A Report of the Long Term Resource Monitoring Program. U.S. Geological Survey, Upper Midwest Environmental Sciences Center, La Crosse, Wisconsin, April 1999. LTRMP 99-T001.

Lohman, K., L.R. Robinson, and J.C. Nelson. 2006. Land cover changes in the Upper Mississippi River System between 1989 and 2000. Contract report (2005V3) prepared for the U.S. Army Corps of Engineers and the Long Term Resource Monitoring Program. 27pp.

Mayer, P. M., S. K. Reynolds, M. D. McCutchen, and T. J. Canfield. 2005 or 2006? Riparian buffer width, vegetative cover, and nitrogen removal effectiveness: A review of current science and regulations. EPA/600/R-05/118. U.S. Environmental Protection Agency, Cincinnati, Ohio.

Smith, R. A., G. E. Schwarz, and R. B. Alexander. 1997. Regional interpretation of water-quality monitoring data. Water Resources Research 33(12):2781-2798.

Theobald, D. 2005. Landscape patterns of exurban growth in the USA from 1980 to 2020. Ecology and Society 10(1):32. Available online at http://www.ecologyandsociety.org/vol10/iss1/art32/.

Thogmartin, W. E., T. J. Fox, J. J. Rohweder, M. G. Knutson, and T. C. Will. 2006. Emerging Technologies: LINK: a land conservation decision support tool. Bulletin of the Ecological Society of America 87(3). Available on line at http://esapubs.org/bulletin/current/web_pdfs_july/emergingjul06bulletin.pdf.

Urich, R., G. Swenson, and E. Nelson, editors. 2002. Upper Mississippi and Illinois River floodplain forests, Desired future and recommended actions. Upper Mississippi River Conservation Committee, Accessed November 6, 2006, from http://www.mississippi-river.com/umrcc/pdf/Floodplain.pdf.

U.S. Department of Agriculture (USDA) Forest Service. (n.d.). Research Programs - North Central Research Station. U.S. Department of Agriculture, Forest Service, St. Paul, Minnesota. Accessed November 06, 2006, from http://www.ncrs.fs.fed.us/IntegratedPrograms/lc/.

USDA Natural Resource Conservation Service (NRCS). (n.d.*a*). Hydric Soils – Introduction | NRCS Soils. U.S. Department of Agriculture, Natural Resource Conservation Service, Accessed September 20, 2006, from http://soils.usda.gov/use/hydric/intro.html.

USDA NRCS. (n.d.*b*). NSSH Part 622 (00-Exhibit 1) | NRCS Soils. U.S. Department of Agriculture, Natural Resource Conservation Service, Accessed September 20, 2006, from http://soils.usda.gov/technical/handbook/contents/part622.html.

U.S. Fish and Wildlife Service. 2002. Birds of conservation concern 2002. Division of Migratory Bird Management, Arlington, Virginia. 99 pp. [Online version available at http://migratorybirds.fws.gov/reports/bcc2002.pdf.]

U.S. Geological Survey. 2006. USGS - The Gulf of Mexico Hypoxic Zone. U.S. Geological Survey, Toxic Substances Hydrology Program. Accessed November 6, 2006. Available online at http://toxics.usgs.gov/hypoxia/hypoxic_zone.html.

Welsch, D. J. (n.d.). Streamside forests are complex ecosystems vital to the protection of our streams and rivers. *In* Riparian forest buffers, function and design for protection and enhancement of water resources. U.S. Department of Agriculture, Forest Service, Radnor, Pennsylvania. NA-PR-07-91. Accessed October 26, 2006, from http://www.na.fs.fed.us/spfo/pubs/n_resource/buffer/part1.htm.

West, E.; and G. Ruark. 2004. A long, long time ago . . . Journal of Soil and Water Conservation. 59(5):105A-110A.

Wiener, J. G., C. R. Fremling, C. E. Korschgen, K. P. Kenow, E. M. Kirsch, S. J. Rogers, Y. Yin, and J. S. Sauer. 1998. Mississippi River. *In* Status and trends of the Nation's biological resources. U.S. Geological Survey. Accessed November 06, 2006, from http://biology.usgs.gov/s+t/SNT/noframe/ms137.htm.