ILLINOIS NATURAL HISTORY SURVEY
PRAIRIE RESEARCH INSTITUTE

Landscapes of Ecological Importance in Illinois

By

Diane L. Szafoni and Chad Hickman

INHS Technical Report 2014(45)
Prepared for:
Illinois Clean Energy Community Foundation
2 N. LaSalle St. Suite 1140
Chicago, IL 60602

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Executive Summary

This project used a series of landscape-scale characteristics related to biotic and landscape integrity to identify lands with the potential capacity to be restored to natural area quality with modern restoration techniques. The best ones would be those that occur in a landscape context that could be viable over the long-term once restore.

In a pilot project for Northeastern Illinois, we developed Landscape Integrity and Restorability parameters and identified statewide datasets for Illinois. We used a three-level system: Ecological, Spatial and Threat parameters, and had INHS mammologists, ornithologists, herpetologists, and botanists assess the value of the parameter and suggest weights used in the final ranking.

These criteria and datasets were used to perform a Geographic Information System (GIS) analysis of undeveloped lands in all of the state of Illinois. This GIS analysis identified lands that, if restored, have the potential for long-term ecological integrity. These landscape integrity and restorability criteria have been aligned with the qualifying size criteria for registration of lands as Illinois Land and Water Reserves (a state designation resulting in protections almost as strong as Illinois Nature Preserve Dedication), to identify large areas of lower grade that could currently qualify or could be restored to qualify for designation as Land and Water Reserves. This analysis provides a score that is used in a ranking system, to establish a hierarchical assessment of the intrinsic capacity of landscapes to sustainably support native flora and fauna with restoration.

The scattered pattern of modern development not only consumes an excessive amount of land, it fragments the landscape. Numerous studies have shown the negative ecological effects of forest fragmentation in the landscape (Wilcox and Murphy, 1985, Robertson et al, 1995). As forest areas are divided and isolated by roads and development, interior habitat decreased. This coupled with increased human disturbance and the spreading of opportunistic edge species results in the populations of many animals becoming too small to persist.

Besides the negative effect on animal populations through the loss of wildlife habitat and migration corridors, normal ecosystem functions such as absorption of nutrients, recharging of water supplies and replenishment of soil are disturbed or destroyed (Saunders et al., 1991). Water quality has been degraded in many rivers and streams and many of Illinois' remaining wetlands have been altered by filling, drainage and impoundment, livestock grazing, logging, direct discharges of industrial wastes and municipal sewage, and indirect pollution from urban and agricultural runoff.

Today, with urban land continuing to sprawl into the surrounding landscape, there is an even more urgent need to accurately identify and protect the most important unprotected natural lands in the state before they are lost.

The Illinois Department of Natural Resources (IDNR), and Conservation and Forest Preserve Districts have many programs for land acquisition, easements, and other forms of land and resource protection. Timely knowledge of where key lands and corridors are situated would facilitate these processes.

A spatial analysis was proposed as a way of assessing the landscape quickly, efficiently, and frequently. Using existing statewide digital data and Geographic Information System (GIS) software allows for periodic review of the landscape and as additional statewide data becomes available, adjustments in the ranking system can be made. Indeed, the use of GIS software and landscape ecology has been a proven tool to aid the locating of remaining areas of ecological significance.

Introduction

The landscapes of Illinois have changed greatly in the past 200 years. Before European settlement, Illinois was 41% forest, 55% prairie, and the remaining 4% open water and wetlands (Cordle, Szafoni and Greer, 2002). Illinois has lost over 90% of its original wetlands, 99.9% of its original prairie, and 36% of its forest. Much of the conversion of Illinois' land to agriculture was largely complete by the early 1900's. Today, most of the land conversion in Illinois is due to expanding urban areas (IDNR, 1996). McGrath (2005) calculated the total urban land areas for major cities in the United States, and found that Chicago increased in size from 708 square miles in 1950, to 960 square miles in 1960, 1,277 square miles by 1970, 1,498 square miles by 1980 and 1,585 square miles by 1990. This more than doubled the urban area (an increase of 877 square miles) in 40 years.

Illinois' population grew from 55,211 in 1820 (just after statehood in 1818) to 12,830,632 in 2010 (U.S. Census Bureau, 2010). The ten year period from 2000 – 2010 saw only a 3.3% increase in Illinois' population, compared to an 8.6% increase in the 1990's, and considerably lower than the 9.7% increase during the 2000's in the total U.S. population. (U.S. Census Bureau, 2010). Chicago has a declining population (a 6.9% reduction), but the collar counties are growing. The five fastest growing counties in Illinois were Kendall (110.4%), Will (34.9), Grundy (33.4%), Boone (29.6%), and Kane (27.5%). Land development has increased even faster than population. The Sierra Club (US Census Bureau data) did a study of urban sprawl and found that Chicago's population increased by one percent from 1970 to 1990, while its urbanized area grew by 24 percent.

The scattered pattern of modern development not only consumes an excessive amount of land, it fragments the landscape. Numerous studies have shown the negative ecological effects of forest fragmentation in the landscape (Wilcox and Murphy, 1985, Robertson et al, 1995). As forest areas are divided and isolated by roads and development, interior habitat decreased. This coupled with increased human disturbance and the spreading of opportunistic edge species results in the populations of many animals becoming too small to persist.

Besides the negative effect on animal populations through the loss of wildlife habitat and migration corridors, normal ecosystem functions such as absorption of nutrients, recharging of water supplies and replenishment of soil are disturbed or destroyed (Saunders et al., 1991). Water quality has been degraded in many rivers and streams and many of Illinois' remaining wetlands have been altered by filling, drainage and impoundment, livestock grazing, logging, direct discharges of industrial wastes and municipal sewage, and indirect pollution from urban and agricultural runoff.

Today, with urban land continuing to sprawl into the surrounding landscape, there is an even more urgent need to accurately identify and protect the most important unprotected natural lands in the state before they are lost.

The Illinois Department of Natural Resources (IDNR), and Conservation and Forest Preserve Districts have many programs for land acquisition, easements, and other forms of land and resource protection. Timely knowledge of where key lands and corridors are situated would facilitate these processes.

The purpose of this study was to develop a way of assessing the landscape quickly, efficiently and frequently. A spatial analysis using existing statewide digital data and Geographic Information System (GIS) software was used because it met the project goals. Indeed, the use of GIS software and landscape ecology has been a proven tool to aid the locating of remaining areas of ecological significance.

Our capacity to restore the natural quality of natural communities through restoration management practices has improved dramatically over the last 30 years. As we protect and manage the remaining high quality (Illinois Natural Areas Inventory Category I) natural areas, many of which are small, the attention of conservationists naturally turns to areas that are of lesser quality, but still possess significant natural values. These lands are often larger than the remaining high quality natural areas, and still have the potential for restoration at a reasonable cost. This project focused on identifying such lands using metrics related to landscape integrity.

Our objective is to identify lands supporting natural communities that can be restored to high natural quality. Using the terminology of the Illinois Natural Areas Inventory (INAI) these areas would not be the Grade A or B natural communities, but rather the degraded, i.e., Grade C, D, or E natural communities in the parlance of the INAI. However, since Grade E communities have essentially had the original community completely removed, Grade E communities cannot be "restored" in the same sense as grade C and D natural communities, but must be "reconstructed" from scratch, often at great cost and seldom achieving very high natural quality. Examples of Grade E communities include cleared land, cropland, improved pasture, residential/commercial development, parking lots, road or railroad embankments and rights of way. Consequently this project was not designed to identify Grade E communities either, since restorability is related to community grade.

Methods

The study area for this project was the State of Illinois (Figure 1). The base land cover data used for this study was the United States Department of Agriculture, National Agricultural Statistics Service (USDA-NASS) Cropland Data Layer (CDL) for 2012 (Figure 2) (USDA, National Agricultural Statistics Service, 2012). The specifications for this data are as follows:

"The USDA, NASS Cropland Data Layer (CDL) is a raster, geo-referenced, crop-specific land cover data layer. The 2012 CDL has a ground resolution of 30 meters. The CDL is produced using satellite imagery from the Landsat 5 TM sensor, Landsat 7 ETM+ sensor, the Spanish DEIMOS-1 sensor, the British UK-DMC 2 sensor, and the Indian Remote Sensing RESOURCESAT-1 (IRS-P6) Advanced Wide Field Sensor (AWiFS) collected during the current growing season. Some CDL states used additional satellite imagery and ancillary inputs to supplement and improve the classification. These additional sources can include the United States Geological Survey (USGS) National Elevation Dataset (NED), the imperviousness and canopy data layers from the USGS National Land Cover Database 2006 (NLCD 2006), and the National Aeronautics and Space Administration (NASA) Moderate Resolution Imaging Spectroradiometer (MODIS) 250 meter 16 day Normalized Difference Vegetation Index (NDVI) composites." (USDA, National Agricultural Statistics Service, 2012).

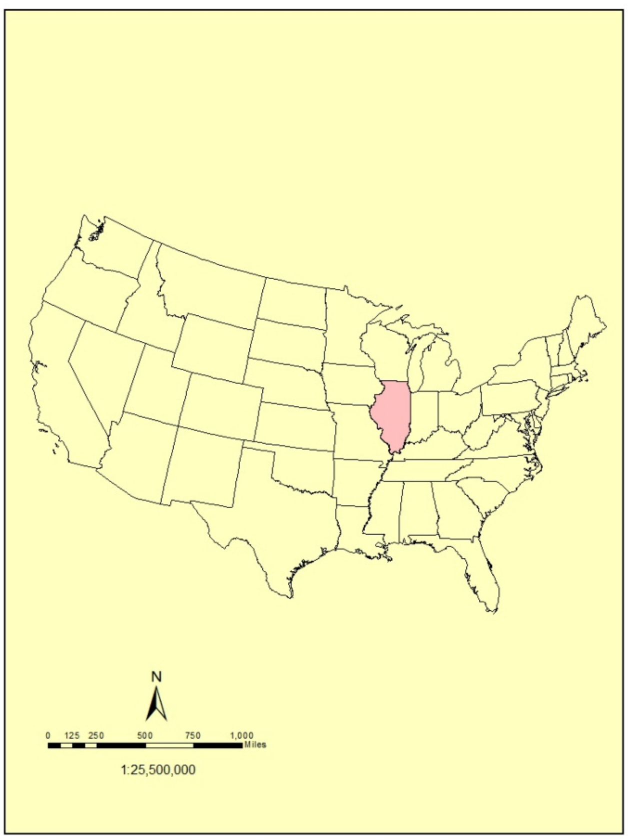

Figure 1. Study Area

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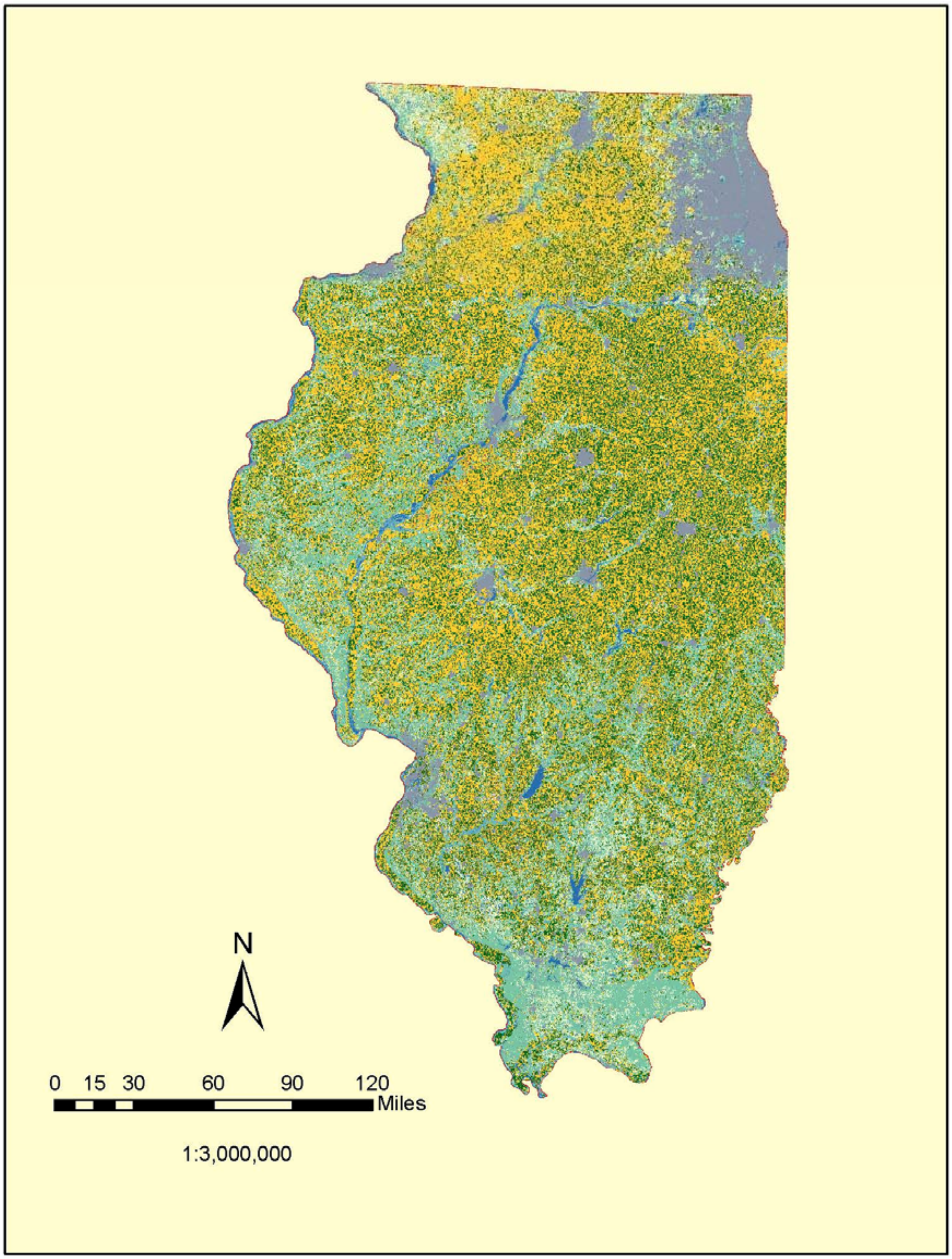

Figure 2. Original USDA-NASS 2012 Land Cover.

Forest, Grassland and Wetland land cover categories were extracted from the NASS-CDL land cover datasets for separate analysis (Table 1). Size constraints, based on the criteria for registration as Illinois Land and Water Reserves (1994), were applied to each land cover category: Forest >= 100 acres, Grassland >= 80 acres, Wetland >= 50 acres (Land and Water Reserve, 1994).

Forest	**Grassland**	**Wetland**
Min. Size: **100 acres**	**Min. Size:** **80 acres**	**Min. Size:** **50 acres**
63 Forest	62 Pasture/Grass	87 Wetlands
141 NLCD Deciduous Forest	171 NLCD Grassland Herbaceous	190 NLCD - Woody Wetlands
142 NLCD Evergreen Forest	181 NLCD Pasture/Hay	195 NLCD - Herbaceous Wetlands
143 NLCD Mixed Forest		

Table 1. NASS 2012 Land Cover categories used in the GIS analysis.

Figures 3-5 shows the extent of each land cover category that remained.

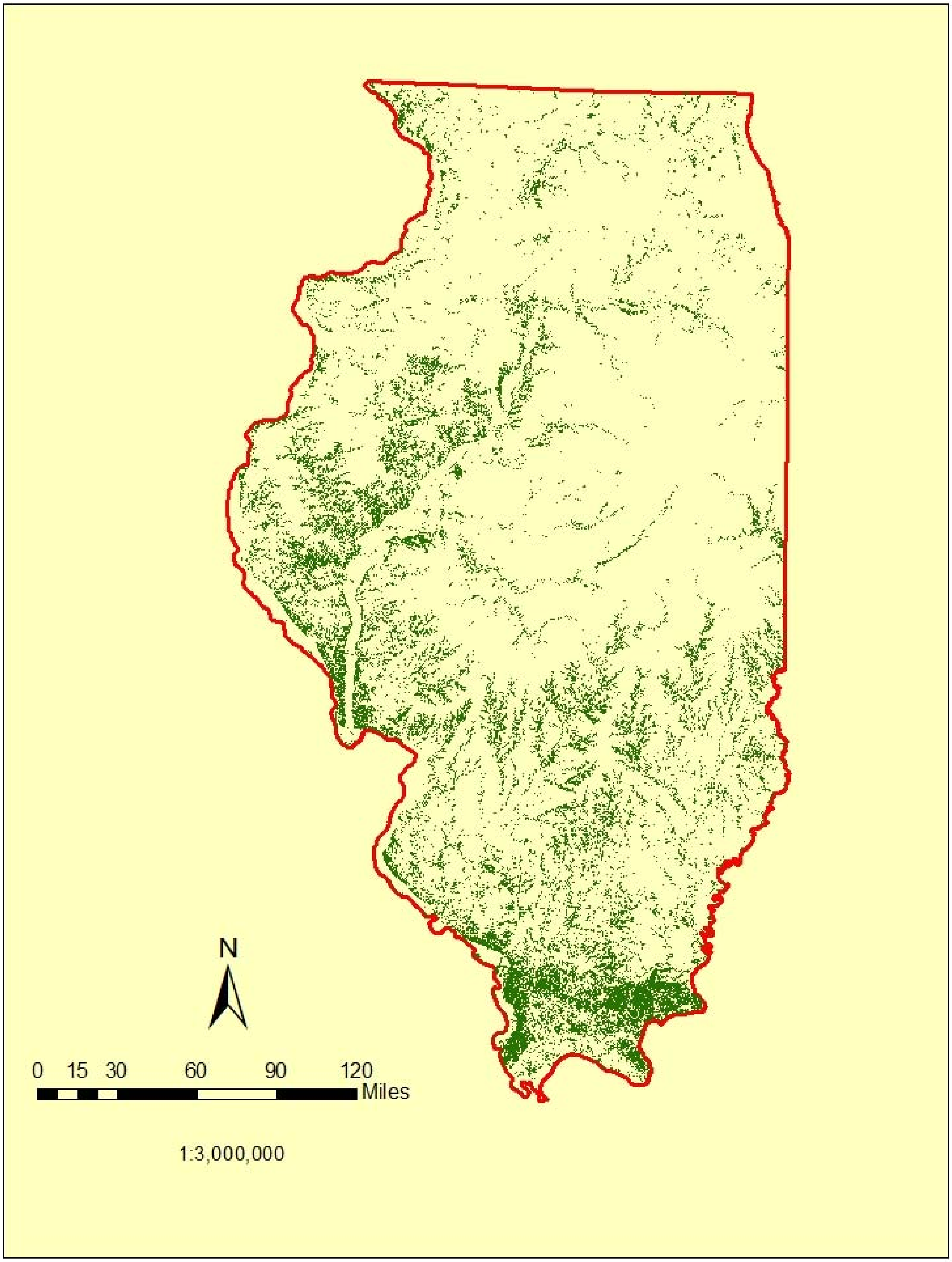

Figure 3. Forests at least 100 acres in size.

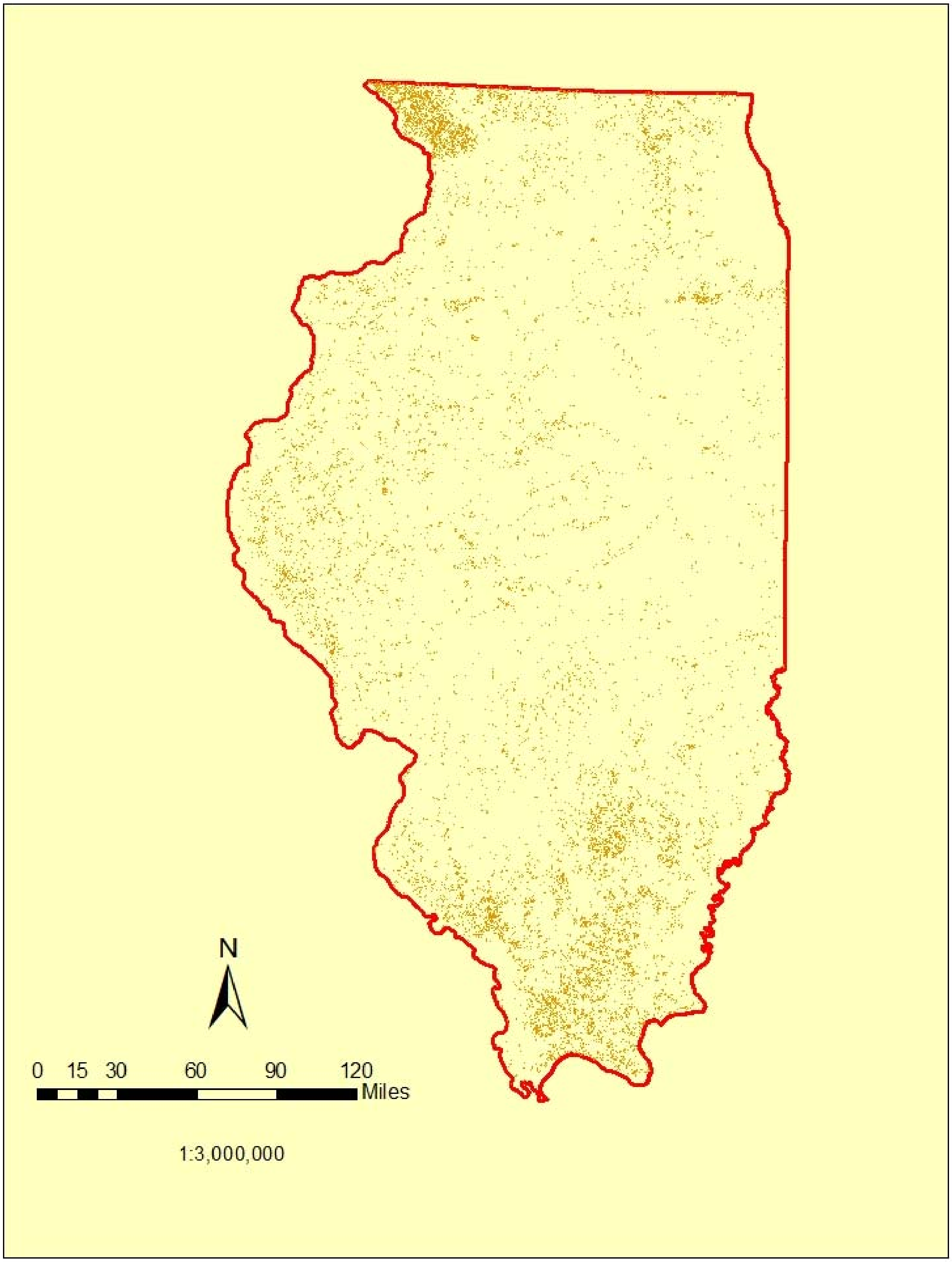

Figure 4. Grasslands at least 80 acres in size.

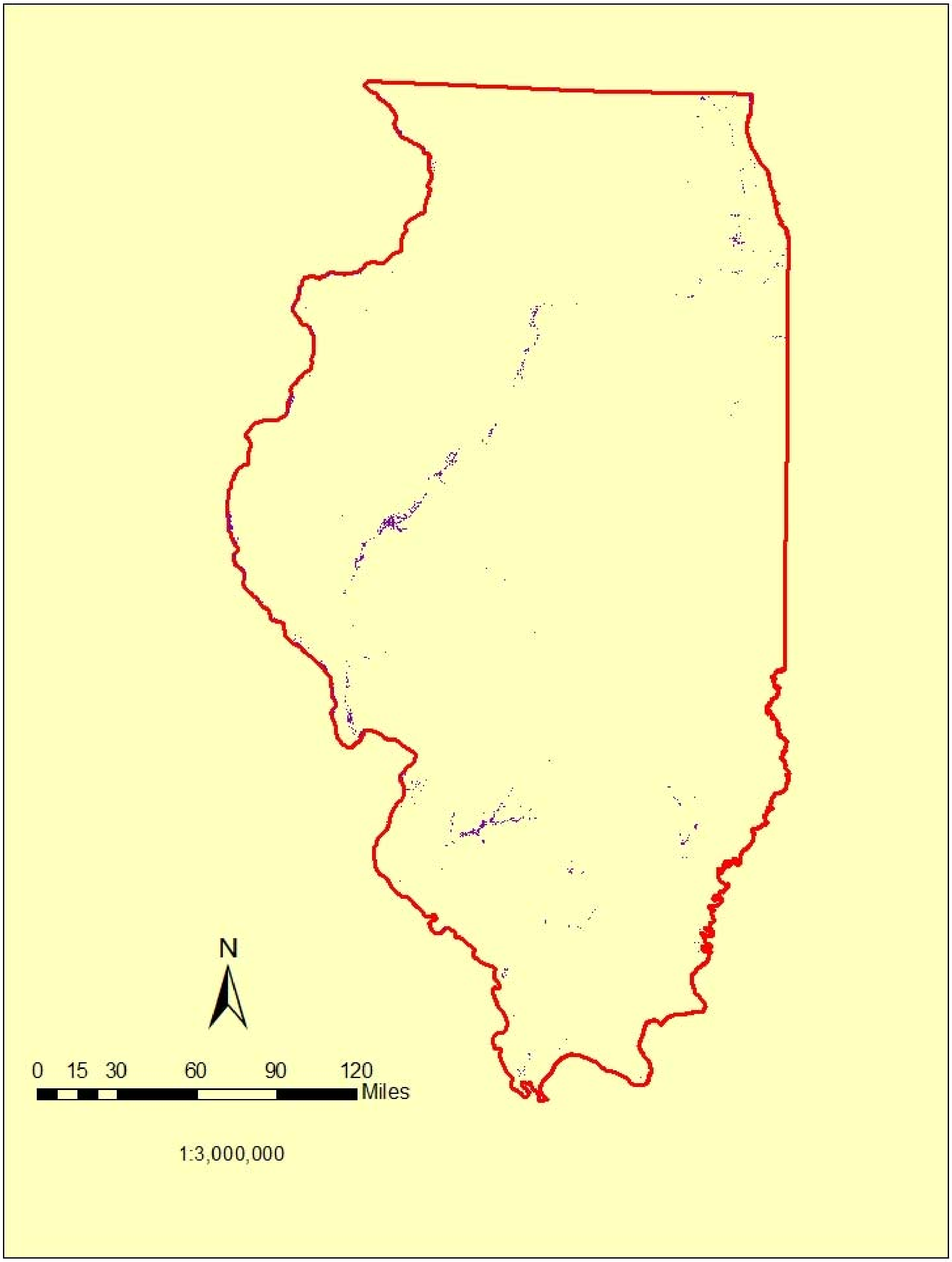

Figure 5. Wetlands at least 50 acres in size.

After selecting the desired land cover categories and applying the size constraints, the resulting Forest, Grassland, and Wetland tracts were evaluated for Landscape Integrity using a suite of data layers and ArcGIS software (ESRI, 2012). The data layers are grouped into Ecological Parameters, Spatial Parameters, and Threat Parameters (Table 2) employing a 3 tier analysis as previously discussed. The parameters chosen were those available as statewide GIS data sets. The ecological parameters used include presence of various ecological quality indicators such as natural communities, amount of protected areas, and presence of unique natural resources. The spatial parameters used include measures of the shape of the area, amount of interior gap or "holes" of different land cover types, and nearness to tracts of similar type. The threat parameters used include development pressures, such as amount of road density, remoteness from roads, and adjacency to agricultural and urban areas.

Type	Source	Date	Cell Size/ Resolution	Source Data
Ecological				
Area of (various) Land Use Category	USDA, National Agricultural Statistics Service 2012 Illinois Cropland Data Layer (CDL)	2012	30 meter	Indian Remote Sensing RESOURCESAT-1 (IRS-P6) Advanced Wide Field Sensor (AWiFS)
Area of Threatened and Endangered Species[1]	Threatened and Endangered Species, Rare Communities, and Valuable Natural Resources of Illinois, Edition 2.0	2009	1:24,000	Illinois Department of Natural Resources, Natural Heritage Database Program
Area of Public Land[1]	Illinois Natural History Survey's 1:100,000 Scale Illinois Gap Analysis Stewardship Layer	2003	1:100 000	Illinois Natural History Survey
Area of Nature Preserves – IDNR (forest and grassland only)[1]	Nature Preserves, Land and Water Reserves, and Natural Heritage Landmarks in Illinois	2009	1:24,000	Illinois Department of Natural Resources, Natural Heritage Database Program
Area of Railroad Prairie Remnant (grassland only)[1]	Prairie Remnants for the Illinois Dept. of Transportation, based on U.S. Geological Survey 1:100,000 Digital Line Graph file, railroad layer	2004	1:100,000	Illinois Natural History Survey, from U.S. Geological Survey railroad data

Type	Source	Date	Cell Size/ Resolution	Source Data
Area of Appropriate Soil (grassland = prairie, forest = forest, wetland = hydric)[1]	SSURGO Soils in Illinois	2012	1:12,000	U.S. Dept. of Agriculture, Natural Resources Conservation Services
Area of Interior Forest (forest only)[1]	USDA, National Agricultural Statistics Service 2012 Illinois Cropland Data Layer (CDL)	2012	30 meter	Indian Remote Sensing RESOURCESAT-1 (IRS-P6) Advanced Wide Field Sensor (AWiFS)
Area of Flood Zones (wetland only) [1]	Illinois State Water Survey (ISWS) – digitized from FEMA FIRM maps	1996	1:6,000 to 1:24,000	Illinois 100-year and 500-year floodzones
Length of Stream Width BSC Diversity ranking[2]	Integrating Multiple Taxa in a Biological Stream Rating System – Diversity component	1997-2006	1:100,000	Illinois Natural History Survey, from U.S. Geological Survey data
Number of Stream Sources and Junctions (wetland only)[2]	National Hydrography Dataset (NHD) Flowline – Medium-resolution (based on Digital Line Graph Data (DLG)	1999 (1994)	1:100,000	U.S. Geological Survey in cooperation with the U.S. Environmental Protection Agency
Illinois GAP Predicted Species Distributions for Bird and Herps (Reptile and Amphibian) Species in Greatest Need of Conservation (SGNC)[3]	Illinois Natural History Survey"s 30m x 30m Amphibian, Bird, Reptile Predicted Species Distribution Models.	2003	30 meter	Illinois Natural History Survey
Spatial				
Proportion of Interior gap (holes) in area[1]	USDA, National Agricultural Statistics Service 2012 Illinois Cropland Data Layer (CDL)	2012	30 meter	Indian Remote Sensing RESOURCESAT-1 (IRS-P6) Advanced Wide Field Sensor (AWiFS)
Patch Shape – used V-LATE software[4]	Vector-based Landscape Analysis Tools Extension (V- LATE) 1.1 for ArcGIS 9.x	2005	N/A	Centre for Geoinformatics (Z_GIS) at Salzburg University
Nearness to Area with same Land Cover Type (nearest neighbor) – used V-LATE software[2]	USDA, National Agricultural Statistics Service 2012 Illinois Cropland Data Layer (CDL)	2012	30 meter	Indian Remote Sensing RESOURCESAT-1 (IRS-P6) Advanced Wide Field Sensor (AWiFS)

Type	Source	Date	Cell Size/ Resolution	Source Data
Threat				
Remoteness from Roads within 1 mile (1609 meters) - NAVTEQ[2]	NAVTEQ"s NAVSTREET Street Data	2007	5 meter	NAVTEQ, 425 W. Randolph St., Chicago, IL 60606
Road Density - NAVTEQ	NAVTEQ"s NAVSTREET Street Data	2007	5 meter	NAVTEQ, 425 W. Randolph St., Chicago, IL 60606
Proximity to Urban Area[2]	USDA, National Agricultural Statistics Service 2012 Illinois Cropland Data Layer (CDL)	2012	30 meter	Indian Remote Sensing RESOURCESAT-1 (IRS-P6) Advanced Wide Field Sensor (AWiFS)
Adjacent to Agriculture (wetlands only)	USDA, National Agricultural Statistics Service 2012 Illinois Cropland Data Layer	2012	30 meter	Indian Remote Sensing RESOURCESAT-1 (IRS-P6) Advanced Wide Field Sensor (AWiFS)

Table 2. List of GIS data layers used for analysis. [1] units = acres, [2] units = meters, [3] units = richness, [4] = index.

The individual parameters for each land cover type were reviewed and weighted by six INHS ecologists covering a broad range of disciplines. The scientist's indicated if the parameter was worth keeping, and suggested a weight to apply. The parameter remained if more than half of the scientists voted to keep it. Once a parameter was selected, the average of the suggested weight was calculated to determine a final weight. The parameter choices and weights are listed in Tables 3–5.

Forest Parameters	INHS Scientists Retain (yes)	INHS Scientist Retain (no)	Weight (average)
Ecological			
Total area of forest	4	2	3
Area of T & E species	6	0	3
Area of public land	4	2	2
Area of nature preserves	5	1	2
Area of forest soils	4	2	2
Area of interior forest	6	0	4

Stream length BSC Diversity	4	2	2
SGNC bird species	5	1	2
SGNC herp species	6	0	3
Spatial			
Proportion of interior gap area in hub	5	1	3
Patch Shape	4	2	2
Proximity to other forest tracts (nearest neighbor)	6	0	3
Threats			
Remoteness from roads	4	2	2
Road density	6	0	3
Proximity to urban area	4	2	3

Table 3. Forest parameters and weights used in the analysis.

Grassland Parameters	INHS Scientists Retain (yes)	INHS Scientist Retain (no)	Weight (average)
Ecological			
Total area of grassland	5	1	4
Area of T & E species	6	0	3
Area of public land	4	2	2
Area of nature preserves	4	2	2
Area of prairie soils	5	1	2
Area of railroad prairie remnant	6	0	3
Stream length BSC Diversity	6	0	3
SGNC bird species	6	0	4
SGNC herp species	5	1	3
Spatial			
Proportion of interior gap area in hub	5	1	3
Patch shape	5	1	3
Proximity to other prairie tracts (nearest neighbor)	4	2	2
Threats			
Remoteness from roads	4	2	2
Road density	6	0	2
Proximity to urban area	4	2	2

Table 4. Grassland parameters and weights used in the analysis.

Wetland Parameters	INHS Scientists Retain (yes)	INHS Scientist Retain (no)	Weight (average)
Ecological			
Total area of wetland	6	0	4
Area of T & E species	5	1	2
Area of public land	4	2	2
Length of headwater streams within wetland	2	4	1
Area of flood zone	5	1	2
Area of hydric soils	5	1	3
Stream Length BSC Diversity	5	1	3
SGNC bird species	6	0	3
SGNC herp species	6	0	3
Spatial			
Proportion of interior gap area in hub	5	1	3
Patch shape	4	2	2
Proximity to other forest tracts (nearest neighbor)	5	1	2
Threats			
Remoteness from roads	5	1	3
Road density	6	0	3
Proximity to urban area	4	2	3
Adjacent to agriculture	4	2	2

Table 5. Wetland parameters and weights used in the analysis.

Parameters overlaid with the land cover are Threatened and Endangered Species, Public lands, Nature Preserves, Railroad prairie remnants (grassland only), Soils, Interior forest (forest only), Flood Zones (wetland only), Proximity to Urban Areas, and Adjacency to Agriculture (wetland only), Length of BSC Streams, Number of Stream Sources and Junctions (wetland only), SGNC birds and herps (Reptiles and Amphibians) – see Appendix I for a complete species list, Remoteness from Roads, and Road density. The Vector-based Landscape Analysis Tools Extension for ArcGIS software (V-LATE, 2005) was used to calculate patch shape and distance to the same land cover type - nearest neighbor. Detailed steps on the analyses for all parameters can be viewed in Appendix II.

The final, weighted parameters were combined (ecological + spatial – threats) for each of the land cover categories (Forest, Grassland, and Wetland) to derive a final rank. The results were divided into three groups (High, Medium and Low) using the Natural Breaks function in ArcGIS.

Results and Discussion

The Forest, Grassland, and Wetland LEI's were ranked within each land cover category to give a sense of how each LEI compared to another. Each parameter was assigned an importance weight based on the advice of INHS scientists and the literature (Tables 3-5). This was also necessary as there were slight differences in parameter types used for each land cover type. The individual, weighted parameters for each area were then added together (for ecological and spatial parameters) or subtracted (for threat parameters). Details on all steps of the analyses are in Appendix II. Maps of the results of the three steps (Ecological, Spatial and Threats) are shown in Appendix III. Figures 6-8 shows the final 3 rankings for each of the land cover types.

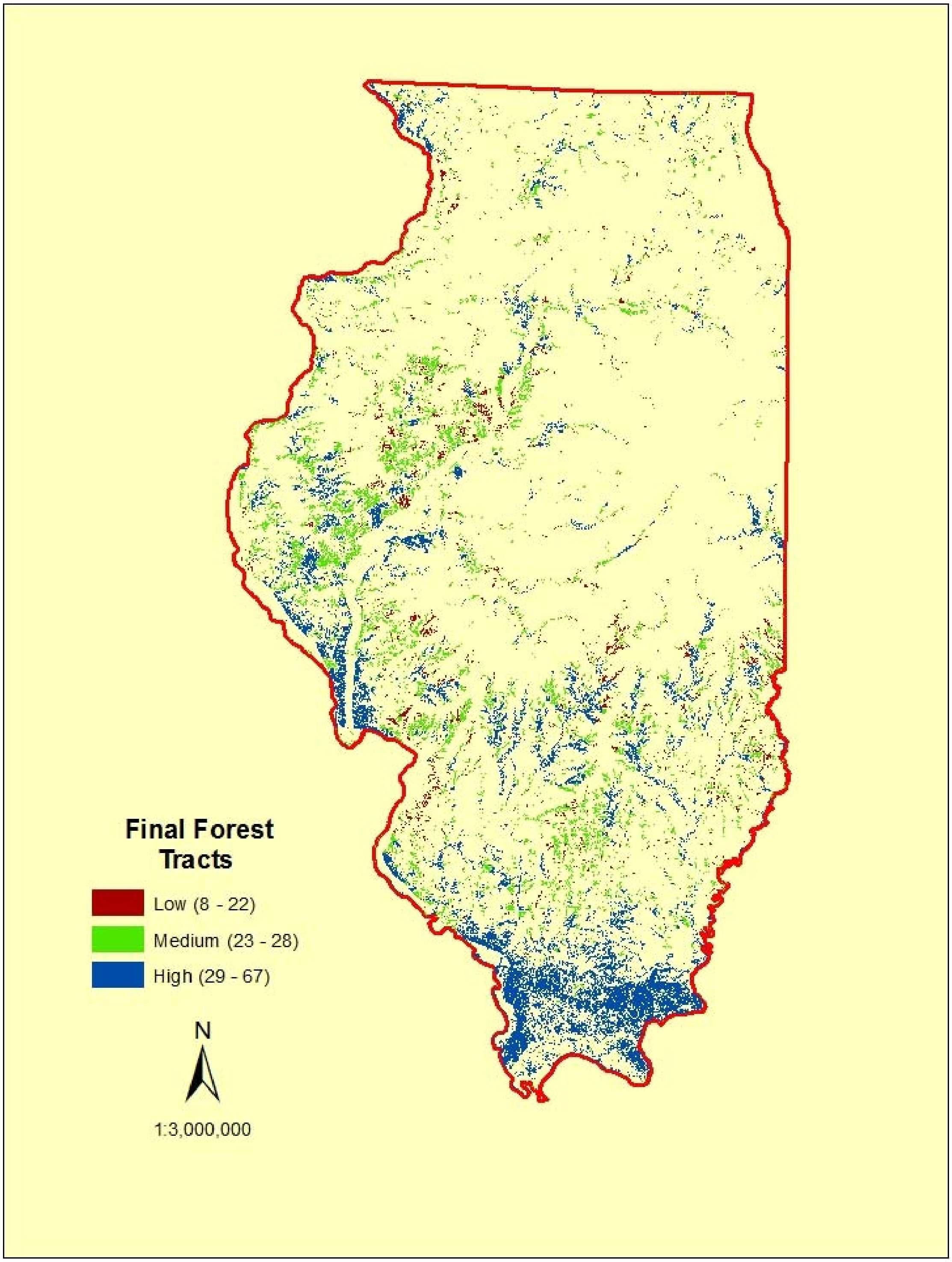

Figure 6. Final Forest rankings.

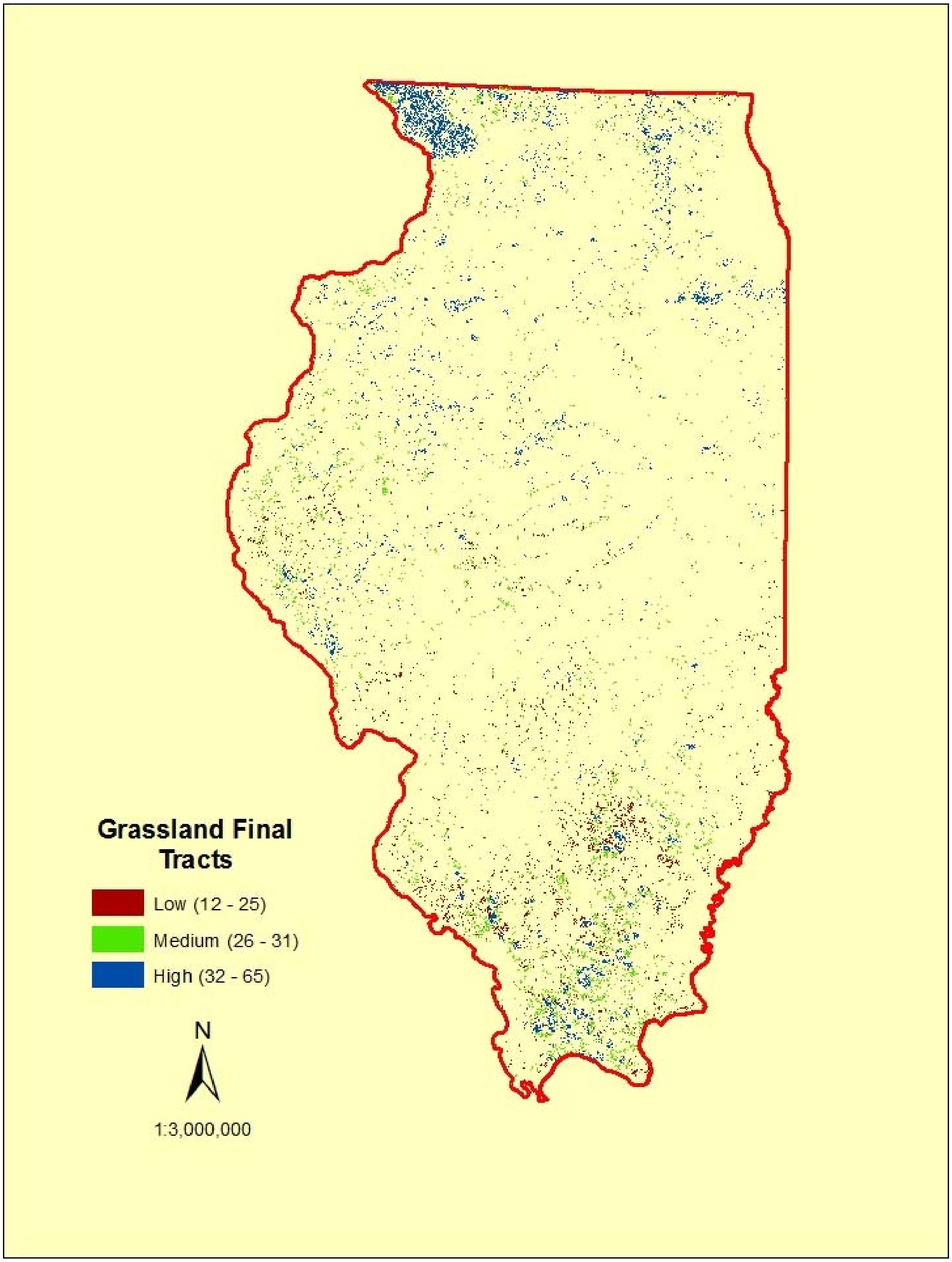

Figure 7. Final Grassland rankings.

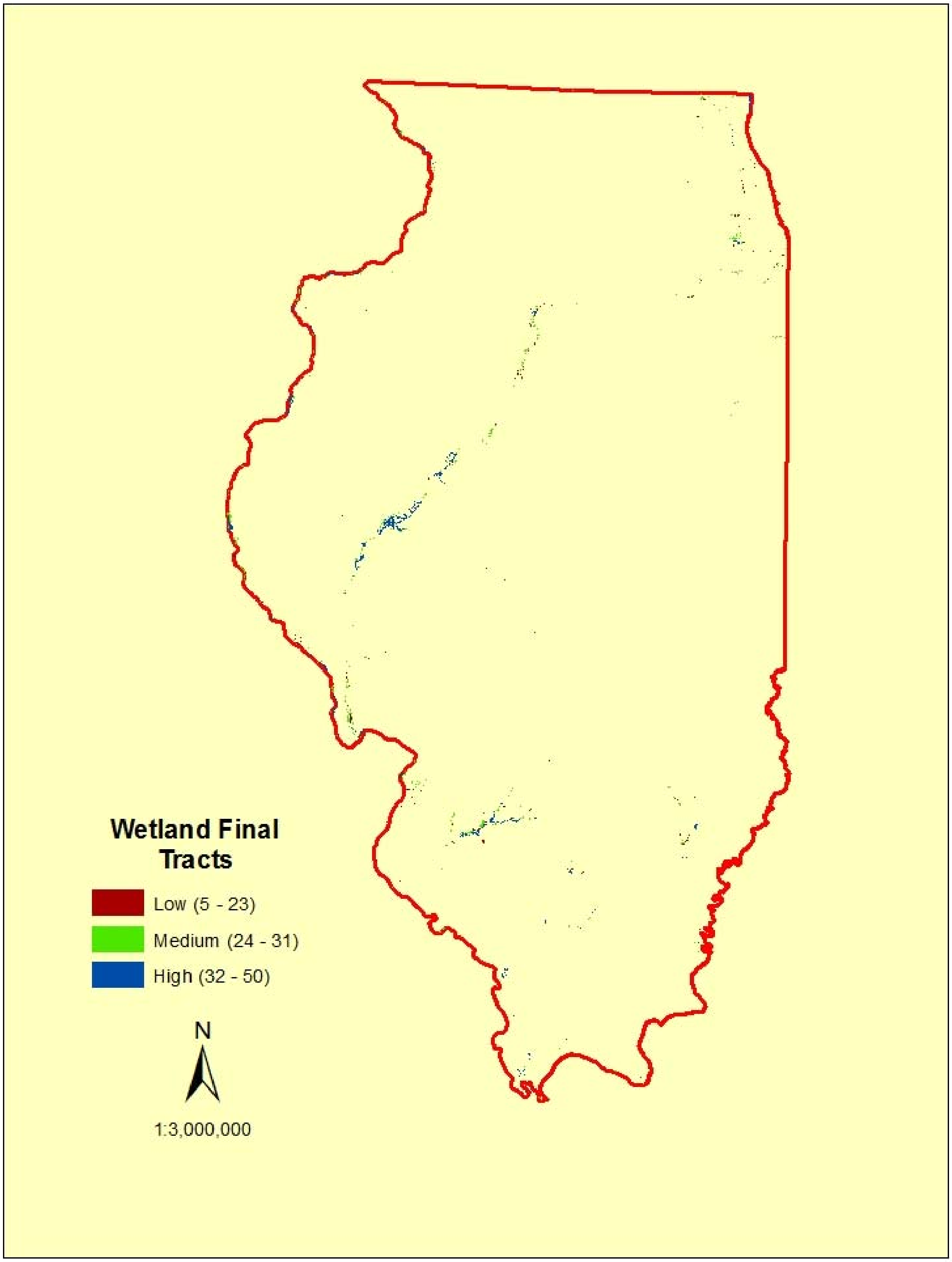

Figure 8. Final Wetland rankings.

Pearson's Correlation Coefficient analysis was calculated for the parameters in the Forest, Grassland, and Wetlands categories to test for parameters looking at the same thing (strong correlation). The results of this analysis and the parameters retained are listed in Tables 6-8. Correlation coefficient values greater than 0.8 (positively correlated), or less than –0.8 (inversely correlated) were considered strong correlation and are indicated in gray in the tables. Only one of the parameters were highly correlated (> 80%).

The Forests, Grasslands, and Wetlands parameters of total area and public land were the only parameters that were strongly correlated. This can be explained by the fact that the larger areas tend to be owned by public entities. The rest of the parameters were not highly correlated, so did not represent redundancy in calculating the final rank.

Forests	Total Area	T & E Species	Public Land	Nature Preserve	Presence of Forest Soil	Interior Forest	Stream Length BSC Diversity	SGNC Birds	SGNC Herps	Proportion Interior Gap	Patch Shape	Nearest Neighbor	Remoteness From Roads 1 mile	Road Density	Proximity to Urban Area
Total Area	1.00														
T & E Species	0.16	1.00													
Public Land	1.00	0.16	1.00												
Nature Preserve	0.17	0.44	0.17	1.00											
Presence of Forest Soil	0.30	0.07	0.30	0.07	1.00										
Interior Forest	0.09	0.03	0.09	0.06	0.08	1.00									
Stream Length BSC Diversity	0.15	0.23	0.15	0.16	0.08	0.05	1.00								
SGNC Birds	0.05	0.16	0.05	0.12	-0.01	-0.03	0.04	1.00							
SGNC Herps	0.06	0.00	0.06	-0.02	0.05	0.08	-0.08	0.05	1.00						
Proportion Interior Gap	0.07	0.03	0.07	0.04	0.04	0.10	0.07	0.11	0.06	1.00					
Patch Shape	0.13	0.33	0.13	0.19	0.03	0.09	0.33	0.11	0.04	0.14	1.00				
Nearest Neighbor	0.01	0.00	0.01	-0.01	0.02	0.10	0.00	-0.03	0.11	-0.08	0.06	1.00			
Remoteness From Roads – 1 mile	0.16	0.28	0.16	0.23	0.04	0.11	0.25	0.11	0.05	0.02	0.45	0.01	1.00		
Road Density	0.11	0.12	0.11	0.09	0.08	0.19	0.09	-0.02	0.07	0.02	0.19	0.07	0.18	1.00	
Proximity to Urban Area	0.21	0.24	0.21	0.25	0.04	0.14	0.18	0.14	-0.01	0.02	0.38	0.04	0.59	0.19	1.00

Table 6. Pearson Correlation Coefficient analysis for Forested tracts. The shaded cells indicate those with significant positive correlations.

Grasslands	Total Area	T & E Species	Public Land	Nature Preserve	Presence of Prairie Soil	Railroad Remnant	Stream Length BSC Diversity	SGNC Birds	SGNC Herps	Proportion Interior Gap	Patch Shape	Nearest Neighbor	Remoteness from Roads 1 mile	Road Density	Proximity to Urban area
Total Area	1.00														
T & E Species	0.19	1.00													
Public Land	1.00	0.19	1.00												
Nature Preserve	0.11	0.34	0.11	1.00											
Presence Prairie Soil	0.07	0.12	0.07	0.10	1.00										
Railroad Remnant	0.04	0.07	0.04	0.03	0.06	1.00									
Stream Length BSC Diversity	0.14	0.11	0.14	0.03	0.14	0.02	1.00								
SGNC Birds	0.04	0.07	0.04	0.05	0.16	-0.01	0.06	1.00							
SGNC Herps	-0.03	0.06	-0.03	0.05	0.36	0.03	0.05	0.23	1.00						
Proportion Interior Gap	0.18	0.05	0.18	0.04	0.06	0.02	0.07	0.04	0.02	1.00					
Patch Shape	0.31	0.18	0.31	0.07	0.03	0.03	0.08	0.06	-0.04	0.10	1.00				
Nearest Neighbor	0.06	0.04	0.06	0.02	-0.14	0.00	-0.03	0.00	-0.09	0.03	0.13	1.00			
Remoteness from Roads- 1 mile	0.29	0.16	0.29	0.05	0.09	0.06	0.08	0.07	0.00	0.08	0.29	0.03	1.00		
Road Density	0.32	0.09	0.32	0.05	0.03	0.02	0.05	0.06	-0.07	0.12	0.29	0.05	0.22	1.00	
Proximity to Urban Area	0.26	0.17	0.26	0.08	0.20	0.07	0.08	0.11	0.09	0.10	0.32	0.06	0.40	0.29	1.00

Table 7. Pearson Correlation Coefficient analysis for Grassland tracts. The shaded cells indicate those with significant positive correlations.

Wetlands	Total Area	T & E Species	Public Land	Head water Stream	Flood zone	Presence of Hydric Soil	Stream Length BSC Diversity	SGNC Birds	SGNC Herps	Prop. Interior Gap	Patch Shape	Nearest Neighbor	Remoteness to Roads	Road Density	Proximity to Urban Area	Adjacent to Agriculture Area
Total Area	1.00															
T & E Species	0.3	1.00														
Public Land	1.00	0.36	1.00													
Headwater Stream	0.11	0.11	0.11	1.00												
Flood zone	0.67	0.24	0.67	0.06	1.00											
Presence of Hydric Soil	0.52	0.25	0.52	0.09	0.40	1.00										
Stream Length BSC Diversity	0.00	0.01	0.00	0.00	-0.04	0.06	1.00									
SGNC Birds	0.06	0.18	0.06	0.05	0.06	0.04	-0.15	1.00								
SGNC Herps	0.01	-0.02	0.01	0.05	0.00	0.01	-0.01	0.22	1.00							
Proportion Interior Gap	0.78	0.39	0.78	0.11	0.53	0.51	0.01	0.12	0.00	1.00						
Patch Shape	0.44	0.33	0.44	0.08	0.37	0.35	0.04	0.18	0.07	0.49	1.00					
Nearest Neighbor	0.06	0.08	0.06	0.02	0.04	0.02	0.03	0.09	0.01	0.06	0.00	1.00				
Remoteness Roads	0.19	0.10	0.19	0.11	-0.18	0.16	0.29	0.05	0.04	0.21	0.10	0.07	1.00			
Road Density	0.38	0.17	0.38	0.17	0.20	0.29	0.12	0.05	-0.02	0.34	0.28	0.07	0.25	1.00		
Prox. to Urban Area	0.16	0.10	0.16	0.14	-0.10	0.13	0.21	0.14	-0.03	0.14	0.09	0.04	0.57	0.35	1.00	
Adjacent Agric. Area	0.30	0.15	0.30	0.00	0.35	0.23	-0.07	0.20	-0.03	0.30	0.34	0.02	-0.15	0.22	0.05	1.00

Table 8. Pearson Correlation Coefficient analysis for Wetland tracts. The shaded cells indicate those with significant positive correlations.

A total of 15,300 LEI's were analyzed in the Illinois study area (Table 9). This number includes 6916 Forest, 7716 Grassland, and 667 Wetland LEI's. The parameters listed in Tables 6-8 were used to rank each tract, following the methods described above.

Land Cover	Acres	Number of LEI's	Percent (by area)	Number with Rank Low	Number with Rank Medium	Number with Rank High
Forest	4,359,016	6917	69%	1991	3283	1643
Grassland	1,690,464	7716	28%	2611	3129	1976
Wetland	163,749	667	3%	237	329	101
Total	6,213,229	15,300	100%	4839	6741	3720

Table 9. Land Cover categories in ranked LEI's.

Quality Assurance/Quality Control (QA/QC)

The land tracts were derived from the 2012 NASS-CDL data. There are some complications associated with the analysis of landscape scale data obtained through remote sensing. The most apparent issues are of spatial compatibility and data quality. The most critical are the time of the year when the imagery was collected and relative positional accuracy between datasets (the satellite imagery and the other GIS layers used in the analysis). In addition, without field-based observations of native vegetation condition the relative natural quality of tracts is not distinguishable using satellite remote sensing data.

Aerial Photos

10 percent of Forest (692) and Grassland (772) LEI's and all Wetland LEI's (667) were compared to the 2012 NAIP aerial photos to identify discrepancies. The NASS-CDL data is classified into the various land cover types based on the reflectance of sunlight "bouncing" off the vegetation and back to the satellite camera. Since this data is collected in a matrix of 30 meter cells or pixels, only the land cover type that makes up the majority of the cell is identified. The source satellite imagery used to create the NASS-CDL data is also collected during the

growing season of April 1 through September 30 (leaf on). This can result in "missed"
classification of small inholdings of land cover types (less than 30 meters), or missed structures under tree canopies. To assess this issue, the final tracts were checked for accuracy by comparing the land cover types classified in the (30 meter) NASS-CDL data to the (1 meter) 2012 NAIP aerial photography. The NAIP 2012 data was chosen because it was collected the same year as the NASS-CDL satellite imagery and form the growing season (leaf-on).

Seven of the 692 quality assured Forest LEIs totaling 1071 acres, 63 of the 772 quality assured Grassland LEIs totaling 9409 acres and 1 Wetland LEI totaling 64 acres were identified as having classification issues or were deemed "culturally exploited." The term "culturally exploited" in the context of this study, implies a limitation within a given LEI that may prevent restoration efforts. Land cover misclassification, presence of residential area(s), presence of manicured areas (i.e. golf courses), and agricultural activity were the most common examples of cultural exploitation. Some examples of the classification problems are illustrated in Figures 9-13. Tracts that exhibited these types of discrepancies in 50% or more of their total area were determined to be culturally exploited. Tracts that exhibited discrepancies in 50% or less of their total area were determined not to be culturally exploited. While this approach to quality assurance and quality control (QA/QC) may quickly preclude a certain number of tracts from ecological viability, visiting the site will ultimately determine the viability of a particular LEI.

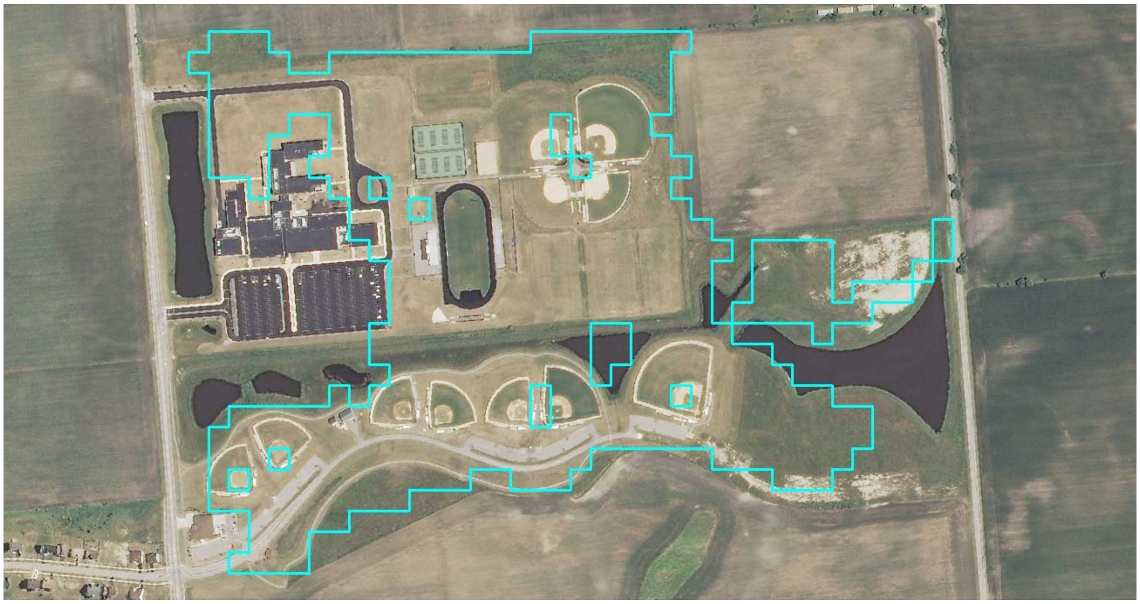

Figure 9. Grassland LEI located within a manicured recreational area.

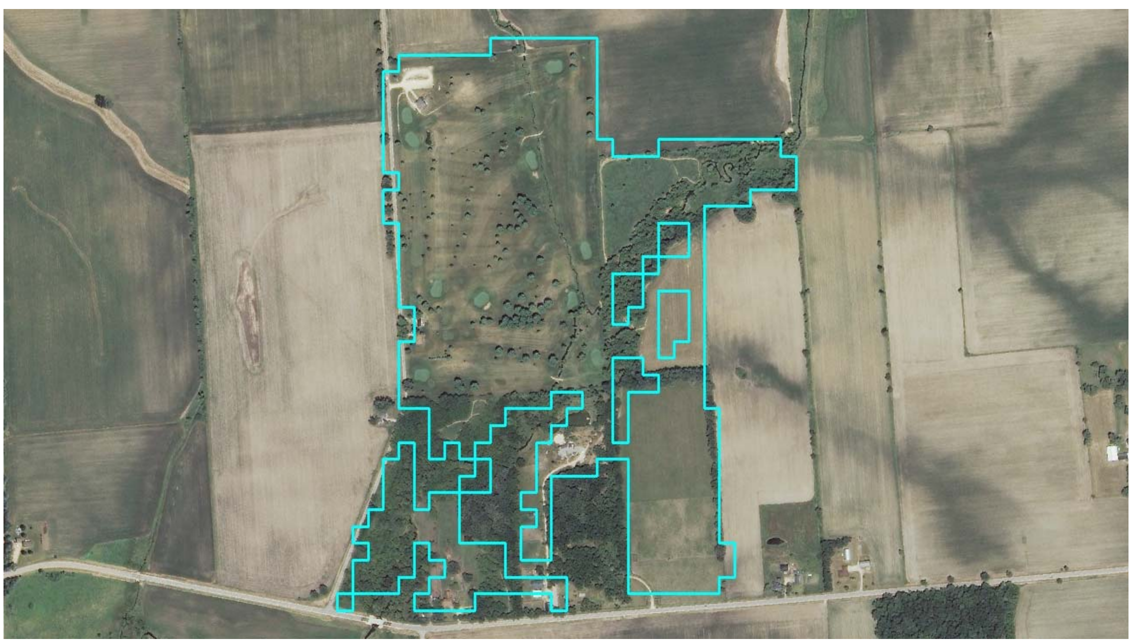

Figure 10. Grassland LEI located within a developing golf course.

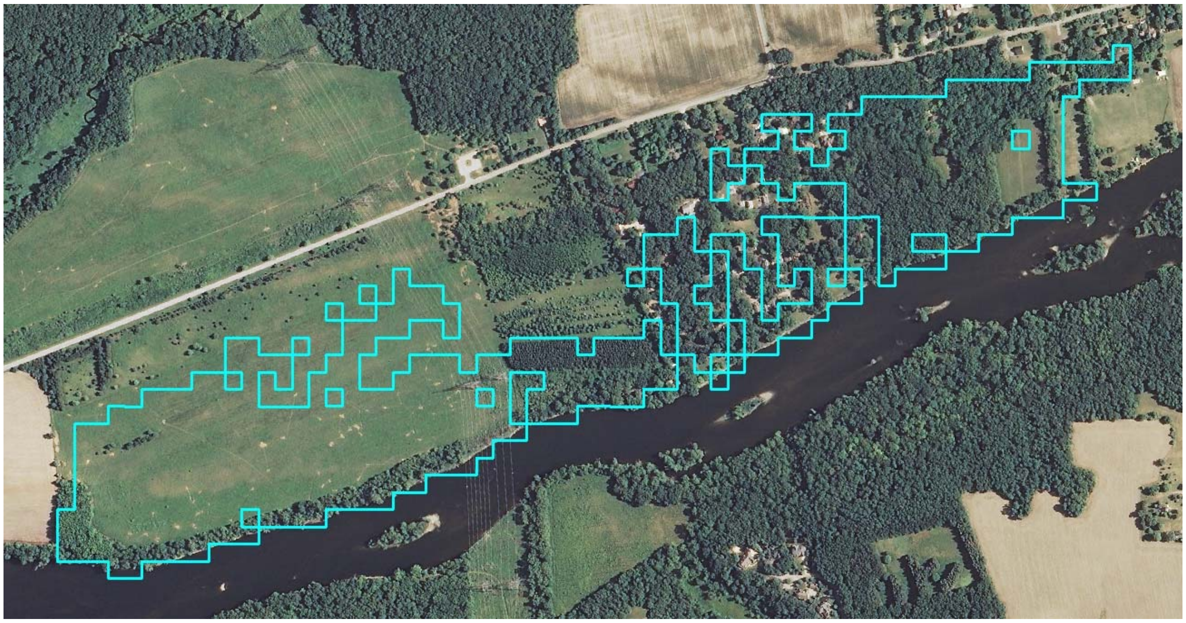

Figure 11. Forest LEI that is partially misclassified and is located within a residential area.

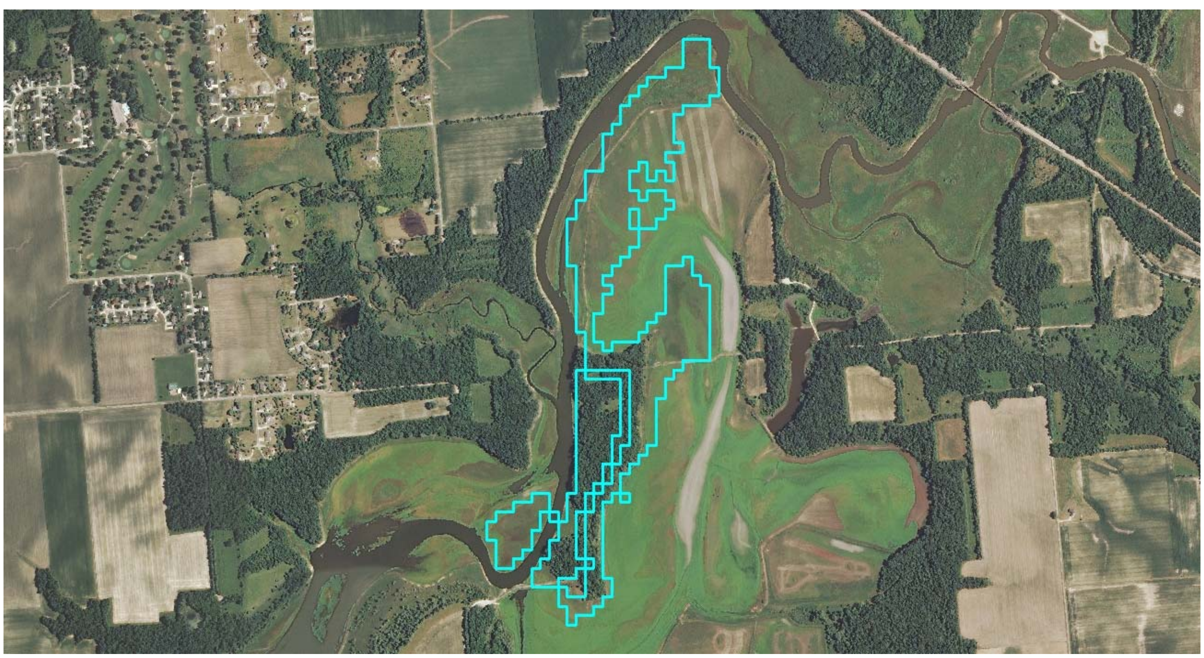

Figure 12. Forest LEI that should be classified as grassland and/or wetland.

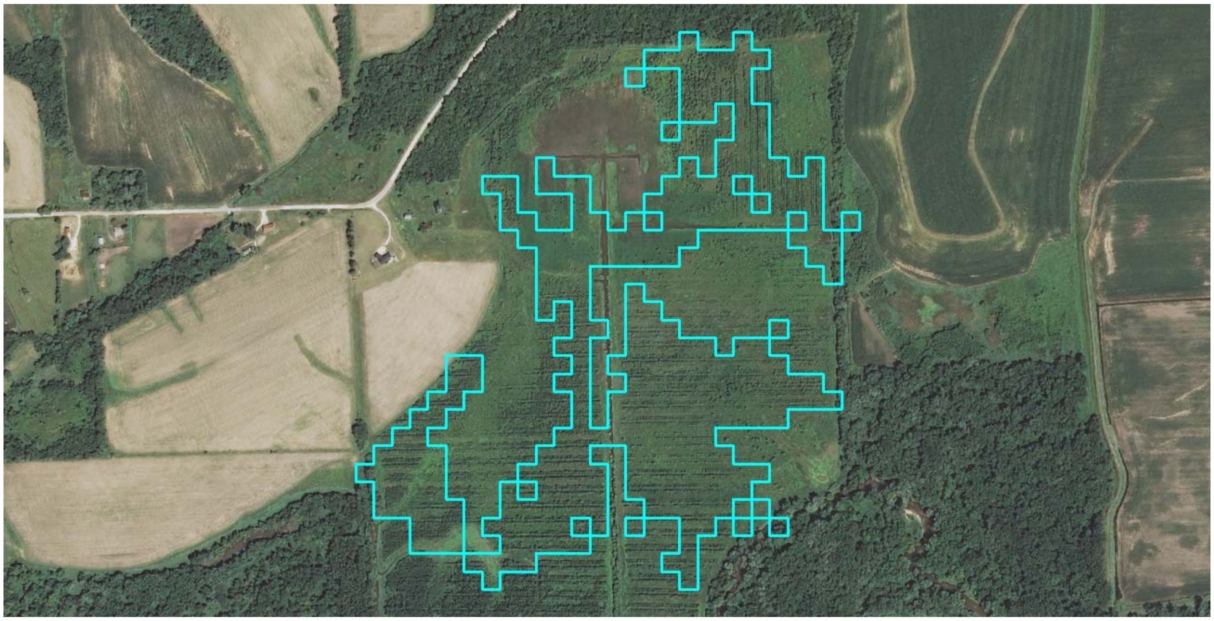

Figure 13. Wetland LEI that is probably misclassified, possibly agriculture (tree farm).

Field Check

In April of 2014, botanist Chris Benda visited 5 sites in Cook County, Illinois (Table 10) to assess the accuracy of the classification. The results show that our classification were very successful overall.

Site Name	NASS classification	LEI classification	Field classification	Comments
Steger and Harlem Ave.	Grassland	High quality grassland	Low to Medium Grassland	Tree farm (evident by row on aerial photo)
Orland Grassland	Grassland	High Quality Grassland	High Quality Grassland	
Bartel Grassland	Grassland	Medium and High Quality Grassland	High and Medium Quality Grassland	Additional forested area cleared.
McGinnis Slough	Wetland and forest	Wetland and Forest	Forest with small ephemeral ponds.	No active management evident.
Plum Creek	Forest	Forest and Grassland	Forest and grassland	Grassland used for hay production.

Table 10. Results of field check on five Cook County sites.

The following is a summary of what was found at each site.

Steger and Harlem Avenue site – The area checked is in the SW ¼ section of section 31. The fields are marked as high quality grassland, but this is a large nursery and so it is incorrectly identified as high potential. (This identification error is due to the way the satellite data is collected and classified. Satellite data is collected in 30 by 30 meter cells or "pixels". The dominant spectral reflectance is what is recorded and classified in each cell. Since the small trees in the nursery are not the dominant feature, the trees are not classified. The grass growing below the trees take up the majority of the 30 by 30 meter cell, so the entire cell is classified as grass.) It should probably be low or perhaps medium since the cultivated trees may offer some bird habitat or because it could be easily converted to wildlife habitat.

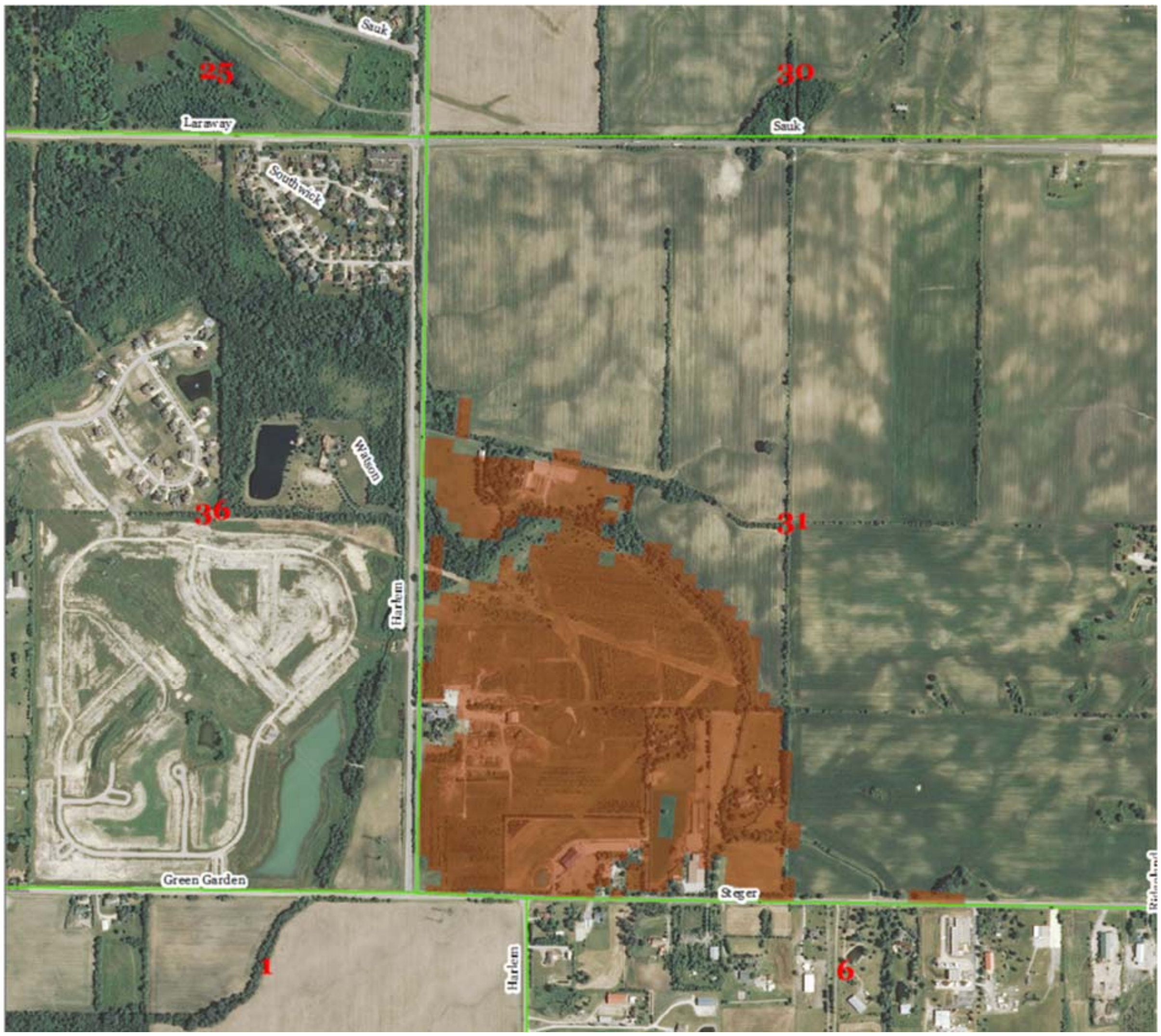

Figure 14. Steger and Harlem Avenue site. Area in brown classified as grassland.

Orland Grassland - This site, located in section 28 and the northern part of section 33, was classified correctly, except there are a bunch of omitted areas in the interior of the high grassland potential. These areas were as good as the surrounding area and should be included. The areas within Section 28 mapped as high potential grassland are mapped correctly but that layer should include a lot more land than it currently does within Orland Grassland. It looked like a bunch of areas formerly classified as reforestation had all of the trees removed (after the NASS data was collected). Also, there were some small areas in the interior that appeared to be scraped (see photo below).

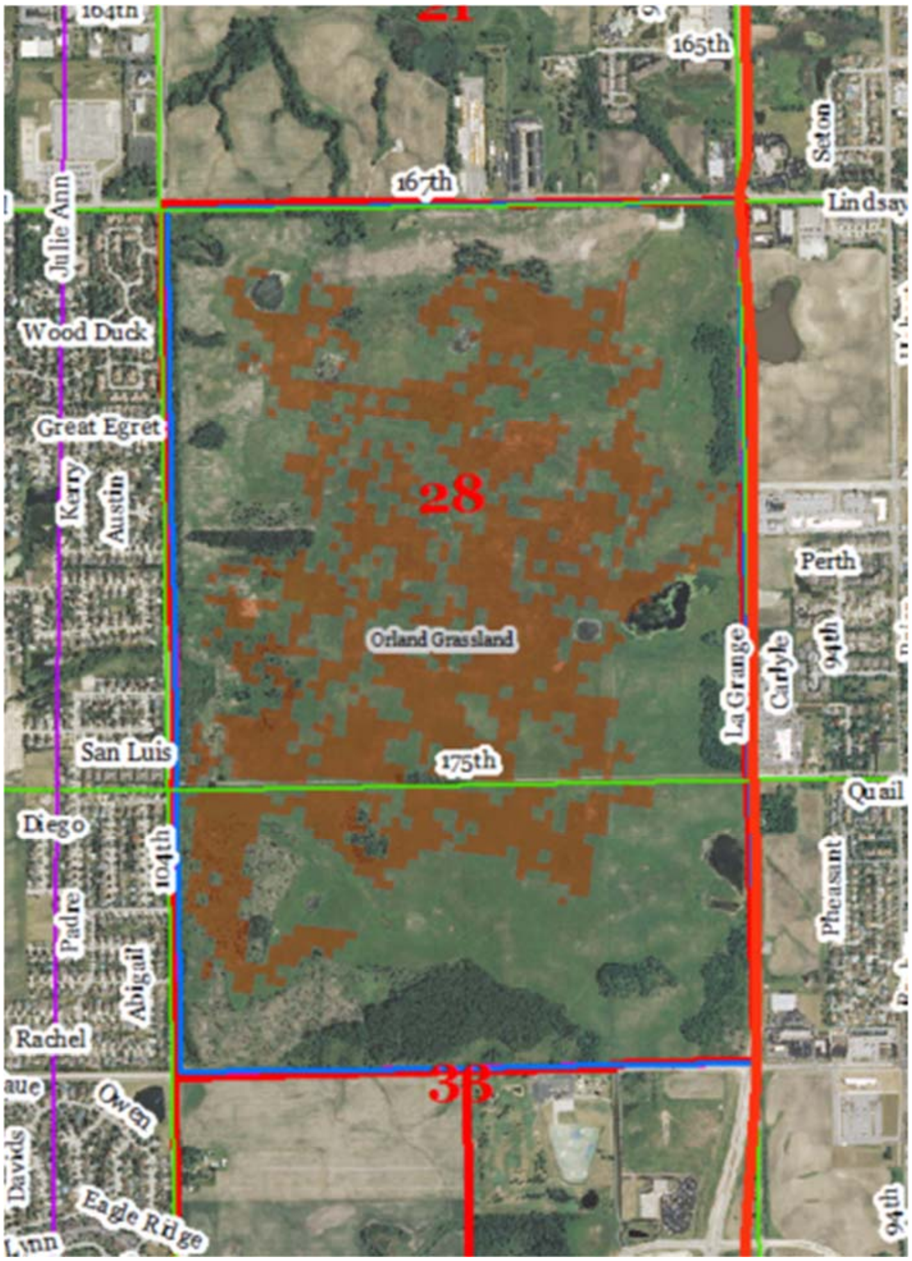

Figure 15. Orland Grassland. Area in brown classified as grassland.

Figure 16. Orland Grassland – scrapped area.

Bartel Grassland - Bartel is mapped correctly, especially the grasslands in Section 8. The forested areas in Section 5 are mapped well as low potential forest, but the medium potential grassland in section 5 should include more land (the tan area should include the interior green areas). Sections 4 & 9 were not surveyed (what is colored in the map is forest). This grassland has active land management, with extensive tree removal. Some of the areas shown as forest in sections 4 & 9 have been cleared of trees and are now grass.

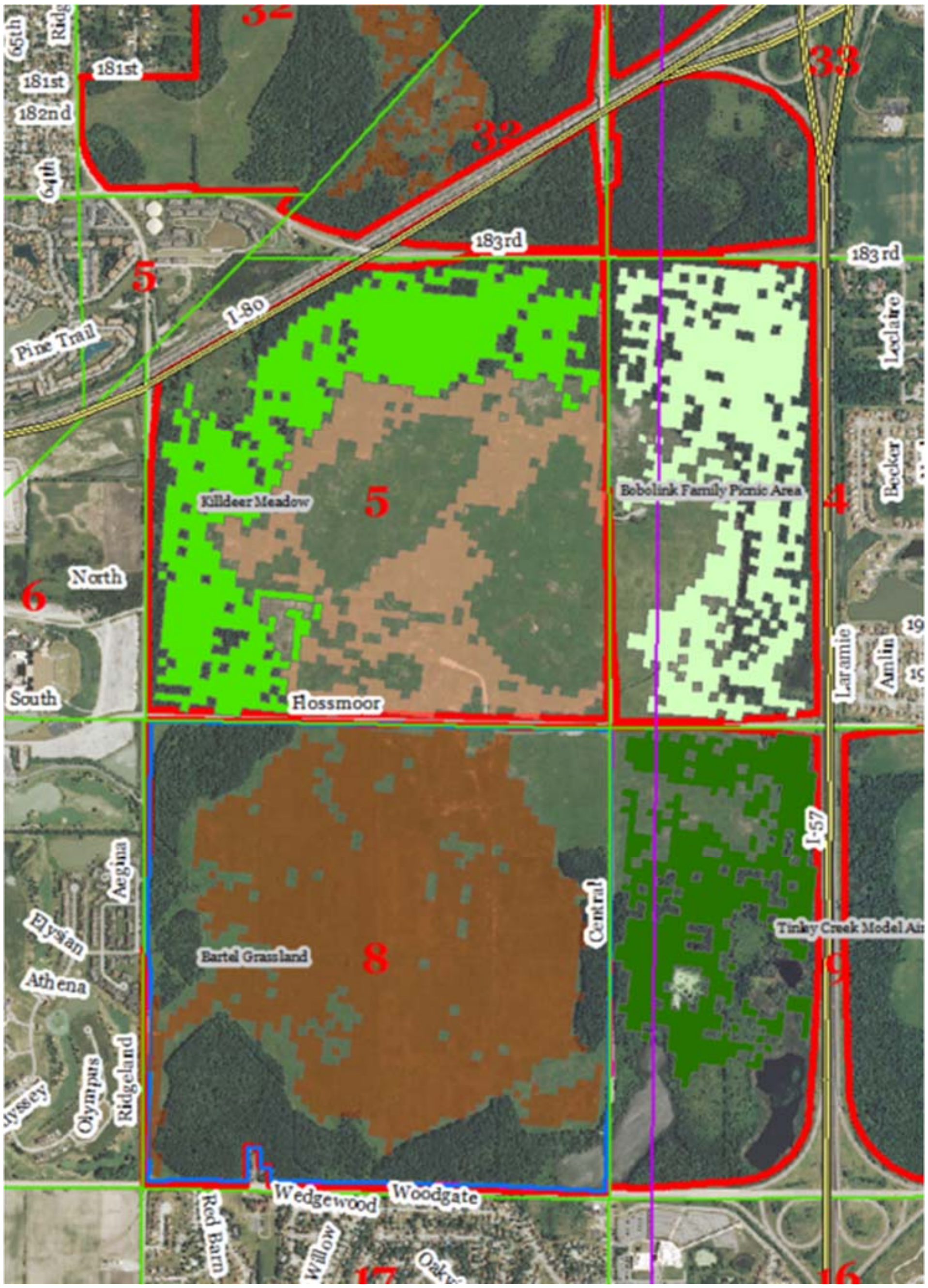

Figure 17. Bartell Grassland. Areas in brown (section 8) and tan (section 5) are grassland, area in green (section 5) is forest.

Figure 18. Bartel Grassland in section 8.

McGinnis Slough - This was the most interesting site we saw during these surveys. The areas marked in blue is listed as wetlands but they are part of the forest, which can be seen on the underlying aerial image. There are some small ephemeral ponds in the forest, one fairly substantial with roosting herons. The forest has invasive species but there were also an encouraging amount of spring ephemerals. The restoration potential of this area is high, but it does not appear to have any active management at this site.

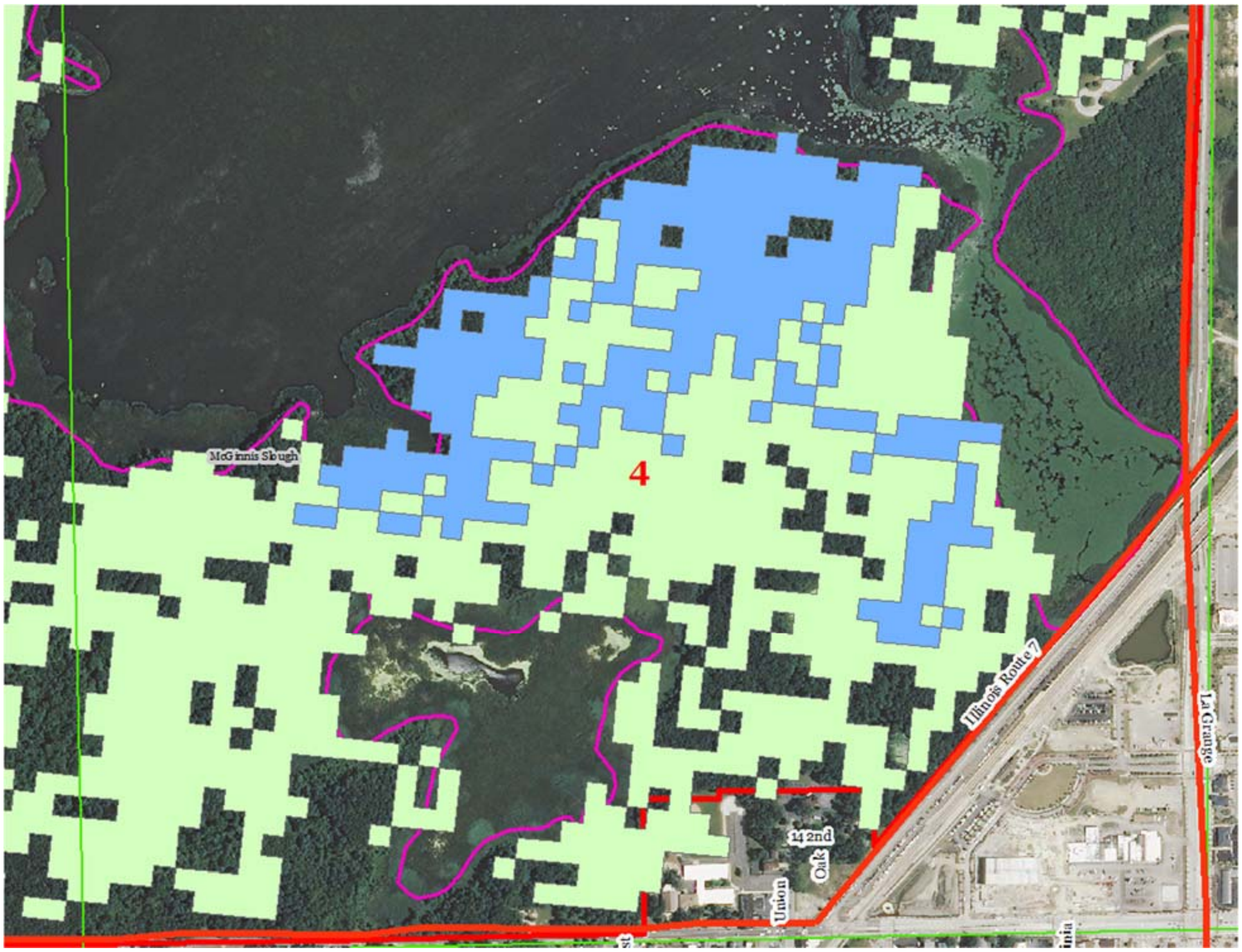

Figure 19. McGinnis Slough. Area in blue is classified as wetland, but should be forest like the light green areas.

Figure 20. McGinnis Slough wetland.

Figure 21. McGinnis Slough forest.

Plum Creek - Only a small part of this forest had a high potential for ecological value. Section 32 had some areas with some nice open grown oaks; however, most of it was low quality. Section 29 was not surveyed. Section 31 contained only a small amount of grassland that was viable. Most of it had been hayed and the hay bales were still there. Hay bales would not show up on satellite imagery as they are not the dominant feature in the 30 by 30 meter cell.

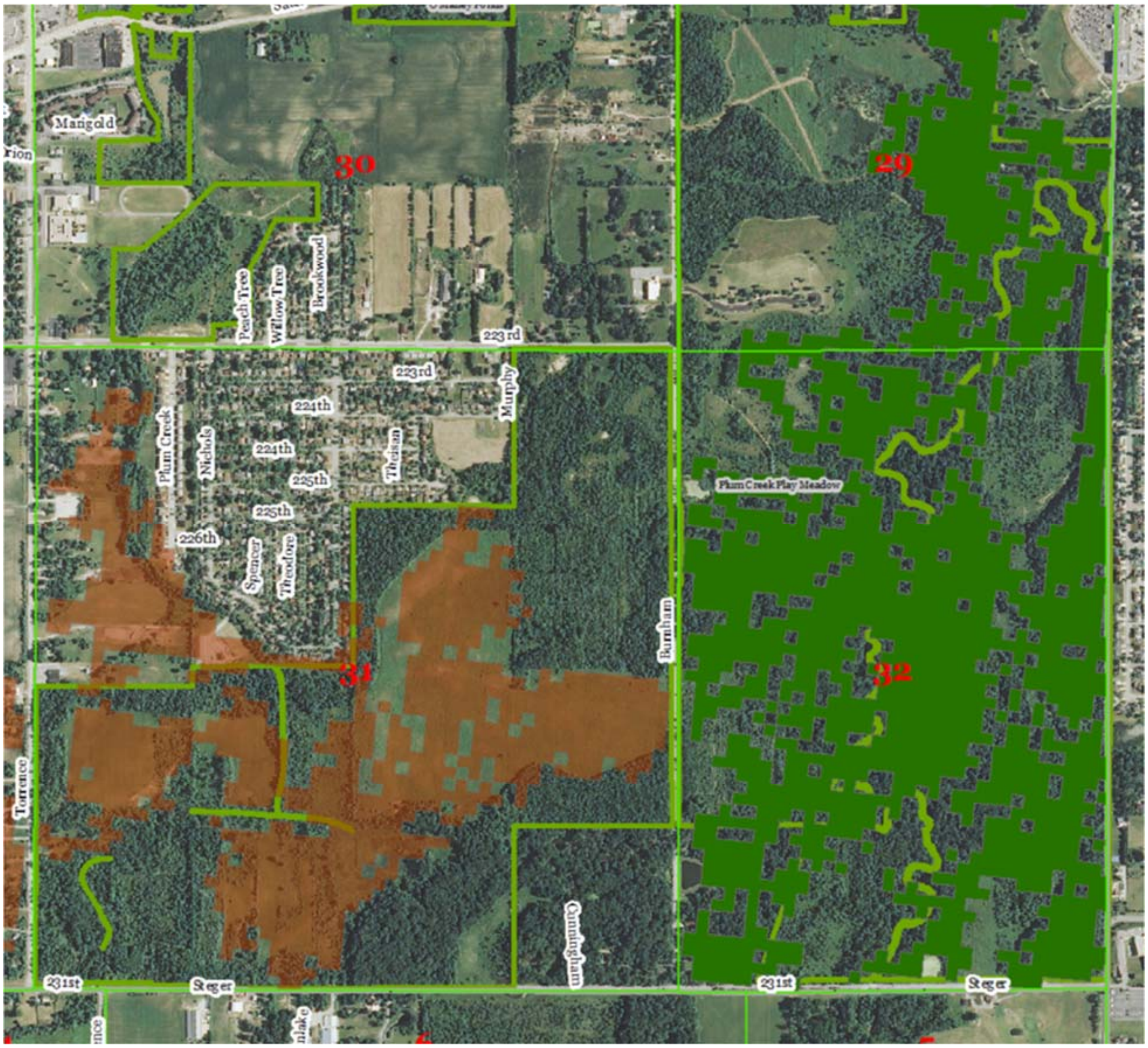

Figure 22. Plum Creek. Area in brown (section 31) classified as grassland. Area in green (section 32) classified as forest.

Figure 23. Plum Creek forest.

Figure 24. Plum Creek grassland. Note evidence of use of field for hay production.

Summary

The goal of this project was to use landscape scale characteristics to identify areas of potential ecological importance using statewide GIS data. The NASS-CDL land cover data is free and released annually, so this process can be repeated yearly, allowing annual assessments of conservation outcomes. There are also many other sources of satellite imagery, some with higher resolution. However, they come with a cost, often very high. We used statewide digital data layers, however, this study can easily be repeated statewide or regionally as higher resolution data layers become available. If better defined or more precise boundaries are needed for LEIs, higher resolution imagery, where available, could be employed to re-map them.

A future step would be to examine the most efficient avenues of connectivity between LEIs, designing buffer areas around the LEIs, and assessing intrinsic flora and fauna potential within them (i.e., conduct natural community grading and assessment of restorability). Another important next step would be to promote the formal recognition of LEIs by the Illinois Nature Preserves Commission as properties that will qualify or at least have high potential for qualifying for designation as Illinois Land and Water Reserves. The statewide identification of LEIs and assessment of their natural quality and restorability, at least for a representative number of them statewide, may be necessary to convince the Nature Preserve Commission that such an acknowledgement is justified.

Finally, designating the elements of Connected Systems and further identifying the alternatives for potential connections between those elements is also an important step in designing a scientifically defensible Green Infrastructure Plan. However, the LEI's were identified solely on their capacity for supporting important components of Illinois' native flora and fauna. The Connected System will not only help protect Illinois' native flora and fauna against region-wide threats like climate change, but it will also provide many ecosystem services, like storm water retention, groundwater recharge, recreational opportunities, clean air and water. While lands identified for inclusion in the Connected System should have the highest priority for delivering ecosystem services, a comprehensive analysis of land protection needs should be conducted relative to each service to assess whether additional lands should be included in a Green

Infrastructure plan beyond those identified as important to achieving the vision for a Connected System of Conservation Lands.

Finally, this project sets the stage for a new generation of conservation work, the era of conservation connectivity. The LEI's will provide the matrix in which the gems that are Illinois' natural areas will thrive.

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Appendix I

List of Species of Greatest Need of Conservation (SGNC) for Forest tracts (37 species)

TNC Element Code	Common Name	Scientific Name
Amphibians		
AAAAA01050	Jefferson Salamander	*Ambystoma jeffersonianum*
AAAAA01060	Blue-spotted Salamander	*Ambystoma laterale*
AAAAA01120	Mole Salamander	*Ambystoma talpoideum*
AAAAAAAAAA	Silvery Salamander	*Ambystoma x platineum*
AAAAD03040	Dusky Salamander	*Desmognathus fuscus*
AAAAD08010	Four-toed Salamander	*Hemidactylium scutatum*
AAABC02030	Bird-voiced Treefrog	*Hyla avivoca*
AAABH01200	Wood Frog	*Rana sylvatica*
Birds		
ABNJB20010	Hooded Merganser	*Lophodytes cucullatus*
ABNKC19030	Red-shouldered Hawk	*Buteo lineatus*
ABNKC19050	Broad-winged Hawk	*Buteo platypterus*
ABNLC11010	Ruffed Grouse	*Bonasa umbellus*
ABNRB02010	Black-billed Cuckoo	*Coccyzus erythropthalmus*
ABNRB02020	Yellow-billed Cuckoo	*Coccyzus americanus*
ABNTA07010	Chuck-Will's-Widow	*Caprimulgus carolinensis*
ABNTA07070	Whip-Poor-Will	*Caprimulgus vociferus*
ABNYF04040	Red-headed Woodpecker	*Melanerpes erythrocephalus*
ABPAE33020	Acadian Flycatcher	*Empidonax virescens*
ABPBA01010	Brown Creeper	*Certhia americana*

TNC Element Code	Common Name	Scientific Name
ABPBG07010	Bewick's Wren	*Thryomanes bewickii*
ABPBJ19010	Wood Thrush	*Hylocichla mustelina*
ABPBX01020	Blue-winged Warbler	*Vermivora pinus*
ABPBX03190	Prairie Warbler	*Dendroica discolor*
ABPBX03240	Cerulean Warbler	*Dendroica cerulea*
ABPBX07010	Prothonotary Warbler	*Protonotaria citrea*
ABPBX08010	Worm-eating Warbler	*Helmitheros vermivorus*
ABPBX09010	Swainson's Warbler	*Limnothlypis swainsonii*
ABPBX10010	Ovenbird	*Seiurus aurocapillus*
ABPBX11010	Kentucky Warbler	*Oporornis formosus*
ABPBX11020	Connecticut Warbler	*Oporornis agilis*
ABPBXB5010	Rusty Blackbird	*Euphagus carolinus*
Mammals*		
AMABA01250	Pygmy Shrew	*Sorex hoyi*
AMACC01030	Southeastern Myotis	*Myotis austroriparius*
AMACC01100	Indiana Bat	*Myotis sodalis*
AMACC08020	Rafinesque's Big-eared Bat	*Corynorhinus rafinesquii*
AMAEB01080	Swamp Rabbit	*Sylvilagus aquaticus*
AMAFB08010	Red Squirrel	*Tamiasciurus hudsonicus*
AMAFF03080	Cotton Mouse	*Peromyscus gossypinus*
AMAFF11150	Woodland Vole	*Microtus pinetorum*
AMAJA04010	Common Gray Fox	*Urocyon cinereoargenteus*
AMAJH03020	Bobcat	*Lynx rufus*

TNC Element Code	Common Name	Scientific Name
Reptiles		
ARAAE01050	Eastern Mud Turtle	*Kinosternon subrubrum*
ARADB14010	Mud Snake	*Farancia abacura*
ARADB22020	Plainbelly Water Snake	*Nerodia erythrogaster*
ARADB35040	Flathead Snake	*Tantilla gracilis*
ARADB36120	Eastern Ribbon Snake	*Thamnophis sauritus*
ARADE02040	Timber Rattlesnake	*Crotalus horridus*

* Mammals were not included in this project

List of Species of Greatest Need of Conservation (SGNC) for Grassland tracts (27 species)

TNC Element Code	Common Name	*Scientific Name*
Amphibians		
AAABC05061	Illinois Chorus Frog	*Pseudacris streckeri illinoensis*
AAABH01010	Crawfish Frog	*Rana areolata*
Birds		
ABNKC11010	Northern Harrier	*Circus cyaneus*
ABNLC13010	Greater Prairie-Chicken	*Tympanuchus cupido*
ABNLC21020	Northern Bobwhite	*Colinus virginianus*
ABNNF06010	Upland Sandpiper	*Bartramia longicauda*
ABNSA01010	Barn Owl	*Tyto alba*
ABNSB13040	Short-eared Owl	*Asio flammeus*
ABNTA02020	Common Nighthawk	*Chordeiles minor*
ABPBG10010	Sedge Wren	*Cistothorus platensis*
ABPBR01030	Loggerhead Shrike	*Lanius ludovicianus*
ABPBW01110	Bell's Vireo	*Vireo bellii*
ABPBX65010	Dickcissel	*Spiza americana*
ABPBX99010	Savannah Sparrow	*Passerculus sandwichensis*
ABPBXA0020	Grasshopper Sparrow	*Ammodramus savannarum*
ABPBXA0030	Henslow's Sparrow	*Ammodramus henslowii*
ABPBXA0040	Le Conte's Sparrow	*Ammodramus leconteii*
ABPBXA0070	Nelson's Sharp-tailed Sparrow	*Ammodramus nelsoni*
ABPBXA6030	Smith's Longspur	*Calcarius pictus*
ABPBXA9010	Bobolink	*Dolichonyx oryzivorus*
Mammals*		
AMAFB05120	Franklin's Ground Squirrel	*Spermophilus franklinii*
AMAJF02020	Least Weasel	*Mustela nivalis*
AMAJF04010	American Badger	*Taxidea taxus*
Reptiles		
ARAAD08020	Western Box Turtle/Ornate Box Turtle	*Terrapene ornata*
ARACB02010	Slender Glass Lizard	*Ophisaurus attenuatus*
ARADB06010	Kirtland's Snake	*Clonophis kirtlandii*
ARADB17010	Western Hognose Snake	*Heterodon nasicus*
ARADB38010	Lined Snake	*Tropidoclonion lineatum*
ARADB47010	Smooth Green Snake	*Opheodrys vernalis*
ARADE03011	Eastern Massasauga	*Sistrurus catenatus catenatus*

* Mammals were not included in this project

List of Species of Greatest Need of Conservation (SGNC) for Wetland tracts (53 species)

TNC Element Code	Common Name	Scientific Name
Amphibians		
AAAAA01050	Jefferson Salamander[#]	*Ambystoma jeffersonianum*
AAAAA01060	Blue-spotted Salamander[#]	*Ambystoma laterale*
AAAAA01120	Mole Salamander[#]	*Ambystoma talpoideum*
AAAAAAAAAA	Silvery Salamander[#]	*Ambystoma x platineum*
AAAAD08010	Four-toed Salamander[#]	*Hemidactylium scutatum*
AAABC02030	Bird-voiced Treefrog[#]	*Hyla avivoca*
AAABC05061	Illinois Chorus Frog[+]	*Pseudacris streckeri illinoensis*
AAABE01010	Eastern Narrowmouth Toad[+]	*Gastrophryne carolinensis*
AAABH01010	Crawfish Frog[+]	*Rana areolata*
AAABH01200	Wood Frog[#]	*Rana sylvatica*
Birds		
ABNCA02010	Pied-billed Grebe[+]	*Podilymbus podiceps*
ABNGA01020	American Bittern[+]	*Botaurus lentiginosus*
ABNGA02010	Least Bittern[+]	*Ixobrychus exilis*
ABNGA11010	Black-crowned Night-Heron[#]	*Nycticorax nycticorax*
ABNGA13010	Yellow-crowned Night-Heron[#]	*Nyctanassa violacea*
ABNKC11010	Northern Harrier[+]	*Circus cyaneus*
ABNKC19030	Red-shouldered Hawk[#]	*Buteo lineatus*
ABNME01010	Yellow Rail[+]	*Coturnicops noveboracensis*
ABNME03040	Black Rail[+]	*Laterallus jamaicensis*
ABNME05020	King Rail[+]	*Rallus elegans*
ABNME13010	Common Moorhen[+]	*Gallinula chloropus*
ABNMK01010	Sandhill Crane[+]	*Grus canadensis*
ABNNB02030	American Golden-Plover[+]	*Pluvialis dominica*
ABNNF01020	Greater Yellowlegs[+]	*Tringa melanoleuca*
ABNNF11190	Stilt Sandpiper[+]	*Calidris himantopus*
ABNNF14010	Buff-breasted Sandpiper[+]	*Tryngites subruficollis*
ABNNF16010	Short-billed Dowitcher[+]	*Limnodromus griseus*
ABNNF18030	Wilson's Snipe[+]	*Gallinago delicata*
ABNNF20010	Wilson's Phalarope[+]	*Phalaropus tricolor*
ABNNM08090	Forster's Tern[+]	*Sterna forsteri*
ABNNM10020	Black Tern[+]	*Chlidonias niger*
ABNUA03010	Chimney Swift[#]	*Chaetura pelagica*
ABPAE33040	Willow Flycatcher[+]	*Empidonax traillii*
ABPBA01010	Brown Creeper[#]	*Certhia americana*
ABPBG10010	Sedge Wren[+]	*Cistothorus platensis*
ABPBG10020	Marsh Wren[+]	*Cistothorus palustris*
ABPBX07010	Prothonotary Warbler[#]	*Protonotaria citrea*

TNC Element Code	Common Name	Scientific Name
ABPBX09010	Swainson's Warbler#	*Limnothlypis swainsonii*
ABPBXA0070	Nelson's Sharp-tailed Sparrow+	*Ammodramus nelsoni*
ABPBXB3010	Yellow-headed Blackbird+	*Xanthocephalus xanthocephalus*
ABPBXB5010	Rusty Blackbird#	*Euphagus carolinus*
Mammals*		
AMAEB01080	Swamp Rabbit	*Sylvilagus aquaticus*
AMAFF01010	Marsh Rice Rat	*Oryzomys palustris*
AMAFF03080	Cotton Mouse	*Peromyscus gossypinus*
AMAFF15010	Muskrat	*Ondatra zibethicus*
Reptiles		
ARAAD02010	Spotted Turtle+	*Clemmys guttata*
ARAAD04010	Blanding's Turtle+	*Emydoidea blandingii*
ARAAD07020	River Cooter#	*Pseudemys concinna*
ARAAE01020	Yellow Mud Turtle+	*Kinosternon flavescens*
ARAAE01050	Eastern Mud Turtle#	*Kinosternon subrubrum*
ARADB06010	Kirtland's Snake+	*Clonophis kirtlandii*
ARADB14010	Mud Snake#	*Farancia abacura*
ARADB22010	Mississippi Green Water Snake#	*Nerodia cyclopion*
ARADB22020	Plainbelly Water Snake#	*Nerodia erythrogaster*
ARADB22030	Southern Water Snake#	*Nerodia fasciata*
ARADB36120	Eastern Ribbon Snake#	*Thamnophis sauritus*
ARADE03011	Eastern Massasauga+#	*Sistrurus catenatus catenatus*

* Mammals were not included in this project.
+ Indicates species found in Herbaceous Wetlands
# Indicates species found in Wooded Wetlands

Appendix II

Preparing the data

Selecting appropriate boundary/extent for study area

1. Selected all HUC-12 watersheds falling within the Upper Illinois River area.
2. Merge selected watershed boundaries into one contiguous polygon.
3. Erase "buffered" roads (which are a combination of US & State Highways 16 m, Interstates 30 m, & County Roads 12 m) from the merged watershed boundary.
    a. **ArcToolbox + Analysis Tools + Overlay + Erase**
        i. "Input Features" select the watershed boundary.
        ii. "Erase Features" select the merged roads polygon.
        iii. "Output Feature Class" select the desired name and path.

Clipping raster and extracting land cover classes

1. Clip the 2012 NASS-CDL land cover using the merged watershed boundary.
    a. Before clipping make sure in the **Spatial Analyst** menu bar that the "Options" are set correctly so the raster pixels match spatially with the original NASS-CDL raster dataset.
        i. **Spatial Analyst** drop-down menu select "Options".
        ii. Next select "General" and make sure the "Analysis mask" is set to the original NASS-CDL raster dataset.
        iii. The defaults may remain for the rest of the **Spatial Analyst** options.
    b. **ArcToolbox + Data Management Tools + Raster + Raster Processing + Clip**
        i. "Input Raster" select the original raster dataset which you will be clipping; in this case 2012 NASS-CDL land cover.
        ii. "Output Extent" select the merged watershed boundary without roads.
        iii. Make sure the "Use Input Features for Clipping Geometry" box is checked.
        iv. "Output Raster Dataset" select the desired name and path.
2. Extract desired land cover types with values 62, 63, 87,141,142,143,171,181,190 and 195.
    a. **ArcToolbox + Spatial Analyst Tools + Extraction + Extract by Attributes**
        i. "Input Raster" select the previously clipped raster.
        ii. "Where Clause" should be a SQL statement for desired land cover classes based on "Value" (see below).
            - Forests Values = 63,141,142,143
            - Grasslands Values = 62,171,181
            - Wetlands Values = 87,190,195
        iii. "Output Raster" select the desired name and path.

3. Join the attribute table of the original NASS-CDL land cover to the clipped raster dataset in order to add the appropriate class names back to the clipped raster.
    b. **ArcToolbox + Data Management Tools + Joins + Join Field**
        i. "Input Dataset" select the raster dataset from step 2.
        ii. "Input Join Field" select value.
        iii. "Join Table" select 2012 NASS-CDL land cover.
        iv. "Output Join Field" select value.
        v. "Join Fields" select class name or any other value you wish (if you do not select anything by default all fields will be added).

Reclassify raster by desired value

1. In the **Spatial Analyst** drop-down select "Reclassify."
    a. Make sure the "Input Raster" is set to the appropriate raster dataset which will be reclassified.
    b. "Reclass field" drop down, select value.
    c. "Set values to reclassify box" push the "unique" button, so all values are reset. Recode the desired values.
        - Forest Value = 1
        - Grassland Values = 2
        - Wetland Combined Values = 3
    d. "Output Raster Path" select desired name and path.

Applying size criteria to reclassified raster data

1. "Clump" or "dissolve" the raster dataset in order to create individual tracts to apply size criteria. After the raster image has been reclassified, a free and downloadable extension called **Patch Analyst for ArcGIS** will be used to "clump" neighboring raster pixels.
    a. First make sure in the **Effects** menu bar that the newly reclassified raster dataset is apparent in the "Layer" field.
    b. From the **Patch Grid** drop down select the "Create Patch Theme from Grid."
        i. A dialog box will appear called "Clumping Field." Select "Value" from the drop-down menu.
        ii. Another dialog box will appear called "Clumping Method," select "8N-Use Diagonals."
        iii. The clumping function will then run (it may or may not be visible when running allow 5-10 minutes to complete). The new raster dataset will then appear in the table of contents.
    c. Once the "clumping" process has completed, open the attribute table and add a new field called "Acreage."

i. Click on the "Options" button located in the right hand corner and select "Add Field."
   1. Field name "Acreage"
   2. "Type" select "Double"
   3. "Precision" = 9
   4. "Scale" = 2

ii. To calculate the acreage of the "Acreage" field
   1. Right-click on "Acreage" and select the "Field Calculator."
   2. When the "Field Calculator" appears you will need to select the "Load" button and load the appropriate conversion number (based on the units of the data (for meters to acres, multiply meters by 0.0002471044).
   3. Double-click the "Acres" formula and select the "ok" button in the lower right hand corner. The acreages should now appear.

2. Once the acreage has been populated, the desired size categories must be extracted (Grasslands = 80 acres, Forests = 100 acres and Wetlands = 50 acres).
   a. **ArcToolbox + Spatial Analyst Tools + Extraction + Extract by Attributes**
      i. "Input Raster" select the clumped raster dataset.
      ii. "Where Clause" the SQL statement should state "Acreage >= xx acres" (this will correspond to the desired size categories listed above).
      iii. "Output Raster" select the desired name and path.
3. After the appropriate size categories have been extracted, the newly created raster dataset will need to have its attribute table built.
   a. **ArcToolbox + Data Management Tools + Raster + Raster Properties + Build Raster Attribute Table**.
      i. In the "Input Raster" field selected the raster dataset created in step 2.
4. Since the attribute table was built important tabular data may not appear, therefore, a join will be performed.
   a. **ArcToolbox + Data Management + Joins + Join Field**
      i. "Input Dataset" find the newly created raster dataset resulting from step 3.
      ii. "Join Table" select the raster dataset from step 2.
      iii. "Input Join Field" and "Output Join Field" drop-down menus, select the common fields which to join.
      Note: In most instances value will be the common field; however, it is a good idea to spatially compare the two datasets prior to joining to verify.
      iv. "Join Fields (optional)" box select the desired attributes to be joined.
5. Each tract will be assigned a unique "Tract ID."
   a. To do this open the attribute table and in the lower left hand corner click the "Options" tab and select "Add Field."
      i. For the name type "Tract ID" and leave the "Type" as "Short Integer."

b. Next, right-click on the “Tract ID” and select the “Field Calculator.”
    i. Double-click “Rowid” in the “Fields” box and then click the “+” sign and type the number 1, click ok.
    ii. The “Tract ID” field should now be calculated.

Converting raster to polygon

1. Convert the appropriate raster dataset to a polygon (shapefile) in order to run several of the spatial tests.
    a. **ArcToolbox** + **Conversion Tools + From Raster + Raster to Polygon**
        i. “Input Raster” select the desired raster dataset. For example, if you desire to convert the Grassland tracts, you would select the raster dataset that contains Grassland tracts.
        ii. “Field” select which fields you wish to use to construct the polygon(s), in most cases this will be the value field.
        iii. Select the desired name and path.
2. Dissolve polygons to get an equal number of tracts compared to the raster tracts. This can be done either in the **Patch Analyst for ArcGIS** extension by using the “Dissolve Polygon” function or in **ArcToolbox**.
    a. **ArcToolbox + Coverage Tools + Data Management + Generalization + Dissolve**
        i. “Input Features” select the shapefile created in step 1.
        ii. “Dissolve_Field(s)_(optional)” check the box next to “Gridcode” and make sure the box next to “Create multipart features (optional)” is checked.
        iii. “Output Feature Class” select the desire name and path.
3. Add two new fields to the attribute table. This can be done by opening the attribute table and select the “Options” tab.
    a. Select “Add Field” and create one new field called “Acreage” (type = double, precision = 9 and scale = 2).
        i. To calculate the acreage of the “Acreage” field right-click on “Acreage” and select “Calculate Geometry” (make sure the units are set to acres).
    b. Add another field called “Tract ID.”
        i. To calculate the “Tract ID” field right-click on “Tract ID” and select “Field Calculator.”
        ii. When the “Field Calculator” appears double-click on “FID.” Next click on the “+” and type in 1, select “ok.”
        iii. The “Tract ID’s” have now been assigned. Compare the polygon tracts spatially to the raster tracts to make sure the “Tract ID’s” and acreages correlate.

Identity Command (for vector data only)

- In order to determine the best available lands suitable for restoration, several geospatial tests will be performed. The following tests will utilize the **Identity** tool in **ArcToolbox** for all 3 landcover categories (Grasslands, Forests and Wetlands).

  Ecological Parameters
    - Area of Threatened and Endangered Species
    - Area of Public Lands
    - Area of Nature Preserves
    - Area of Railroad Prairie Remnant
      - Used for Grasslands only
    - Area/Presence of (forest, prairie or hydric) soils
      - Grasslands = Prairie Soils
      - Forests = Forest Soils
      - Wetlands = Hydric Soils
    - Area of Interior Forest
    - Area of Flood Zones
      - Used for Wetlands only

  Threats
    - Proximity to Urban Area
      - *Prior additional step(s) necessary (see next section below)*
    - Adjacent to Agriculture
      - Used for Wetlands only.
      - *Prior additional step(s) necessary (see next section below).*

1. Since all of the layers above are statewide, they will first need to be "clipped" to the boundary of the NEIL study area. In order to perform this action repeat step 1 in the "Clipping raster and extracting land cover classes" section.
2. After the desired dataset(s) have been clipped, obtain the appropriate land cover type (Grasslands, Forests or Wetlands) polygon dataset that was created in the "Converting raster to polygon" section.
   a. **ArcToolbox + Analysis Tools + Overlay +Identity.**
      i. "Input Features" select the appropriate polygon (Grasslands, Forests or Wetlands) created in the "Converting raster to polygon" section.
      ii. "Identity Features" select one of the datasets from above.
      iii. "Output Feature Class" select the desired name and path.
3. Once the **Identity** command has finished, open the attribute table of the newly created polygon. Several new fields will appear find the field named "FID_polygo."
   a. Right-click the field named "FID_polygo" and "Sort Ascending."

b. In ArcMap select the "Editor" box, then "Start Editing."
c. In the attribute table of the newly created polygon dataset, highlight all the records were "-1" appears in the field name "FID_polygo."
d. After the records have been selected, right-click in the far left side of the attribute table and select "Delete Selected."
e. The records should now be deleted from the table.
f. Save edits and in the "Editor" box, then select "Stop Editing."

4. Due to the fact that the **Identity** command only selects the portion(s) of a specific polygon that is within a tract, there may be multiple records for any one tract. Therefore, the **Dissolve** command will be performed on the newly created polygon dataset.
   a. **ArcToolbox + Coverage Tools + Data Management + Generalization + Dissolve**
      i. "Input Features" select the newly created polygon dataset.
      ii. "Dissolve_Field(s)_(optional)" box, check the box next to "Tract ID."
      iii. Check the box next to "Create multipart features (optional)."
      iv. "Output Feature Class" select the desired name and path.
5. After the **Dissolve** command has been performed, open the attribute table. Five fields should appear (FID, Shape, Tract ID, Area and Perimeter). Three new fields will be created. To do this select the "Options" box in the right-hand corner and select "Add Field."
   a. The first field name should be called "xxx_acre" (xxx = the polygon which was intended to be identified i.e. Area Floodzone, Area Nature Preserve etc.).
   b. "Precision" = 9 and "Scale" = 2.
   c. Finally, right-click the field name "xxx_acre" and select "Calculate Geometry," make sure the units are set to acres.
6. Next the fields will be created: "Nat Brk ID" (this stands for Natural Break ID) and "Weight."
   a. Both of these fields will have the default "Type" of "Short Integer."
   b. Right-click the polygon dataset in the "Table Contents" of ArcMap and select "Properties."
   c. From the "Symbology" tab, select "Quantities" from the box on the left side.
   d. From the "Value" drop-down select "Acreage."
   e. From the "Classes" in the "Classification" box, select "3" (3 represents the computed natural break for acreages).
   f. Three unique "Acreage" ranges should appear.
   g. In the attribute table highlight all records that fall in the first range of "Acreage" values.
   h. Right-click the field "Nat Brk ID"
      i. Select the "Field Calculator" enter "1" and select "ok."

        ii. Repeat until each "Tract" has an associated "Nat Brk ID."
    i. Right-click the field name "Weight"
        i. Select the "Field Calculator."
        ii. Make sure that under "Weight =" is blank and then double-click "Nat Brk ID" from the "Fields" box.
        iii. Select "*" and enter the appropriate weight that has been previously determined (i.e. Area Wetlands = 3).

Proximity to Urban Area and Adjacent to Agriculture

- As noted above, in order to create the desired item(s) for these two polygon datasets an additional step must take place prior to step 1 of the "Identity command" section. Due to the sensitivity of natural areas to Urban and Agricultural landscapes a buffer will be created to allow these areas adequate distance to mitigate negative effects. The process of creating a buffer is stated below.

    1. **ArcToolbox + Analysis Tools + Proximity + Buffer**
        a. "Input Features" select the applicable polygon dataset that contains the tracts for a desired land cover.
        b. In the "Distance" field labeled "Linear Unit" type the desired buffering distance and from the drop-down menu select the appropriate units (see below for applicable distances and units for each land cover category). Leave the remaining fields set to the default.
            i. Wetlands: 275 ft., 550 ft., 1100 ft.
            ii. All other categories: 162 ft., 325 ft., 650 ft.
        c. "Output Feature Class" select the desired name and path.
    2. Repeat step 1 for each stated distance.
    3. Begin step 1 of the "Identity Command" section and repeat three times for each land cover category using the stated buffering distances that resulted from steps 1 and 2.

Intersect command

- Similar to the **Identity** command, the **Intersect** command will be run on more than one polygon datasets.

    Ecological Parameters
    - Length of BSC Streams
    - Number of Stream Sources and Junctions (headwater streams)
        - Used for Wetlands only
        - *Additional step(s) necessary (see next section below)*
    - SGNC species – bird and herps (reptiles and amphibians)

Threats

- Remoteness from Roads
- Road Density

1. Since all of the layers above are statewide, they will be "clipped" to the boundary of the NEIL study area. To perform this action repeat step 1 in the "Clipping raster and extracting land cover classes" section.
2. After the desired datasets have been clipped, obtain the appropriate land cover type (Grasslands, Forests or Wetlands) polygon datasets that was created in the "Converting raster to polygon" section.
    a. **ArcToolbox + Analysis Tools + Overlay +Intersect.**
        i. "Input Features" select the appropriate polygon dataset (Grasslands, Forests or Wetlands) created in the "Converting raster to polygon" section.
        ii. Select the dataset, listed above, to be intersected (both should appear in the lined box).
        iii. "Output Features" select the desired name and path.
3. Similar to running the **Identity** command there may be multiple records for a unique "Tract ID." In order to get only one record for an applicable tract, the **Dissolve** command will be performed. See step 4 in the "Identity command" section.
   Note: Since the **Intersect** command is performed on line data, an error box will be displayed, the error box can be disregarded. The reason for this error is that the **Dissolve** command computes area and perimeter when dissolving and since line data does not produce either, the error box is displayed.
4. Once the new item has been created, open the attribute table. The instructions thereafter will be similar to those outlined in steps 5 and 6 of the "Identity command section." However, instead of creating a field named "xxx_acre," a field named "xxx_length" will be created. Furthermore, units of meters will be calculated instead of units of acres. The remaining steps are the same.

Number of Stream Sources and Junctions (headwater streams)

- As noted above, to get the desired item(s) for this line dataset an additional step must take place after step 3 of the "Intersect command section."

    1. After completing step 3 of the "Intersect command section," display the newly created line dataset in ArcMap. Also display the original Headwater Streams dataset. Note: Make sure each dataset is colored uniquely.
    2. Open the attribute table and select a record, right-click in the far right side of the attribute table and select "Zoom to Selected."

3. Now “Zoom-Out” far enough so that it can be depicted if the intersected portion of the stream is a headwater stream. Repeat until all records have been verified.
4. Repeat steps 5 and 6 in “Identity command” section.
    a. However, instead of creating field named “xxx_length” create a field named “num_strm.”
    b. Additionally, instead of calculating geometry, the number of headwater streams will be calculated by right-clicking on said field name and selecting “Field Calculator.”
    c. In the “num_strm” box type in the number of headwater streams for each tract and select “ok.”
    d. Once this has been completed repeat step 4 in the “Identity command” section, if necessary.

SGNC bird & herps

1. Hyperdistribution GRID’s from the Illinois Gap Analysis Project will be used for this analysis. As part of the Illinois Wildlife Action Plan, hyperdistribution GRID’s were created that include each of the SGNC species grouped by habitat type (ie. forest, grassland, herbaceous wetland, wooded wetland, etc).
2. Open ArcCatalog and find the raster dataset for SGNC species group (i.e forest_hyp30). Right-click on said file and select “copy,” then “paste” then place the dataset into a desired location.
3. Next, select either the copied or original file and preview its table by selecting the “Preview” tab in ArcCatalog and “Table” from the “Preview” drop-down menu located at the bottom of the screen. Each species is represented by its TNC Element Code (see Appendix I for complete species list). Amphibian species are represented by alphanumeric strings that begin with “AA”, bird species begin with “AB”, mammals begin with “AM”, and reptiles begin with “AR” . Therefore, in order to obtain only bird and herp species, the alphanumeric field(s) or string(s) that begin with “AM” must be deleted from the table. In order to delete the desired string(s), right-click on the appropriate string and select “Delete Field.” A message box will appear asking to “Confirm Delete Field,” select “yes.” Repeat until there are only bird and herp species in the table.
4. Repeat steps 1 and 2 for each land cover category.
5. Once each land cover category has a SGNC raster dataset for birds and herps only open ArcMap and in the **Patch Grid** extension select “Intersect (Combine) Grids.”
    i. When the dialog box appears, select the raster dataset which contains all the tracts of the applicable land cover category (Grassland, Forest, or Wetlands) and also the applicable SGNC bird or herps raster dataset.

   ii. A new window will appear asking were you would like to save, select the desired name and path. The tool will now begin running and usually takes about five minutes to complete.
   Note: For the Wetlands category, the bird or herp raster dataset(s) for Emergent and Forested Wetlands will first have to be intersected using "Intersect Combine Grids" prior to combining it with Wetlands tracts dataset.
   iii. Remove any duplicate species that may occur in more than one habitat group (i.e ARADE03011, Eastern Massassaga, *Sistrurus catenatus catenatus* occurs in grasslands, herbaceous wetlands, and wooded wetlands

6. Now that tracts and SGNC species file have been intersected, close ArcMap and open ArcCatalog (make sure you know the location of the raster dataset(s) created in step 4 before closing ArcMap).
7. Since the newly created raster dataset(s) resulting from step 4 have "lost" most of the important tabular data due to running the "Intersect (Combine) Grids" command, two joins will need to be performed in order to bring back the "lost" tabular data. One to join the "Tract ID's" and the other to join the bird or herp species. Prior joining, examine both the newly created raster dataset and the original raster dataset used in step 4, to find a common field to join.
   a. **ArcToolbox + Data Management + Joins + Join Field**
      i. "Input Dataset" find the raster dataset resulting from step 4.
      ii. "Join Table" select the raster dataset which contains the tracts for the appropriate land cover category.
      iii. "Input Join Field" and "Output Join Field" drop-down menus, select the common fields which to join.
      iv. "Join Fields (optional)" box select the desired attributes to be joined.
8. After joining the necessary tabular data, open ArcMap and add the newly created raster dataset with the joined tabular data.
   a. Open the attribute table and right-click on the "Tract ID" field and select "Summarize," a Summarize window will appear. Make sure field 1 is set to the "Tract ID" and in field 2 expand only the species alphanumeric strings and check the box next to "Maximum" for each species string.
   b. For field 3 select the desired name and path.
9. Once the species summarize table has been created, it will be joined to the newly created raster dataset. This can be down in the same process described in step 6, however joining the tables based on "Tract ID."
10. In ArcMap open the attribute table and add three new fields (Richness, Nat Brk ID, and Weight) following the process stated in previous section(s). However, for the "Richness" field, the Maximum for each species will be added together.

a. Right-click on the field name “Richness” and select the “Field Calculator.”
b. In the fields box double-click on a “Maximum” species name and the select the “+.”
c. Repeat until all “Maximum” species have been added together and select “ok.”
d. “Nat Brk ID” and “Weight” fields follow the process stated in previous sections.

Proportion of interior gap area in tract

- This test will be performed all land cover categories.

1. This test will be done in a polygon coverage.
   a. Create a personal geodatabase and import the desired tracts that are currently polygons.
   Note: In order to identify the “interior gaps” the shapefile must first be converted into a feature class, then to a coverage.
   b. **ArcToolbox** + **Conversion Tools + To Coverage + Feature Class to Coverage**
      i. “Input Feature Classes” select the feature class that was converted in the previous step
         - Do not check the “Double Precision” box.
      ii. “Output Coverage” select the desired name and path.
2. Next the **Union** command will be performed. This step will “bring back in” the “Tract ID’s.”
   a. **ArcToolbox + Analysis Tools + Overlay + Union**
      i. “Input Features” select the polygons that were imported into the geodatabase.
      ii. Select the coverage dataset that was converted from the feature class file.
         - Make sure the box next to “Gaps Allowed” is not checked.
      iii. Select the desired name and path.
3. Once the **Union** command has been performed, the **Erase** command will be performed. This step will extract the “interior gaps” of each land cover tracts.
   a. **ArcToolbox + Analysis Tools + Overlay + Erase.**
      i. “Input Features” select the coverage from the previous step.
      ii. “Erase Features” select the polygon dataset which contains the tracts.
      iii. “Output Feature Class” select the desired name and path.
      Note: After the **Erase** command has been executed, double check the attribute table for any “gaps” that are smaller than .77 acres (this is the acreage of one pixel). Gaps should not be smaller than .77 acres.
4. Next a **Spatial Join** will be performed to associate “interior gaps” with the appropriate tract(s).
   a. **ArcToolbox + Analysis Tools + Overlay + Spatial Join.**
      i. “Target Features” select the coverage from the previous step.
      ii. “Join Features” select the polygons which contained the original tracts.

iii. "Join Operation" select "Join_One_To_Many" and check the box next to the "Keep All Target Features."
iv. "Match Option" dialog select "Closest."
v. "Output Feature Class" select the desired name and path.

5. **Dissolve** the polygons based on "Tract ID."
   a. **ArcToolbox + Coverage Tools + Generalization + Dissolve**
      i. "Input Coverage" select the coverage created from the previous step.
      ii. "Dissolve Item" select "Tract ID."
      iii. "Output Coverage" select the desired name and path.
6. Repeat steps 5 and 6 in the "Identity command" section.

Remoteness from roads

1. Using a specified road dataset, repeat steps 1 - 2 in the "Proximity to urban area and adjacent to agriculture" section except the applicable land cover polygon(s) should only be buffered once at a distance of 1 mile or 1,609 meters.
2. Repeat 2 – 4 in the "Intersect command" section.

Patch shape

1. Download and install V-LATE 1.1 for ArcGIS 9 software from http://www.geo.sbg.ac.at/larg/
2. Use V-LATE to calculate Form Analysis
   a. Add item to attribute table – ID
   b. Calculate new item to equal FID + 1 (to remove zeroes)
   c. Run Form Analysis, using new ID item as class field. Select all items. This way, all polygons will have Shape_Idx calculated and added to the attribute table.

Nearness to area with same land cover type (nearest neighbor)

1. Use V-Late to calculate nearest neighbor
   d. Add item to attribute table – flag
   e. Calculate new item – flag to equal 1
   f. Run Nearest Neighbor analysis, using flag as the class field. This way distances to all polygons will be calculated and the distance to the nearest one will be added to the attribute table. Export the results in the "Class_Edge_Analysis.txt" output file.

Creating Landscapes of Ecological Importance (LEIs)

Combine sized constrained Forests, Grasslands and Wetlands tracts

1. Repeat the "Reclassify raster by desired value" section for each land cover.
   Note: You will be reclassifying the completed and ranked land cover tracts for each land cover category. It may be beneficial to assign each land cover category a different number. "NoData" should be equal to 0.
2. From **Patch Grid** drop down select "Intersect (Combine) Grids."
   i. A dialog box will appear asking to "Pick first grid," select a land cover created from step 1.
   ii. A second dialog box will appear asking to "Pick second grid," select a second land cover category created from step 1.
   iii. Select the desired name and path.
   iv. Repeat, using the newly created raster dataset and the remaining land cover category.

Extract non-sized constrained land cover

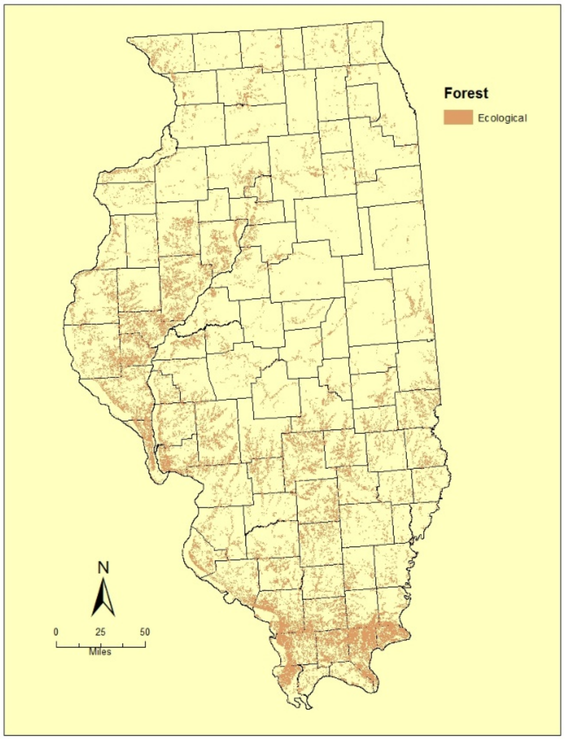
1. From the original raster dataset(s) that were created for each land cover category, extract land cover that did not meet the original size criteria (i.e. Forest tracts < 100 acres, Grassland tracts < 80 acres and Wetland tracts < 50 acres).
2. Refer to step 2 in the "Applying size criteria to reclassified raster data" section.

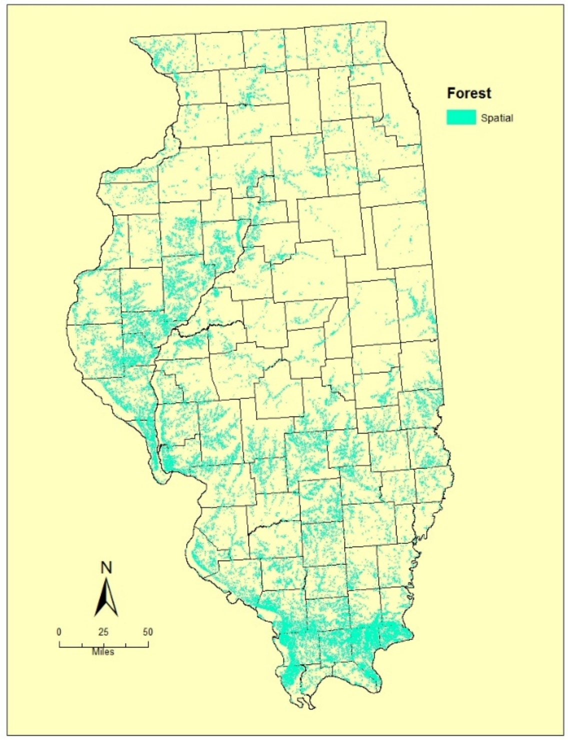
Combine sized constrained and non-sized constrained land cover

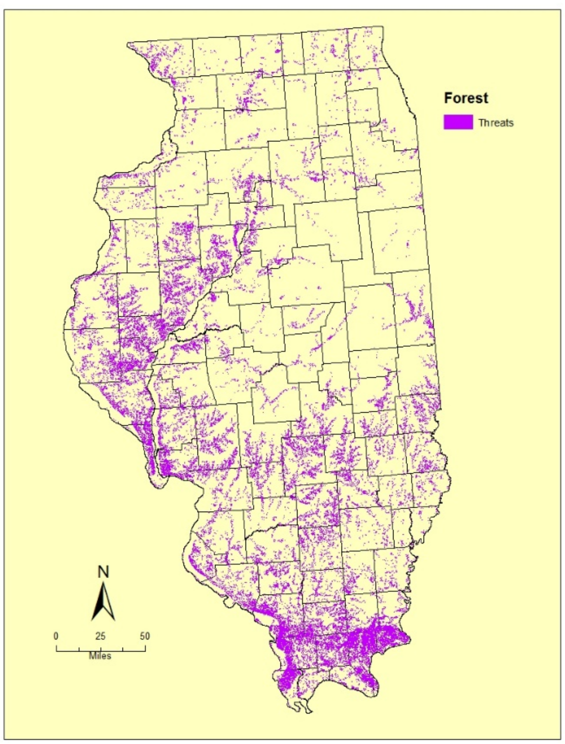
1. Repeat the "Combine size constrained Forests, Grasslands and Wetlands tracts" section above.
   Note: This step will be repeated three times. Initially select the raster created in the final step of the "Combine size constrained Forests, Grasslands and Wetlands tracts" section and one land cover category from the non-sized constrained land cover (i.e. Forests < 100 acres, Grasslands < 80 acres and Wetlands < 50 acres).
2. Repeat step 1 – 4 in the "Applying size criteria to reclassified raster data" section.

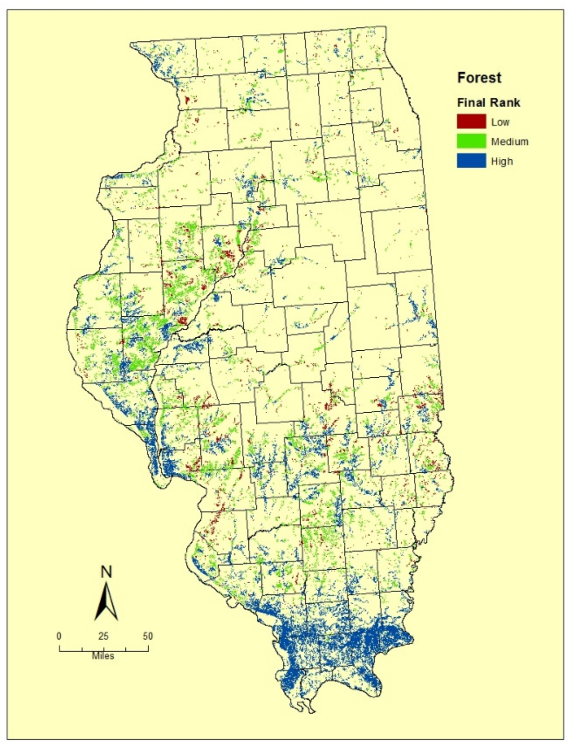
Appendix III

Maps of Forest Ecological, Spatial, Threat results and Final Ranks.

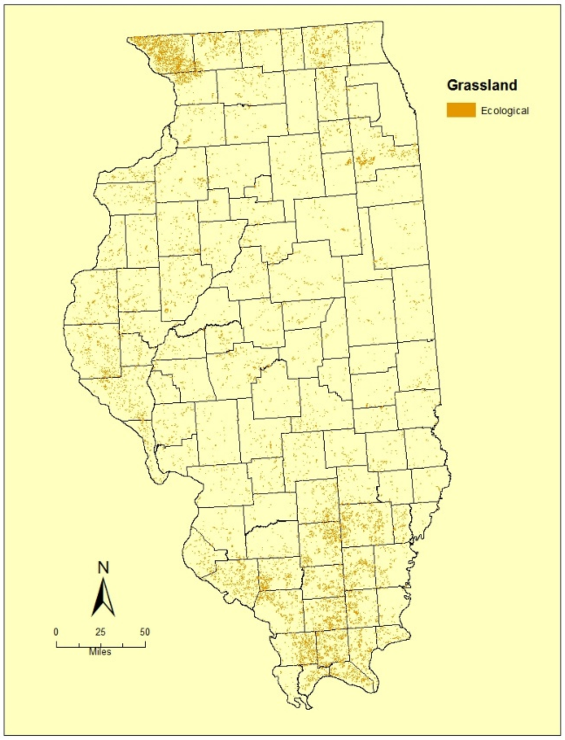


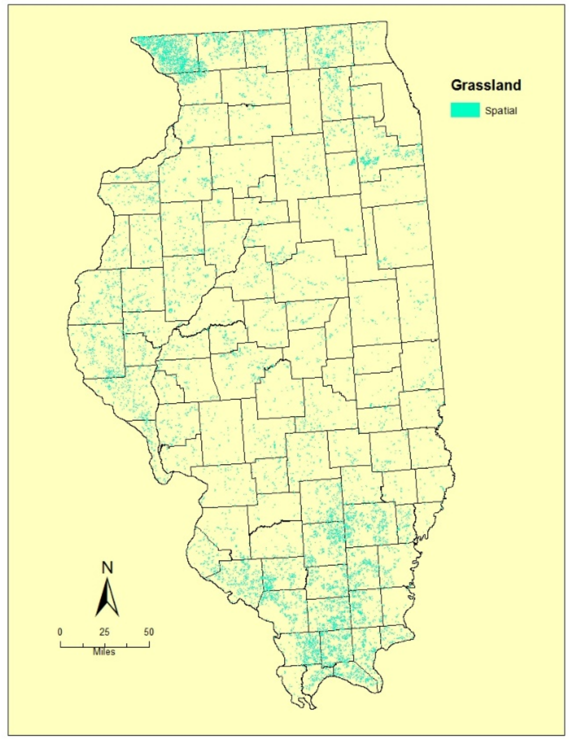


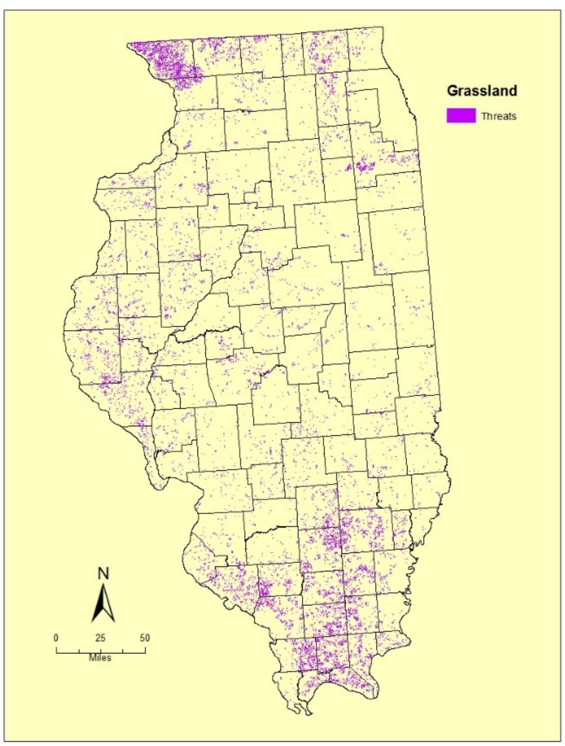


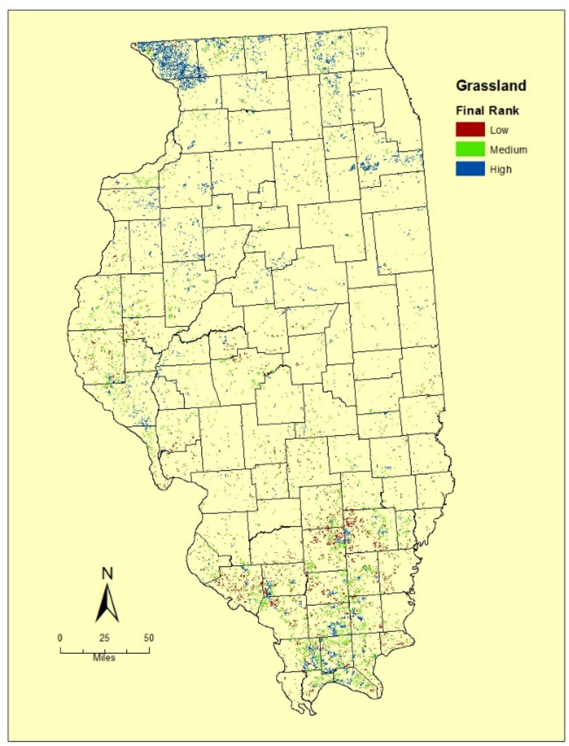


Maps of Grassland Ecological, Spatial, Threat results and Final Ranks.









Maps of Wetland Ecological, Spatial, Threat results and Final Ranks.