Identification of Priority Forests in the Upper Mississippi River System – 2001 Land Cover Update

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

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by

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Introduction

- This document is a revision of a document produced in 2006. Updated text throughout this document will have a red font color and updated tables and figures will have a red caption.

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).

In 2006, the Upper Mississippi Forest Partnership (UMFP) along with the U.S. Geological Survey, Upper Midwest Environmental Sciences Center (UMESC), conducted several analyses to help in assessing forest conditions within the Upper Mississippi River System (UMRS). More specifically, relevant spatial data was acquired and modified for use in the Geographic Information System (GIS), and then spatial models were created to help answer pertinent questions related to:

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

The goal of the study was to generate products that will help UMFP focus its activities and limited resources within the UMRS.

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.

Upon project completion, the UMFP was given the input data layers, the outputs derived from the models in the form of data layers and maps, and a contract report summarizing the analyses available for download from: (http://na.fs.fed.us/watershed/upper_mississippi_partnership/current.shtm).

Much of the analyses that were performed used the National Land Cover Dataset (NLCD) developed in 1992 as the foundation for what was defined as forest and the type of the forests depicted therein. Since the completion of these analyses, a more current NLCD has been developed (2001). The UMFP re-ran several of the basin-wide analyses including those related to "Existing Bottomland Forests and Priority Areas for Bottomland Afforestation", "Important Migratory Bird Habitat", and "Priority Forests for Conservation" using the more recent land cover dataset to give a more current depiction of the basin and its forest resources.

Those utilizing the data should note that direct comparison of the 1992 and 2001 NLCD products is not advised (MRLC 2009) due to the data sets being mapped using slightly different methods and into slightly different classes. NLCD 1992 was based on an unsupervised classification algorithm, whereas NLCD 2001 was based on a supervised classification and regression tree algorithm. If comparison is done in this manner, differences in classification methods are typically highlighted and not real land cover change perceptible on the ground (MRLC 2009).

The GIS software used for this analysis was ArcGIS 9.3 (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 9.3. 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 was 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 9.3 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). Only those polygons labeled with the NWI attribute "FO" (Forested) or "SS" (Scrub-Shrub) were included in the analysis. 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 as described in the next paragraph.
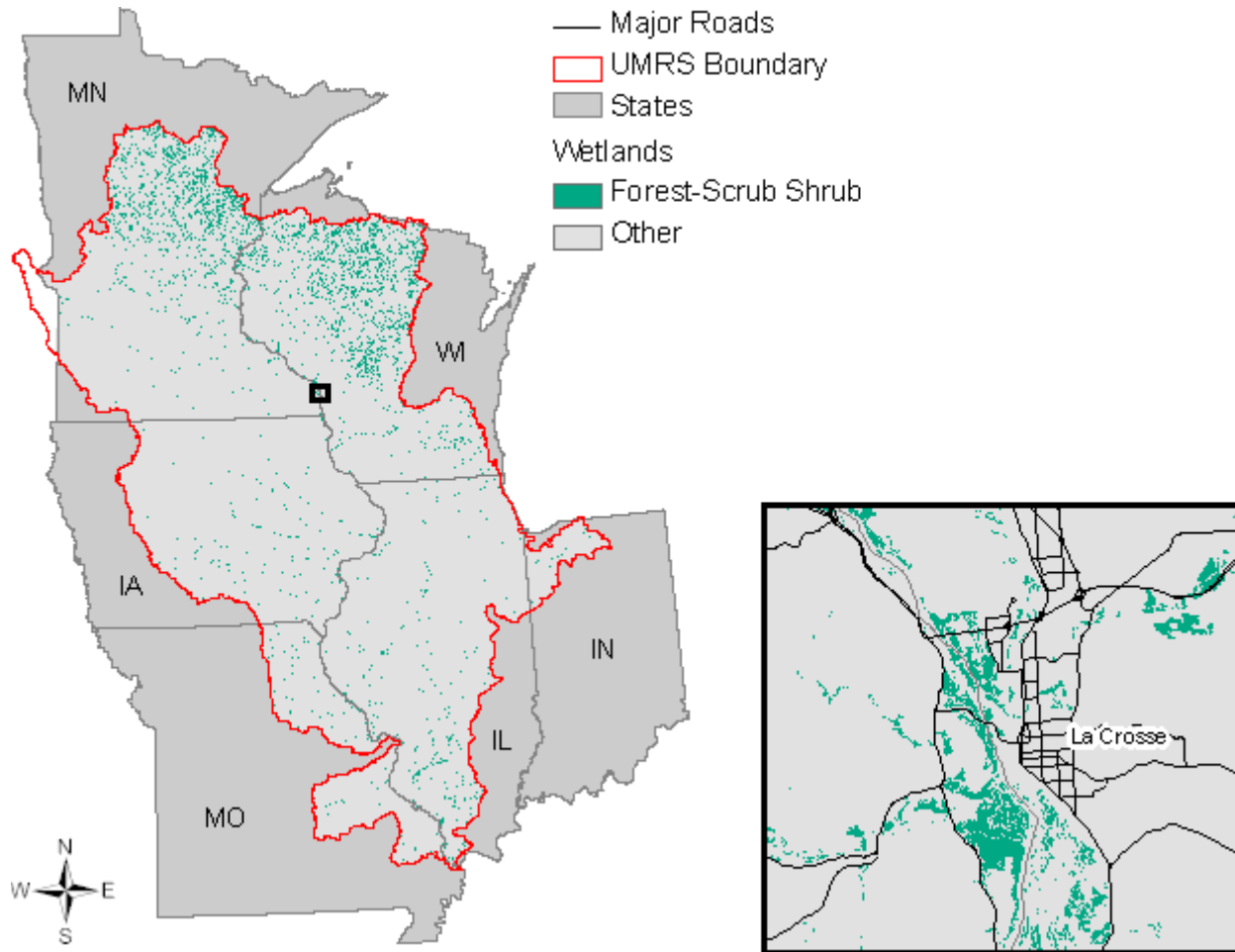
Figure 2. Forested wetlands

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.
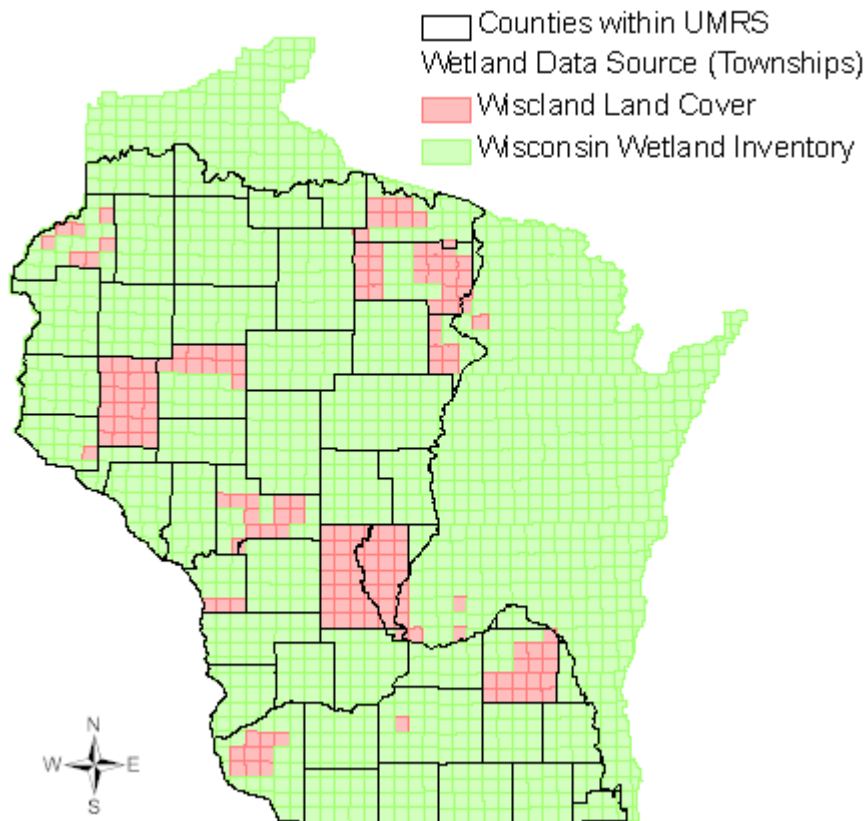
Figure 3. Wisconsin wetland data composition

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; 2001). 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 2001 Landsat thematic mapper imagery and supplemental data (Figure 4). NLCD 2001 improves upon NLCD 1992 in several ways. Whereas NLCD 1992 was simply a land-cover data set, NLCD 2001 is a land-cover database comprised of three elements: land cover, impervious surface and canopy density. Also, NLCD 2001 used improved classification algorithms, which have resulted in data with more precise rendering of spatial boundaries between the 16 classes (EPA n.d.). The seamless NLCD contains information suitable for a variety of state and regional applications, including landscape analysis, land management, and modeling nutrient and pesticide runoff. The NLCD is distributed by state as 30-meter resolution raster images in an Albers Equal-Area map projection.
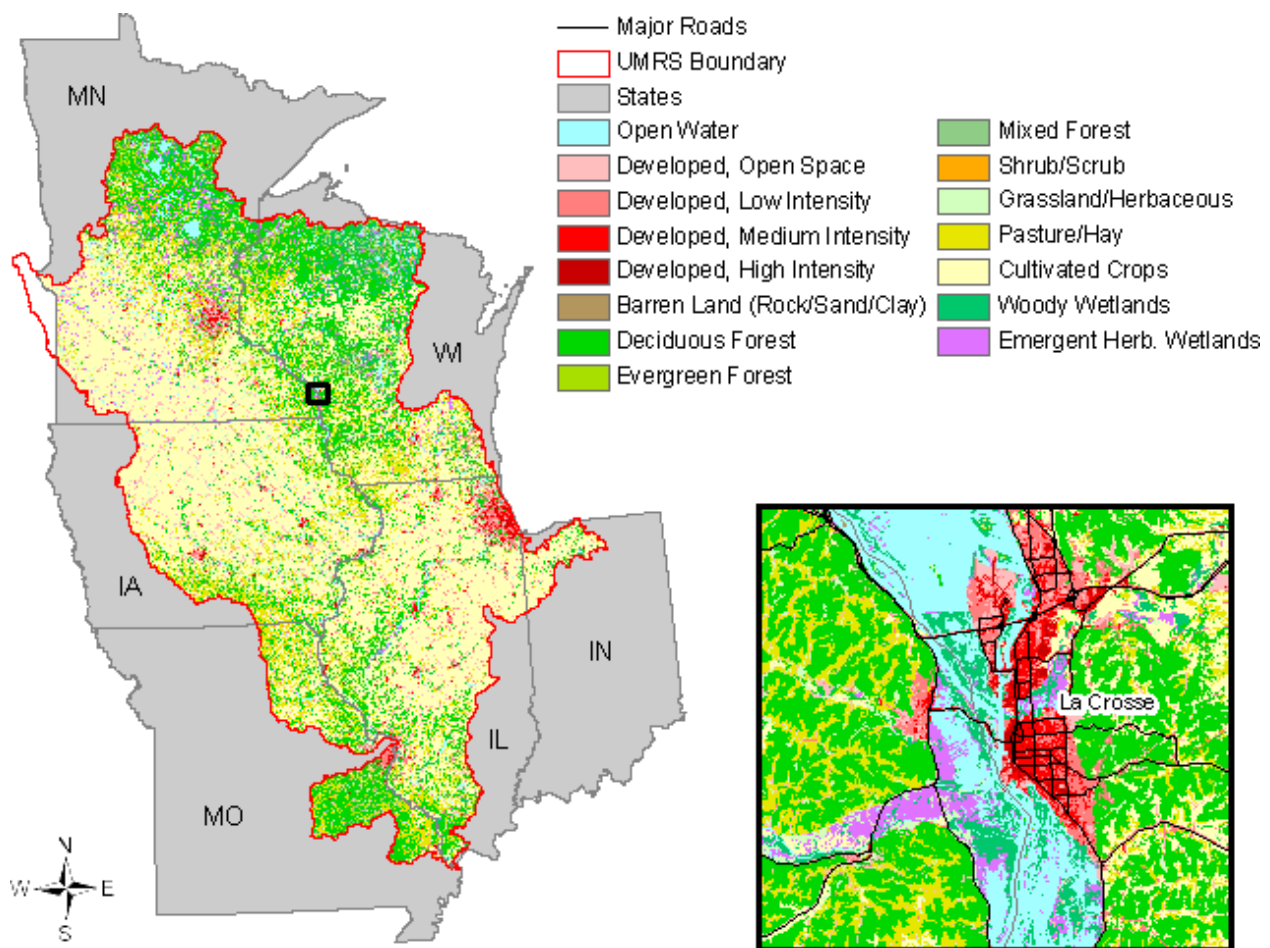
Figure 4. National Land Cover Dataset (NLCD; 2001)

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://www.mrlc.gov/.

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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.
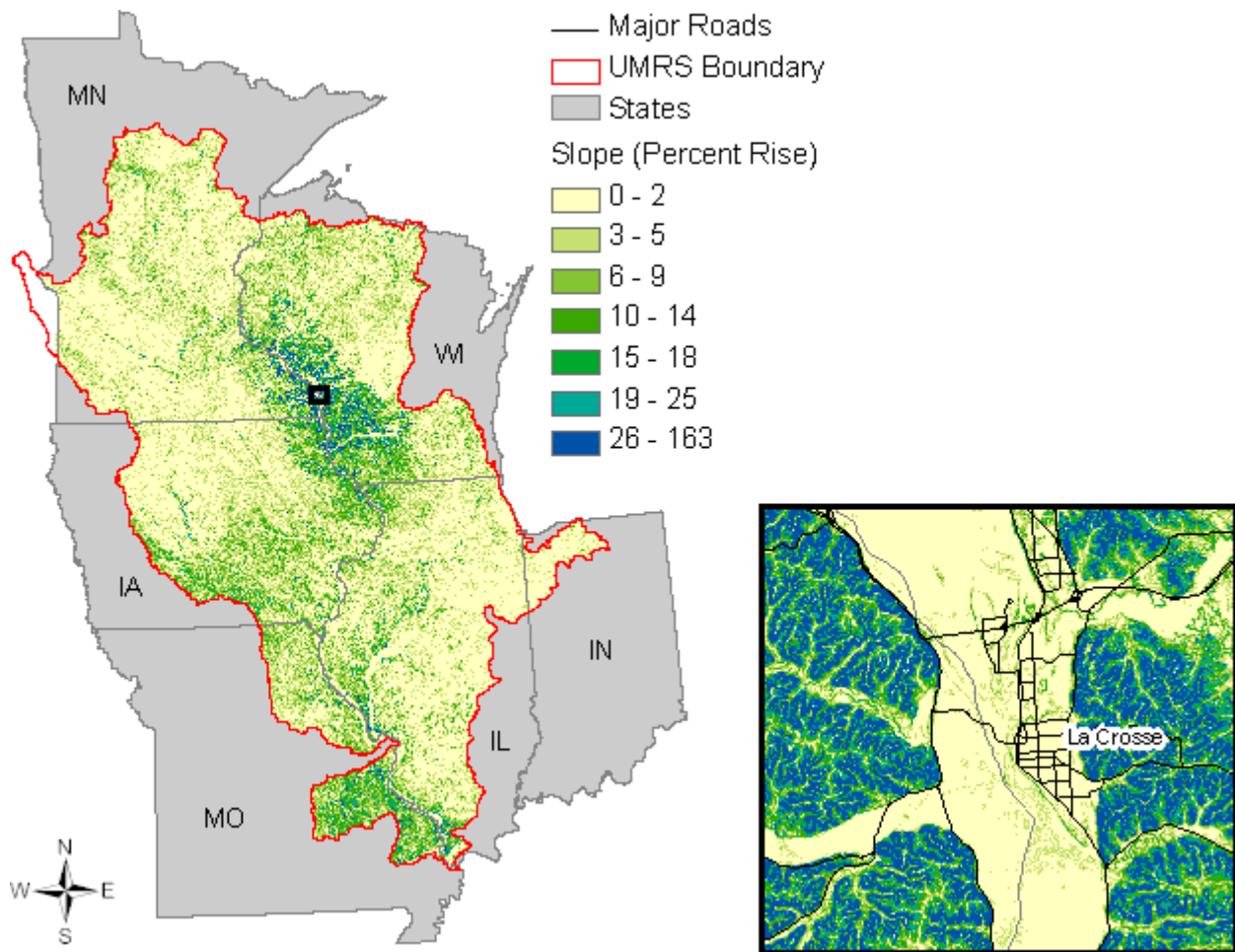
Figure 5. Slope (Percent Rise)

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.
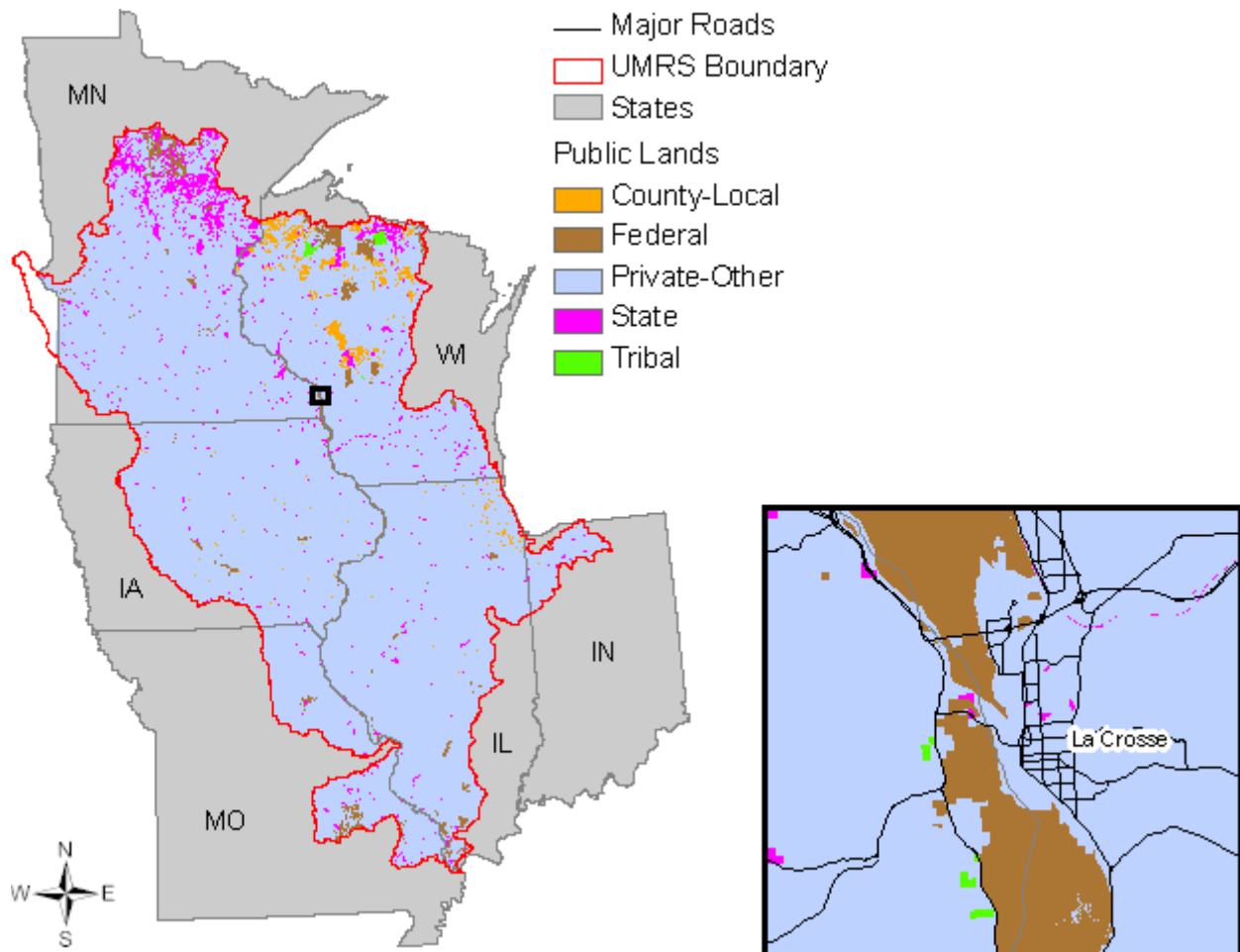
Figure 6. Public lands

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.

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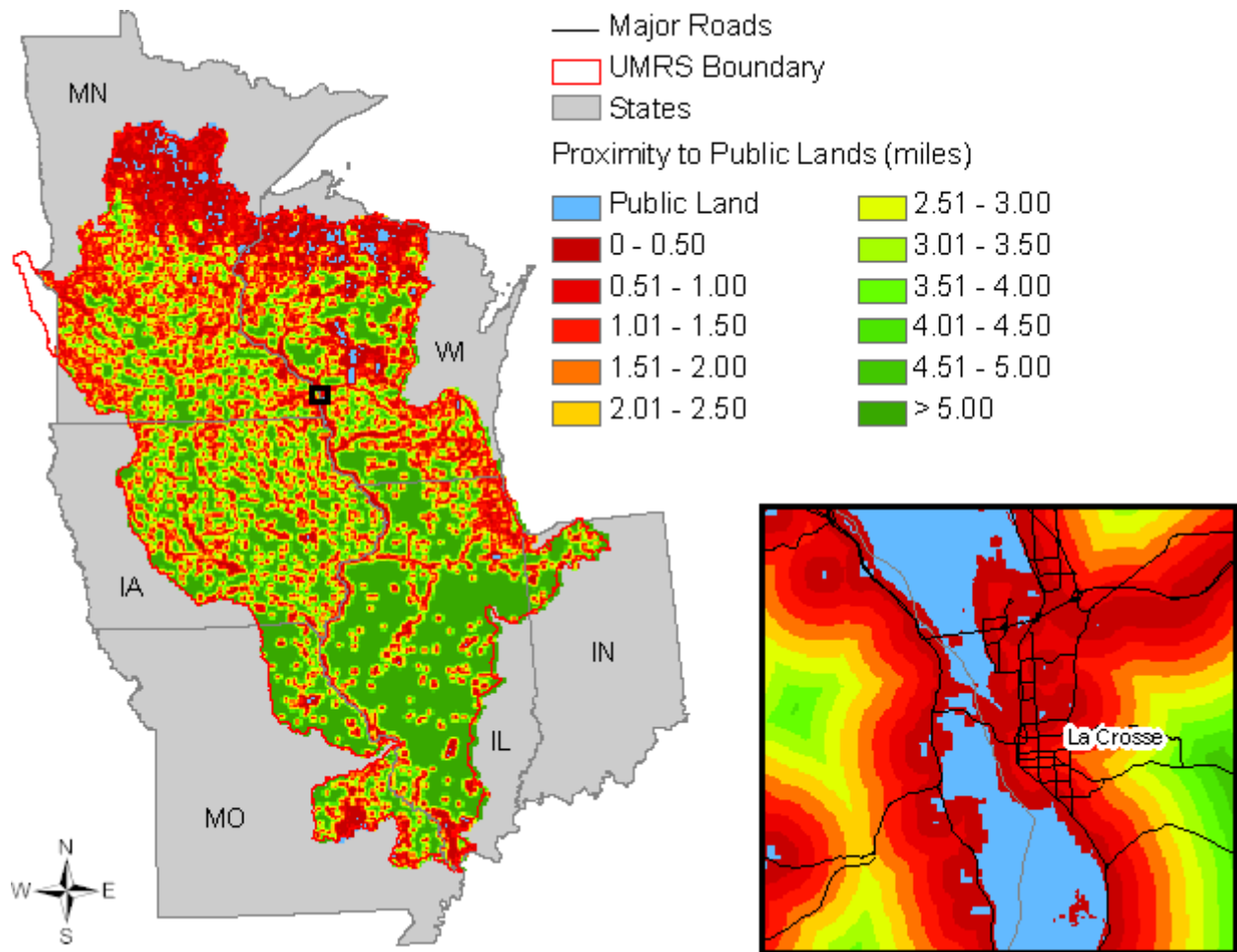
Figure 7. Proximity to public lands

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).
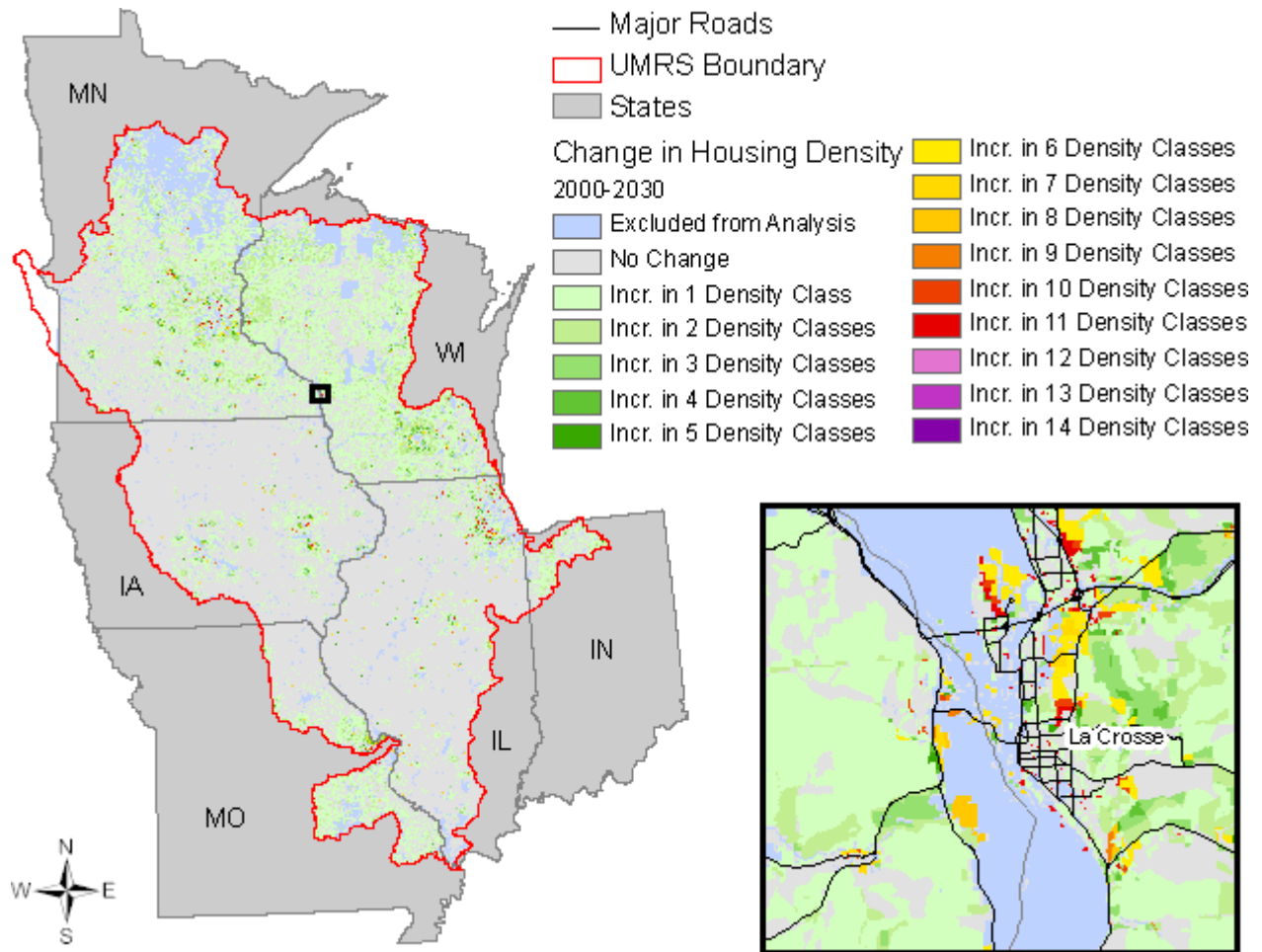
Figure 8. Predicted change in housing density

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.
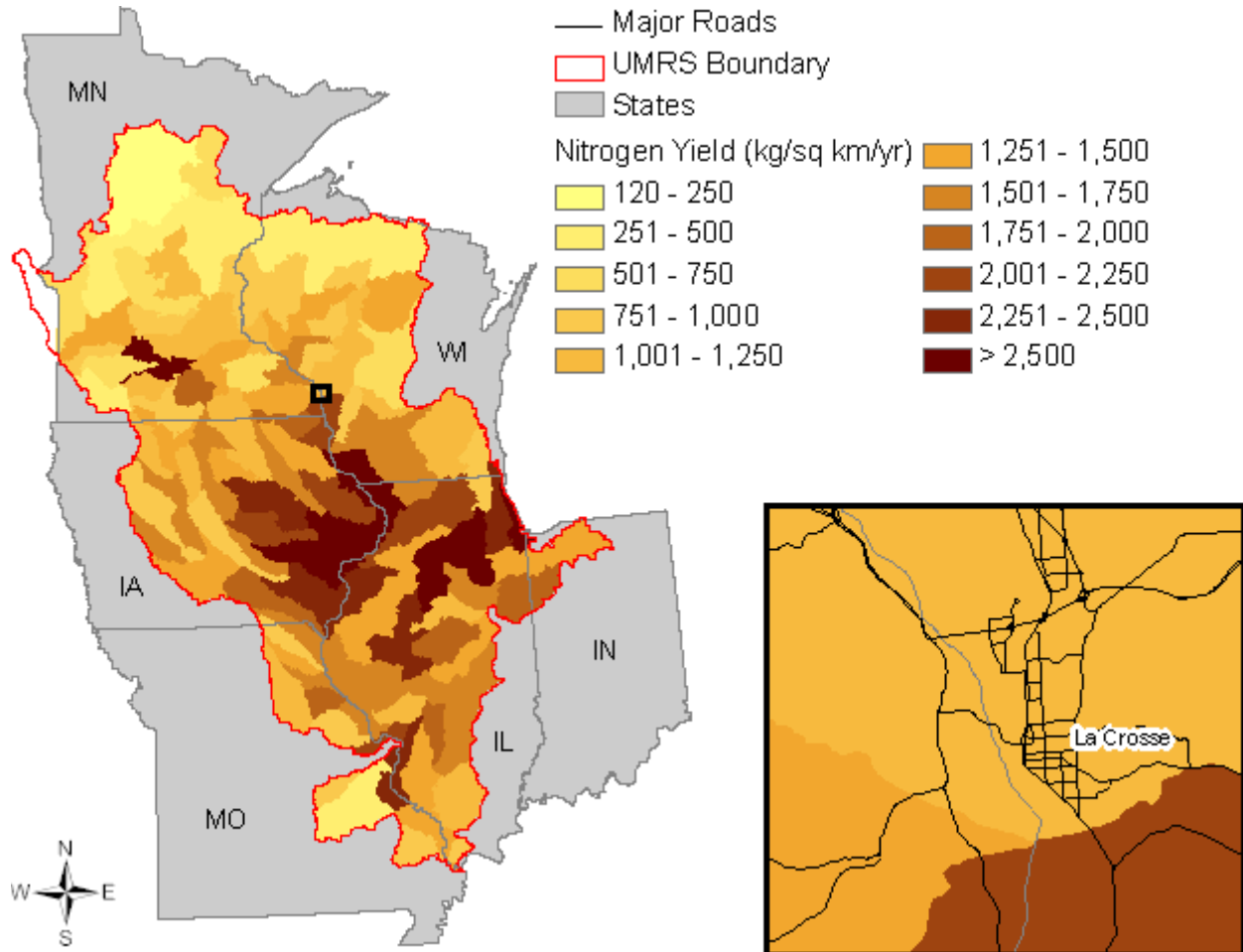
Figure 9. Nitrogen yield

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.
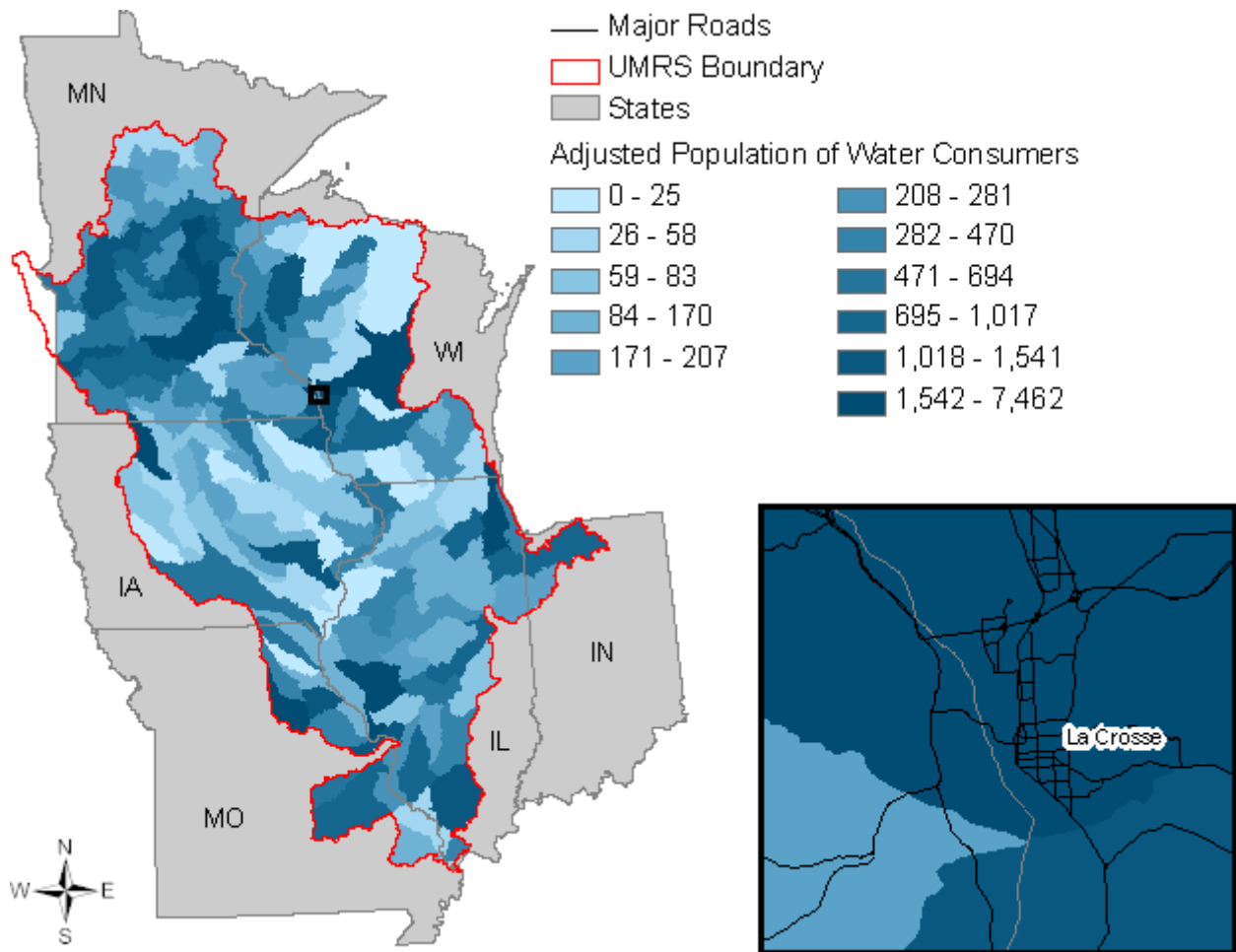
Figure 10. Adjusted population of water consumers

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.
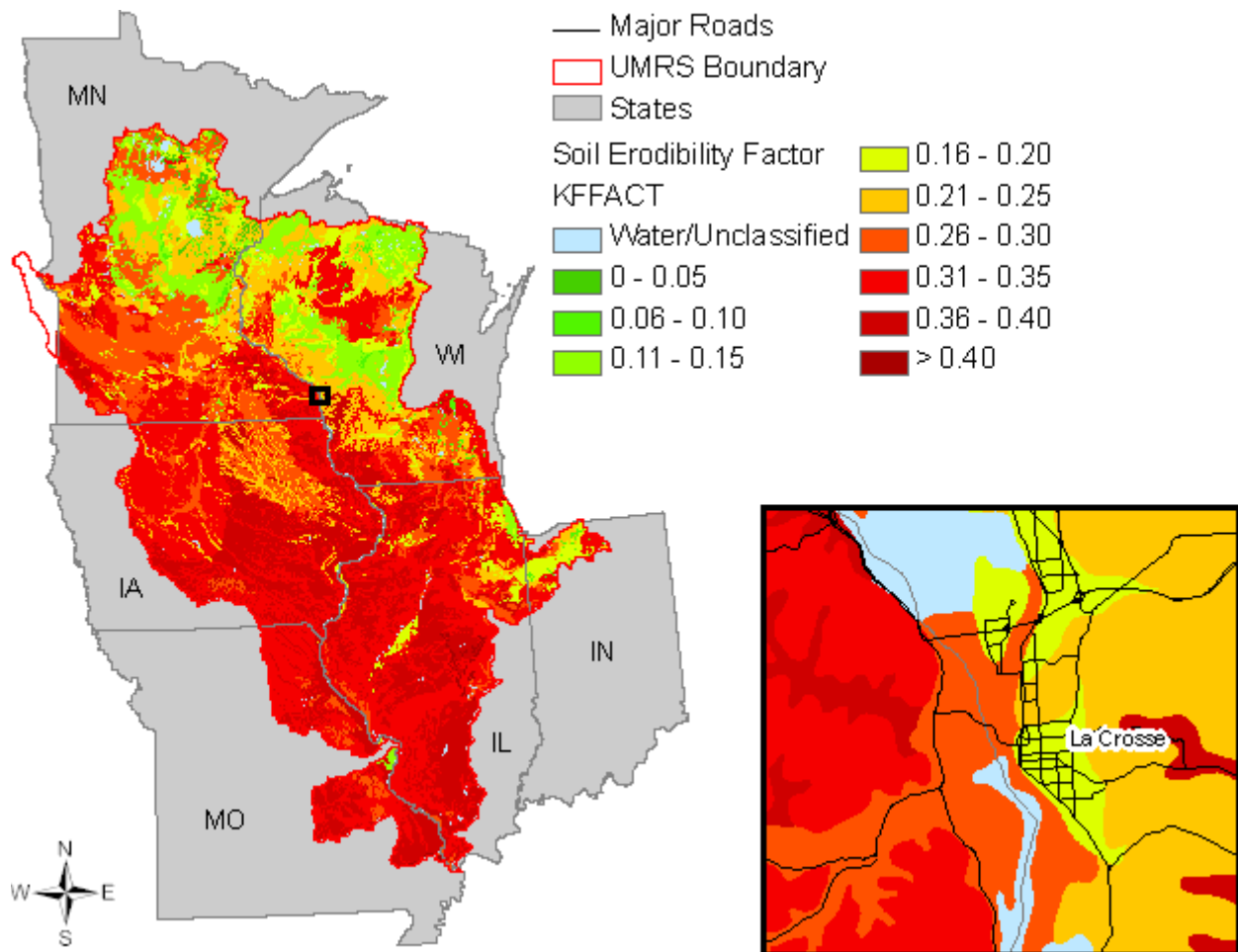
Figure 11. Soil erodibility

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

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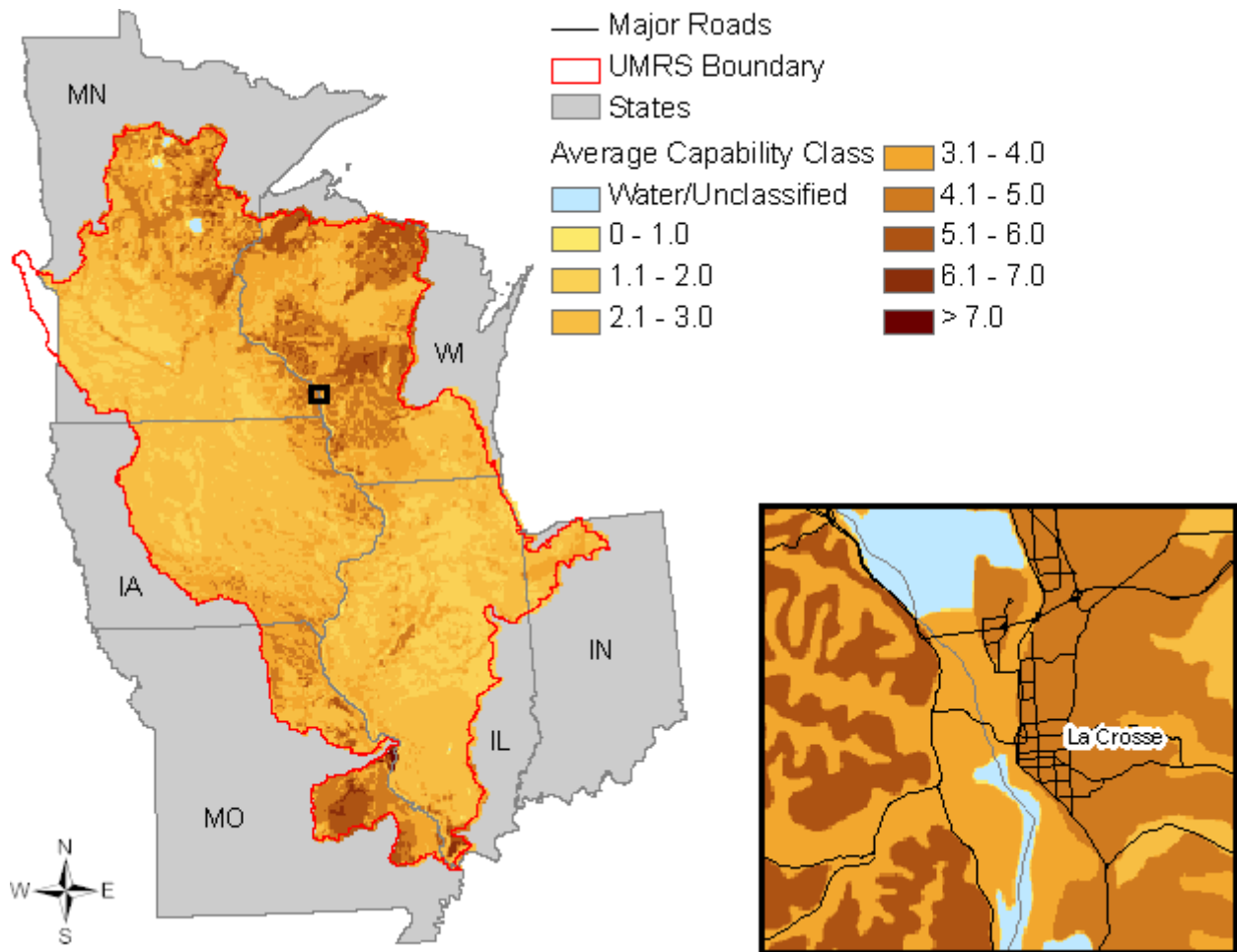
Figure 12. Average soil capability class for non-irrigated soils

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).
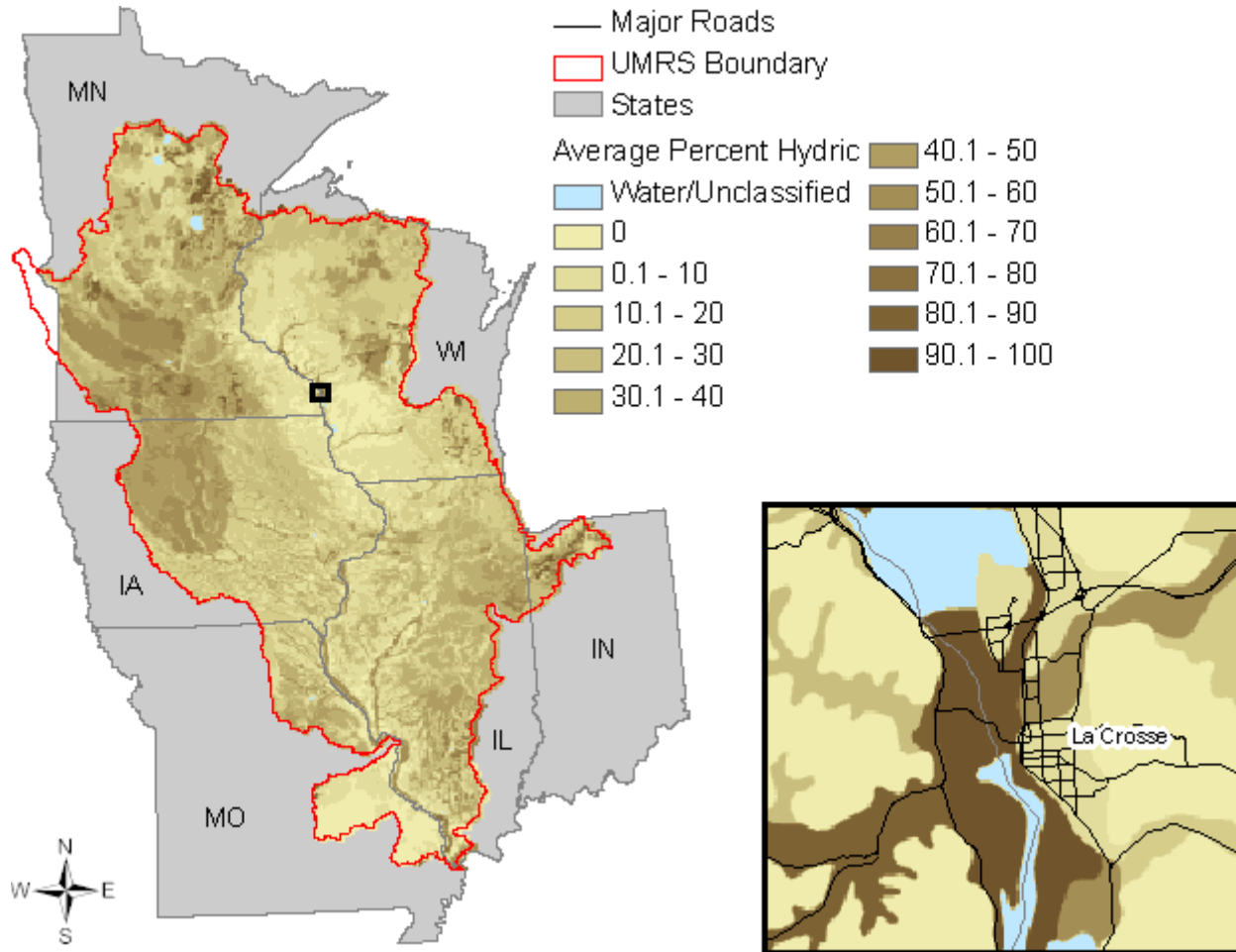
Figure 13. Average percent of soils classified as hydric

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).
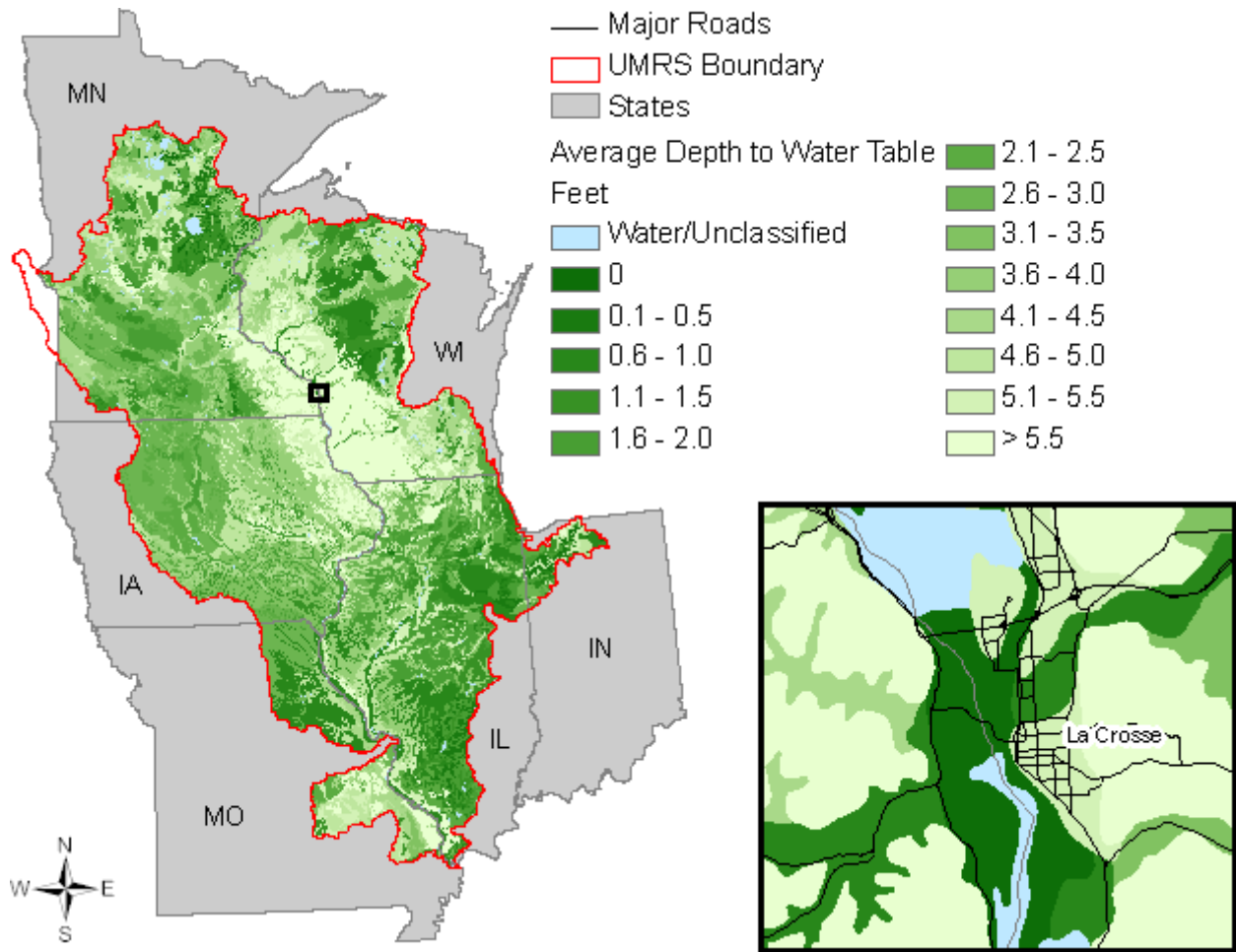
Figure 14. Average depth to water table

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.
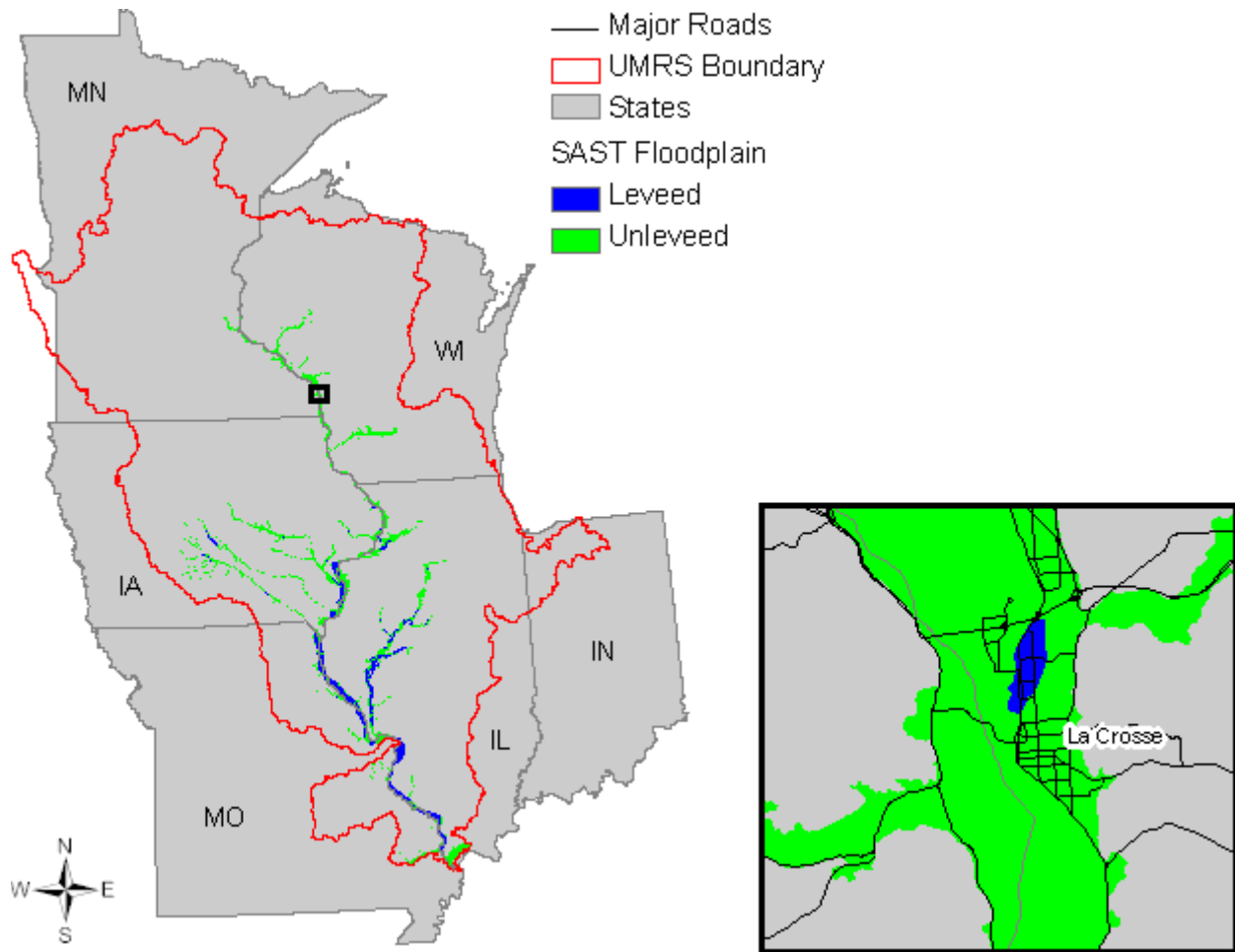
Figure 15. Natural floodplain boundary

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).
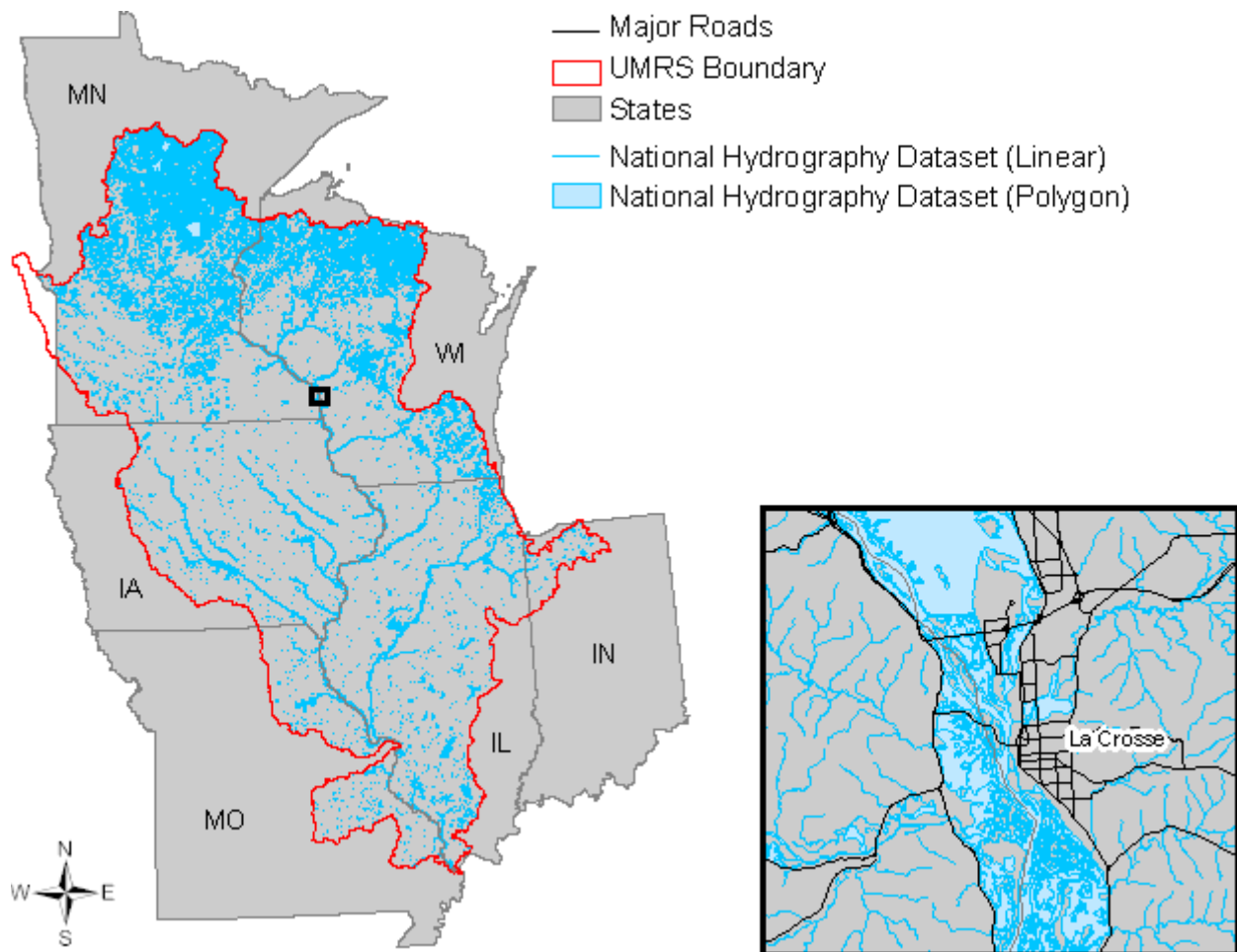
Figure 16. National Hydrography Dataset

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.
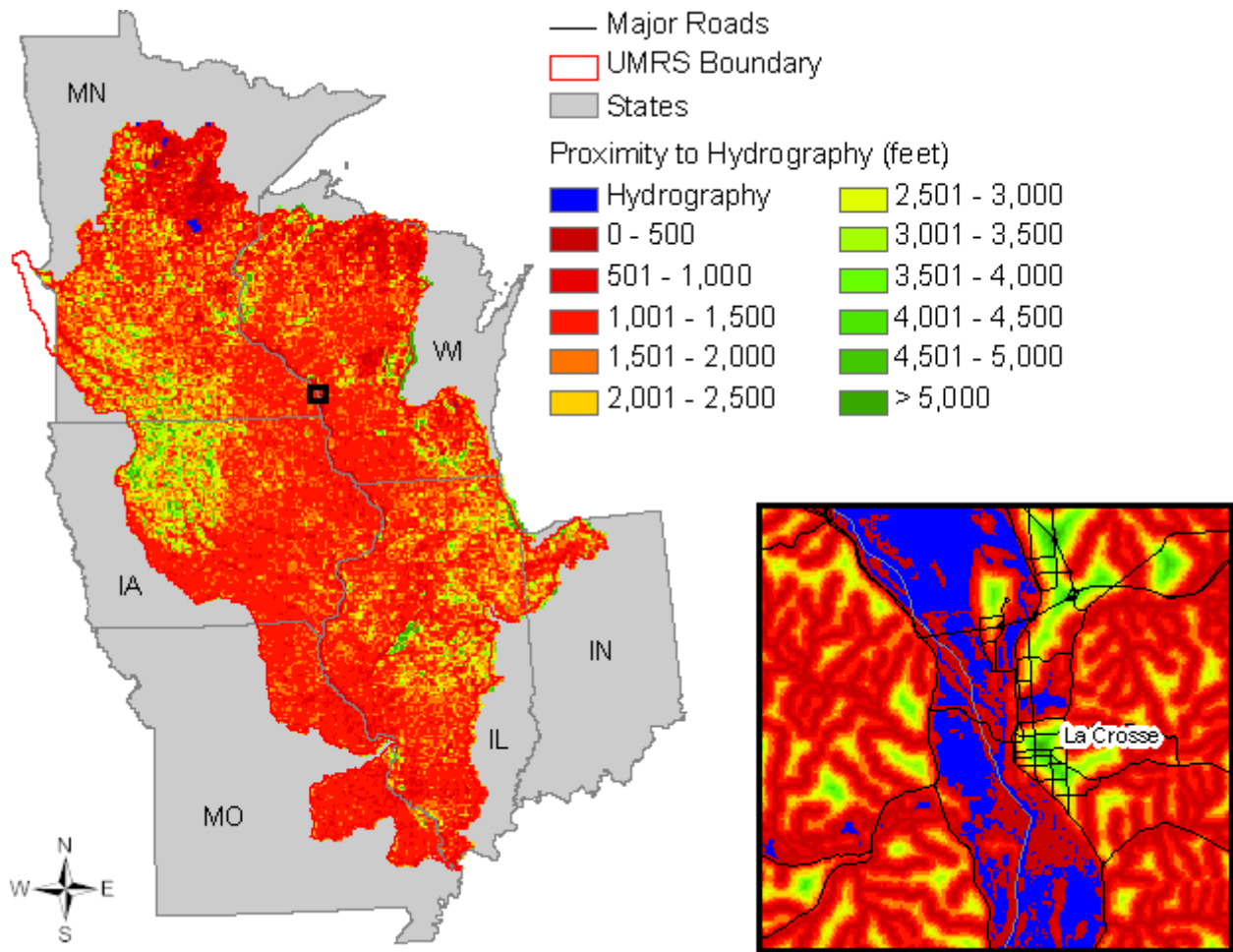
Figure 17. Proximity to hydrography

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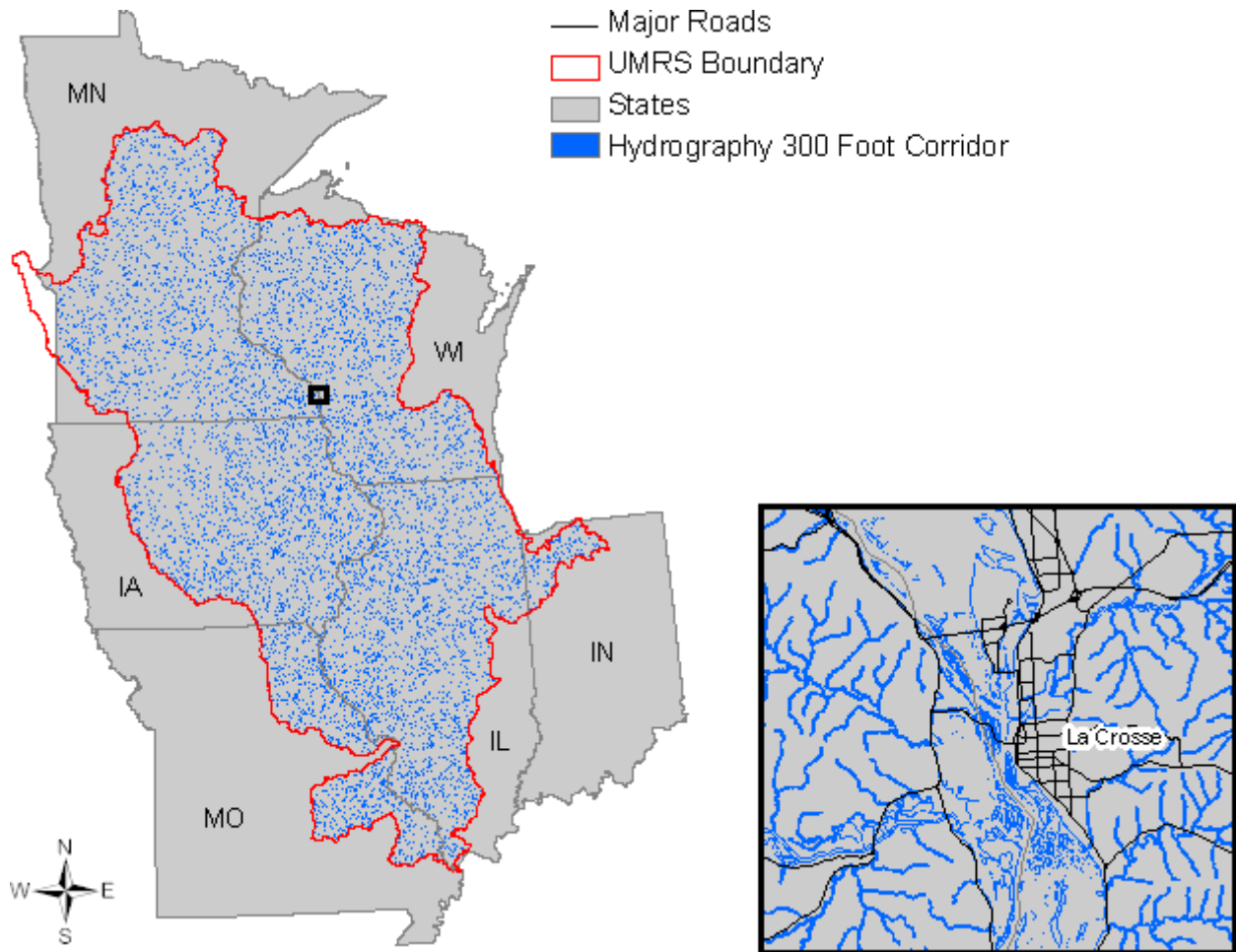
Figure 18. Hydrography 300 foot corridor

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 2001.

In ArcMap, pixels were selected within the NLCD 2001 data layer (Figure 4) that had a code of 41 (deciduous forest), 42 (evergreen forest), 43 (mixed forest), or 90 (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.
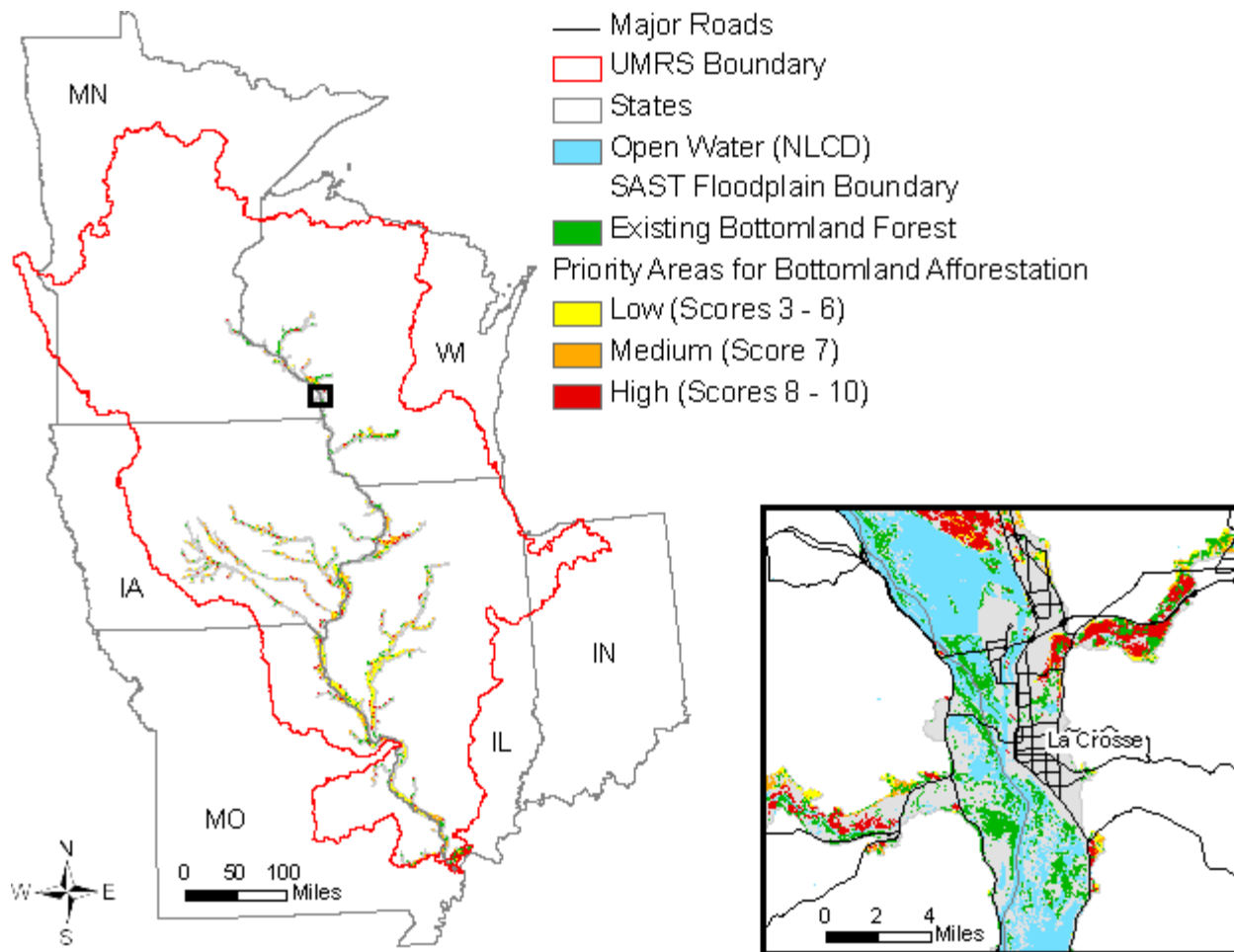
Figure 19. Existing bottomland forests and priority areas for bottomland afforestation

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 (2001)		STATSGO (Ave. Depth to Water Table)	
Score	Description	Score	Description
NoData	11 - Open Water	10	Water
NoData	21 - Developed, Open Space	10	0

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Left column:

Score	Description
NoData	22 - Developed, Low Intensity
NoData	23 - Developed, Medium Intensity.
NoData	24 - Developed, High Intensity
NoData	31 - Barren Land (Rock/Sand/Clay)
NoData	41 - Deciduous Forest
NoData	42 - Evergreen Forest
NoData	43 - Mixed Forest
10	52 - Shrub/Scrub
NoData	71 - Grassland/Herbaceous
10	81 - Pasture/Hay
10	82 - Cultivated Crops
NoData	90 - Woody Wetlands
NoData	95 - Emergent 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
4	31 - 40
5	41 - 50
6	51 - 60
7	61 - 70
8	71 - 80
9	81 - 90
10	91 - 100
12%	Model Influence

Right column:

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

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.

The model was created in ModelBuilder 9.3 (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).

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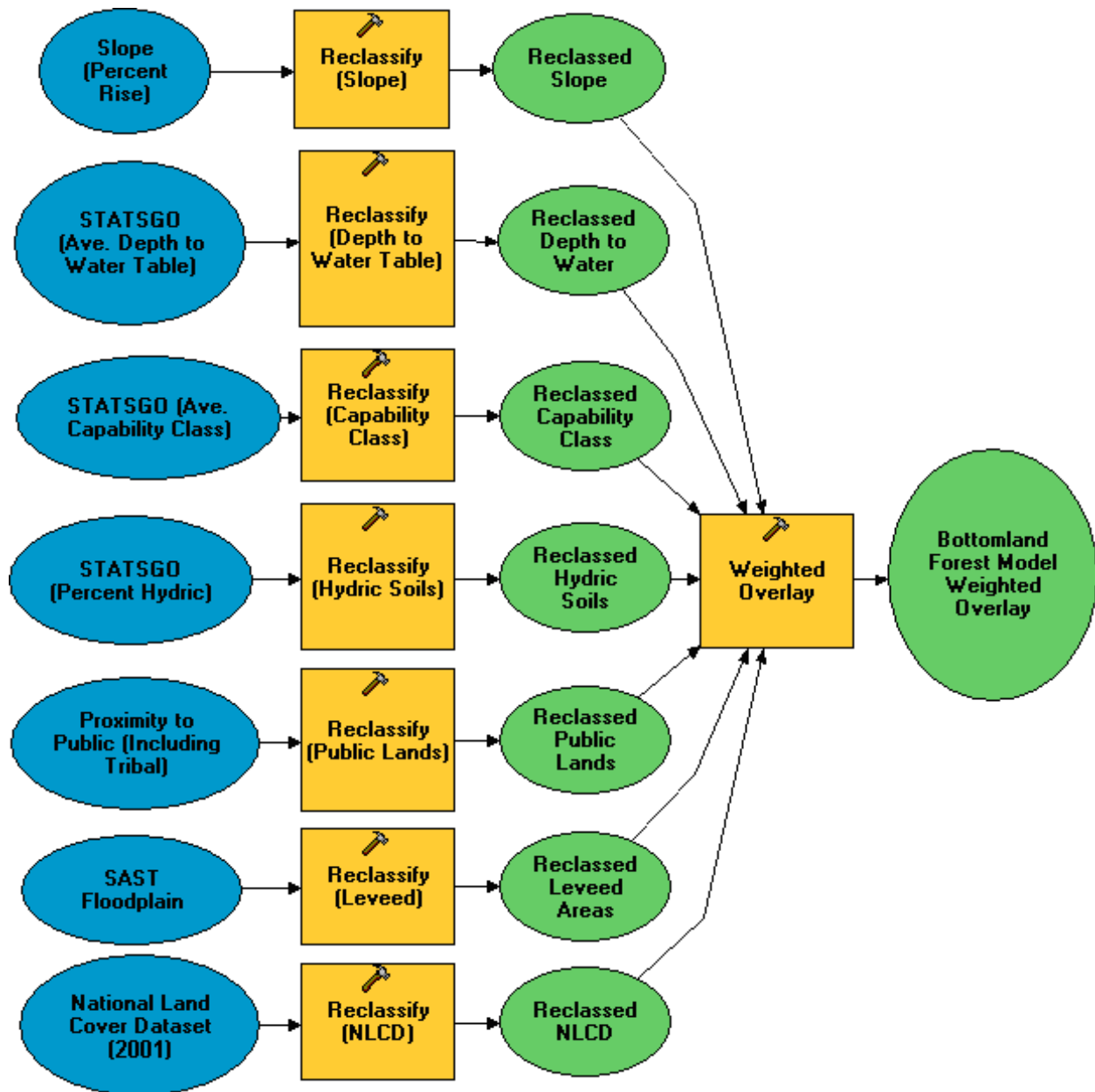
Figure 21. Priority areas for bottomland afforestation model diagram

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 and percentages 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	886,740.49	41.99	749,216.02	35.48	475,684.47	22.53	2,111,640.98	48.68
Existing Bottomland Forest							836,108.58	19.27
Other							1,390,185.39	32.05
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/.

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 4. 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 4. 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 2001. The zonal layer used within the analysis is counties. The range maps used for the analysis were the ones obtained from NatureServe. Figure 22 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.
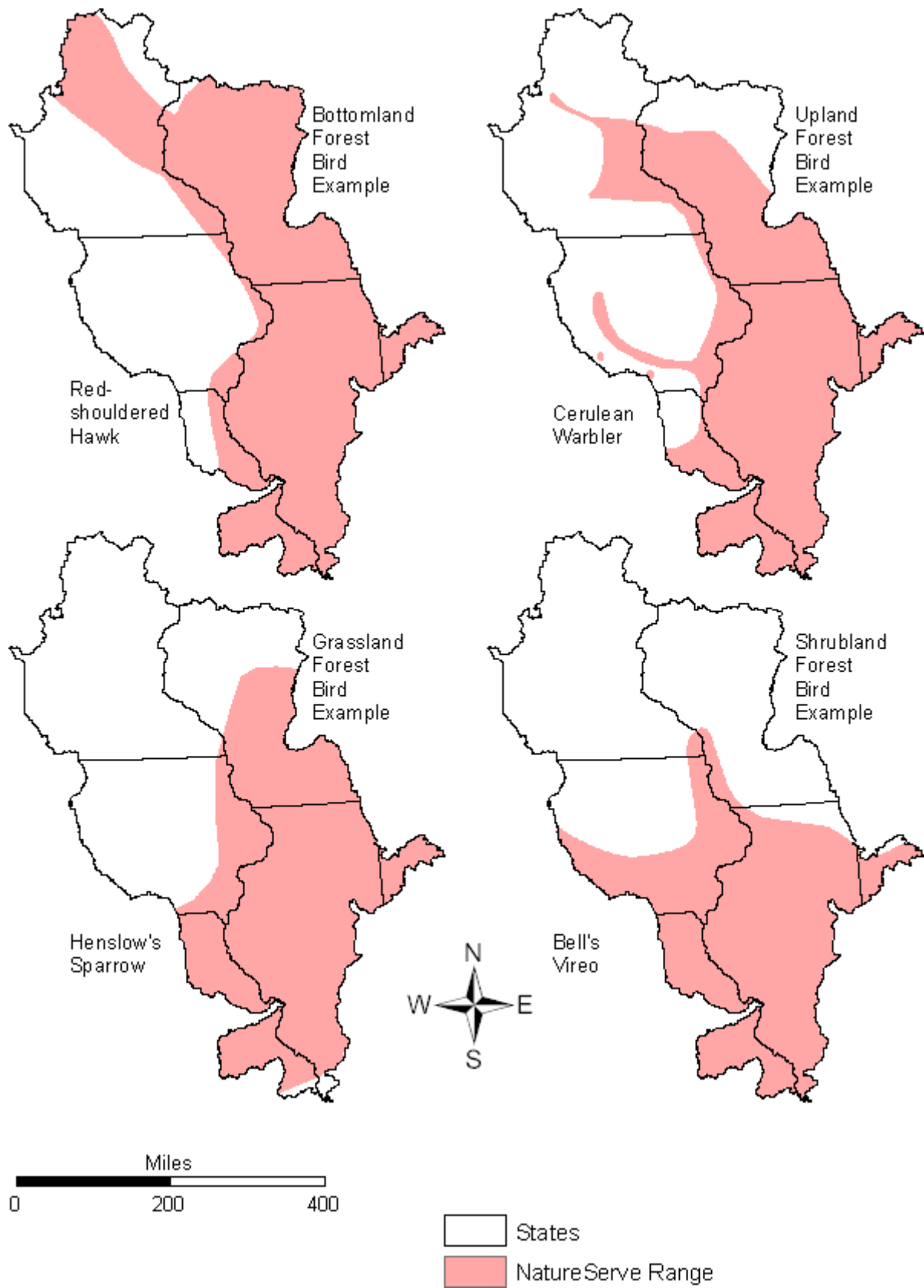
Figure 22. Example of NatureServe range maps

Conversion of LINK bird species habitat matrix from NLCD 1992 to NLCD 2001

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 and specifically for the NLCD 1992. This matrix was scored by experts in the field of migratory bird ecology.

To run LINK using the NLCD 2001 to model important migratory bird habitat for upland forest, bottomland forest, grassland, and shrubland birds, it was first necessary to update the species-habitat matrix values for each land cover (habitat) type. Most land cover classes are fairly intuitive to match between 1992 and 2001 (e.g., "Shrubland" in 1992 = "Shrub/Scrub" in 2001), however, there were instances where several classes from the 1992 NLCD were aggregated to form a single class in the 2001 NLCD (Table 5). Direction on how best to aggregate and match classes was taken from the MRLC website (MRLC n.d.).

Table 5. Proposed matching of land cover classes between the National Land Cover Dataset for 1992 and 2001.

NLCD 1992 Class Code	NLCD 1992 Description	NLCD 2001 Class Code	NLCD 2001 Description
11	Open Water	11	Open Water
85	Urban, Recreational Grasses	21	Developed, Open Space
21	Low Intensity Residential	22	Developed, Low Intensity
22	High Intensity Residential	23	Developed, Medium Intensity
23	Commercial, Industrial, Trans.	24	Developed, High Intensity
31	Bare Rock, Sand	**31**	Barren Land (Rock/Sand/Clay)
32	Quarry, Strip Mine, Gravel Pit		
33	Transitional Barren		
41	Deciduous Forest	41	Deciduous Forest
42	Evergreen Forest	42	Evergreen Forest
43	Mixed Forest	43	Mixed Forest
51	Shrubland	52	Shrub/Scrub
61	Orchards, Vineyards, Other		
71	Grasslands, Herbaceous	71	Grasslands/Herbaceous
81	Pasture, Hay	81	Pasture/Hay
82	Row Crops	**82**	Cultivated Crops
83	Small Grains		
91	Woody Wetlands	90	Woody Wetlands
92	Emergent, Herbaceous Wetland	95	Emergent Herbaceous Wetlands

To recalculate the species-habitat matrix score for the NLCD 2001 class 31 "Barren Land (Rock/Sand/Clay)" the total area for the class codes 31, 32, and 33 were summed for the 1992 NLCD data set. Next, the area of each class code (31, 32, and 33) was then divided by this total to get a relative percent. Then the species-habitat scores for class codes 31, 32, and 33, for each bird species were multiplied by the relative percent for each class code. Finally, these individual scores were summed to get the new species-habitat matrix score for the aggregated class code 31 "Barren Land (Rock/Sand/Clay)". This methodology was also applied to calculate the 2001 class code 82 "Cultivated Crops" by aggregating the scores from the 1992 data set for classes 82 and 83 "Row Crops" and "Small Grains", respectively.

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 Table 6 shows to what level each individual species was determined to use each of the NLCD habitat types. The poorest habitat type is scored zero and the best is 100.

Table 6. Bottomland forest birds matrix

	Open Water	Developed - Open Space	Developed - Low Intensity	Developed - Medium Intensity	Developed - High Intensity	Barren Land (Rock - Sand - Clay)	Deciduous Forest	Evergreen Forest	Mixed Forest	Shrub - Scrub	Grassland - Herbaceous	Pasture - Hay	Cultivated Crops	Woody Wetlands	Emergent Herbaceous Wetlands
				Bottomland Forest Birds											
American Woodcock	0	0	0	0	0	0	100	0	80	80	0	0	0	80	0
Canada Warbler	0	0	0	0	0	0	40	20	100	0	0	0	0	80	0
Connecticut Warbler	0	0	0	0	0	0	0	100	20	0	0	0	0	20	0
Louisiana Waterthrush	0	0	0	0	0	0	20	0	20	0	0	0	0	100	0
Prothonotary Warbler	0	0	0	0	0	0	0	0	0	0	0	0	0	100	0
Red-shouldered Hawk	0	0	0	0	0	0	60	0	40	20	0	0	0	100	20

Once the analysis is completed using LINK, one of the products created is a raster dataset depicting mean potential species occurrence. Figure 23 shows this output for bottomland forest birds.
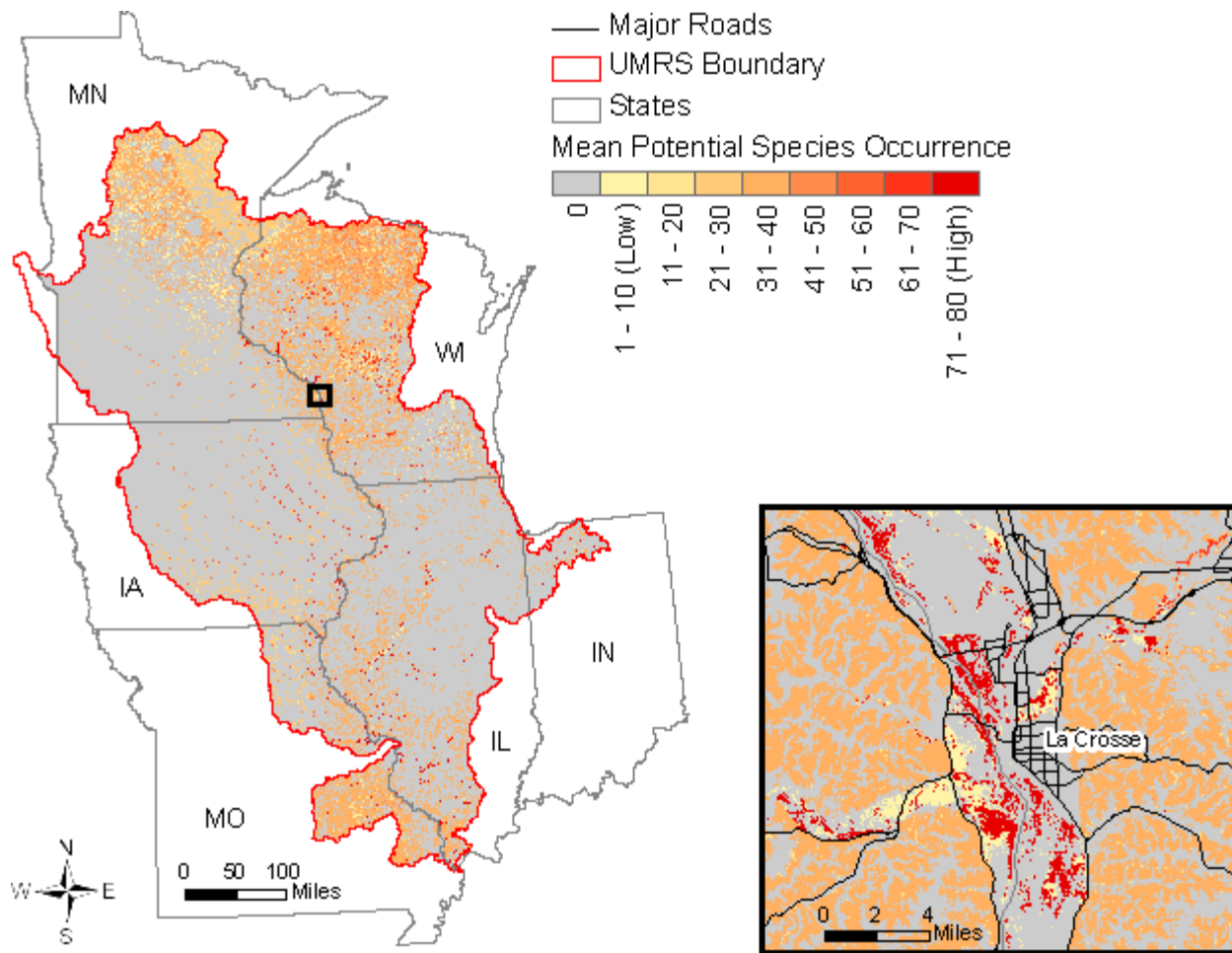
Figure 23. Bottomland forest birds LINK output

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.

($\sum$ (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 **8.79**. The area-weighted mean PSO scores for the four bird guilds range from a low of 7.73 to a high of 18.68 (Table 10). 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. Table 7 shows each of the species along with the individual potential species occurrence scores for each NLCD land cover type.

Table 7. Upland forest birds matrix

Upland Forest Birds	Open Water	Developed - Open Space	Developed - Low Intensity	Developed - Medium Intensity	Developed - High Intensity	Barren Land (Rock - Sand - Clay)	Deciduous Forest	Evergreen Forest	Mixed Forest	Shrub - Scrub	Grassland - Herbaceous	Pasture - Hay	Cultivated Crops	Woody Wetlands	Emergent Herbaceous Wetlands
Black-billed Cuckoo	0	0	20	0	0	23	100	0	60	100	0	0	0	60	0
Brown Thrasher	0	20	60	0	0	23	40	0	60	100	20	0	0	60	0
Cerulean Warbler	0	0	0	0	0	0	100	0	0	0	0	0	0	100	0
Golden-winged Warbler	0	0	0	0	0	34	60	0	80	100	0	0	0	100	0
Kentucky Warbler	0	0	0	0	0	0	100	0	0	0	0	0	0	20	0
Ovenbird	0	0	0	0	0	0	100	20	80	0	0	0	0	40	0
Red-headed Woodpecker	0	20	40	0	0	0	60	0	40	20	20	20	0	40	0
Rose-breasted Grosbeak	0	0	40	0	0	11	100	0	80	60	0	0	0	60	0
Ruffed Grouse	0	0	0	0	0	11	100	40	100	0	0	0	0	0	0
Veery	0	0	0	0	0	0	80	0	100	40	0	0	0	100	0
Whip-poor-will	0	0	0	0	0	23	60	20	60	60	20	20	0	20	0
Wood Thrush	0	0	0	0	0	0	100	0	80	0	0	0	0	40	0
Yellow-billed Cuckoo	0	0	40	0	0	11	100	0	20	80	0	0	0	80	0
Yellow-shafted Flicker	0	40	60	0	0	43	100	20	60	80	80	80	0	80	0
Yellow-throated Vireo	0	0	20	0	0	0	80	0	60	0	0	0	0	100	0

Figure 24 shows the mean PSO output map for upland forest birds.
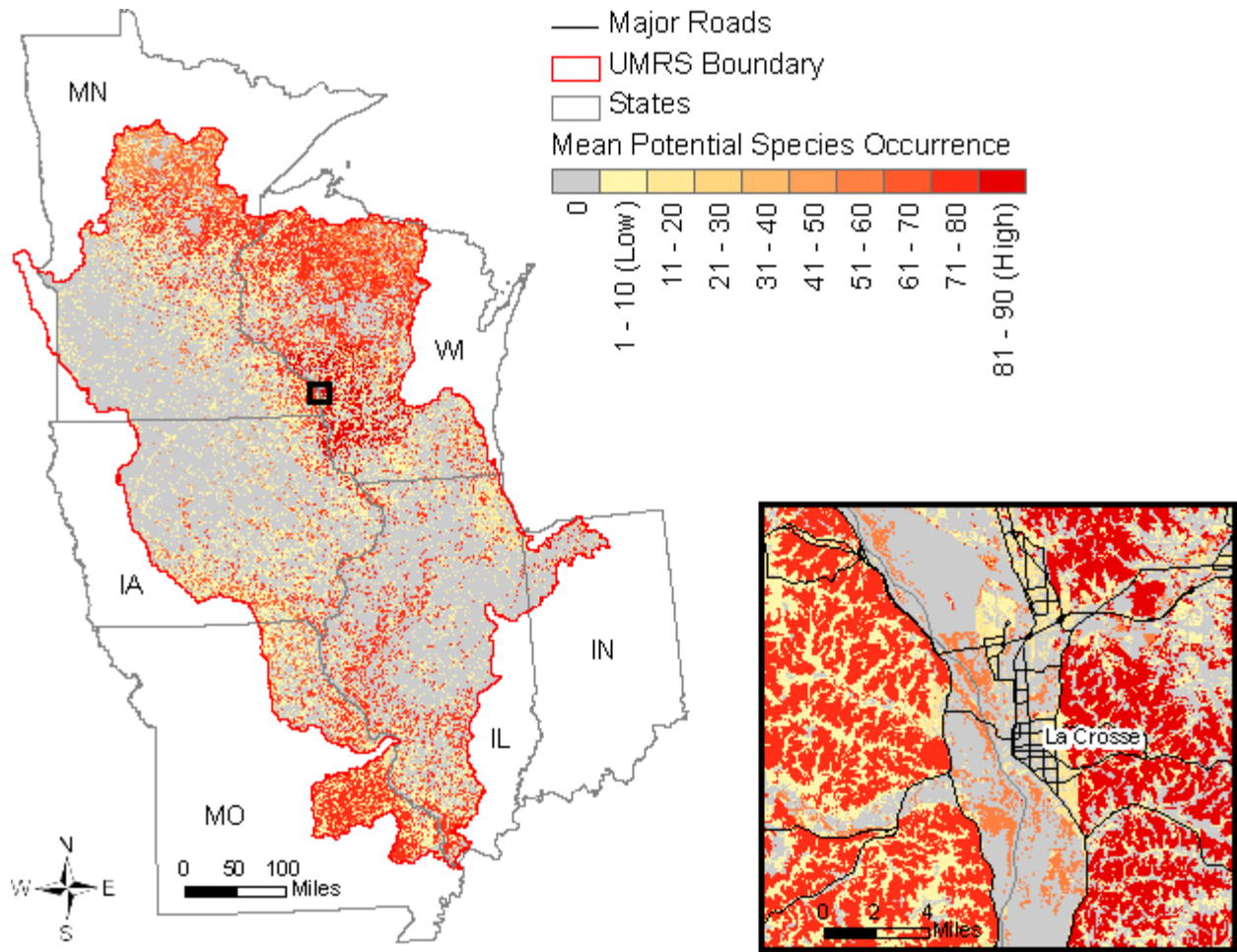
Figure 24. Upland forest birds LINK output

The area-weighted mean PSO score for upland forest birds was calculated to be **18.68**. The area-weighted mean PSO scores for the four bird guilds range from a low of 7.73 to a high of 18.68 (Table 10). 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.

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Grassland Birds LINK Output

There were 13 species aggregated to form the grassland birds guild. Table 8 shows each of the species along with the individual potential species occurrence scores for each NLCD land cover type.

Table 8. Grassland birds matrix

|	Open Water	Developed - Open Space	Developed - Low Intensity	Developed - Medium Intensity	Developed - High Intensity	Barren Land (Rock - Sand - Clay)	Deciduous Forest	Evergreen Forest	Mixed Forest	Shrub - Scrub	Grassland - Herbaceous	Pasture - Hay	Cultivated Crops	Woody Wetlands	Emergent Herbaceous Wetlands
Grassland Birds															
Bobolink	0	20	0	0	0	11	0	0	0	0	100	100	0	0	20
Dickcissel	0	0	0	0	0	0	0	0	0	0	100	80	20	0	0
Eastern Meadowlark	0	20	20	0	40	9	0	0	0	40	80	100	20	0	20
Grasshopper Sparrow	0	20	0	0	0	0	0	0	0	0	100	80	0	0	0
Greater Prairie-Chicken	0	0	0	0	0	11	0	0	0	20	100	100	1	0	0
Henslow's Sparrow	0	0	0	0	0	0	0	0	0	20	100	40	0	0	40
Le Conte's Sparrow	0	0	0	0	0	0	0	0	0	0	60	40	0	0	100
Loggerhead Shrike	0	0	0	0	0	11	0	0	0	40	100	100	0	0	0
Northern Bobwhite	0	0	20	0	0	34	40	0	0	60	100	80	100	20	0
Northern Harrier	0	0	0	0	0	11	0	0	0	40	100	100	0	40	80
Sedge Wren	0	0	0	0	0	0	0	0	0	0	60	40	0	40	100
Sharp-tailed Grouse	0	0	0	0	0	34	0	20	40	100	60	100	2	0	0
Upland Sandpiper	0	40	0	0	0	0	0	0	0	0	100	100	39	0	0

Figure 25 shows the mean PSO output map for grassland birds.

Figure 25. Grassland birds LINK output

The area-weighted mean PSO score for grassland birds was calculated to be **16.13**. The area-weighted mean PSO scores for the four bird guilds range from a low of 7.73 to a high of 18.68 (Table 10). 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. Table 9 shows each of the species along with the individual potential species occurrence scores for each NLCD land cover type.

	Open Water	Developed - Open Space	Developed - Low Intensity	Developed - Medium Intensity	Developed - High Intensity	Barren Land (Rock - Sand - Clay)	Deciduous Forest	Evergreen Forest	Mixed Forest	Shrub - Scrub	Grassland - Herbaceous	Pasture - Hay	Cultivated Crops	Woody Wetlands	Emergent Herbaceous Wetlands
Shrubland Birds															
Bell's Vireo	0	0	0	0	0	0	0	0	0	100	40	0	0	40	0
Blue-winged Warbler	0	0	0	0	0	34	100	0	20	80	0	0	0	60	0
Least Flycatcher	0	0	0	0	0	11	100	0	100	20	0	0	0	40	0
Willow Flycatcher	0	0	0	0	0	0	20	0	0	100	0	0	0	100	0
Yellow-breasted Chat	0	0	0	0	0	11	0	0	0	100	0	0	0	40	0

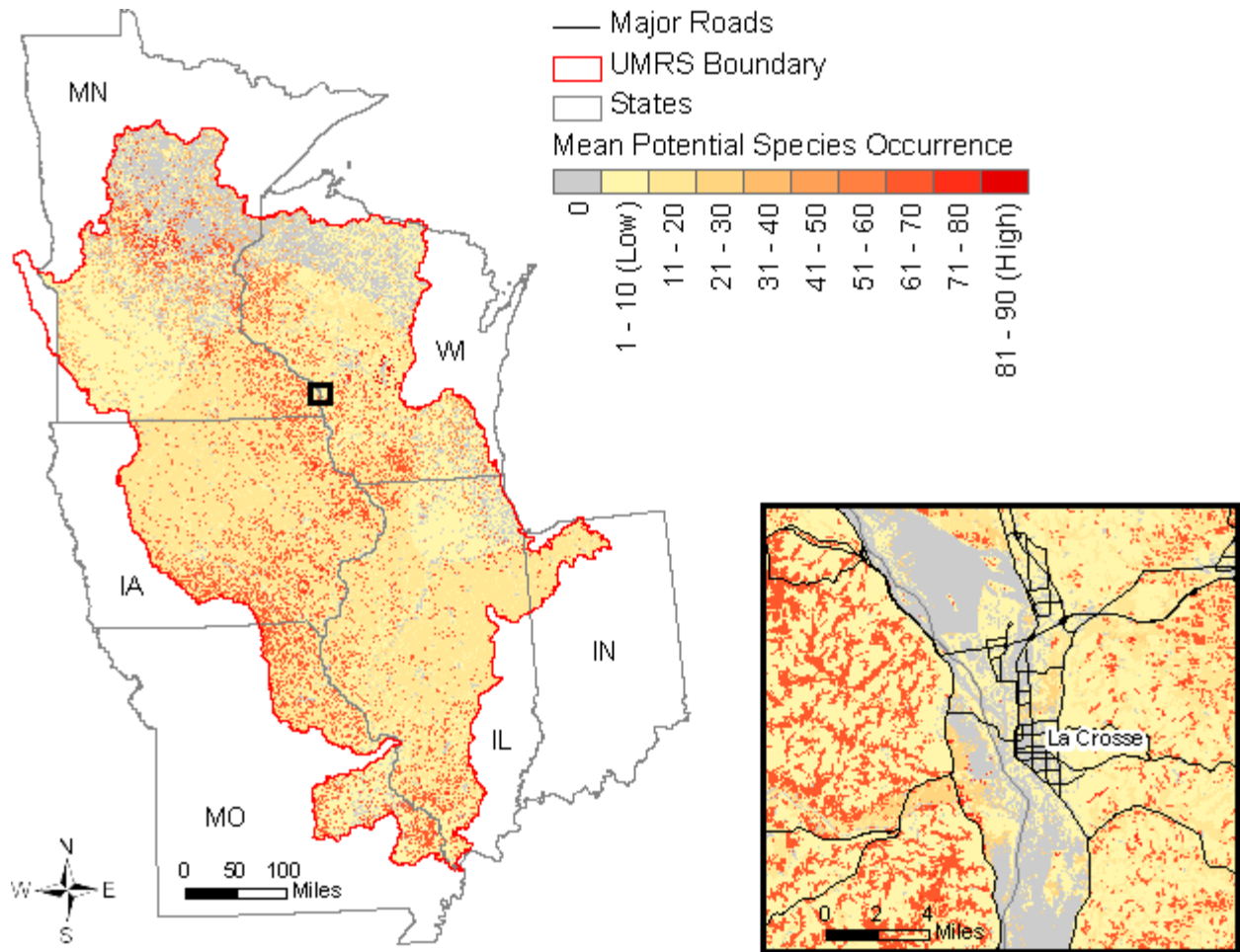Figure 26 shows the mean PSO output map for shrubland birds.
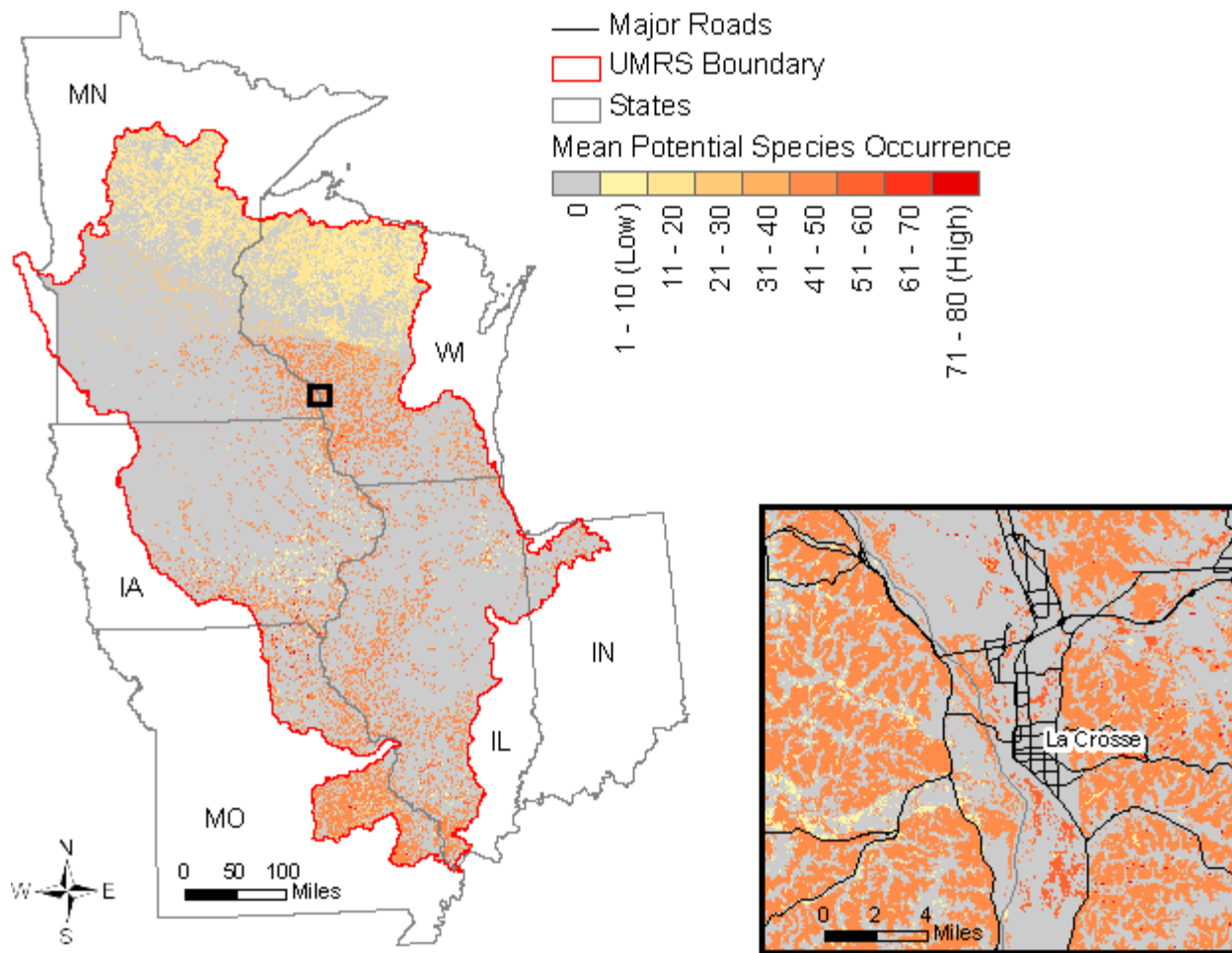
Figure 26. Shrubland birds LINK output

The area-weighted mean PSO score for shrubland birds was calculated to be **7.73**. The area-weighted mean PSO scores for the four bird guilds range from a low of 7.73 to a high of 18.68 (Table 10). 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.

Table 10. Area-weighted mean potential species occurrence by bird guild

Bird Guild	Area Weighted Mean PSO
Grassland Birds	16.13
Upland Forest Birds	18.68
Bottomland Forest Birds	8.79
Shrubland Birds	7.73

The individual species area-weighted mean PSO values are displayed in Table 11. The values are sorted (in descending order) for each guild by area-weighted mean PSO. This table identifies the individual species from each guild with the highest area-weighted mean PSO value.

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Table 11. Area-weighted mean potential species occurrence by bird species

Bottomland Forest Birds	Area Weighted Mean PSO	Upland Forest Birds	Area Weighted Mean PSO
American Woodcock	22.75	Yellow-shafted Flicker	37.42
Red-shouldered Hawk	12.37	Rose-breasted Grosbeak	23.12
Canada Warbler	11.13	Black-billed Cuckoo	22.66
Louisiana Waterthrush	3.61	Yellow-billed Cuckoo	21.27
Connecticut Warbler	1.92	Ovenbird	20.82
Prothonotary Warbler	0.94	Wood Thrush	19.98
Grassland Birds		Veery	19.39
Northern Bobwhite	49.74	Yellow-throated Vireo	19.29
Upland Sandpiper	34.35	Red-headed Woodpecker	17.94
Eastern Meadowlark	22.73	Whip-poor-will	16.09
Dickcissel	20.47	Golden-winged Warbler	15.70
Northern Harrier	17.12	Brown Thrasher	13.52
Bobolink	15.29	Ruffed Grouse	12.94
Loggerhead Shrike	13.40	Cerulean Warbler	12.21
Grasshopper Sparrow	12.52	Kentucky Warbler	7.83
Sedge Wren	9.54	Shrubland Birds	
Le Conte's Sparrow	8.36	Least Flycatcher	21.45
Henslow's Sparrow	3.48	Blue-winged Warbler	12.18
Sharp-tailed Grouse	2.27	Willow Flycatcher	3.85
Greater Prairie-Chicken	0.43	Bell's Vireo	0.72
		Yellow-breasted Chat	0.46

Mean PSO can be broken down for each bird guild according to area percentages. Mean PSO was categorized in groupings of 10 and each bird guild was 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). This is displayed as a table (Table 12) and as a graph (Figure 27). 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 11.50% of the UMRS is considered "non-habitat" according to the LINK model for the grassland bird species selected.

Table 12. Table depicting bird guild mean potential species occurrence scores separated by area percentage

meanPSO	Bottomland Forest Birds	Upland Forest Birds	Grassland Birds	Shrubland Birds
0 (non-habitat)	73.55	53.86	11.50	75.44
1 - 10	1.59	**19.86**	36.30	2.83
11 - 20	1.80	2.69	**35.98**	**8.11**
21 - 30	**3.82**	0.00	2.31	1.00
31 - 40	**16.48**	0.12	0.00	0.51
41 - 50	1.66	0.98	1.03	**11.33**
51 - 60	0.09	4.04	1.44	0.69
61 - 70	0.44	2.39	10.50	0.00
71 - 80	0.56	**14.11**	0.89	0.09
81 - 90	0.00	1.96	0.06	0.00
91 - 100	0.00	0.00	0.00	0.00
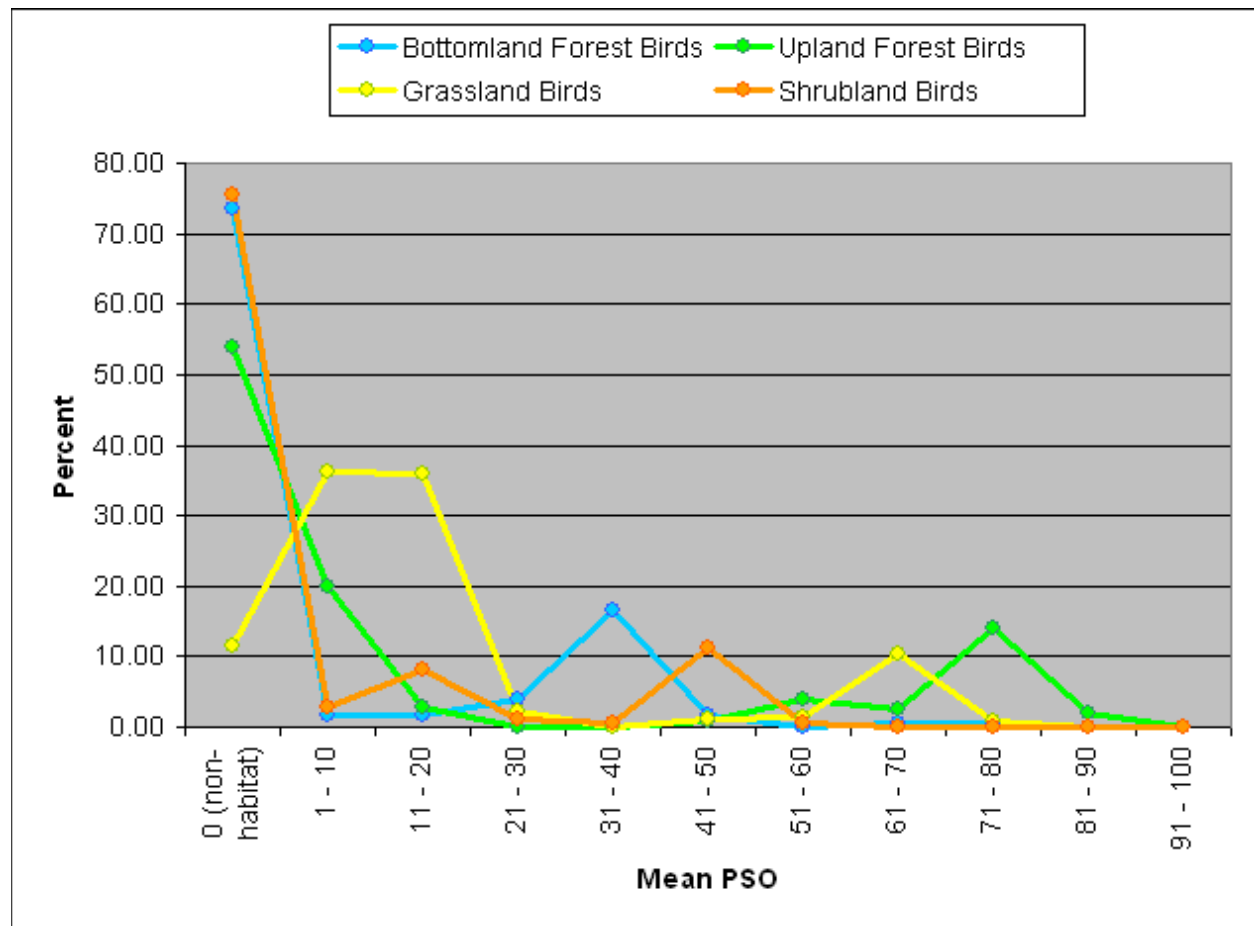
Figure 27. Graph depicting bird guild mean potential species occurrence scores separated by area percentage

Next, a zonal analysis was completed for each bird guild according to mean PSO, PSR, and SDI. Figure 28 displays mean PSO averaged by county, Figure 29 displays PSR averaged by county, and Figure 30 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).

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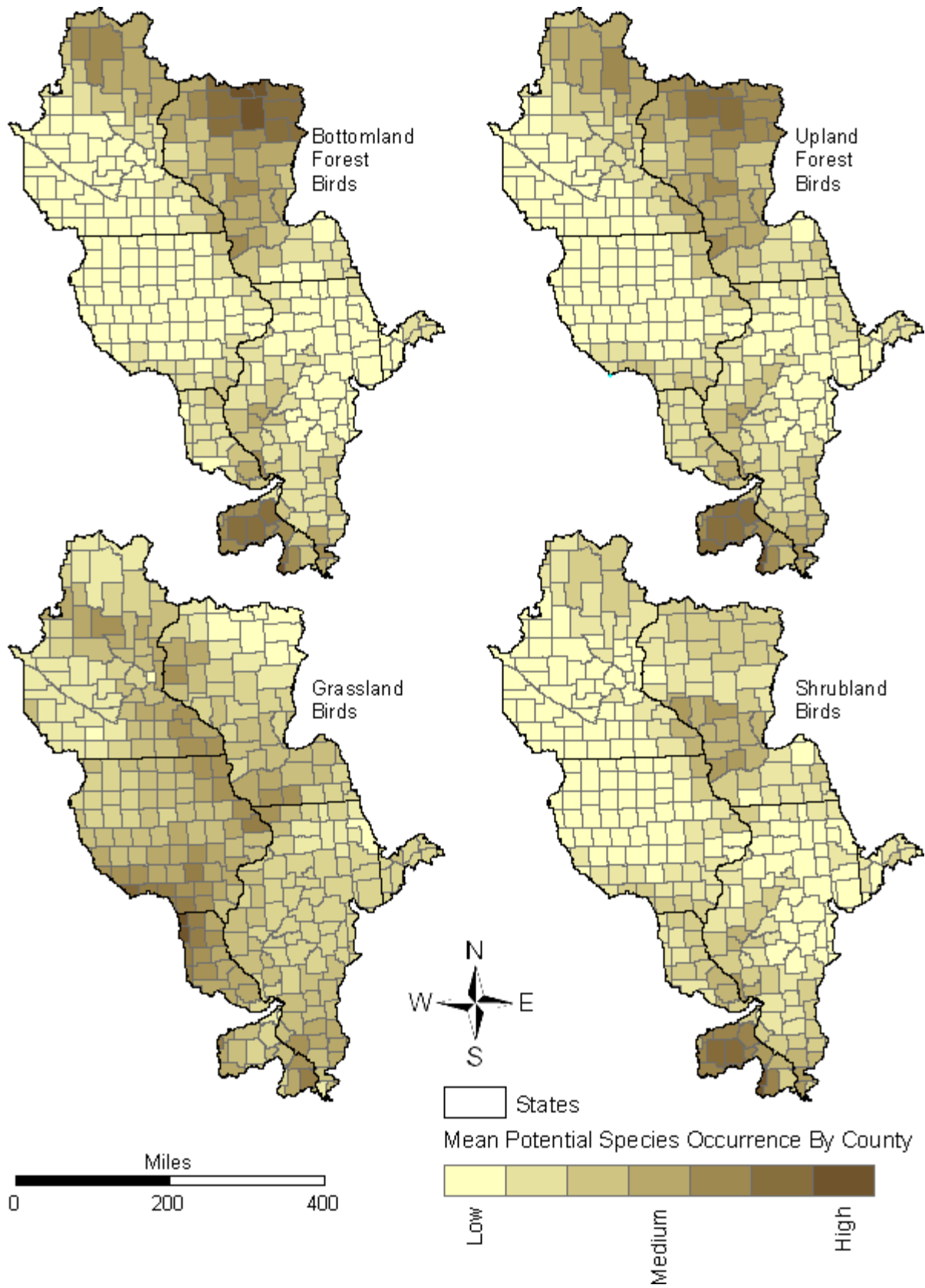
Figure 28. Mean potential species occurrence averaged by county
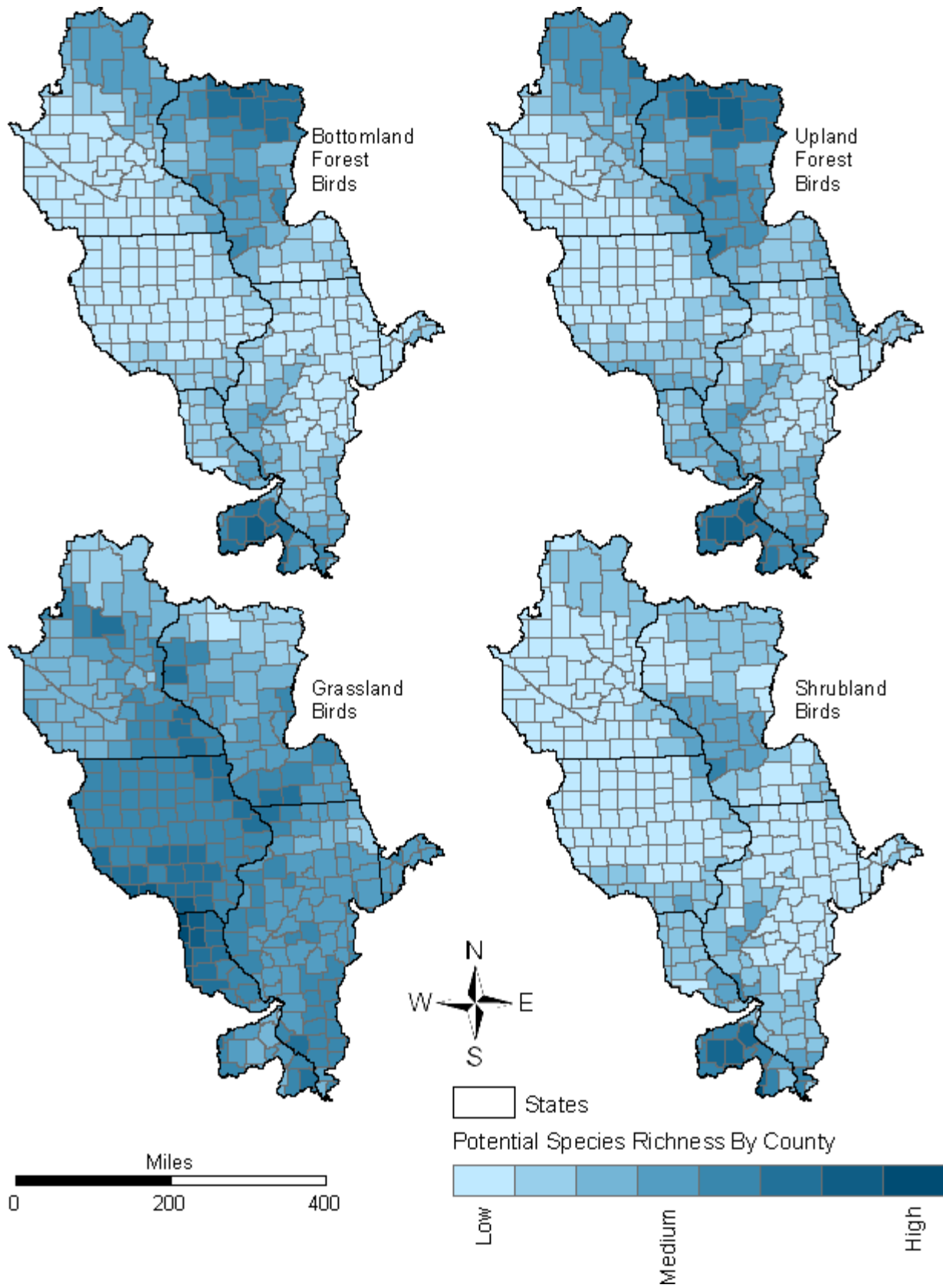
Figure 29. Potential species richness averaged by county
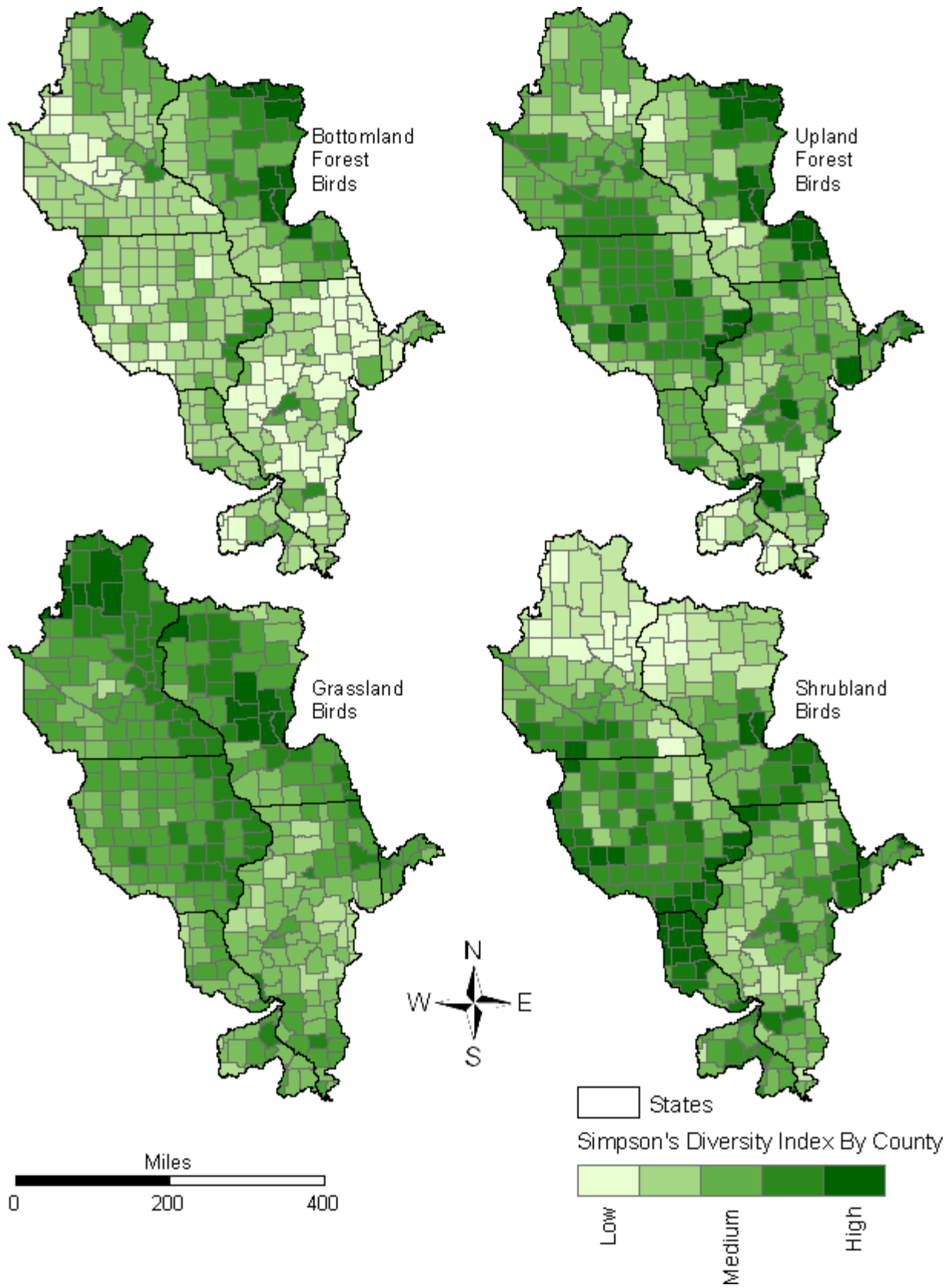
Figure 30. Simpson's diversity index averaged by county

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 parcels 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. 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)
- Had high percent slope
- Resided on erodible soils
- Were close to water
- Were delineated as a forested or scrub/shrub wetland
- Were in close proximity to publicly managed lands
- Were feeling pressure from projected housing development
- Were in close proximity to a threatened or endangered species

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 13 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 13. 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 – 10	0	4.0 – 4.5
2	10 – 20	0	4.5 – 5.0
3	20 – 30	0	> 5.0
4	30 – 40	0	Public Lands
5	40 – 50	5%	Model Influence
6	50 – 60	**Theobald Change in Housing Density**	
7	60 – 70	Score	Description
8	70 – 80	8	No Change
12%	Model Influence	10	Increase of 1 Density Class
LINK Upland Forest Model Results		5	Increase of 2 Density Classes
Score	Mean Potential Species Occurrence Score	0	Increase of 3 Density Classes
0	0	0	Increase of 4 Density Classes
1	1 – 10	0	Increase of 5 Density Classes

Score	Description
2	10 − 20
3	20 − 30
4	30 − 40
5	40 − 50
6	50 − 60
7	60 − 70
8	70 − 80
9	80 - 90
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

Score	Description
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 9.3 (Figure 31) and then run within the ArcMap GIS platform. NLCD 2001 forest class types (41, 42, 43, and 90) were used as an analysis mask for this analysis, meaning anything non-forested is given a value of NoData. Figure 32 shows the results of the "Priority Forests for Conservation" model. The "Forests, Water, and People" priority HUCs were developed by the USDA-Forest Service's Northeastern Area State and Private Forestry to highlight the connection between forests and the protection of surface drinking water quality (USDA 2009).
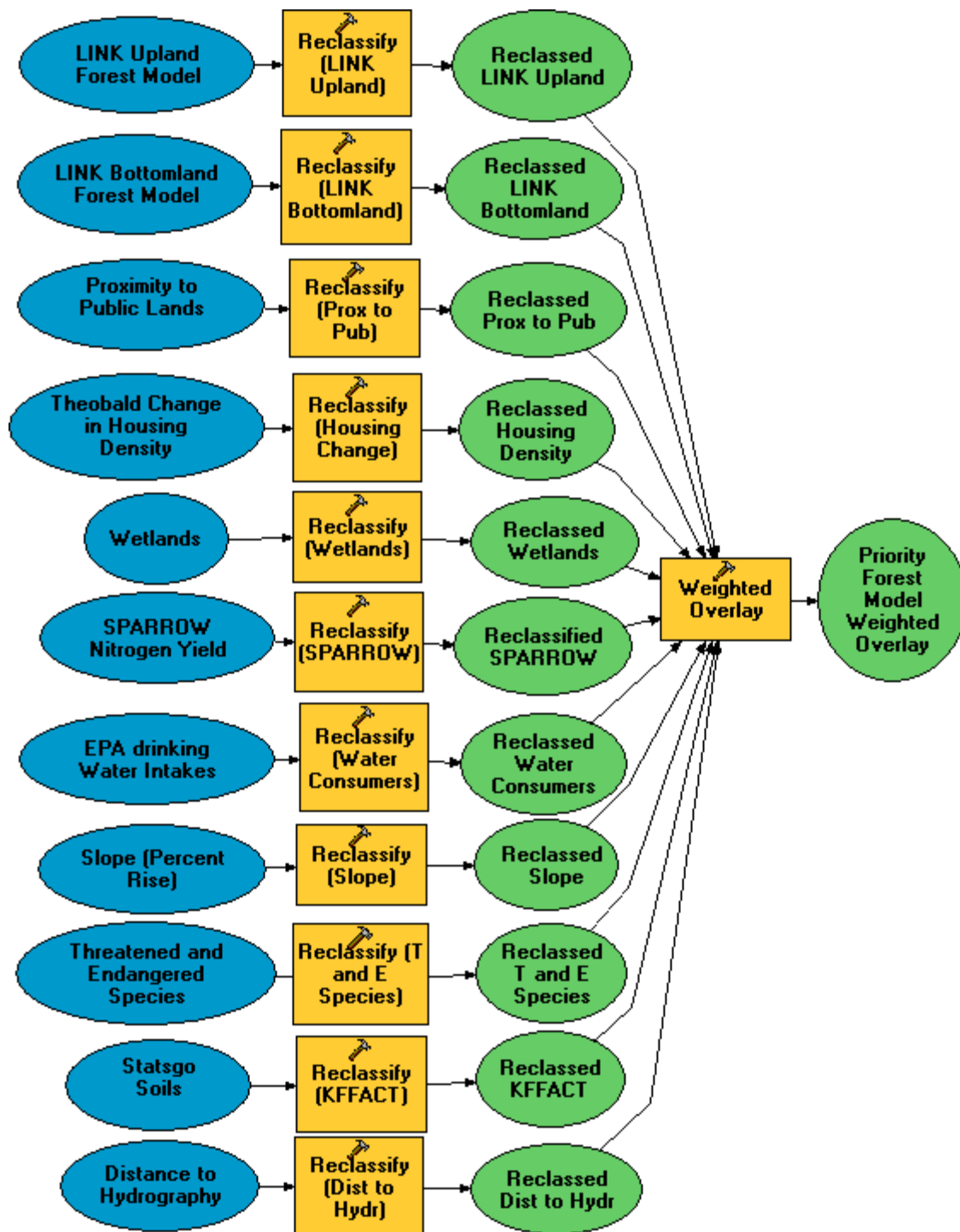
Figure 31. Priority forest model diagram

Priority Forest Model Results

Zero Priority/Non-forested — Low — Medium — High

"Forests, Water, and People" Priority HUCs

UMRS Boundary

States

8-Digit HUC

Counties

MN

WI

IA

IN

IL

MO

N
W — E
S

0   100   200
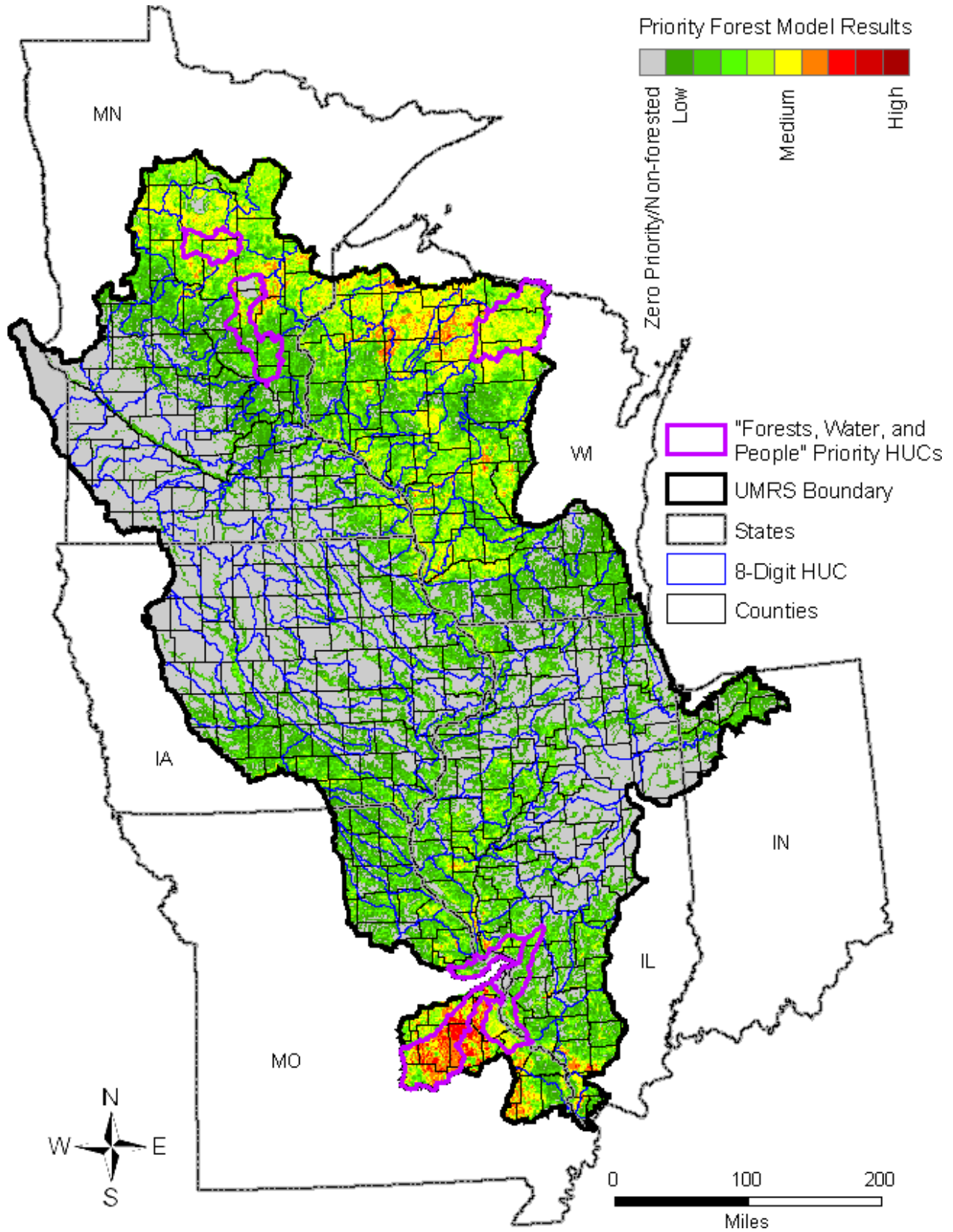Miles

Figure 32. Priority forest model output

The model output was then averaged by 8-digit HUC (Figure 33 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 33 right).
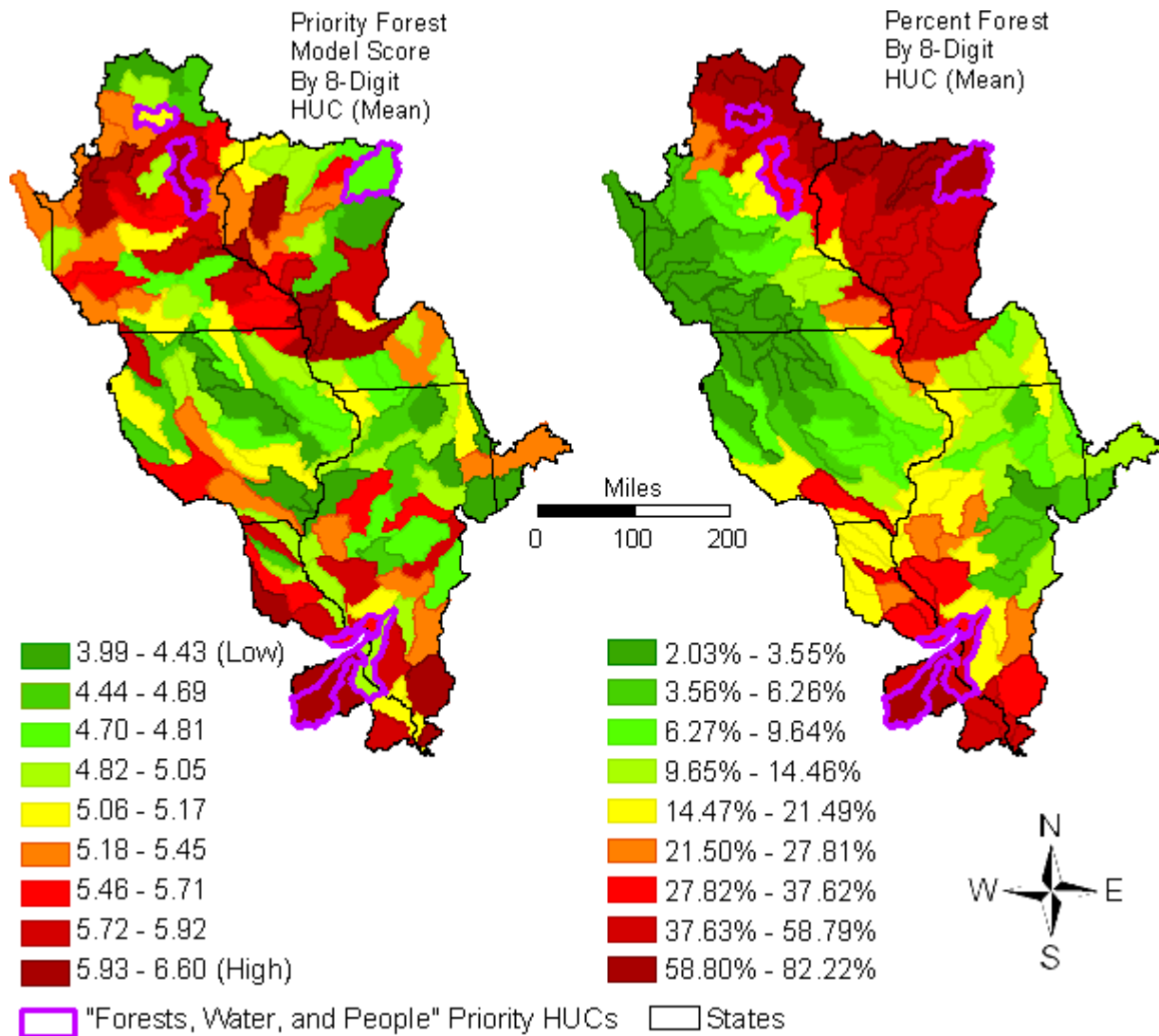

Priority Forest Model Score By 8-Digit HUC (Mean)

■	3.99 - 4.43 (Low)
■	4.44 - 4.69
■	4.70 - 4.81
■	4.82 - 5.05
■	5.06 - 5.17
■	5.18 - 5.45
■	5.46 - 5.71
■	5.72 - 5.92
■	5.93 - 6.60 (High)

Percent Forest By 8-Digit HUC (Mean)

■	2.03% - 3.55%
■	3.56% - 6.26%
■	6.27% - 9.64%
■	9.65% - 14.46%
■	14.47% - 21.49%
■	21.50% - 27.81%
■	27.82% - 37.62%
■	37.63% - 58.79%
■	58.80% - 82.22%

☐ "Forests, Water, and People" Priority HUCs   ☐ States

Figure 33. 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 this analysis indicates would be valuable areas for conservation. 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 could 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 these analyses could influence their decision making including the State forest assessments as required in the 2008 Farm Bill. It could also be used in evaluating proposals submitted to the National Fish and Wildlife Foundation to the Upper Mississippi River Watershed Fund.

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