DELINEATING SUTIABLE WETLAND AREAS FOR RECONNECTION OF HABITAT IN SOUTHWEST ILLINOIS

by

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A REPORT

submitted in partial fulfillment of the requirements for the degree

MASTER OF LANDSCAPE ARCHITECTURE

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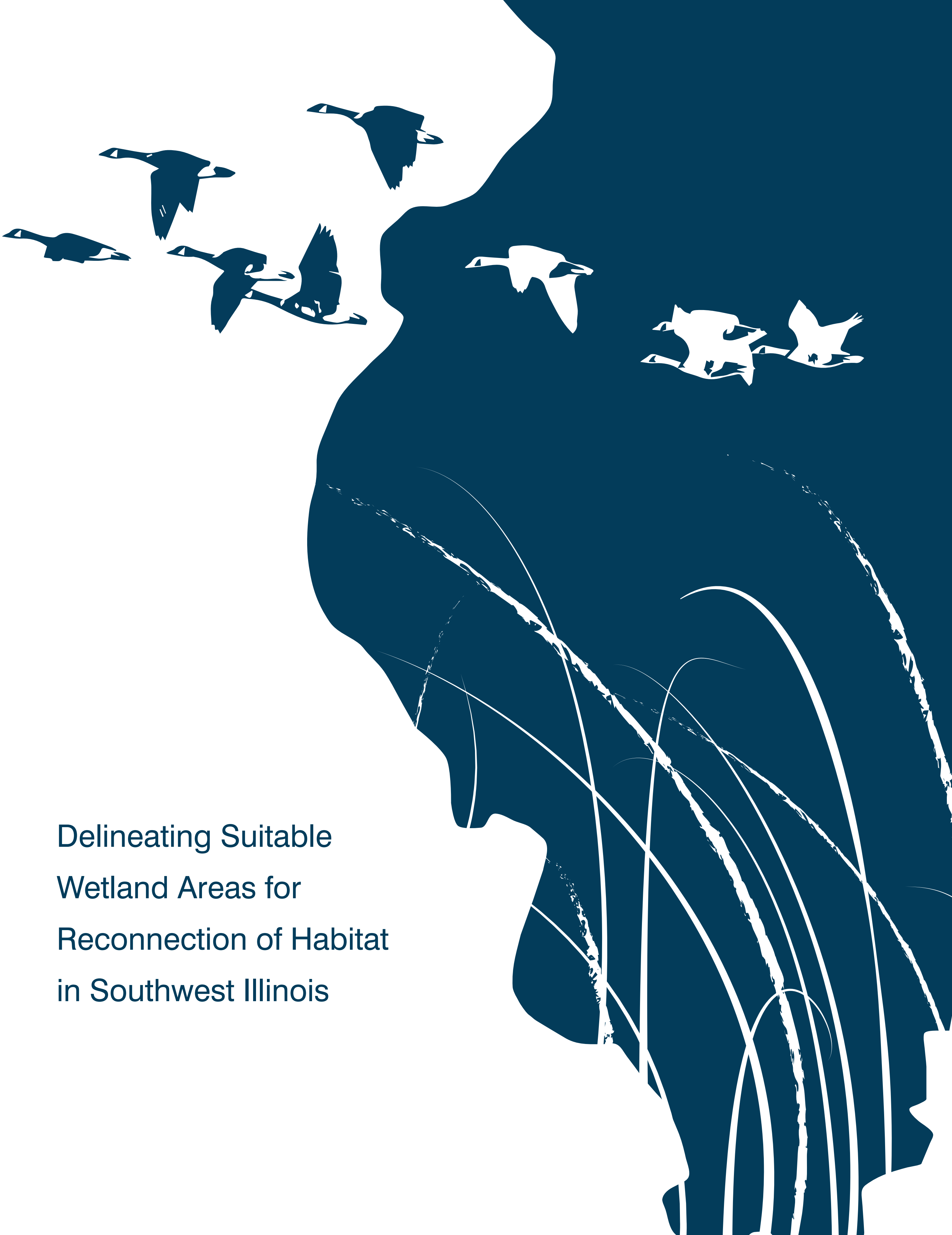
Abstract

Over 90 percent of presettlement wetlands in Illinois have been destroyed or impacted, yet wetlands continue to diminish. Sizable, public stretches of Illinois wetlands are lacking. Wetlands are an environmentally and economically valuable amenity, but can also enhance the quality of life of communities of people and organisms. Conservation efforts should be made to preserve natural services wetlands provide. Southwest Illinois was the focus of the study, which encompassed the counties of Jackson, Madison, Monroe, Perry, Randolph, St. Clair, and Washington.

Critical areas suitable to sustain wetlands were identified through a suitability analysis utilizing Geographic Information Systems (GIS). Factors that influenced the analysis included soils, hydrology, existing wetlands, natural areas, and infrastructure. Areas ranked most suitable were in close proximity to existing wetlands or hydrologic features, contained hydric soils, and had minimal roadway infrastructure impact. Proximity to wetland and natural areas were informed by the home ranges of endangered and threatened species of Southwest Illinois.

Potential suitable wetland areas for palustrine, lacustrine, and riverine wetlands were delineated on individual maps. With suitable areas known, site visits could further verify the suitability of the areas. The state of Illinois can use the specific areas to begin to focus efforts on conservation and rehabilitation to reconnect habitat and provide natural open space for a sustainable community amenity.



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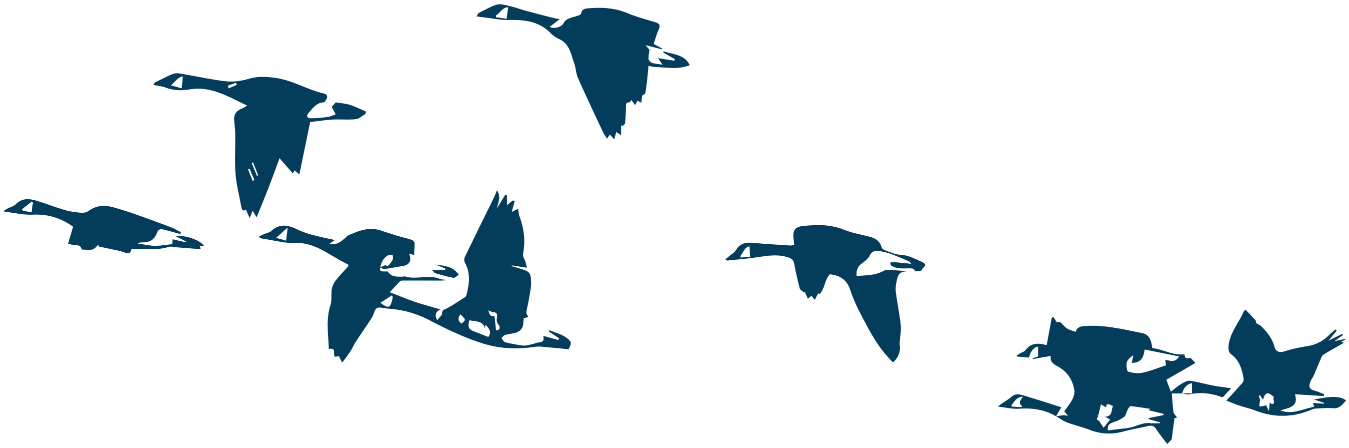

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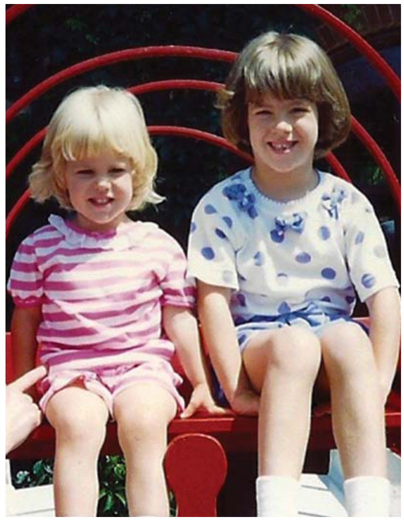

To the ones I love most:
Mom, Dad, Allese, Grandma, Grandpa

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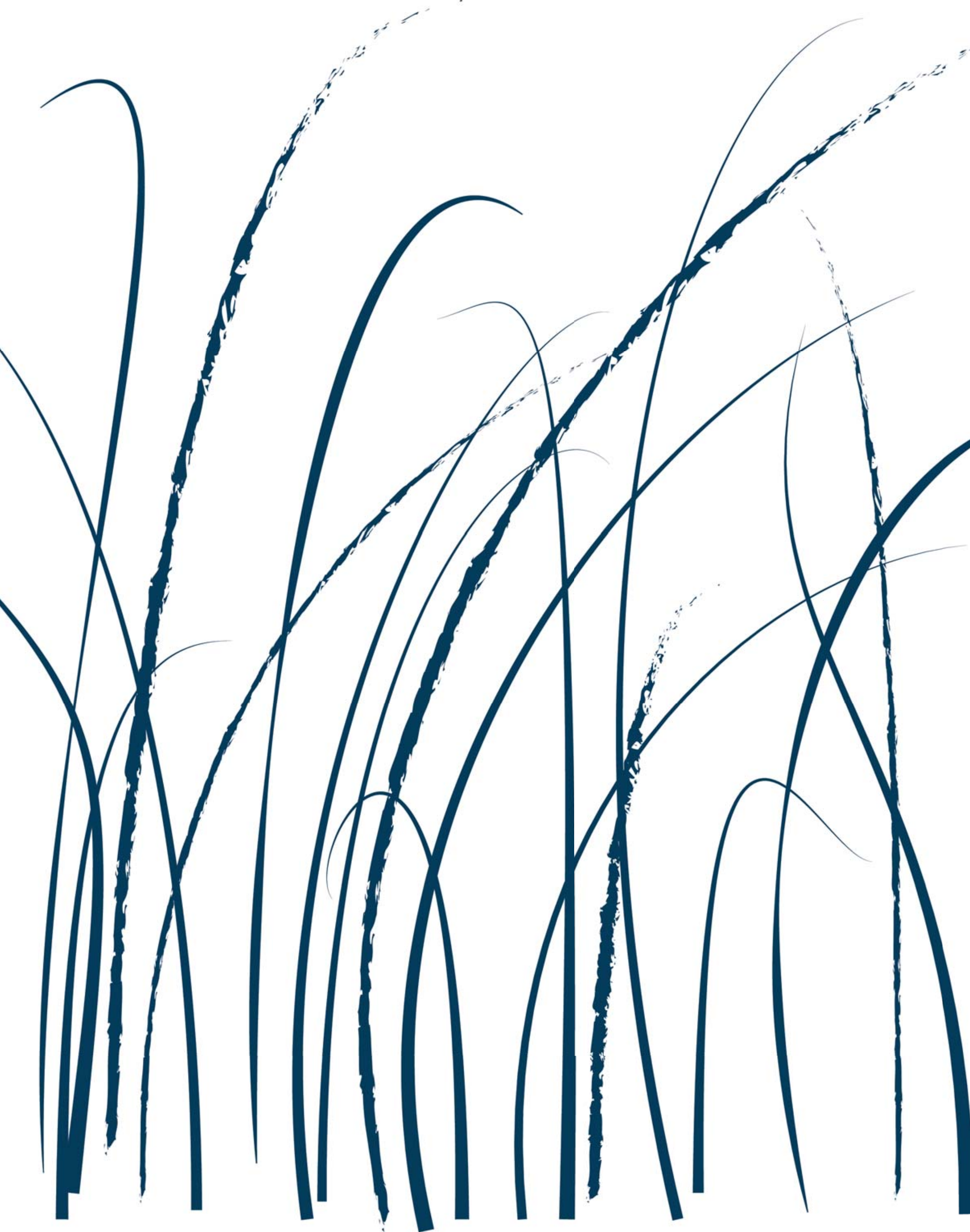


Table of Contents

List of Figures

List of Tables

Introduction

[1]

Sustainable community amenities

A social unit with similar interests or objectives, or in simpler terms, a group of organisms, within a geographical location is a community (Cox, Ewald, Kisler, Mayer, & Wood, 2013). Communities incorporate amenities to better the quality of life of its social unit. When the amenity can serve the community socially and economically, but also perform ecologically, the amenity is sustainable (Appendix A).

A community can be interpreted at a wide range of scales, while the type and function of an amenity can vary as well. Initially focused on a broader level, the state of Illinois (Figure 1.1, 1.2) functions as the community, while the wetland areas served as the amenity (Figure 1.3). There are communities of organisms within the wetland that would benefit from habitat rehabilitation. Both types of communities benefit: communities of people benefit from accessible natural open space, while ecological communities of organisms benefit from habitat expansion and quality improvements.

Wetlands

Illinois's wetlands are a valuable natural resource and can be sparsely found state-wide (Figure 1.3). Wetlands are capable of serving as a natural amenity for communities. Wetlands are useful for more than aesthetics. The quality of life can be improved for the citizens it serves. Wetlands can also be beneficial economically to the state and individual cities (Conservation, 2009). In a survey conducted in Illinois, a pleasant, natural environment, like a wetland, was ranked as one of the most desired amenities (Conservation, 2009).

Conditions + driving forces

The natural environment is an amenity; one that is often taken for granted. As the population grows in the United States, urban sprawl and agricultural land continue to plague our remaining natural landscapes (Figure 1.4). Over half of the United States' natural wetlands have been drained or destroyed (Maltby, 1986; Sullivan, Kowal, Slinde, Kirk, & Williamson, n.d.). In 1818 there were eight million acres of wetlands, today there are 1,251,240 acres (Sullivan, n.d.) Illinois suffered a loss of approximately 90% of original wetlands yet wetlands continue to be damaged (Suloway &Hubbell, 1994; Sullivan et al., n.d.).

Figure 1.1: State of Illinois aerial.
(by Author adapted from Google Earth, 2013)

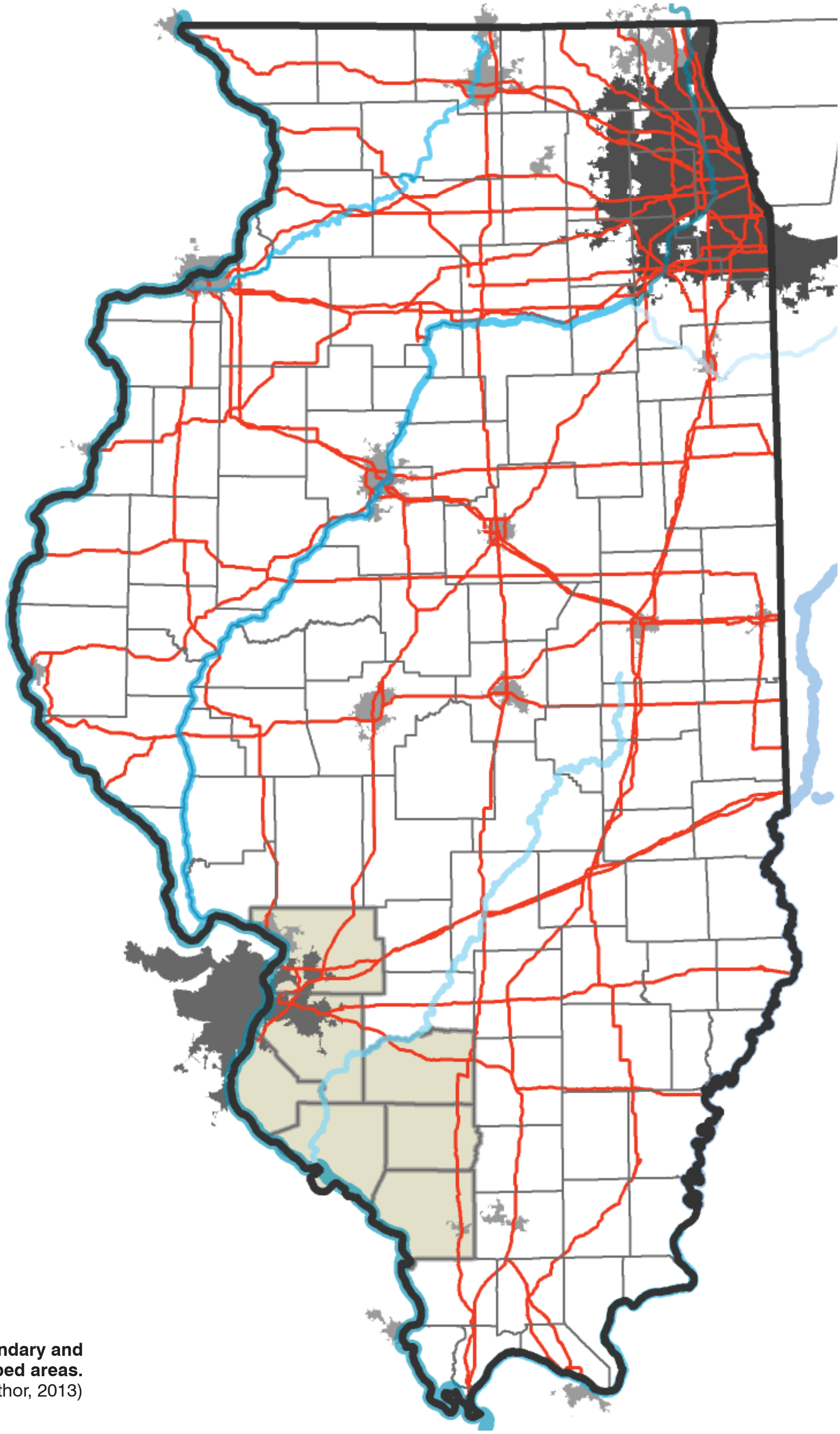


Figure 1.2: Illinois boundary and developed areas.
(by Author, 2013)

Legend

Illinois State Boundary

Rivers

- Des Plains River
- Illinois River
- Kankakee River
- Kaskaskia River
- Mississippi River
- Ohio River
- Rock River
- Wabash River

Major Urban Areas

- Chicago, IL--IN
- St. Louis, MO--IL
- Other Urbanized Areas

Primary Roadways

- Interstates and Highways

County

- Southwest Counties
- County Boundary

0 125,000 250,000 500,000 Feet

Figure 1.3: Illinois existing wetlands.
(by Author, 2013)

Legend

Illinois State Boundary

Rivers

- Des Plains River
- Illinois River
- Kankakee River
- Kaskaskia River
- Mississippi River
- Ohio River
- Rock River
- Wabash River

Primary Roadways

- Interstates and Highways

County

- County Boundary

Wetland Types

- Freshwater Emergent Wetland
- Freshwater Forested/Shrub Wetland
- Freshwater Pond
- Lake
- Riverine
- Other

Floodplain

- Floodplain area

N

0 125,000 250,000 500,000 Feet

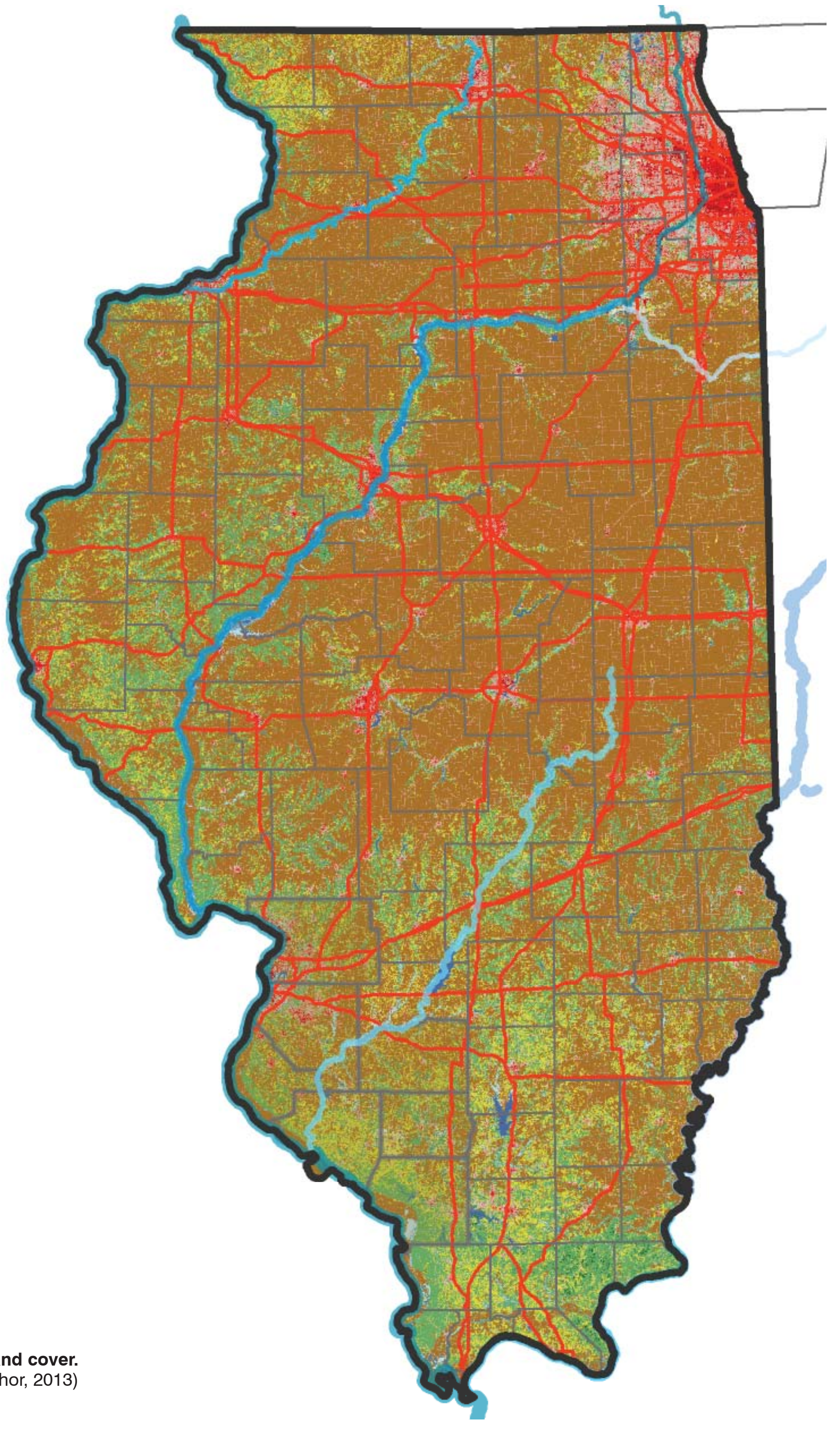


Figure 1.4: Illinois land cover.
(by Author, 2013)

Legend

Illinois State Boundary

Rivers

- Des Plains River
- Illinois River
- Kankakee River
- Kaskaskia River
- Mississippi River
- Ohio River
- Rock River
- Wabash River

Primary Roadways

- Interstates and Highways

County

- Southwest Counties
- County Boundary

Land Cover

- 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
- Open Water

N

0 125,000 250,000 500,000 Feet

Section 404 of the Clean Water Act regulates the "waters of the United States," which includes wetlands (Connolly, Johnson, & Williams, 2005). In Section 404, if a wetland is drained or destroyed, an equal or larger amount of wetland must be enhanced, restored, or replaced within an appropriate distance (Connolly et al., 2005). Laws and regulations were put in place to protect wetlands, yet the laws and regulations are not strictly enforced.

When mitigation does occur, the replacement is not always the same wetland system nor does the wetland always establish into an equivalent ecosystem (DNR, 2012c). Implementing constructed wetlands helps to ease the net loss, but does not replace the function and biodiversity of a natural wetland (Illinois, n.d.; DNR, 2012c).

As wetlands are lost, Illinois loses wildlife habitat, potential water storage area, and recreation space. Compared to other states highly motivated in conservation, such as Colorado, Wyoming, and Florida, minimal efforts have been made to preserve Illinois's natural ecosystems at a state-wide scale. Wetlands are one of the most biodiverse ecosystems capable of sustaining sensitive life and sequestering carbon. Altering or destroying wetlands affects a larger web of issues. Because of the quickly diminishing wetland habitat, several species are in decline, affecting overall biodiversity in the eco-region. Investing in Illinois's natural capital through preserves, reserves, and parks would allow future generations access to local resources, and would ensure educational and recreational benefits.

Illinois currently faces issues with policy, enforcement, and funding as a whole. State-wide issues are affecting conservation efforts.

Dilemma + research question + thesis

Illinois lacks public, sizable stretches of wetlands, and the remaining natural wetlands of Illinois continue to diminish.

Are there critical areas of diminished wetlands which need to be rehabilitated to reconnect the ecological network, and if so, where are the most suitable areas located?

The most critical areas suitable to sustain wetlands can be identified through a suitability analysis based on potential linkage to existing wetlands and site characteristics, such as soils, hydrology, and infrastructure.

Boundaries

According to the Illinois Department of Natural Resources (2013c), southern Illinois has the most wetlands compared to central and northern Illinois. Per county, Jackson, Clinton, St. Clair, Lake, and Franklin counties have the most acreage of wetland habitat remaining (Suloway & Hubbell, 1994). Jackson and St. Clair are both located in the southwestern portion of the state, therefore the area of focus was concentrated in southwestern Illinois. Jackson, Madison, Monroe, Perry, St. Clair, Randolph, and Washington counties composed the area of interest (Figure 1.5). County boundaries were utilized because data is made available by county.

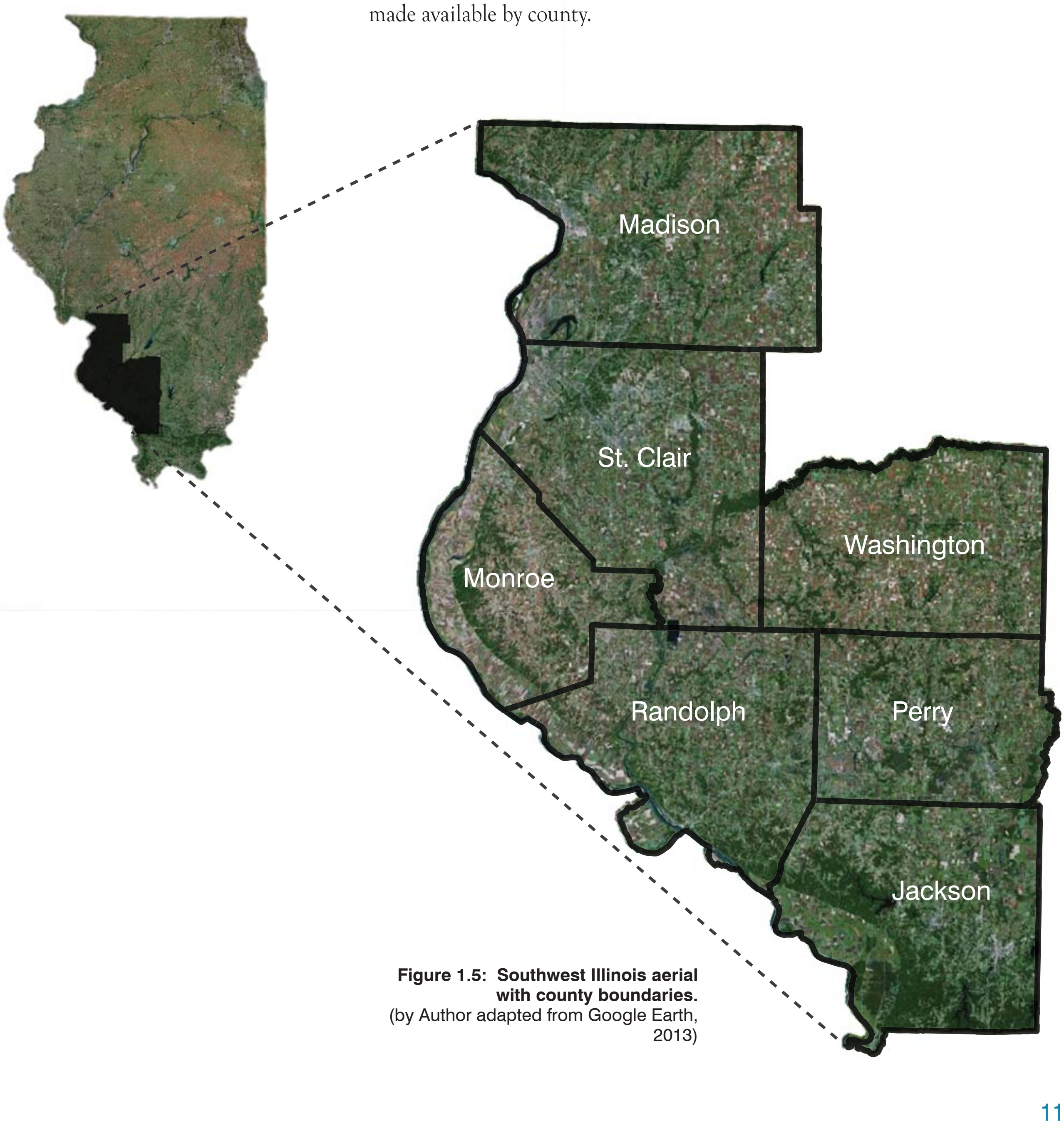
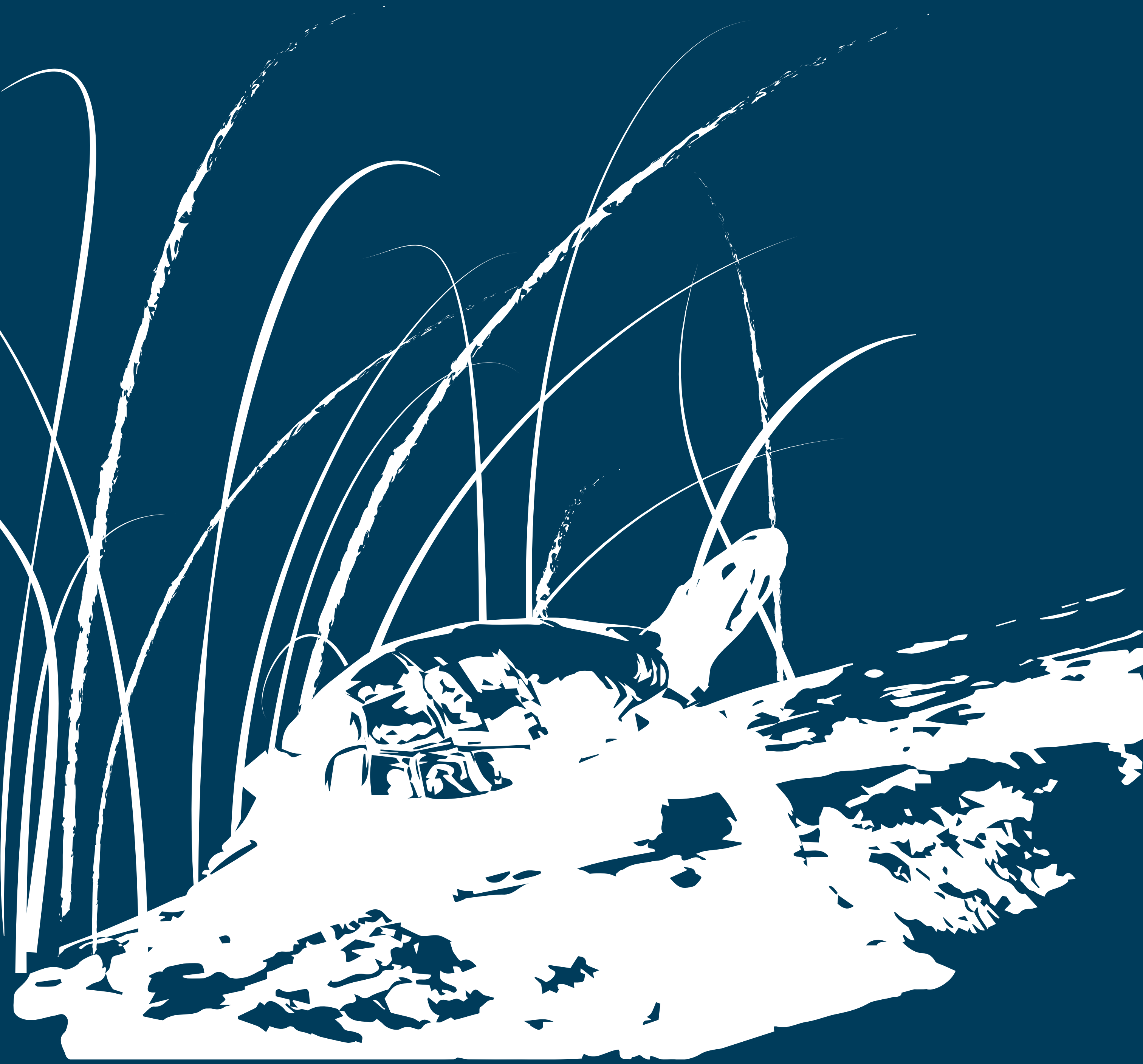


Figure 1.5: Southwest Illinois aerial with county boundaries.
(by Author adapted from Google Earth, 2013)



Understanding wetlands + Illinois

[2]

What is a wetland?

According to the Illinois Department of Natural Resources' (2013a) Interagency Wetland Policy Act of 1989, a wetland is: Land that has a predominance of hydric soils (soils which are usually wet and where there is little or no free oxygen) and that is inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances does support, a prevalence of hydrophytic vegetation (plants typically found in wet habitats) typically adapted for life in saturated soil conditions. Areas which are restored or created as the result of mitigation or planned construction projects and which function as a wetland were included in this definition even when all three wetland parameters were not present.

Essentially, wetlands are environments with shallow standing water (Figure 2.1) for some period of time in one year, with waterlogged soils and plant species specific to wet conditions (Hammer, 1997; J. Clark Slayer, 2011). Not always wet and not always dry, a sizable wetland will have both wet and dry areas. Wetlands are a meeting point of both terrestrial and aquatic areas (Hammer, 1997). Boundaries of wetlands are difficult to define. Definitions of related wetland terms can be found in Appendix A. Three vital components differentiate a wetland from other environments: hydrology, soils, and vegetation (Hammer, 1997).

Hydrology is imperative to wetland existence and functionality. Hydrology affects the type of vegetation present in the ecosystem (Hammer, 1997). Only specialized plants called hydrophytes can endure the water-logged soil (Hammer, 1997). Flows of water carry sediments in and out, influencing the nutrient cycle by introducing nutrients (Hammer, 1997). "In summary, water moving within the system functions analogous to the bloodstream where nutrients, energy, and byproducts are physically transported throughout the system" (Hammer, 1997, p. 45).

Soils support plant growth with available nutrients and minerals. Wetland soils differ because of their better ability to store water (Hammer, 1997). Because wetland soils are able to hold a high amount of water for long periods of time, the soil becomes anaerobic, or without oxygen, except for a thin band across the surface (Hammer, 1997; USDA & NRCS, 2010). Because of the durations of saturation, certain distinctive characteristics develop (USDA & NRCS, 2010). "Wetland soils are generally considered hydric soils in the NRCS soil classification system…" (Hammer, 1997, p. 52). Hydric soils are a component of wetlands and are used as an indicator because of their unique characteristics (USDA & NRCS, 2010). The anaerobic characteristic of hydric soils allows only specific types of plants to grow (USDA & NRCS, 2010).

Figure 2.1: Wetland area in the Mississippi floodplain, Monroe County.
(by Author, 2006)

Vegetation in a wetland area, or hydrophytes, have adapted to saturated soils (Hammer, 1997). Annual and seasonal wet and dry patterns of a specific wetland influence types of vegetation present (Hammer, 1997). Certain types of vegetation are characteristic to different wetland types and help to identify a type of wetland (Hammer, 1997). Wildlife diversity in a wetland ecosystem is reliant on vegetal diversity (Knight, 1997).

Types of wetlands

Illinois wetland communities are classified by types. Illinois has three of the five wetland types: palustrine, lacustrine, and riverine (DNR, 2012e). Systems are then broken down further into subsystems, classes, and subclasses with modifiers (DNR, 2012e). See Table 2.1.

Palustrine wetland communities include bogs, swamps, and bottomland forests (DNR, 2012e). Palustrine wetlands are characterized as the transitional areas primarily dominated by trees and shrubs (Cowardin, Carter, Golet, LaRoe, 2013). Usually located adjacent to lakes, ponds, or river channels; within a river floodplain; or on slopes, palustrine wetlands are non-tidal (Cowardin, Carter, Golet, LaRoe, 2013). Palustrine wetlands are commonly bound by upland habitat (Cowardin, Carter, Golet, LaRoe, 2013). No subsystems exist for the palustrine wetland type (DNR, 2012e).

Open water areas, such as lakes, reservoirs, and impounded rivers, or dammed rivers, are considered lacustrine wetlands (DNR, 2012e). Lacustrine wetlands are also commonly located in topographic depressions, or "sinks" (Cowardin, Carter, Golet, LaRoe, 2013). Trees, shrubs, persistent emergents, and emergent mosses are non-existent in lacustrine wetlands and will form the lacustrine wetland's boundary (Cowardin, Carter, Golet, LaRoe, 2013). At times, palustrine wetlands occur within the boundaries of a lacustrine wetland (Cowardin, Carter, Golet, LaRoe, 2013). Littoral and limnetic are the two lacustrine subsystems (DNR, 2012e; Cowardin, Carter, Golet, LaRoe, 2013). The subsystems vary based on differences in hydrology (DNR, 2012e). Littoral encompasses all wetland habitats in the lacustrine system from the shore boundary to a depth of 6.6 feet below low water (Cowardin, Carter, Golet, LaRoe, 2013). Deepwater wetland habitats within the lacustrine system are categorized under the limnetic subsystem (Cowardin, Carter, Golet, LaRoe, 2013).

Riverine wetland communities consist of free-flowing water systems, such as un-impounded rivers and streams (DNR, 2012e). Located within a channel, riverine systems are bounded by uplands and the channel bank (Cowardin, Carter, Golet, LaRoe, 2013). Riverine wetland systems consist of four types of subsystems: lower perennial, upper perennial, intermittent, and tidal (DNR, 2012e; Cowardin, Carter, Golet, LaRoe, 2013). Low gradient and slow water velocity is typical of lower perennial subsystems, while upper perennial subsystems have a higher gradient and a faster water velocity (Cowardin, Carter, Golet, LaRoe, 2013). Intermittent may only have flowing water for a portion of the year (Cowardin, Carter, Golet, LaRoe, 2013). Tidal has a low gradient with varying water velocities, and is similar to the lower perennial subsystem (Cowardin, Carter, Golet, LaRoe, 2013).

Wetland significance

Wetlands are significant for multiple reasons. Wetlands are capable of providing ecological services that are currently being handled by man-made services. Because of wetlands' water storage capacity and associated vegetation, wetlands are necessary for stabilization and control of water, natural flood control, and natural water filtration (Conservation, 2009; Hammer, 1997; Sullivan, Kowal, Slinde, Kirk, Williamson, n.d.). Wetlands affect soil, air quality, and biodiversity (Conservation, 2009). Wetlands are one of the most biodiverse ecosystems (Sullivan et al., n.d.). Because wetlands consist of terrestrial and aquatic habitat, also known as an ecotone, an overlap of organisms is present (Sullivan et al., n.d.). Cover, nesting, breeding, and feeding areas for wildlife are provided throughout wetlands (Sullivan et al., n.d.). Recreational, cultural, and historical values are also important (Hammer, 1997).

Illinois Wetland Classification

Classification system

Systems: highest classification	Palustrine	Lacustrine	Riverine
System description	soggy, transitional areas	open water areas	free-flowing bodies of water
Examples	marshes, bogs, swamps, bottomland forests	lakes, rivers, resrvoirs, impounded rivers	un-impounded rivers, streams
Subsystems: based on differences in hydrology	No subsystems	Littoral: shoreline to 2 meters	Lower Perennial: low gradient, slow water velocity, no tial influence, constant water flow
		Limnetic: 2 meters to deepwater	Upper Perennial: high gradient, fast water velocity, no tidal influence, constant water flow
			Intermittent: channel contains flowing non-tidal water for a portion of year, may remain in isolated pools or below the surface
Classes: based on condition of substrate and hydrophytic vegetation			
Subclasses & Modifiers: based on vegetation dominance			

Table 2.1: Illinois wetland classification.
(DNR, 2012e)

Wetland policy

Historically, wetlands were viewed negatively (DNR, 2012c; Hammer, 1997). Benefits were not recognized, and wetlands were thought to spread disease and amount to nothing more than a waste of land (DNR, 2012c; Hammer, 1997). Across the United States, wetlands were drained so land could be usable (DNR, 2012c; Hammer, 1997). Drainage trends continued up until the mid-1900s, causing significant annual loss of wetlands (Hammer, 1997). Fortunately, attitudes towards wetlands changed in the past couple decades. People have started to recognize wetlands as a valuable ecosystem because of their advantageous qualities and services (DNR, 2012c; Hammer, 1997).

The Clean Water Act was initiated in 1972. Section 404 came later, and made the federal government the authority which governed the wetlands (Connolly, Johnson, & Williams, 2005). In 1977, Carter put into effect Executive Order 11990 which was to protect wetlands as well (Hammer, 1997). In the 1980s, "no net loss" with wetlands was announced, and in 2004 net gain of wetlands was made the new goal (Connolly et al., 2005).

Illinois recognizes the Interagency Wetland Policy Act of 1989 as the state's wetland policy (DNR, 2013a). The Act recognizes the importance of wetlands, strives to "preserve, enhance, and create" wetlands, and avoids harmful impacts to wetlands (DNR, 2013a). According to the Act, Illinois's goal is to achieve no net loss of wetlands and to increase the quantity and quality of wetlands (DNR, 2013a). The State Wetland Mitigation Policy is part of the Interagency Wetland Policy Act of 1989 and states wetland preservation should be a priority over development (DNR, 2013a). If the wetlands are impacted or destroyed, compensation must occur (DNR, 2013a).

Mitigation banking is utilized in Illinois for wetland compensation when impacts are unavoidable (DNR, 2013b). A mitigation bank site should restore "chemical, physical, and biological functions of wetlands and/or other aquatic resources…" (DNR, 2013b). Size and function of each mitigation site is given a value which counts as credit towards the deposit (DNR, 2013b). Credits are held in the deposit until an unavoidable wetland impact or destruction occurs (DNR, 2013b). Credits are deducted to compensate for approved loss of wetland acreage (DNR, 2013b).

Illinois

Prior to settlement, Illinois was covered in tallgrass prairies with wet meadows and shallow water marshes intermixed (DNR, 2012c). Wetlands covered 23%

of the total presettlement land area of Illinois, which was about 8.2 million acres (Admiraal, Morris, Brooks, Olson, & Miller, 1997, & Sullivan et al., n.d.), as represented in Figure 2.2. "Today, only 1,251,240 acres (2.5% of the state) remains as wetlands" (Sullivan et al., n.d.). As stated earlier, Illinois has lost more than 90% of its original wetlands (Sullivan et al., n.d.).

Wetlands are an important ecosystem of Illinois. Illinois wetlands are composed of wet prairies, marshes, floodplain forests, and swamps (Admiraal, Morris, Brooks, Olson, & Miller, 1997). The distribution of wetland across the state are represented in Figure 2.3. As seen in Figure 2.4, palustrine wetlands are the most frequently occurring in Illinois, consuming 93.7% of total state wetlands (DNR, 2013c). Conversely, riverine is the rarest wetland type, primarily because of the large amounts of alterations made to river and stream channels for human use (DNR, 2013c).

Structure and organization in Illinois are in transition and recovery (New, 1995). The Illinois Department of Conservation no longer exists; Governor Jim Edgar merged the Department of Conservation, Department of Mines and Minerals, majority of Department of Energy and Natural Resources, Abandoned Mined Lands Reclamation Council, and Department of Transportation's Division of Water Resources in 1995 (New, 1995). The group was combined for efficiency and to create a great base of knowledge (New, 1995). The state hopes "...the cooperation and overlap among disciplines will continue and expand" (New, 1995, p.2). The merge combined several specialized groups into one entity, which could be beneficial to take advantage of in-house resources, but could be detrimental to the individual departments as well (New, 1995).

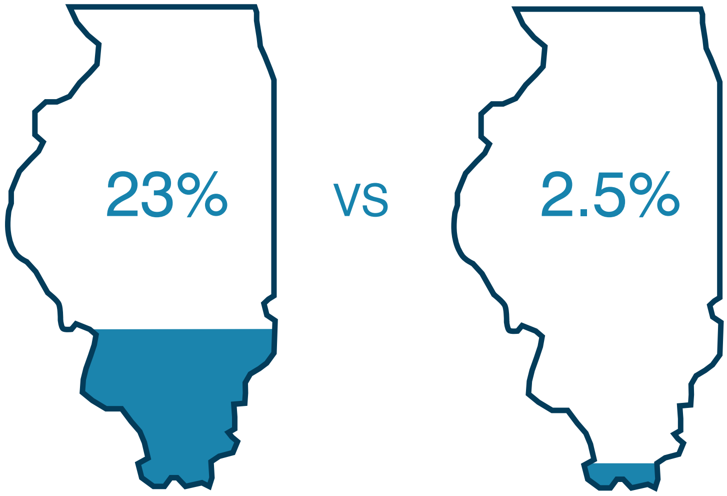
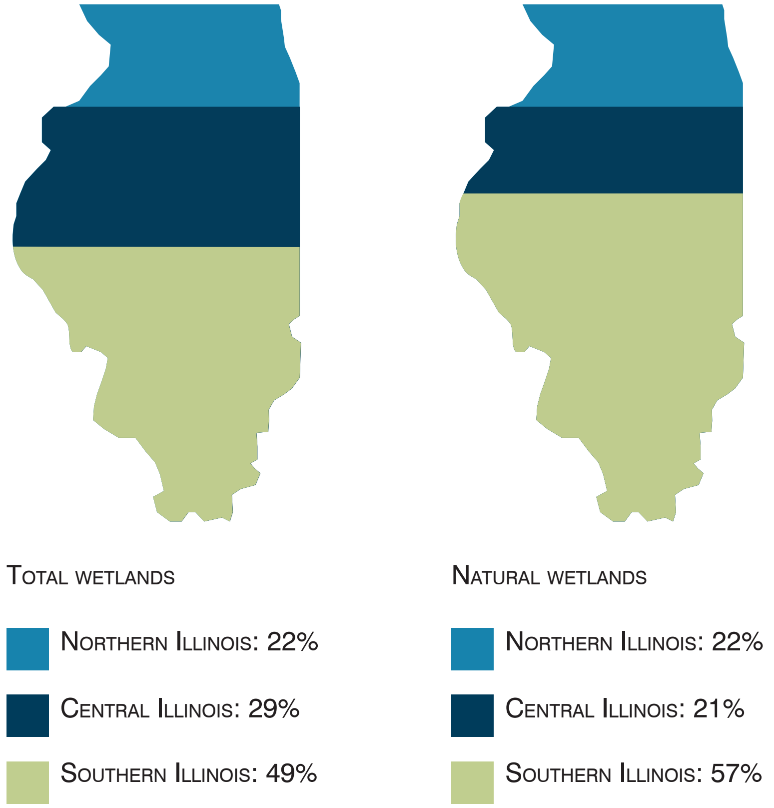


Figure 2.2: Illinois wetlands: 23% presettlement land cover vs. 2.5% current land cover.
(by Author adapted from Admiraal et al, DNR 2013c, & Sullivan et al, n.d.)

Figure 2.3: Illinois wetlands: current distribution of total and natural wetlands across the state.
(by Author, 2013, adapted from DNR 2013c)



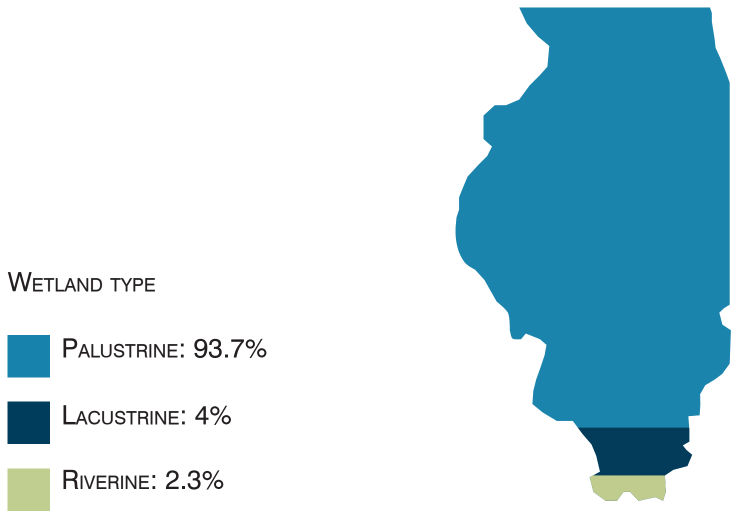


Figure 2.4: Illinois wetlands: current distribution of wetland type.
(by Author, 2013, adapted from DNR 2013c)

Habitat and wildlife

"Context and content" of a natural area influences the functionality and quality of habitat (Barnes, n.d.). Land adjacencies (Figure 2.5) affect species composition and transfer of nutrients, materials, and species (Barnes, n.d.). Habitat fragmentation (Figure 2.6) can cause significant negative effects to the habitat patch. A patch is an area of land or habitat that differs from the patch's adjacencies (Barnes, n.d.) (Figure 2.5). The "remaining patches of...wetlands may be too small, too isolated, and too influenced by edge effects to maintain viable populations..." (Johnson, 2001, p. 12). Certain species require large habitat ranges, and reduction of habitat size can affect density and occurrence of organisms (Johnson, 2001). Species composition can be negatively affected by invasive or exotic species (Barnes, n.d.). Invasive species and nest parasitism begin to decline 150 feet from the edge of the habitat patch (Barnes, n.d.) (Figure 2.7). On the other hand, some species require unrelated adjacent patches to exist (Johnson, 2001). Diverse adjacent patches (Figure 2.5) provide a variety of habitat types for organisms that utilize multiple habitat types throughout their life cycle (Brown & Strayner, 1994).

Landscape connectivity to natural areas is beneficial to habitat quality and is dependent on species type (Taylor, Fahrig, With, 2010). Movement patterns and behaviors, size and arrangement of resource patches, and matrix of habitat patches directly affect connectivity (Taylor, Fahrig, With, 2010). Sparse patches make species movement difficult (Figure 2.8), so the denser the habitat patches

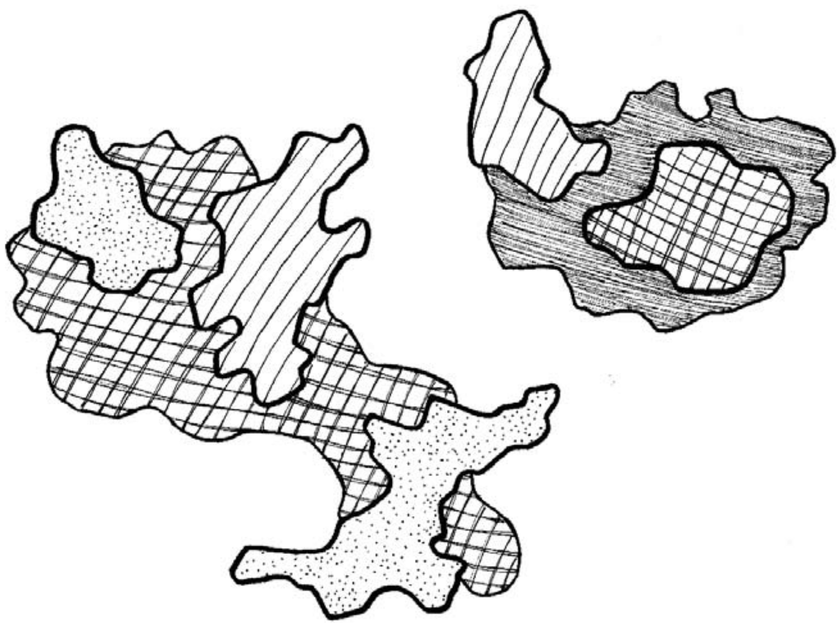


Figure 2.5: Variety of adjacent habitat patches.
(by Author, 2013, created from Barnes, n.d.)

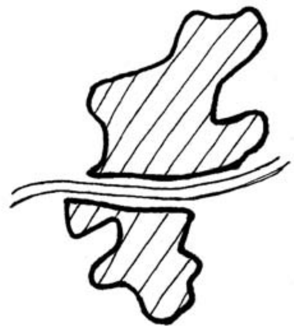


Figure 2.6: Habitat patch fragmentation.
(by Author, 2013, created from Barnes, n.d.)

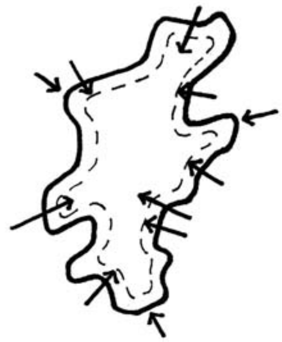


Figure 2.7: Invasive species decline at 150 feet from edge.
(by Author created from Barnes, n.d.)

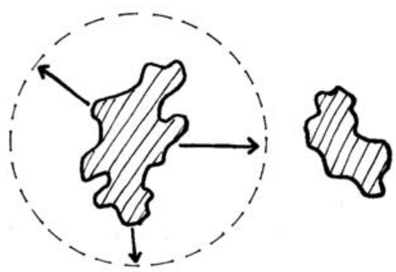


Figure 2.8: Sparse, distant patches become island habitats.
(by Author created from Barnes, n.d.)

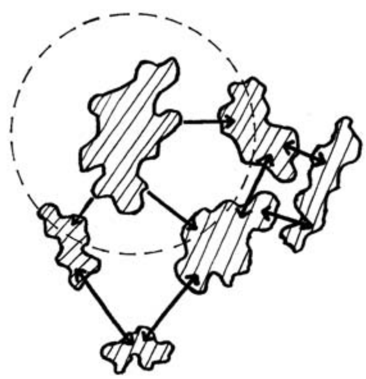


Figure 2.9: "Stepping stone" habitat patches enable species movement.
(by Author created from Barnes, n.d.)

are in the landscape, the more feasible species movement is from patch to patch (Figure 2.9), like a series of stepping stones (Barnes, n.d.). Habitat corridors can link the isolated patches. A habitat corridor is a landscape component, such as an existing, rehabilitated, or created natural area, that links one habitat to another and facilitates movement of species and processes (Meiklejohn, Ament, Tabor, 2009).

Loss of wetlands equates to loss of habitat, negatively affecting endangered and threatened species inhabiting the ecosystem and crop pollinators (Conservation, 2009). "Of the 11 most endangered grassland and shrub land birds in the nation, 7 spend their winter or summer months in Illinois" (Conservation, 2009, p.5). Many endangered and threatened species exist in southwest Illinois (Appendix B). Biodiversity relies on a mix of organisms and vegetation to sustain the larger whole (Gopal, Junk, & Davis, 2000).

Precedents

Wyoming and Iowa utilize Geographic Information Systems (GIS) to map and evaluate wetlands for the states' respective conservation programs (Evelsizer & Johnson, 2010; Wyoming, 2010). Wyoming has a series of maps illustrating the integrity of existing wetland complexes (Wyoming, 2010). Wyoming's series of maps make clear, simple gestures about which wetland systems are higher quality and top priority in conservation (Wyoming, 2010). Iowa clearly states wetland restoration is of high importance (Evelsizer & Johnson, 2010). Restoration criteria prioritizes areas which were previously wetland systems and contain hydric soils (Evelsizer & Johnson, 2010). Iowa is in the process of creating a map that prioritizes wetlands for conservation, similar to Wyoming's priority maps (Evelsizer & Johnson, 2010). Iowa is transparent about mapping tools used to plan and implement conservation efforts. Maps are generated by GIS and utilize digitalized aerial photos dating back to the 1930s (Evelsizer & Johnson, 2010). The collection of annual photos is able to portray the progression of landscape transformations (Evelsizer & Johnson, 2010). Iowa utilizes National Wetlands Inventory (NWI), but recognizes not all wetland areas are represented since NWI creates files from aerial photos (Evelsizer & Johnson, 2010). LiDAR is used to generate surface elevation data and maintains a high level of accuracy (Evelsizer & Johnson, 2010).

Iowa's use of GIS became clearer after contacting Vince Evelsizer, a biologist in Iowa's Department of Natural Resources (DNR). GIS is used to understand and become familiar with wetlands and if the wetlands are existing or drained (V. Evelsizer, personal communication, January 8, 2013). Individual maps and layers of maps are created and used to find and rehabilitate wetlands, utilizing digitalized soils data, specifically hydric soil data, and data representing basins as polygons (V. Evelsizer, personal communication, January 8, 2013). Iowa is developing an Interactive Web-based Wetland Mapping Tool for internet users to access and view different wetland areas and their function (V. Evelsizer, personal communication, January 8, 2013). Even with all of the advancements in programs and technology, Iowa is not currently producing wetland suitability analyses or maps (V. Evelsizer, personal communication, January 8, 2013).

Wyoming's DNR Headquarters Office connected me with Larry Roberts. Roberts said Wyoming is not creating GIS maps within the state but sends Wyoming's GIS work to The Nature Conservancy (TNC) (L. Roberts, personal communication, January 8, 2013). TNC of Wyoming handles much of the map-generating and conservation efforts in Wyoming (L. Roberts, personal communication, January 8, 2013). Roberts suggested contacting the TNC spatial ecologist, but significant communication was not made to gather information.

Florida actively conserves land and is in the process of rehabilitating many of its wetlands. John Humphreys from Water Resource Management explained GIS is used for interpreting and comparing aerial imagery and studying hydrologic patterns (personal communication, January 9, 2013). GIS is not currently being used to study or represent wetland quality or functionality (J. Humphreys, personal communication, January 9, 2013). Grant proposals are being written for the Environmental Protection Agency (EPA) to fund further progression with GIS and wetland studies (J. Humphreys, personal communication, January 9, 2013).

Michigan and Oregon were contacted as well, but information and comments were not obtained.

Similar to Illinois, states are producing GIS data layers for public use, but are not able to utilize the software to its fullest extent (or not at all) because of lack of funding and lack of GIS-capable employees. States who are using GIS maps are calling upon outside organizations for mapping and analysis studies.

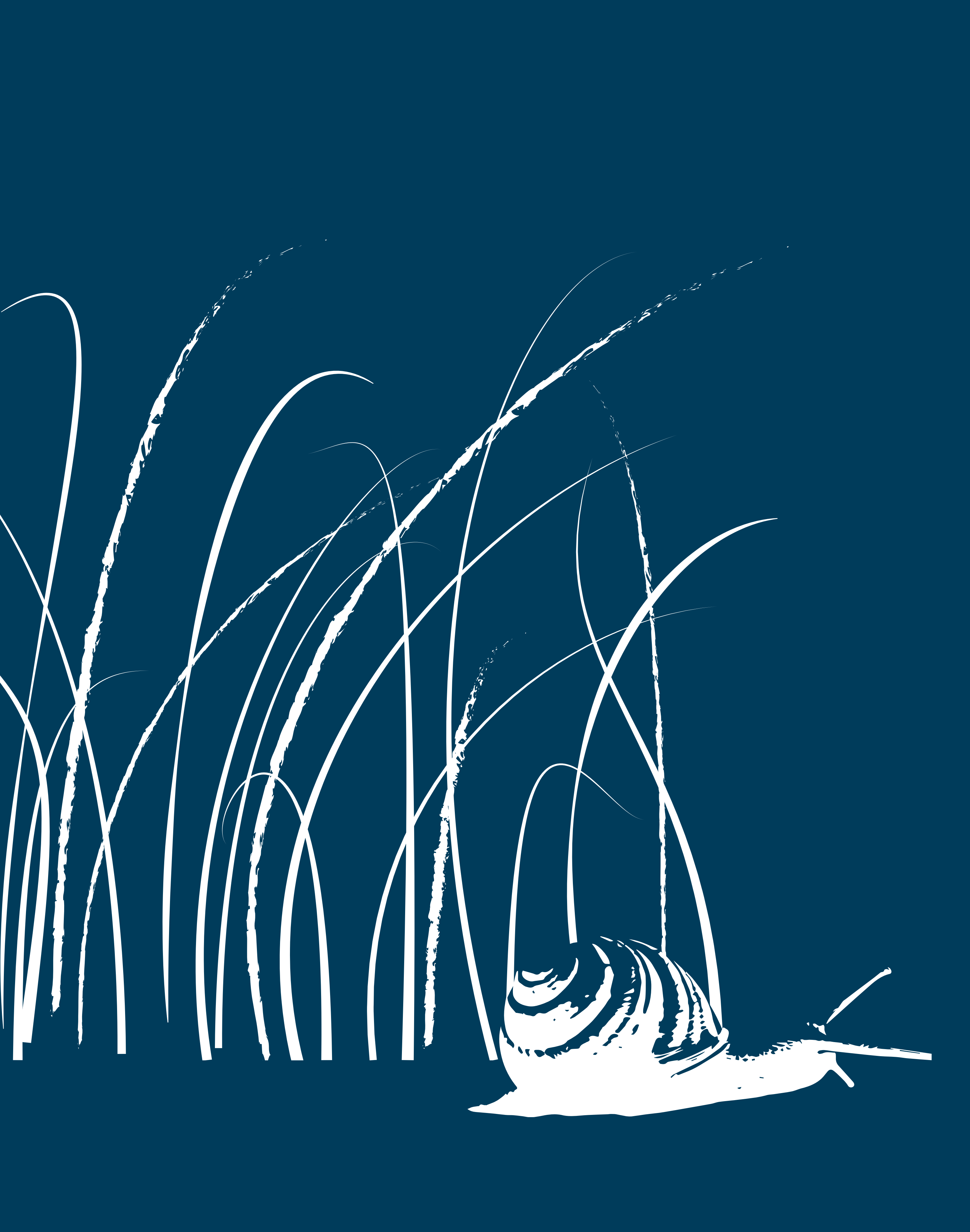
Organizations and researchers continue to develop wetland analyses for their respective region or state. Each analysis has several factors which make up the pieces that are given a suitability ranking. Suitability rankings for individual factors are combined to generate an output showing suitable areas, or a suitability map. Generating a suitability map simplifies concepts so a person can manageably work with the information (Deming & Swaffield, 2011). Suitability analyses are created to find the most and least suitable areas for development or conservation, which can inform decision-making

(NC DCM & NC CGIA, 2005). The analyses varied but placed importance on similar factors. The Watershed Restoration Registry, Center for Watershed Protection, Kramer and Carpendedo, and Brown and Stayner's analysis approach were examined. The Watershed Restoration Registry listed criteria for a wetland restoration suitability analysis. Areas considered cannot be an existing wetland or forested area, but should have poorly draining soils (Watershed Resource Registry, 2013). A preferable location for the restored wetland is in close proximity, 200 feet, to existing natural areas, streams, or wetlands (Watershed Resource Registry, 2013).

Criteria focused on in the Wetlands-At-Risk Protection Tool (WARPT) from the Center for Watershed Protection included hydric soils, vegetation, topography, floodplains, aerial imagery, and existing wetlands (CWP, 2010). Depressions, sinks, and drainage patterns were found utilizing the topography data (CWP, 2010). Although aerial imagery was used to help identify wetland areas, the Center for Watershed Protection noted the probable error by when identifying wetland through imagery (CWP, 2010). Similar to the Water Restoration Registry, WARPT removed existing wetland areas from the analysis (CWP, 2010).

Kramer and Carpenedo (2009) discuss an approach for wetland restoration and mitigation banking for Georgia. Potential restoration or mitigation sites should have a restorable land cover, which excludes low or high density urban areas, open water greater than five acres, forested wetlands, freshwater emergent marshes, and saltwater brackish marshes (Kramer & Carpenedo, 2009). Hydric soils, water quality and quantity index, maintenance of high water quality in streams, and hydrologic connectivity to wetlands were several influential factors in the approach (Kramer & Carpenedo, 2009). Connectivity between conserved lands, wetlands, and upland habitat adjacencies were important to the wetland identification approach (Kramer & Carpenedo, 2009). To ensure the wetland would be protected under Section 404 of the Clean Water Act, jurisdictional designation was considered in the approach (Kramer & Carpenedo, 2009). The wetland location must be within 100 feet of navigable waters or within the floodplain (Kramer & Carpenedo, 2009).

Brown and Strayner's (1994) methodology for identifying potential wetland sites focused on soils, roads, hydrology, land use, drainage order, Natural Areas Inventory, and existing wetlands. Brown and Strayner (1994) recognized the importance of the physical ability to support a wetland, but also acknowledged land ownership, number of land owners, and land acquisition feasibility. The ability of the sites to benefit the public was significant (Brown & Strayner, 1994). Each site was examined for wildlife habitat capacity, water quality enhancement, and water storage (Brown & Strayner, 1994).



Exploring
Southwest Illinois

[3]

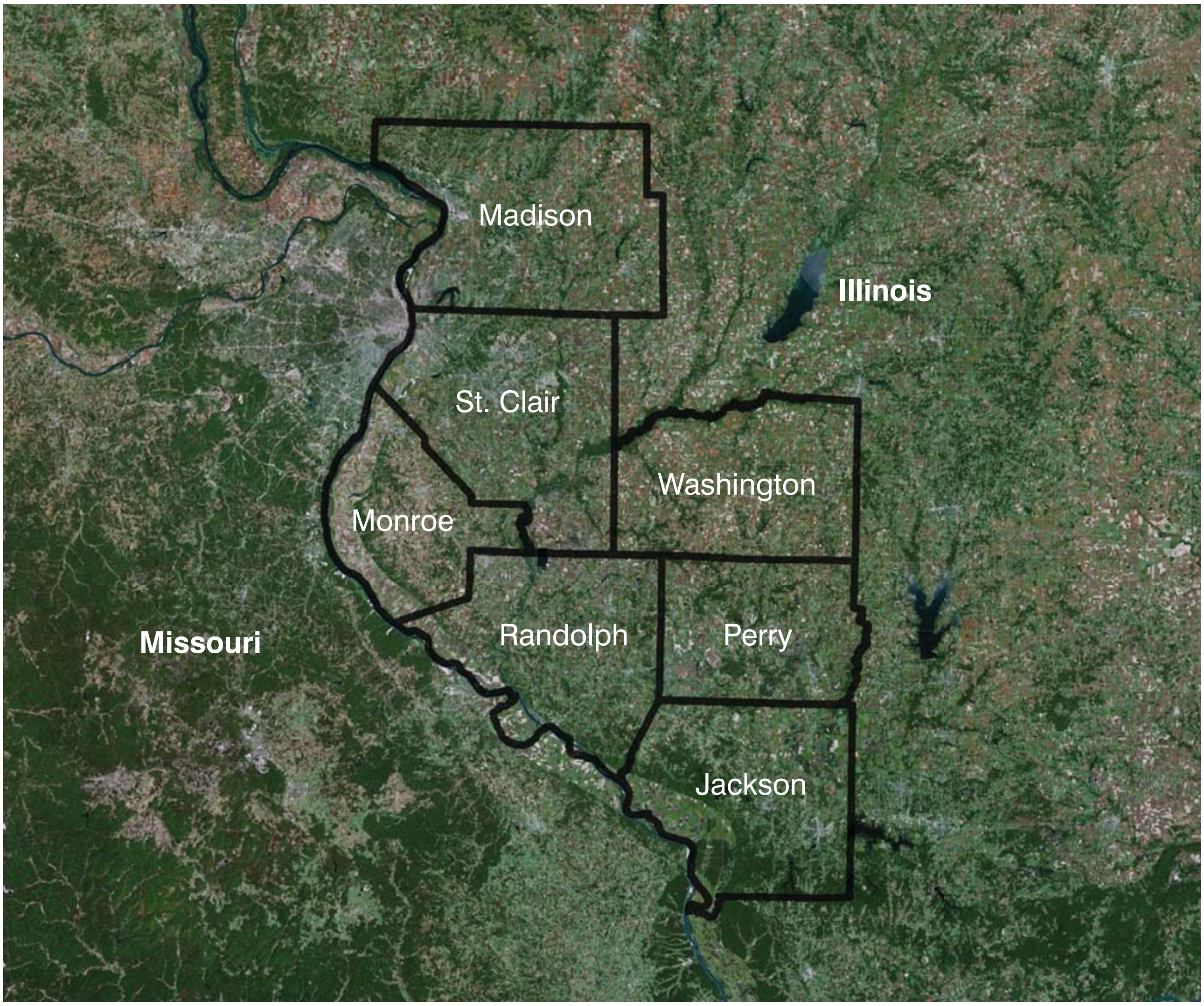


Figure 3.1: Southwest Illinois counties and context.
(by Author, 2013)

Looking in on Southwest Illinois

Southwest Illinois is comprised of seven counties, which are Jackson, Madison, Monroe, Perry, Randolph, St. Clair, and Washington counties (Figure 3.1). Suburbs and agricultural land dominate the Southwest Illinois landscape.

The Mississippi and Kaskaskia Rivers are the two largest river systems in Southwest Illinois. The Mississippi River forms the west border of five of the seven counties of interest (Figure 3.1), separating Illinois from Missouri. St. Louis, Missouri is the largest city adjacent to Southwest Illinois, located directly across the Mississippi from St. Clair and Madison counties. Development from St. Louis slowly leaked across the river and established East St. Louis and a greater metropolitan area. The remaining developed areas consist of suburban and rural communities sprinkled among the corn and soybean fields (Figure 3.2).

Mississippi River floodplains abruptly stop at the foot of tall limestone outcroppings, while the upland prairie landscape begins at the top of the bluffs. The bluffs divide the watersheds; the “bottoms” or land below the bluffs drain to the Mississippi, while the uplands drain to streams which feed into the Kaskaskia. Eventually the Kaskaskia meets the Mississippi in the northwestern portion of Randolph

County. Both river systems have been altered for human purposes. Much of the Mississippi's riparian vegetation was stripped, as seen in the aerial image in Figure 3.1, to establish areas for commercial loading and transportation of goods (Figure 3.3), and to create agricultural land in the floodplains (Figure 3.4). The Kaskaskia River has more riparian vegetation intact (Figure 3.1) and is not as highly commercialized as the Mississippi.

Collection of data

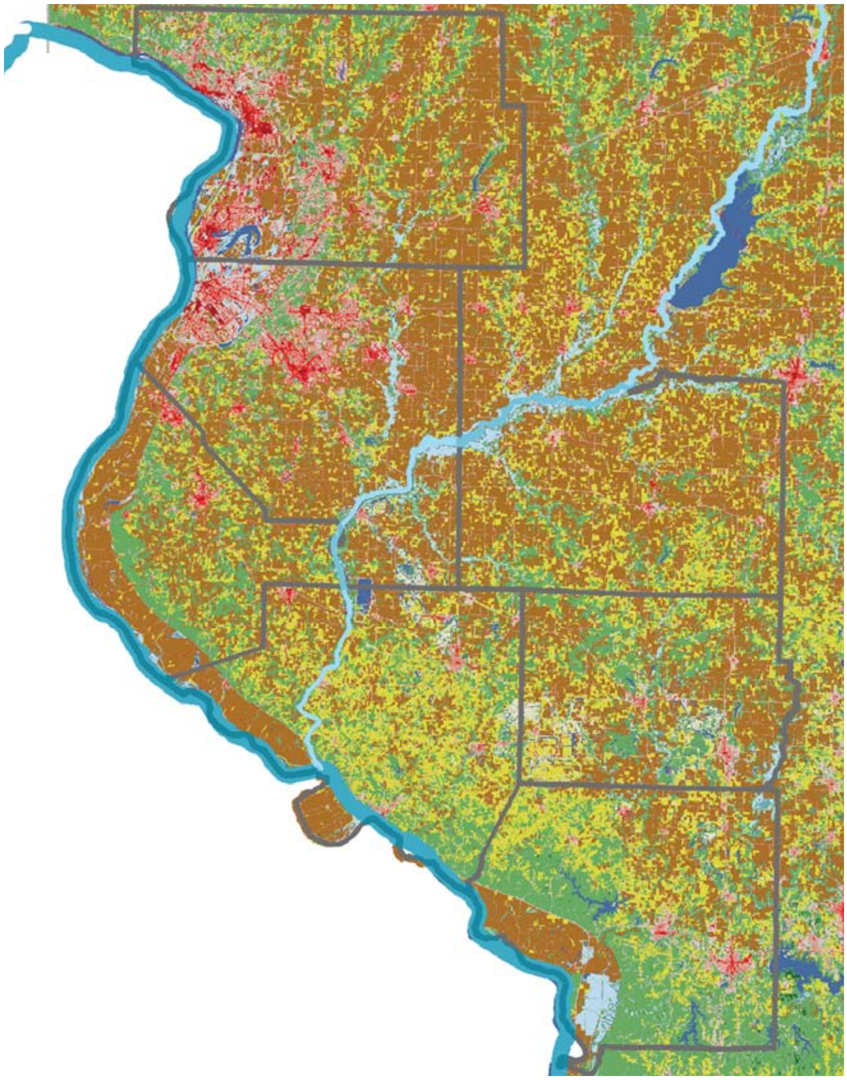
Geospatial data was needed to utilize GIS. County boundaries, existing wetlands, flood zones, river systems, watershed boundaries, natural areas, soils data, roadways, land cover, urbanized areas, digital elevation model (DEM), and aerial imagery were shapefiles needed. Shapefiles for GIS were publicly available from several governmental or institutional outlets. The United States Department of Agriculture (USDA) and Natural Resources Conservation Service (NRCS) Geospatial Data Gateway, National Wetlands Inventory (NWI), Illinois Natural Resources Geospatial Data Clearinghouse, Geo.data.gov, and NRCS Soil Data Mart were several data centers that offered applicable shapefiles. Illinois Natural Areas Inventory (INAI) data was requested specifically for this project and is not publicly available without consent.

Once shapefiles were obtained and loaded into the GIS program, data was prepared to generate maps. After the data was in the correction projection and format, inventory maps were created. Becoming familiar with Southwest Illinois will allow a better understanding of the landscape for the analysis to come.

Inventory

The following pages present a series of maps and images, Figures 3.2 through 3.15, which collectively act as an inventory of Southwest Illinois. Each inventory map focuses on one key aspect of understanding the area of interest. The spatial illustration of each aspect is accompanied by a brief explanation of the map and the aspect's relevance to the study. To further aid in the depiction of the landscape of Southwest Illinois, panoramic photographs complement several of the maps.

Figure 3.2: Land cover.
(by Author, 2013)



Land cover

As seen in Figure 3.2, much of Southwest Illinois is dominated by cropland and pasture (Figure 3.4), with development, shown in red, sprinkled throughout the seven counties. Forested areas, represented by shades of green, loosely follow the pattern of the rivers and streams, and are also represented along the bluff edge.

Figure 3.3: Commercial transportation along the Mississippi River.
(by Author, 2013)

Figure 3.4: Agricultural field in St. Clair County, adjacent to the Mississippi River.
(by Author, 2013)

Figure 3.5: Boundaries and major rivers.
(by Author, 2013)

County boundaries + major rivers

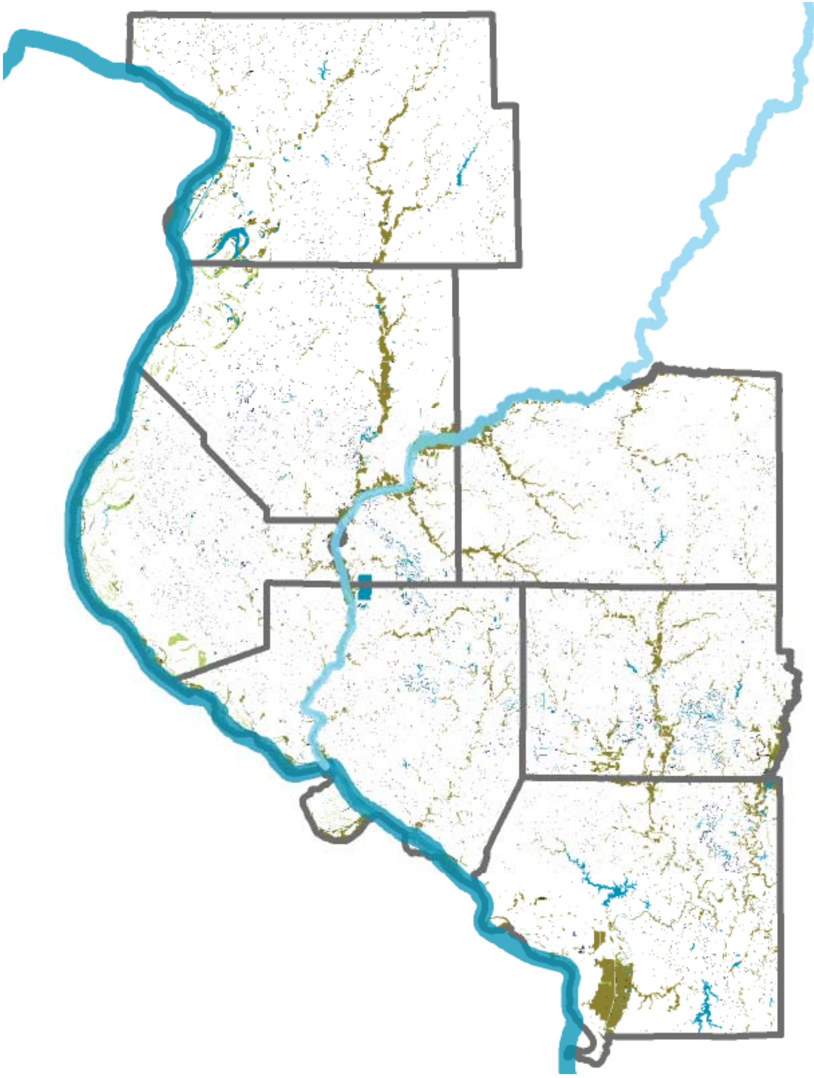
St. Louis, Missouri triggered heavy development, mostly industrial, along the western edge of St. Clair County, which is considered East St. Louis (Figure 3.5). The St. Louis Metropolitan area expanded into Madison County, developing much of the western edge. The Mississippi River is a major hydrologic feature of Southwest Illinois and forms the western boundary of Jackson, Madison, Monroe, Randolph, and St. Clair counties. The Kaskaskia River, a tributary of the Mississippi, forms approximately half of the northern boundary of Washington County, flows through the southeastern portion of St. Clair County, creates the eastern edge of Monroe County, and flows through west-central area of Randolph County before joining with the Mississippi River.

Figure 3.6: Watersheds and floodplains.
(by Author, 2013)

Watersheds + floodplains

Flooding occurs often along the Mississippi and influences the adjacent land use. The Mississippi's floodplain extends to the base of the bluffs and is utilized for agricultural fields. The Cahokia-Joachim and Upper Mississippi-Cape Girardeau watersheds encompass most of the Mississippi River in Southwest Illinois. The Kaskaskia River is highly meandering and varies in volume throughout the length of the river (Kaskaskia, 2013). Several smaller tributaries drain into the Kaskaskia River, connecting floodplain areas. The Lower Kaskaskia watershed covers the greater part of Southwest Illinois, and encompasses the stretch of the Kaskaskia within Southwest Illinois and most of the associated tributaries and respective floodplains. All watersheds and floodplains are shown above in Figure 3.6.

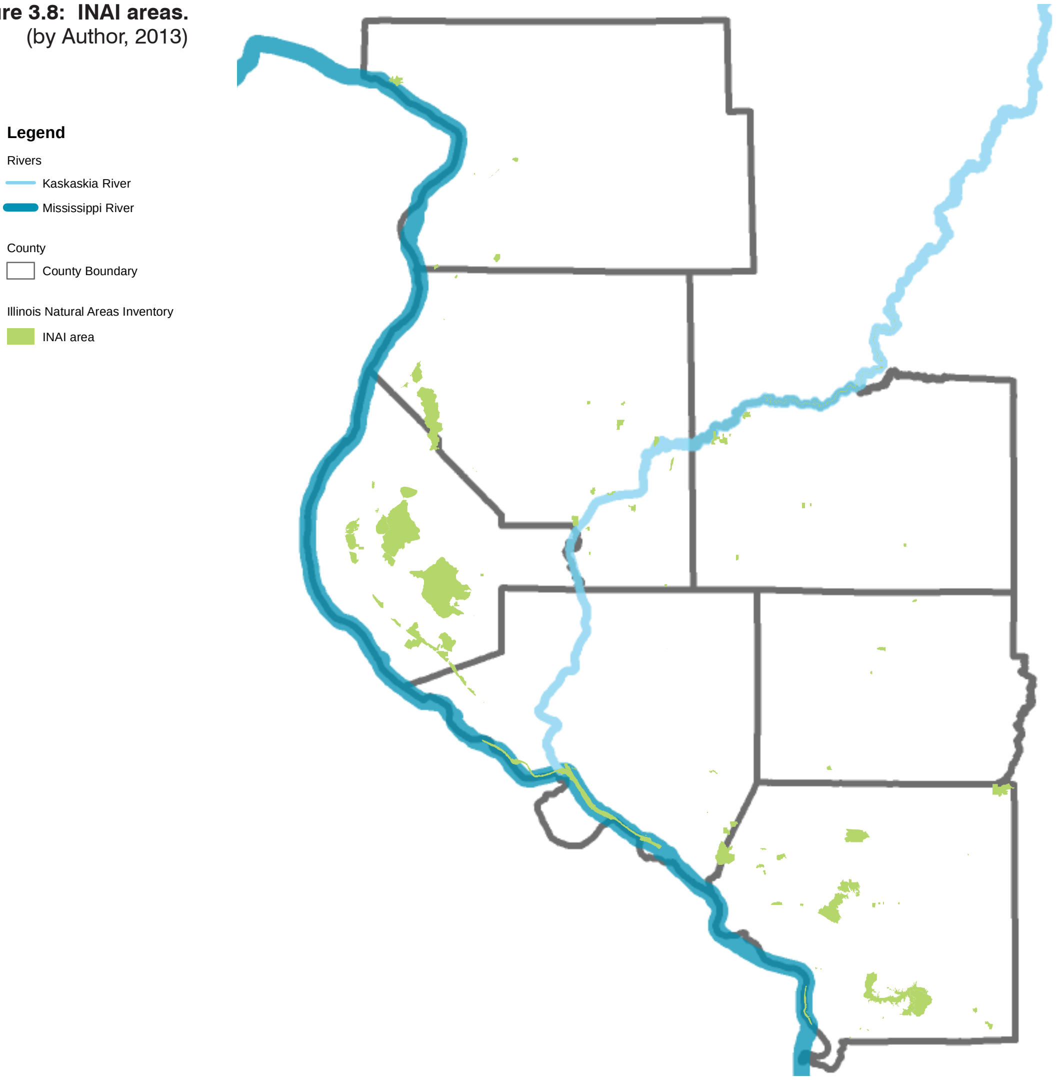
Figure 3.7: Wetlands.
(by Author, 2013)



Wetlands

According to the National Wetlands Inventory (NWI), the spatial data displays the current existing wetlands (Figure 3.7). Existing wetlands are mainly located along the Mississippi and Kaskaskia River or along a tributary of the Kaskaskia. Any depression capable of collecting water can sustain a wetland habitat, which allows a range of wetland sizes to occur (Figure 3.9). Freshwater emergent and freshwater forested/shrub wetlands are classified as palustrine wetlands, while freshwater pond and lake wetlands are categorized lacustrine wetlands. The riverine wetland type includes wetlands along a river or stream channel.

Figure 3.8: INAI areas.
(by Author, 2013)



Illinois natural areas Inventory

Illinois Natural Areas Inventory (INAI) compiles information of all of the natural and conserved areas in Illinois, and each area is represented spatially in Figure 3.8. Several of the areas are important because of the karst landscape, which in Southwest Illinois consists of limestone, and forms sinkholes, caves, and the outcropping parallel to the Mississippi (Figure 3.10). Other natural areas consist of upland prairie, wetland, and forest habitat along with significant water feature areas.

Figure 3.9: Weland area in Monroe County.
(by Author, 2012)

Figure 3.10: Limestone outcropping, or bluffs, in the karst landscape unique to Southwest Illinois. (by Author, 2012)

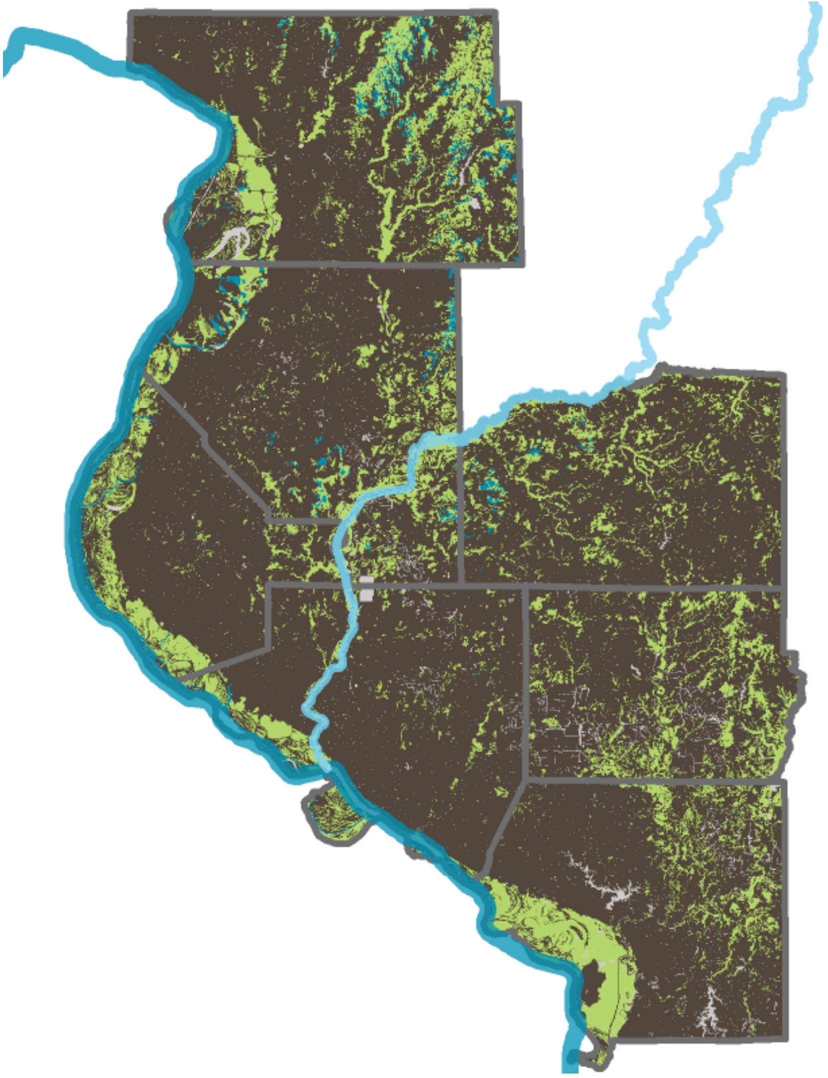


Figure 3.11: Hydric soils.
(by Author, 2013)

Legend

Rivers
- Kaskaskia River
- Mississippi River

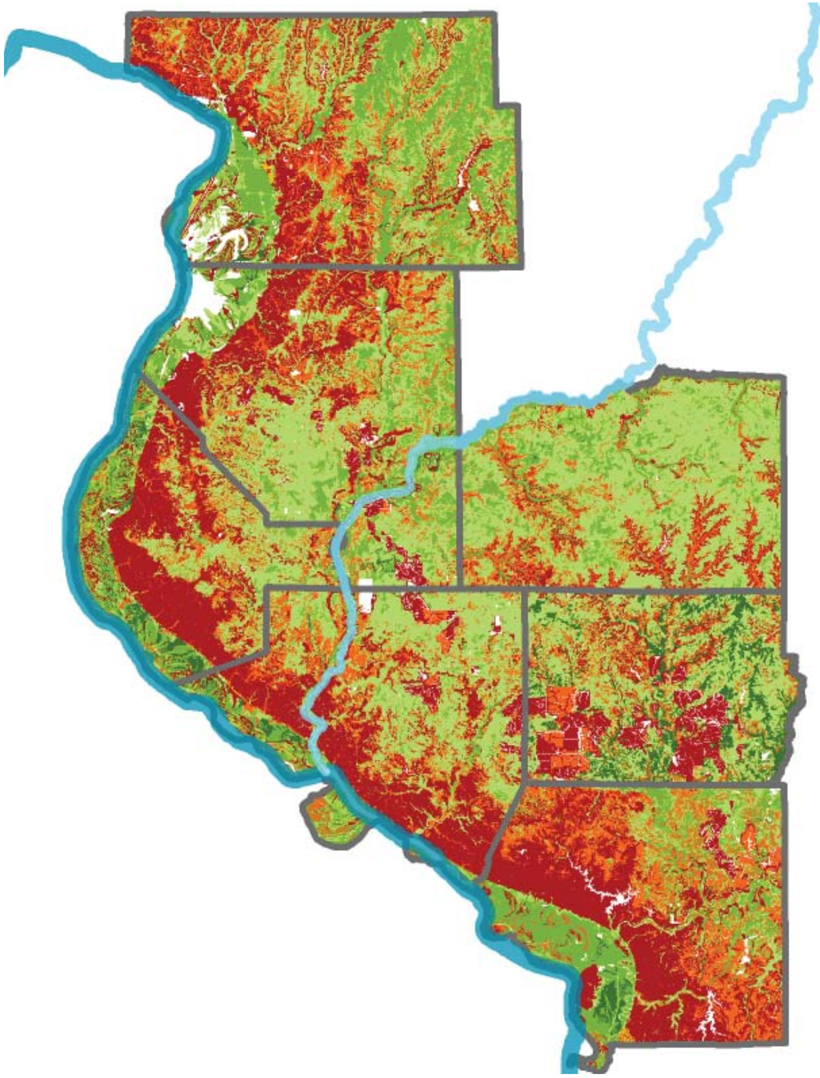
County
- County Boundary

Hydric Soil
- All hydric
- Partially hydric
- Not hydric
- Unknown

Hydric soils

Wetlands contain hydric soils more often than any other type of soil. Traits specific to hydric soils are allowed to form when water has a prolonged presence in an area. Therefore, hydric soils are primarily found in close proximity to hydrologic features, such as rivers (Figure 3.11). Most of the hydric soils found in Southwest Illinois are present along the Mississippi and Kaskaskia River and the smaller streams feeding into the rivers. Because of current agriculture and development practices, original hydric soils in some areas are degraded or no longer in existence.

Figure 3.12: Soil drainage class.
(by Author, 2013)



Soil drainage class

Even though hydric soils are the most common soil type in wetlands, wetlands are capable of existing with other soil types. The most important feature a soil type can posses is the ability to drain poorly, or hold water. Well drained soils do not retain water to sustain the hydrophytes necessary for wetland habitat. The consistent well drained area, shown in continuous red (Figure 3.12), parallel to the Mississippi River is the limestone bluffs (Figure 3.10). The slope and composition of the bluffs tend to drain the water toward the Mississippi's floodplain or farther inland to smaller streams and tributaries of the Kaskaskia.

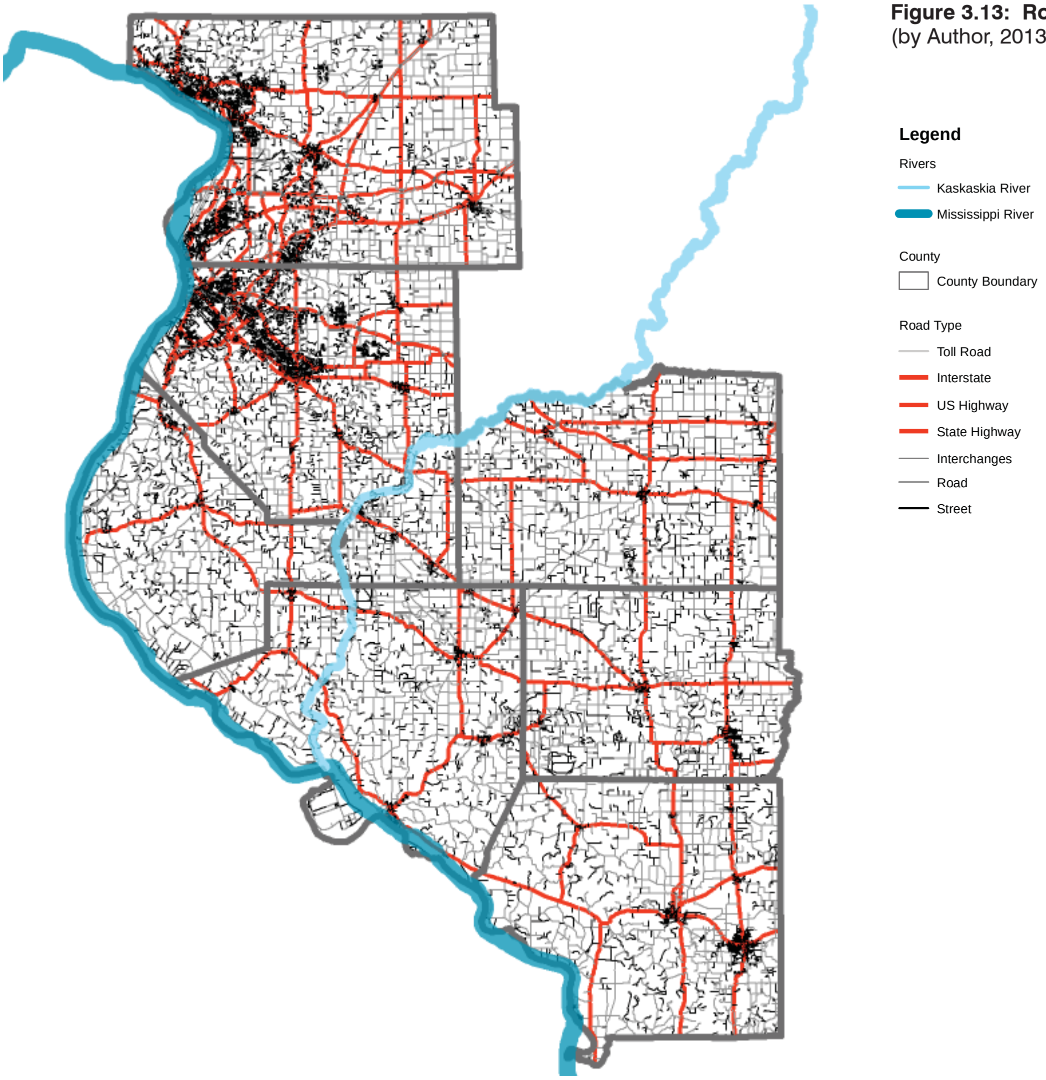
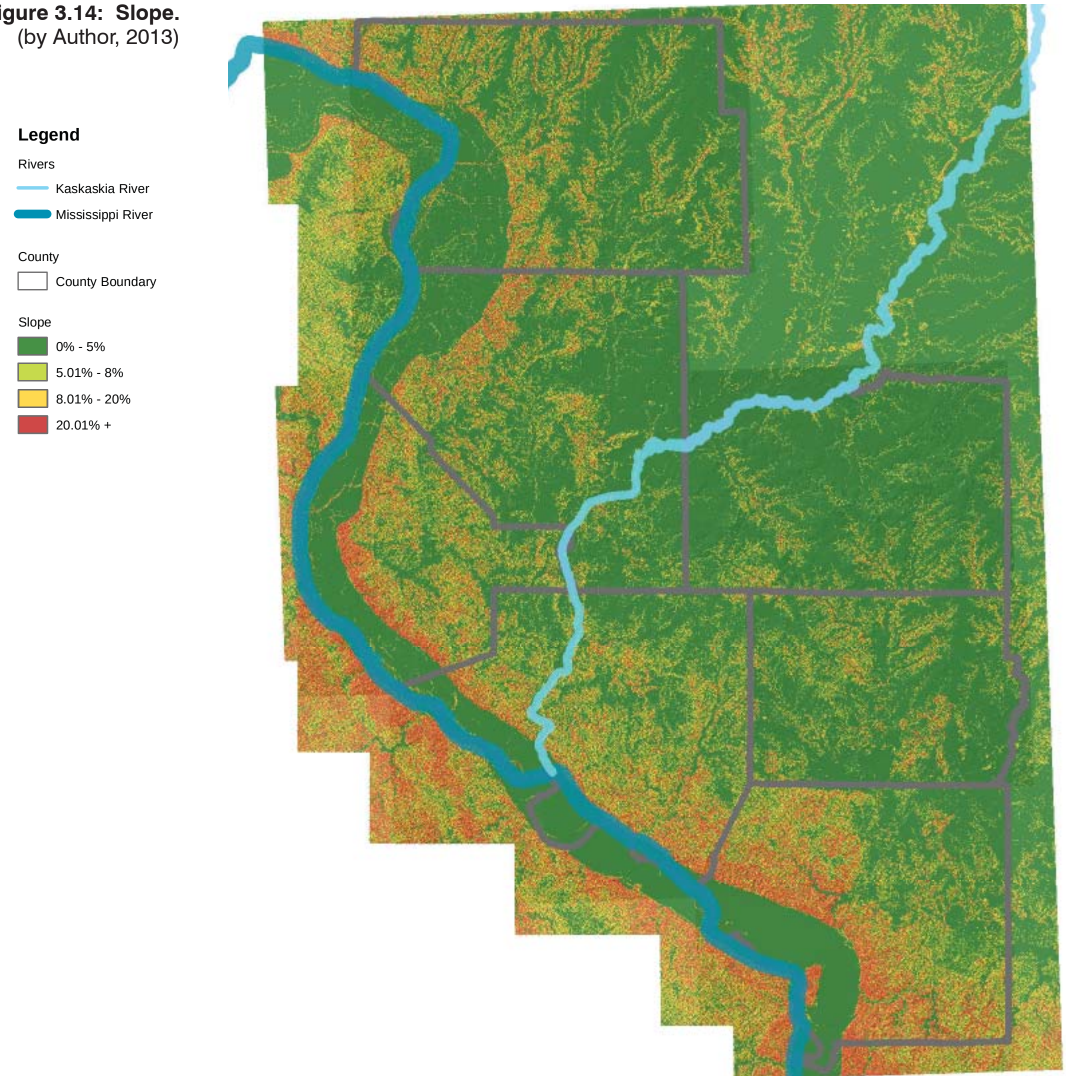


Figure 3.13: Roadways.
(by Author, 2013)

Roadways

Roadways consume the majority of the seven counties (Figure 3.13) and become more concentrated near dense development. Interstates, US highways, and state highways, represented in red, are sparse in comparison to the large amount of roads and streets. Because Southwest Illinois is suburban and primarily rural, many of the roads are not as highly trafficked (Figure 3.15) or as physically wide as roadways near a city center, such as major highways.

Figure 3.14: Slope.
(by Author, 2013)



Slope

Wetlands do not commonly occur on highly inclined landscapes because the water would have a greater chance of draining. Low slopes, displayed in green (Figure 3.14), are more preferred for wetland existence. High slopes are visible along the bluffs, but slopes gradually lessen and flatten closer to river and stream areas. Overall, slopes between 0% and 8% is most common throughout Southwest Illinois.

Figure 3.15: Agricultural fields between the bluffs and Mississippi River along Bluff Road, Monroe County.
(by Author, 2013)

Analyzing for wetlands

[4]

Method of analysis

After the inventory, research began again to find and develop information for analysis. Research was conducted to find Illinois wetland types and their differentiating elements. The three types of wetlands, palustrine, lacustrine, and riverine (DNR, 2012e), are primarily differentiated by hydrology and vegetation (DNR, 2012e). Critical elements to a wetland's existence, such as hydrology and soils, and influences impacting wetlands were noted. Wetland analysis precedents were collected and examined for analysis criteria. The reoccurring analysis factors between the precedents were noted. The critical wetland elements, influences impacting wetlands, differentiating elements, and reoccurring analysis factors were synthesized and combined to create the analysis criteria for this project. Each wetland type's factors can be found in Table 4.1, 4.2, and 4.3. The figure in Appendix C shows diagrammatic form of the development process.

To analyze suitable areas of Southwest Illinois based on the analysis criteria, a GIS model was created (Figure 4.1). The GIS model utilized shapefiles acquired from the inventory phase as inputs for the model, which included floodplains, hydrology (rivers, streams, lakes), existing wetlands, natural areas, soils, roadways, and slope. The shapefiles corresponded with factors of the analysis. For example, the roadways shapefile was used to analyze the suitability for proximity to roadways.

Each factor's shapefile was reclassified so the factor's respective attributes were assigned values, one through four, which represented a level of suitability. The range one through four was chosen for simplicity and clarity, giving each attribute a clear suitability rating: Four meant "high" suitability, three meant "moderate", two meant "low", while one was "not suitable". Green, yellow, red, and gray represented the suitability rankings respectively. Reclassifying was necessary so each factor had a "common language" that could be combined in the weighted overlay to achieve an overall suitability map.

Each factor's shapefile was transferred into a raster file with a cell size of 90 meters, or 295 feet. Raster files were then combined in a weighted overlay (Figure 4.1). Each factor was given a weight in the form of a percentage out of 100. Weights were allocated based on research and my general understanding of wetlands. Hydrology and soils were given more weight in the analysis because of the importance hydrology and hydric soils hold in the existence of wetlands. Weights per analysis factor can be seen in Table 4.1, 4.2, and 4.3. The higher the weight, the more influence the factor has on the analysis output. Assigned values and weights are multiplied, then the sum of the products of

			Suitability Rating			
Suitability Scale for Wetlands			**1 Not Suitable**	**2 Low**	**3 Moderate**	**4 High**
Weight	Weight as %	Analysis Layer	Exclusionary	Least favorable <----------	------------------------------------	------------> Most favorable
1	0.10	*Floodplain*		Outside of floodplain	500 year	100 year
2	0.20	*Proximity to hydrologic features: lakes, ponds, rivers*				
		Lakes, ponds		300.01' - 500'	100.01' - 300'	0' - 100'
		Rivers		3,000.01' - 5,000'	1,000.01' - 3,000'	0' - 1,000'
1	0.10	*Proximity to wetlands*				
		10.00-50 acres	1,800.01' +	600.01' - 1,800'	200.01' - 600'	0.00' - 200'
		50.01-100 acres	5,400.01' +	1,800.01' - 5,400'	600.01' - 1,800'	0.00' - 600'
		100.01+ acres	16,200.01' +	5,400.01' - 16,200'	1,800.01' - 5,400'	0.00' - 1,800'
1	0.10	*Proximity to natural areas*				
		10.00-50 acres	1,800.01' +	600.01' - 1,800'	200.01' - 600'	0.00' - 200'
		50.01-100 acres	5,400.01' +	1,800.01' - 5,400'	600.01' - 1,800'	0.00' - 600'
		100.01+ acres	16,200.01' +	5,400.01' - 16,200'	1,800.01' - 5,400'	0.00' - 1,800'
2	0.20	*Soils - Hydric*		Not hydric, unknown	Partially hydric	All hydric
1	0.10	*Soils - Drainage class*	Somewhat excessively drained, excessively well drained, no data	Well drained	Somewhat poorly drained, moderately well drained	Very poorly drained, poorly drained
1	0.10	*Proximity to roadways*				
		Collector		0' - 100'	100.01' - 400'	400.01+
		County	0' - 100'	100.01' - 400'	400.01'-2,100'	2,100.01+
		Highways/Interstates	0' - 400'	400.01' - 2,100'	2,100.01 - 3,000'	3,000.01'+
1	0.10	Slope	25.01% +	20.01% - 25%	8.01% - 20%	0.0% - 8%
10	1.00					

Table 4.1: Palustrine analysis layers.
(by Author, 2013)

Lacustrine Wetland Suitability

			Suitability Rating			
Suitability Scale for Wetlands			**1 Not Suitable**	**2 Low**	**3 Moderate**	**4 High**
Weight	Weight as %	Analysis Layer	Exclusionary	Least favorable <----------	------------------------------------	------------> Most favorable
1	0.10	*Floodplain*		Outside of floodplain	500 year	100 year
2	0.20	*Proximity to hydrologic features: lakes, impounded rivers, reservoirs, sinks/depressions*				
		Lakes, reservoirs		300.01' - 500'	100.01' - 300'	0' - 100'
		Impounded rivers		300.01' - 500'	100.01' - 300'	0' - 100'
		Sinks/depressions		150.01' - 250'	50.01' - 150'	0' - 50'
1	0.10	*Proximity to wetlands*				
		10.00-50 acres	1,800.01' +	600.01' - 1,800'	200.01' - 600'	0.00' - 200'
		50.01-100 acres	5,400.01' +	1,800.01' - 5,400'	600.01' - 1,800'	0.00' - 600'
		100.01+ acres	16,200.01' +	5,400.01' - 16,200'	1,800.01' - 5,400'	0.00' - 1,800'
1	0.10	*Proximity to natural areas*				
		10.00-50 acres	1,800.01' +	600.01' - 1,800'	200.01' - 600'	0.00' - 200'
		50.01-100 acres	5,400.01' +	1,800.01' - 5,400'	600.01' - 1,800'	0.00' - 600'
		100.01+ acres	16,200.01' +	5,400.01' - 16,200'	1,800.01' - 5,400'	0.00' - 1,800'
2	0.20	*Soils - Hydric*		Not hydric, unknown	Partially hydric	All hydric
1	0.10	*Soils - Drainage class*	Somewhat excessively drained, excessively well drained, no data	Well drained	Somewhat poorly drained, moderately well drained	Very poorly drained, poorly drained
1	0.10	*Proximity to roadways*				
		Collector		0' - 100'	100.01' - 400'	400.01+
		County	0' - 100'	100.01' - 400'	400.01'-2,100'	2,100.01+
		Highways/Interstates	0' - 400'	400.01' - 2,100'	2,100.01 - 3,000'	3,000.01'+
1	0.10	Slope	25.01% +	20.01% - 25%	8.01% - 20%	0.0% - 8%
10	1.00					

Table 4.2: Lacustrine analysis layers.
(by Author, 2013)

Suitability Scale for Wetlands			Suitability Rating: 1 Not Suitable	2 Low	3 Moderate	4 High
Weight	Weight as %	Analysis Layer	Exclusionary	Least favorable <----------	-----------------------------------	------------> Most favorable
1	0.10	*Floodplain*		Outside of floodplain	500 year	100 year
2	0.20	*Proximity to hydrologic features: un-impounded rivers, streams*				
		Rivers		3,000.01' - 5,000'	1,000.01' - 3,000'	0' - 1,000'
		Streams		300.01' - 500'	100.01' - 300'	0' - 100'
1	0.10	*Proximity to wetlands*				
		10.00-50 acres	1,800.01' +	600.01' - 1,800'	200.01' - 600'	0.00' - 200'
		50.01-100 acres	5,400.01' +	1,800.01' - 5,400'	600.01' - 1,800'	0.00' - 600'
		100.01+ acres	16,200.01' +	5,400.01' - 16,200'	1,800.01' - 5,400'	0.00' - 1,800'
1	0.10	*Proximity to natural areas*				
		10.00-50 acres	1,800.01' +	600.01' - 1,800'	200.01' - 600'	0.00' - 200'
		50.01-100 acres	5,400.01' +	1,800.01' - 5,400'	600.01' - 1,800'	0.00' - 600'
		100.01+ acres	16,200.01' +	5,400.01' - 16,200'	1,800.01' - 5,400'	0.00' - 1,800'
2	0.20	*Soils - Hydric*		Not hydric, unknown	Partially hydric	All hydric
1	0.10	*Soils - Drainage class*	Somewhat excessively drained, excessively well drained, no data	Well drained	Somewhat poorly drained, moderately well drained	Very poorly drained, poorly drained
1	0.10	*Proximity to roadways*				
		Collector		0' - 100'	100.01' - 400'	400.01+
		County	0' - 100'	100.01' - 400'	400.01'-2,100'	2,100.01+
		Highways/Interstates	0' - 400'	400.01' - 2,100'	2,100.01 - 3,000'	3,000.01'+
1	0.10	*Slope*	25.01% +	20.01% - 25%	8.01% - 20%	0.0% - 8%
10	1.00					

Table 4.3: Riverine analysis layers.
(by Author, 2013)

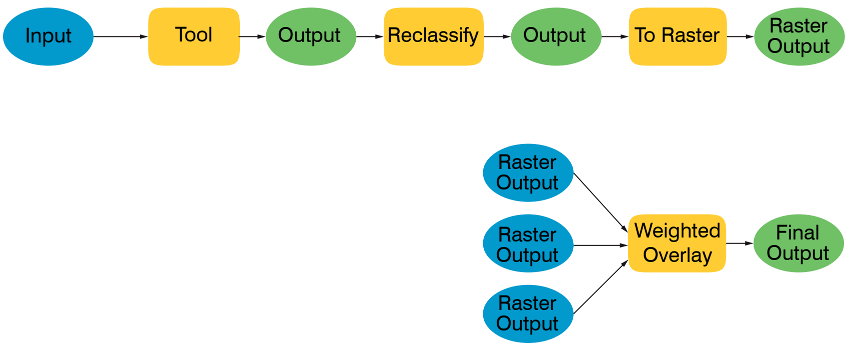
the multiplied ratings achieve the overall suitability rating for that specific land area (Hopkins, 1977). The weighted overlay step is comparable to if several layers of maps were manually drawn and stacked on one another to determine relationships or common suitable areas (NC DCM & NC CGIA, 2005). A weighted factor would include multiple layers of the same map.

By running the GIS model, suitability maps were generated. The maps represent a range of suitability, from most to least suitable wetland areas based on the given analysis layers. Highly suitable areas generated from the model were an indication of areas potentially highly capable of serving as a rehabilitation site. Suitable areas were not meant to be guaranteed suitable wetland rehabilitation locations, without a site visit, and were also not meant to serve as a method of wetland delineation (CWP, 2010).

Reflection and evaluation of the model, factors, weighting, and suitability map was important. As opportunities to clarify or issues arose, elements were adjusted. Originally, the wetland suitability model was generalized and did not differentiate between wetland types. Three models were created to cater to the specific characteristics of each wetland type. The original shapefile for existing wetlands contained wetlands from less than an acre to thousands of acres. When a proximity range was placed around each wetland patch, the map became unreadable. Larger stretches of wetlands, which provide more core habitat, were more important to the analysis so wetland patches under ten acres were removed from the shapefile. Proximity to wetlands and natural areas each previously had a uniform distance representing proximity. Uniform distances did not take into account the size of the habitat patch. Wetlands and natural areas were grouped by patch acreage, and each acreage group was given a set of distances appropriate for proximity which were ranked for suitability (Table 4.1, 4.2, 4.3). Combining the three different acreage layers into one shapefile masked some of the smaller patches completely, which was an unforeseen error in GIS. To avoid exclusion of these smaller areas, an additive method was used to combine the three acreage categories into one comprehensive shapefile. For the weighted overlay, different weights were applied to the analysis factors to see if result maps would differ, such as equal weights for all factors. Results varied only slightly. Minimal change in results is most likely due to the number of factors being assessed. If there were fewer factors, the results would vary more. Because results varied only slightly, the assigned weights were not changed.

Once adjustments were made to the suitability factors, and final suitability maps were generated, maps were inspected to find the most suitable areas for wetlands.

Figure 4.1: Simplified GIS model for suitability analysis and weighted overlay.
(by Author, 2013)



Analysis layers

Factors used to analyze Southwest Illinois were as follows:

- Floodplain
- Proximity to hydrologic features
- Proximity to wetlands
- Proximity to natural areas
- Hydric soils
- Soil drainage class
- Proximity to roadways
- Slope

Although vegetation type is a major defining component of wetlands and wetland types, vegetation was not included in the analysis. Determining vegetation type from aerial imagery can be inaccurate if not assessed by a professional, and and would therefore skew the results if included in the analysis.

According to Kramer and Carpenedo (2009), developed areas and existing wetlands are not restorable land cover classes. All developed areas, including low, medium, and high intensity; open areas; and barren land were excluded from the analysis (Kramer & Carpenedo, 2009). Existing wetland areas and open water areas greater than five acres were excluded from the analysis as well (Kramer & Carpenedo, 2009). If development or wetlands were in existence already, the land was not suitable for potential wetland restoration.

On the following pages, Figures 4.2 through 4.14 show the suitability of each factor included in the analysis. Individual analysis maps focus on one aspect and illustrate the suitability ranking given to each attribute of the factor. The importance of the factor to the analysis is explained. Precedents are mentioned in the explanation if the precedents utilized the analysis layer in their respective studies.

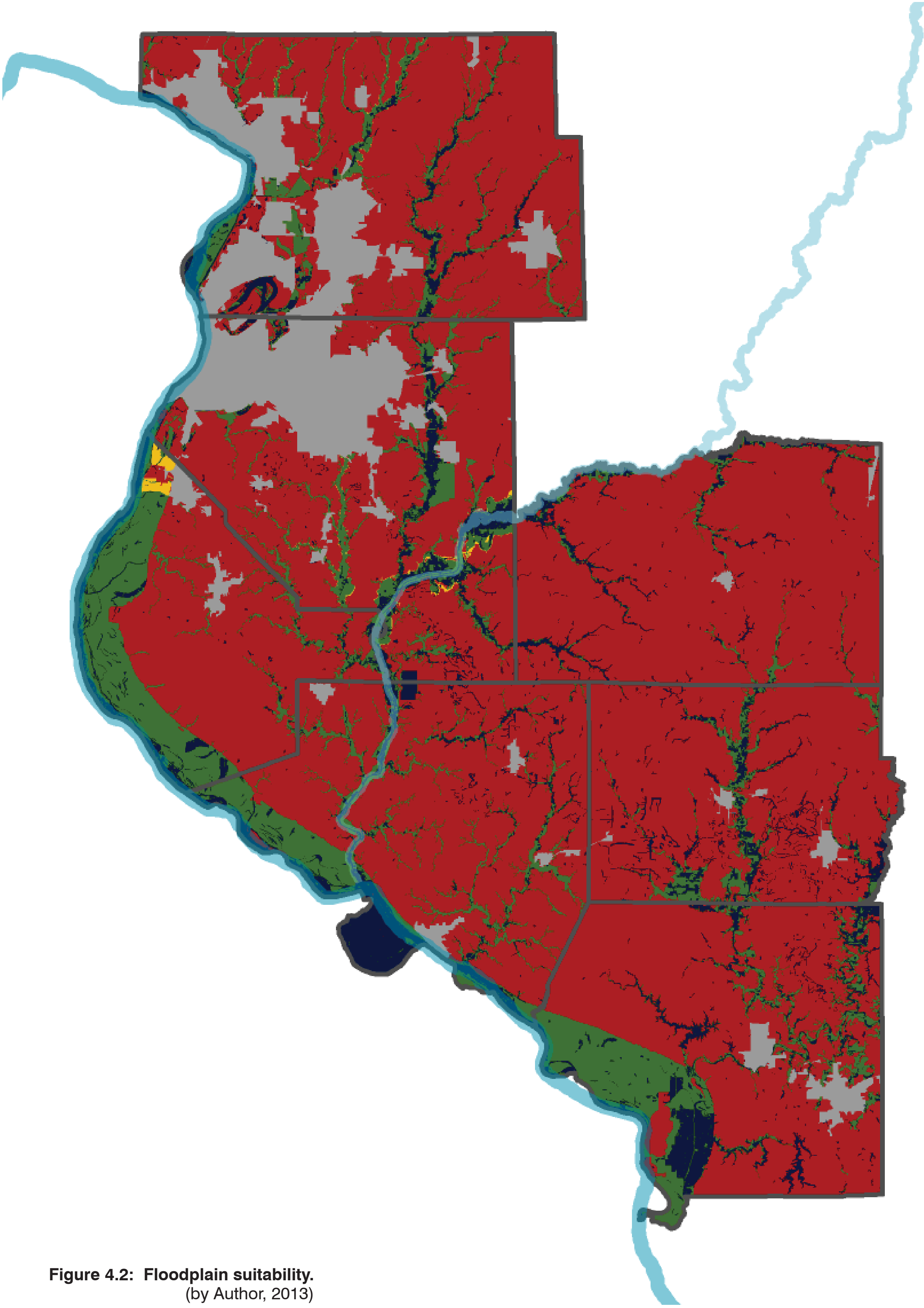
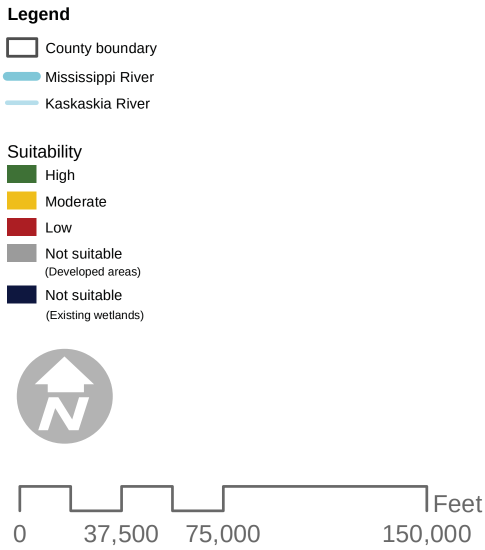


Figure 4.2: Floodplain suitability.
(by Author, 2013)



Floodplain suitability

Because the land is saturated during periods of flooding, a floodplain is suitable for a wetland. A location within the 100 year floodplain was highly suitable, while an area located within the 500 year floodplain was moderately suitable (Figure 4.2). A location outside of both floodplain areas was considered least suitable (Figure 4.2). A wetland could potentially exist outside of the floodplain so a suitability ranking of not suitable was avoided. Palustrine, lacustrine, and especially riverine wetlands can occur within the floodplain.

The Center for Watershed Protection (2010) used floodplains as an indicator of wetlands for their research on delineating wetlands.

The floodplain suitability layer was given a weight of 10% for the overall weighted overlay.

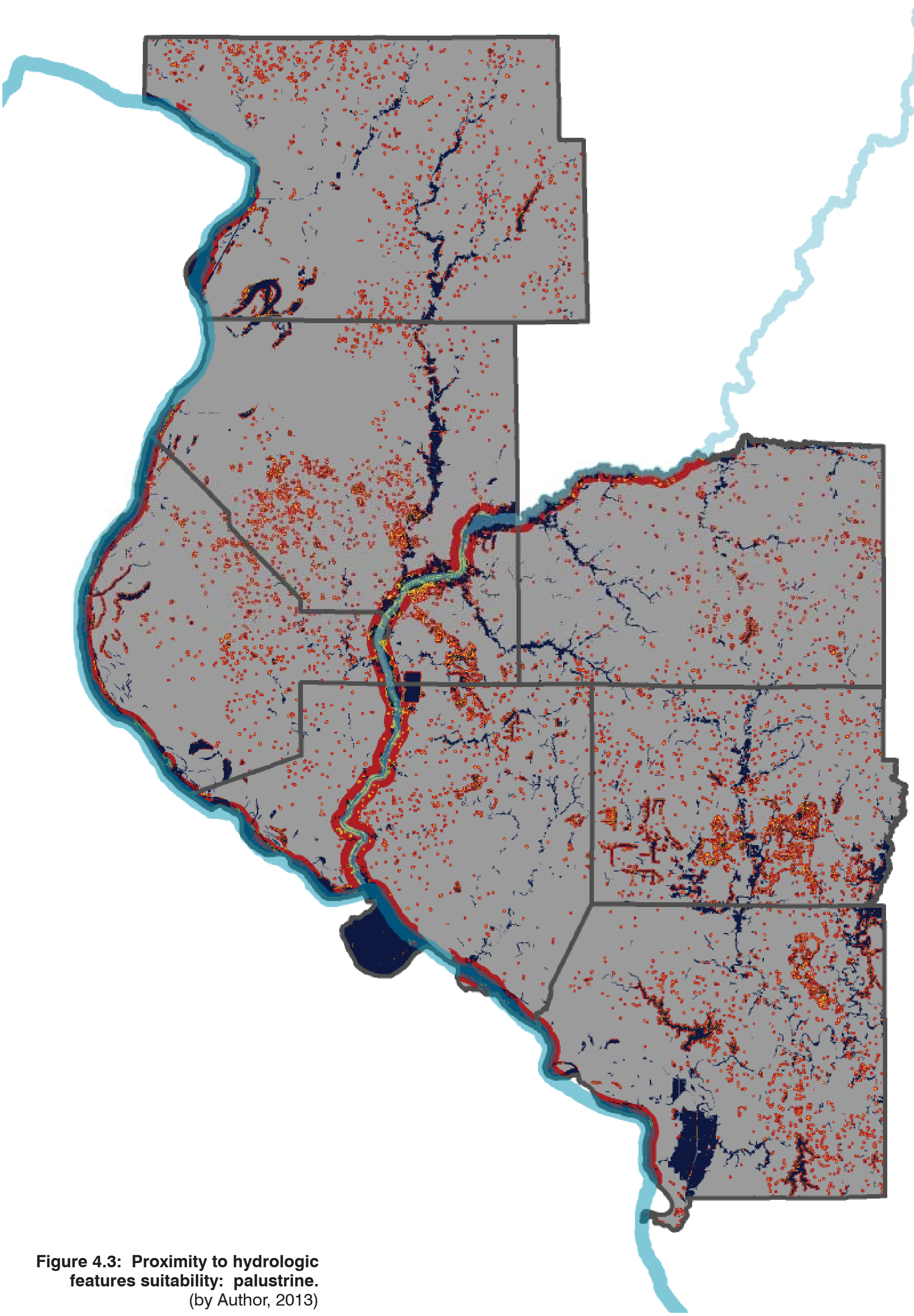
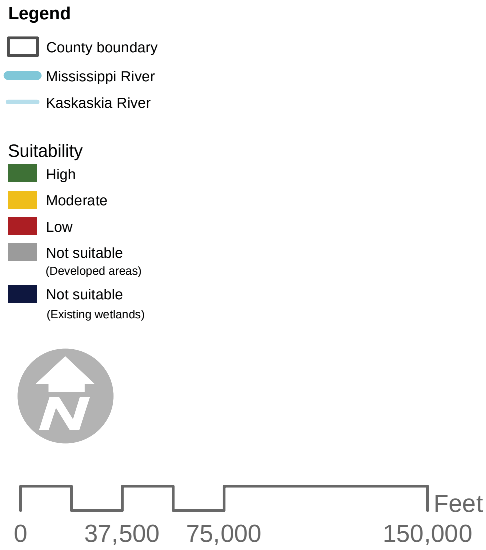


Figure 4.3: Proximity to hydrologic features suitability: palustrine.
(by Author, 2013)



Proximity to hydrologic features suitability

The presence of water is crucial to wetland existence. A water source must be located within a feasible distance from the wetland so the wetland may still obtain necessary water. The water source type depends on the proximity considered suitable. Rivers have a wider proximity range for suitability than streams, because both river systems in Southwest Illinois are larger and convey more water. By the fluvial geomorpholic definition, rivers and streams cannot be differentiated. For this analysis, rivers and streams were differentiated by data availability and classification.

Specific wetland types are usually associated with certain hydrologic features. Hydrologic features used in the analysis for palustrine wetlands were lakes, ponds, and rivers. Lakes, reservoirs, impounded rivers, and depressions were used for lacustrine wetland hydrologic features, and riverine wetland hydrologic features included un-impounded rivers and streams. Exact hydrologic features and proximity ranges can be found in Table 4.1, 4.2, and 4.3 respectively. Proximity to hydrologic features for palustrine wetlands is found to the left, Figure 4.3, while lacustrine and riverine suitability maps are on the followings pages (Figure 4.4, Figure 4.5).

Proximity to hydrologic features was given a weight of 20%.

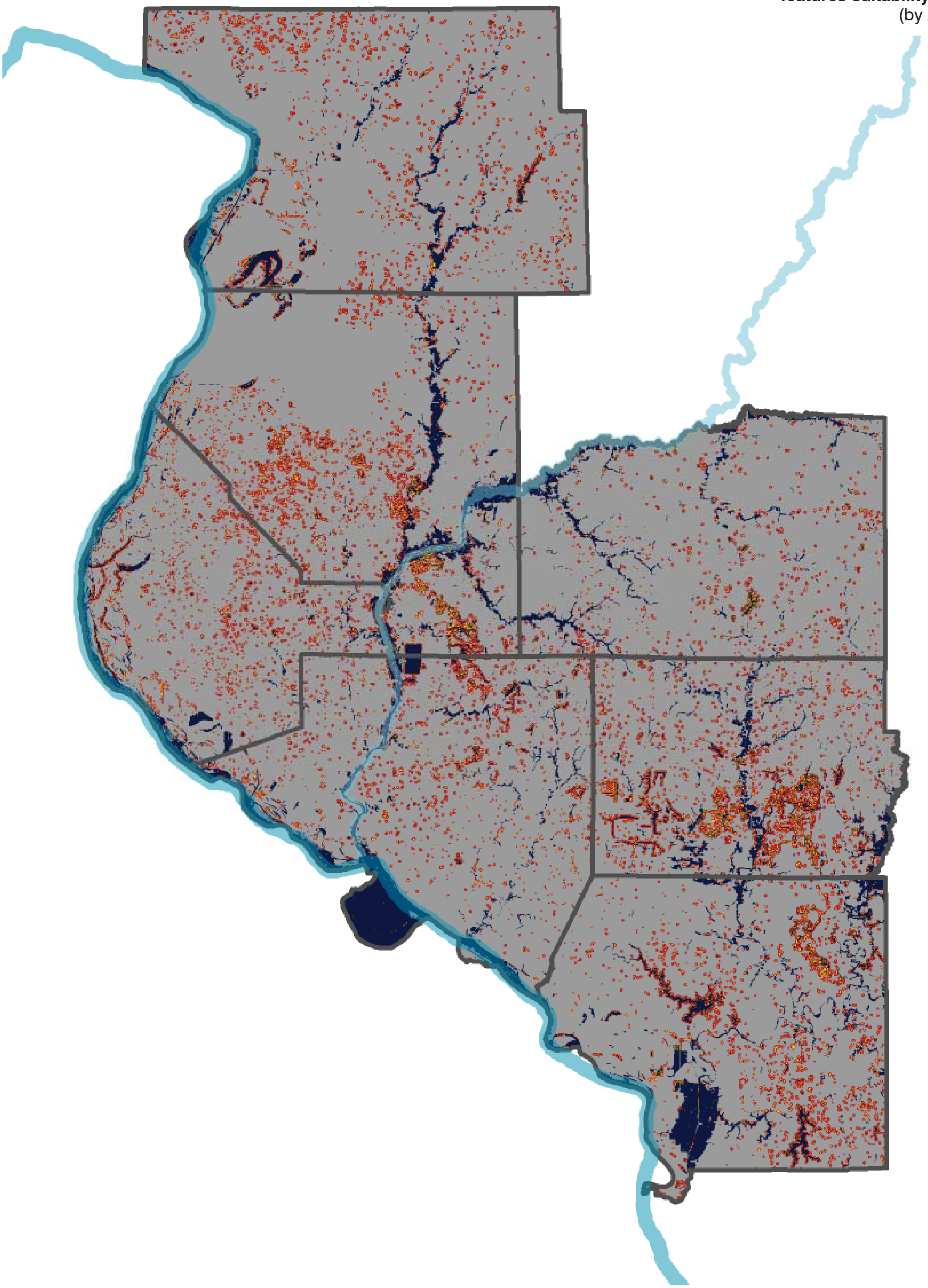
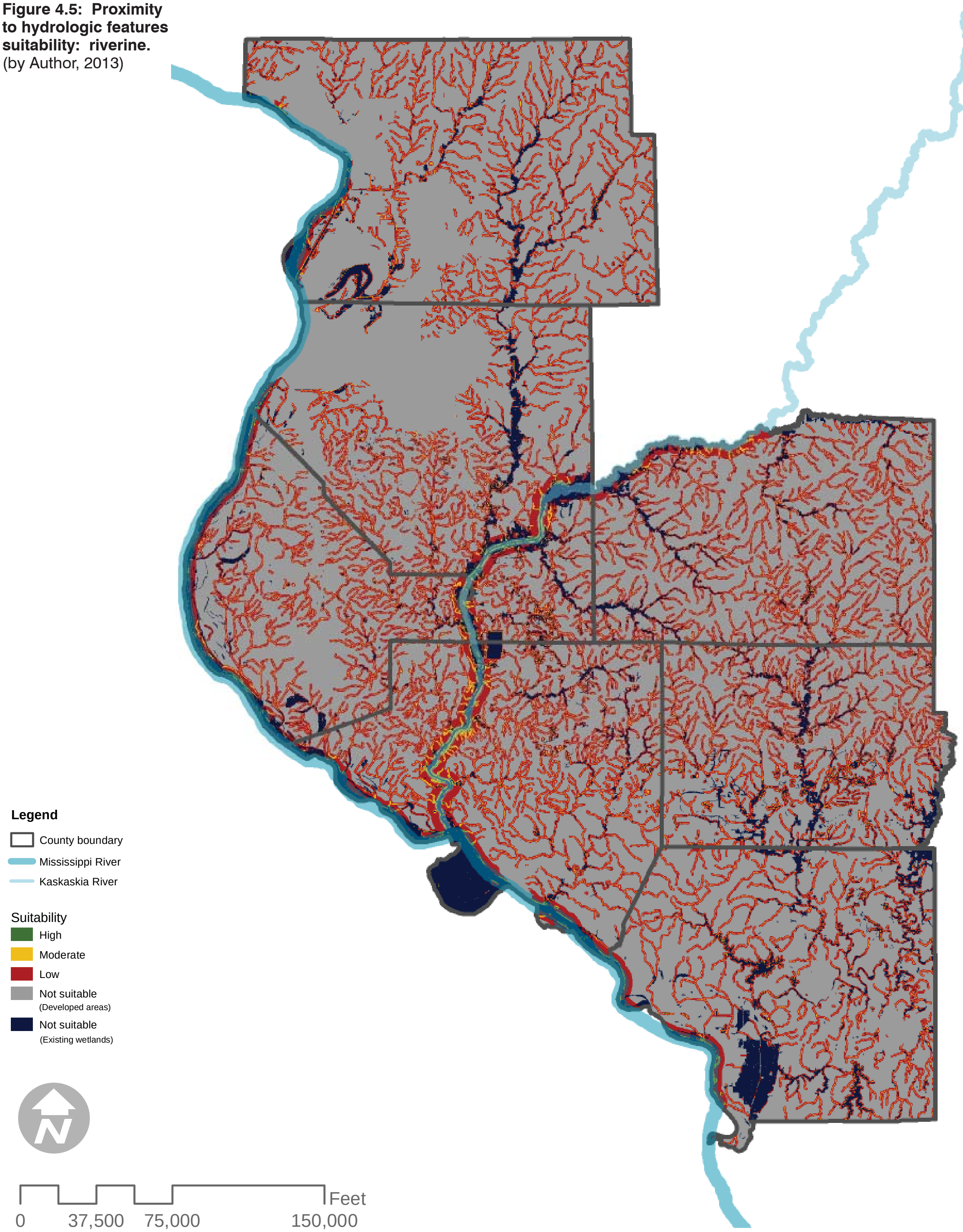


Figure 4.4: Proximity to hydrologic features suitability: lacustrine.
(by Author, 2013)

Figure 4.5: Proximity to hydrologic features suitability: riverine.
(by Author, 2013)



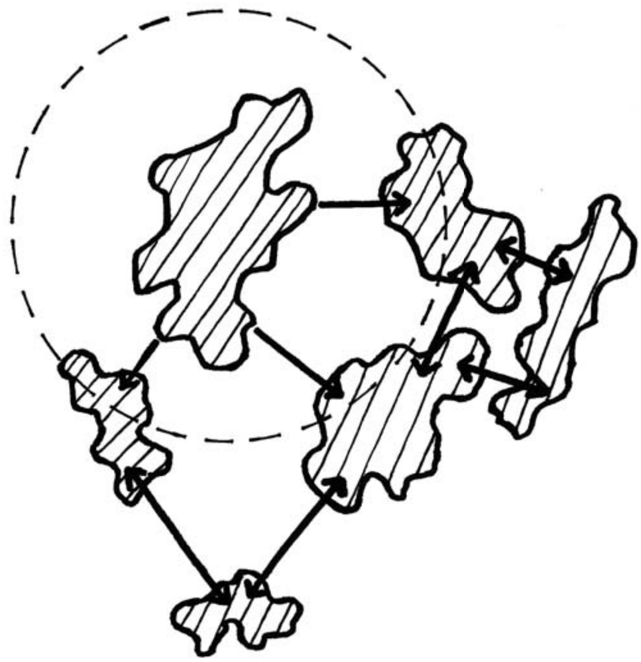


Figure 4.6: Transfer of species between patches, "home ranges".
(by Author, 2013, created from Barnes, n.d.)

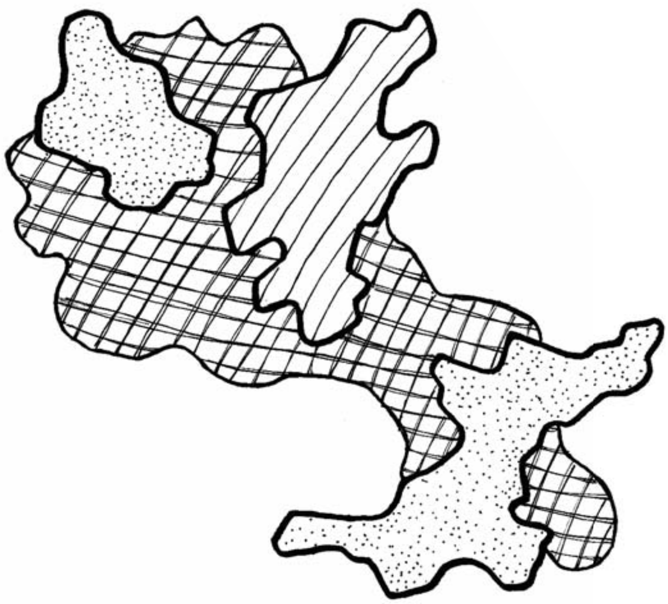


Figure 4.7: Diversity of habitat adjacencies.
(by Author, 2013, created from Barnes, n.d.)

Proximity to wetlands + INAI suitability

"Context is just as important as content" (Barnes, n.d., p. 2). Connecting to existing wetlands and other natural or conserved areas is beneficial to restored or created wetlands (Brown & Stayner, 1994; Kramer & Carpenedo, 2009). The closer the potential wetland site is to an existing natural or conserved area, the more the natural site can positively affect the wetland. Close proximity allows feasible species, nutrients, seeds, and materials transfer can be between patches (Figure 4.6) (Barnes, n.d.). If native species surround a habitat, the more likely native species will be present in the restored or created wetland. As the distance increases between a natural or conserved habitat patch from a potential wetland site, the less important and impactful the natural or conserved patch becomes to the potential site (Kramer & Stayner, 1994). A variety of adjacent habitat patches are valuable to wildlife species (Figure 4.7), especially for wildlife needing several different habitat types throughout their life cycle (Brown & Stayner, 1994). Brown and Stayner (1994) used the Natural Areas Inventory as the natural areas to connect with. For this analysis, the data from Illinois Natural Areas Inventory (INAI) and the National Wetlands Inventory was used.

Existing wetlands (Figure 4.8) and INAI areas were grouped into three size categories: 10.01-50 acres, 50.01-100 acres, and 100.01 acres and above. All wetland and INAI patches under ten acres were excluded from the analysis (Brown & Stayner, 1994) to allow focus on larger land areas that could provide a better core habitat, and for clarity of the overall analysis and graphics. Pautler-Annbriar Karst System and Renault Karst Area, the two large INAI areas in Figure 3.8, were excluded from the analysis because the areas' surfaces are not conserved; rather the underground features are protected, like the ground water and cave systems. Including the two large "natural areas" would skew the results for the overall analysis.

There is no set distance between habitat patches that serves as the ideal proximal distance. Proximity is dependent upon ecosystem or habitat type, habitat size, and organisms inhabiting the ecosystem. Because of the lack of time to analyze all habitat types, sizes, and organisms, the home range of select endangered and threatened species were used to inform the proximity distance for this analysis. Home ranges are the distance a species travels for resources, mating, and nesting. Similar to proximity ranges, the home range is dependent on habitat type, habitat size, and the organism itself.

The home ranges of the Common Moorhen, Least Bittern, Barn Owl, Black-crowned Night Heron, Eastern Narrowmouth Toad, Illinois Chorus Frog, and Eastern Massasauga (Table 4.4) were used to create proximity ranges.

Figure 4.8: Conserved wetland area dominated by Bald Cypress, Monroe County. (opposite page)
(by Author, 2012)

The Watershed Resources Registry (2013) suggested a 200 foot proximity as the most desirable distance between habitat patches that accommodates species travel. The 200 foot buffer was the beginning range of the smallest acreage group, as seen in Tables 4.1, 4.2, and 4.3. A multiplier of three was applied horizontally and vertically in the wetland and INAI proximity portion of the analysis tables to best align with the home ranges of the specified endangered and threatened species (Tables 4.1, 4.2, 4.3). Suitable proximities for the 100.01+ acreage group reach the maximum end of the species' home ranges, but the habitat patch is large enough to support the species internally. For the 10-50 acres group, the suitable proximity ranges are smaller to accommodate the lack of habitat size, not substantial enough for species to solely inhabit.

The most suitable areas for wetlands were located along major hydrologic features, such as the Mississippi and Kaskaskia River. Small clusters of highly suitable areas for proximity to wetlands were located in eastern Perry and Jackson Counties.

Suitable areas proximal to INAI are primarily located around areas near the Mississippi and Kaskaskia River.

Proximity to wetlands and proximity to INAI received a weight of 10% each for the final weighted overlay.

Home Range of Select Endangered and Threated Species of Southwest Illinois

Species	Species type	Minimum range	Maximum range	
Common Moorhen	bird	580'	920'	(Takano & Haig, 2004)
Least Bittern	bird	440'	1960'	(Bogner & Baldassarre, 2002)
Barn Owl	bird	4030'	18485'	(Martin, Raid, & Branch, 2005)
Black-crowned Night Heron	bird	1040'	3280'	(Sharp, 1995)
Eastern Narrowmouth Toad	amphibian	590'	1970'	(Dodd & Cade, 1998)
Illinois Chorus Frog	amphibian	15748'	25200'	(Trauth, Trauth, & Johnson, 2006)
Eastern Massasauga	reptile	1200'	2775'	(Durbian, King, Crabill, Lambert-Doherty, & Seigei, 2008)

Table 4.4: Home ranges.
(by Author, 2013, created from sources integrated in table)

Figure 4.9: Proximity to wetlands suitability.
(by Author, 2013)

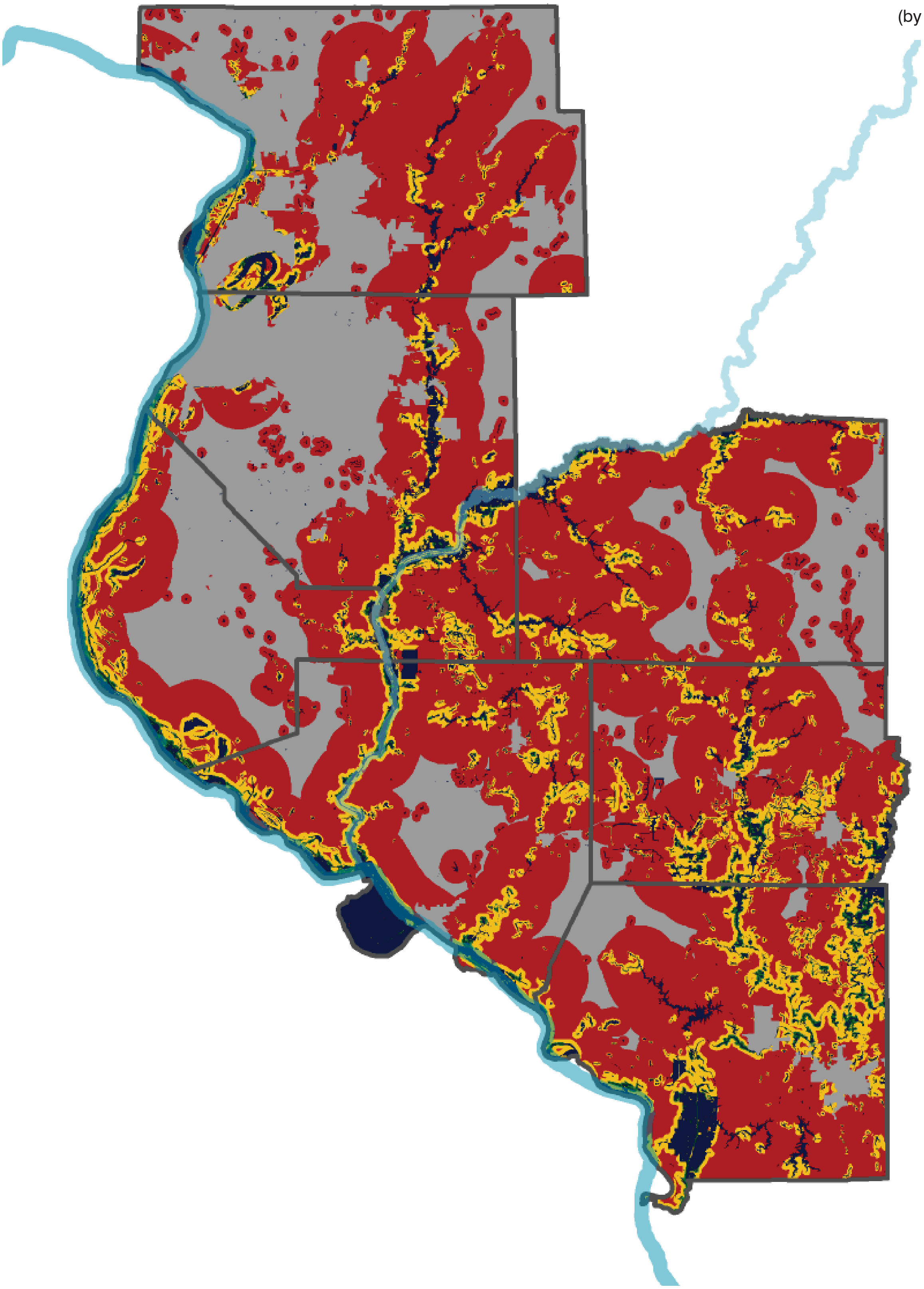
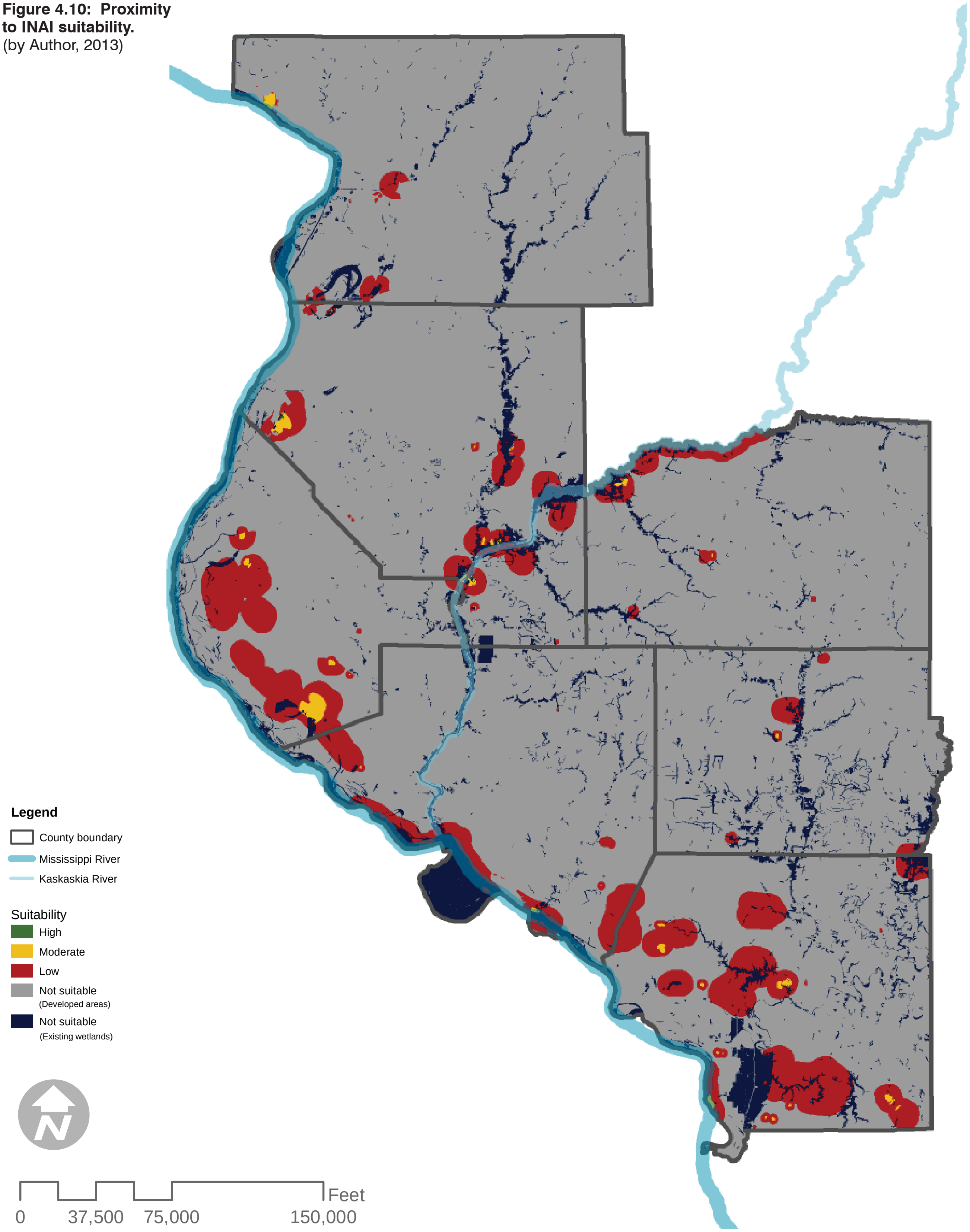


Figure 4.10: Proximity to INAI suitability.
(by Author, 2013)



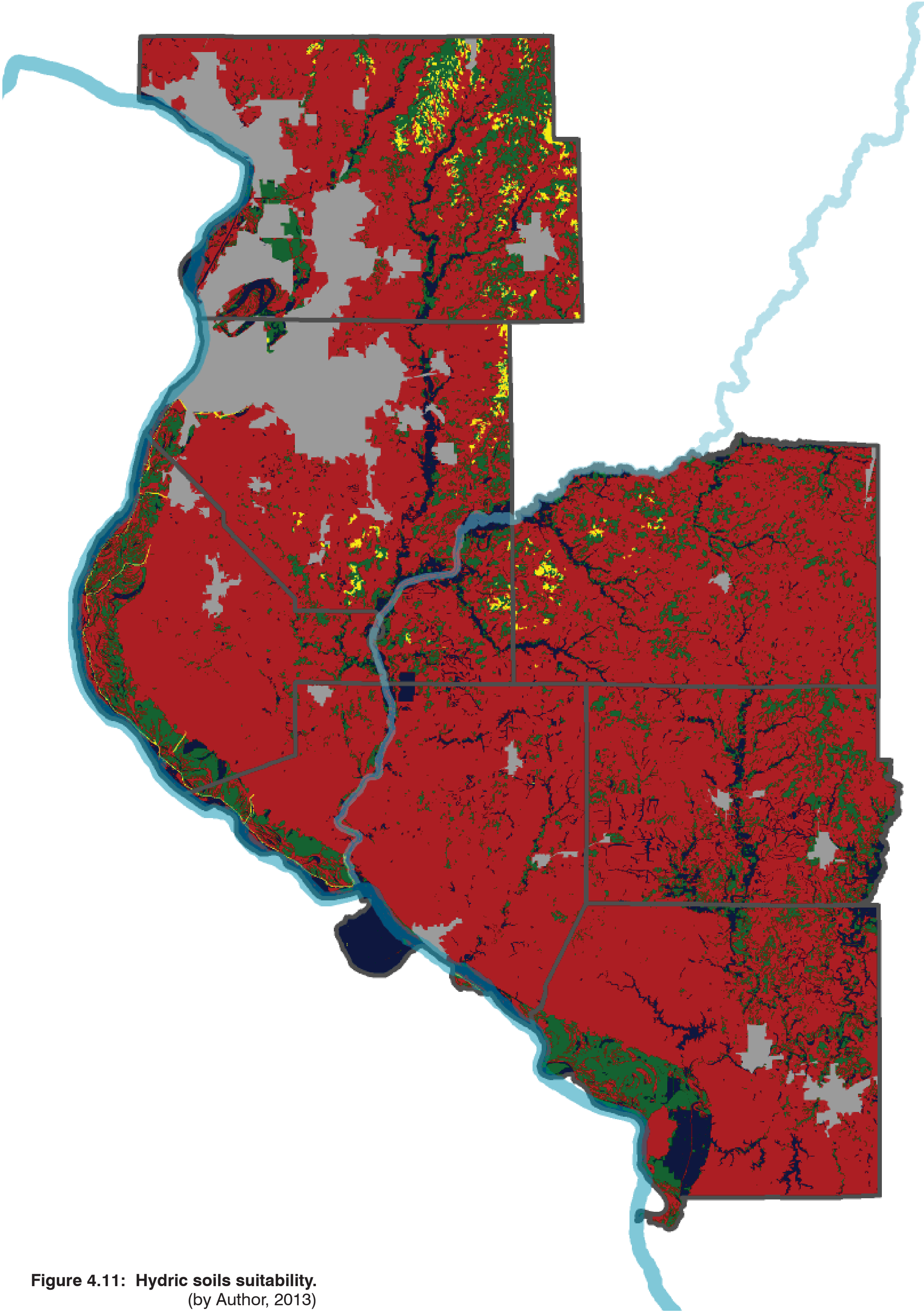
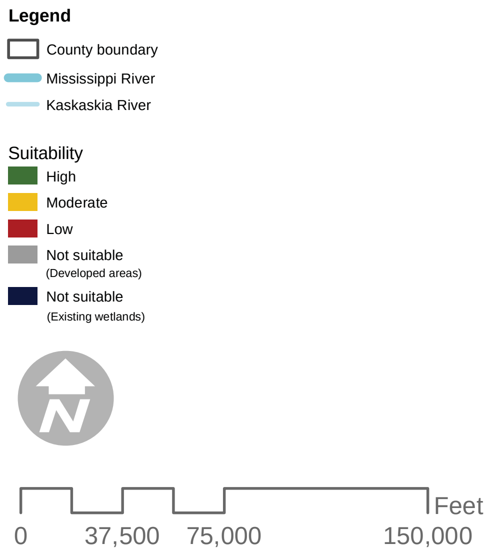


Figure 4.11: Hydric soils suitability.
(by Author, 2013)



Hydric soils suitability

The generally accepted soil of wetlands is hydric soils (Hammer, 1997; USDA & NRCS, 2010). Vegetal life present is affected by hydric soils, which influences the ecosystem as a whole. Wetlands were more likely to have existed where hydric soils are present than where hydric soils are absent. The Center for Watershed Protection (2010) included hydric soils in an analysis for wetland identification, and ranked the presence of hydric soils as most suitable, partial hydric soils as moderately suitable, and non-hydric soils as not suitable. Brown and Stayner (1994) also identified hydric soils as a critical element to wetlands. Existing hydric soils make an area more physically suitable to successfully restore or mitigate a wetland (Brown & Stayner, 1994).

For the Southwest Illinois wetland analysis, hydric soils were ranked similarly to the Center for Watershed Protection's suitability rankings. All hydric soils were most suitable, represented in green, partial hydric soils were moderately suitable, and non-hydric soils were least suitable (Figure 4.10). Much of Southwest Illinois does not contain hydric soils, potentially due to human alterations to the soil. Soils which remain are located along the Mississippi and Kaskaskia, with patches in northeast Madison County and the eastern edge of Washington, Perry, and Jackson Counties.

Hydric soils were given a weight of 20% for the weighted overlay.

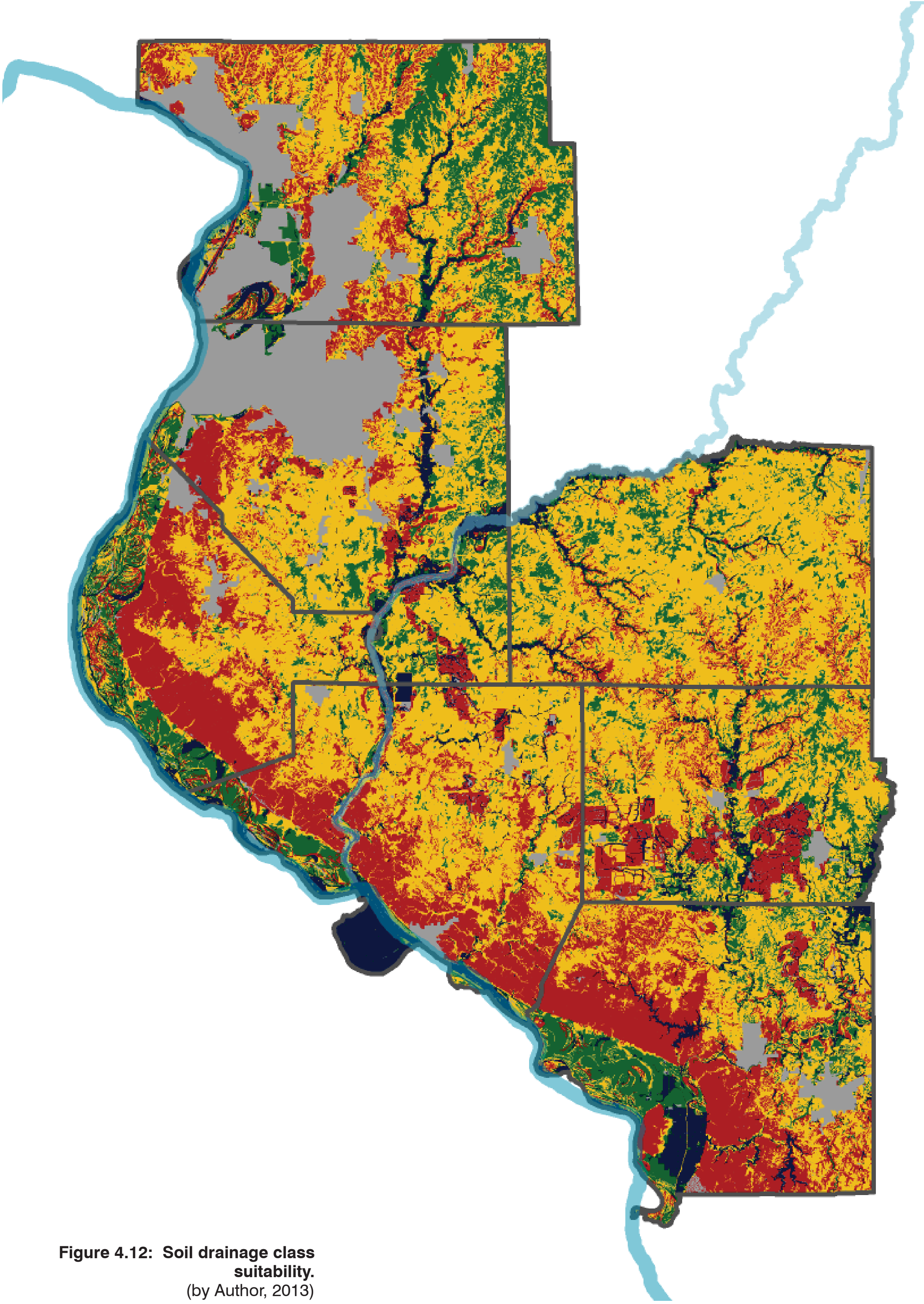
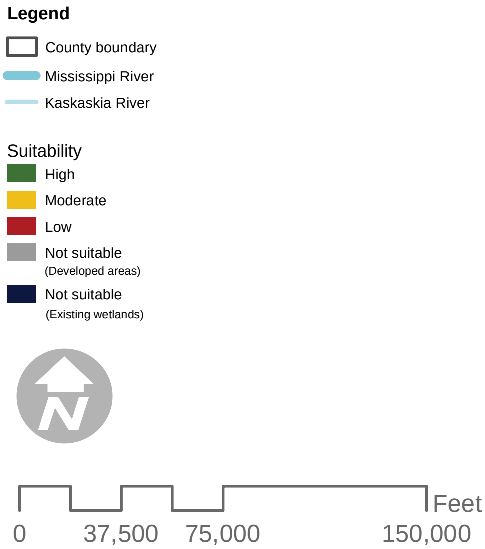


Figure 4.12: Soil drainage class suitability.
(by Author, 2013)



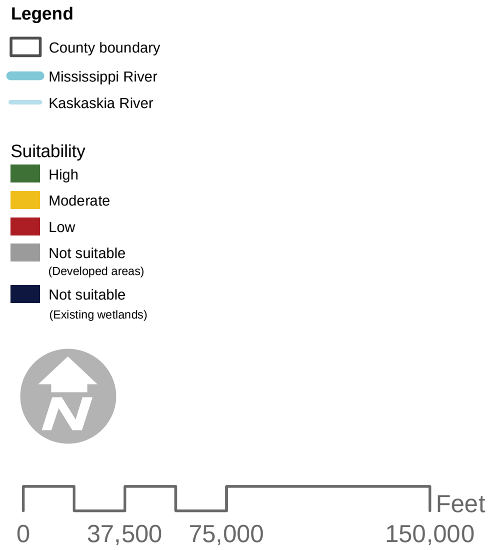
Soil drainage class suitability

To encompass all soil types wetlands may exist on, drainage class was included in the analysis. A wetland can be sustained on soils other than hydric, but the soil type must have the capability to allow water pooling or soil saturation. Brown and Stayner (1994) included drainage class for similar reasons in their methodology for identifying potential mitigation sites.

Each attribute was reclassified and received a suitability rating of one through four. Because of the multiple attributes available for soil drainage class, some attributes received the same suitability rating: Excessively well drained = 1, somewhat excessively drained = 1, well drained = 2, moderately well drained = 3, somewhat poorly drained = 3, poorly drained = 4, and very poorly drained = 4. As seen to the left (Figure 4.11) in green and yellow, most of Southwest Illinois is poorly drained to moderately well drained, which is suitable, with the exception of the area along the bluff edge.

Soil drainage class received a 10% weight in the overall weighted overlay.

Figure 4.13: Proximity to roadways suitability.
(by Author, 2013)



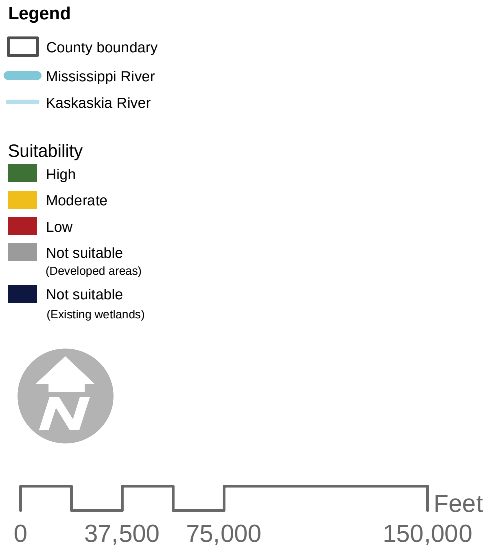
Proximity to roadways suitability

Roadways greatly impact surrounding ecosystems. Pollutants contaminate soils and runoff erodes soils and incises stream systems. Wildlife organisms are easily deterred from natural areas if roadways are in close proximity or there are dense amounts present. Brown and Stayner (1994) considered roadways harmful to habitat environments as well, not only impacting the site with toxins and noise pollution, but also physically fragmenting habitat patches.

Different types of roadways have different affects on the adjacent land. Interstates, U.S. highways, and state highways have a greater impact, negatively affecting land up to 3,000 feet away from the actual roadway (Lawrence & Brown, 2008; Forman & Alexander, 1998; Forman & Deblinger, 2000). County roadways are less impactful than highways, but are able to affect land up to 2,100 feet from the roadway (Lawrence & Brown, 2008; Forman & Alexander, 1998; Forman & Deblinger, 2000).. Both highways and county roadways are not suitable for wildlife habitat wetlands directly adjacent to the roadway, while a wetland could exist adjacent to a collector road. Collector roadways are the least impactful of the roadway classes (Lawrence & Brown, 2008; Forman & Alexander, 1998; Forman & Deblinger, 2000). See Table 4.1, 4.2, or 4.3 for proximity ranges. Southwest Illinois was highly fragmented by the roadway network, but overall had many highly suitable areas (Figure 4.12). The low suitability areas occur where highways and interstates impact the land (Figure 4.12).

Proximity to roadways received a 10% weight.

Figure 4.14: Slope suitability.
(by Author, 2013)



Slope suitability

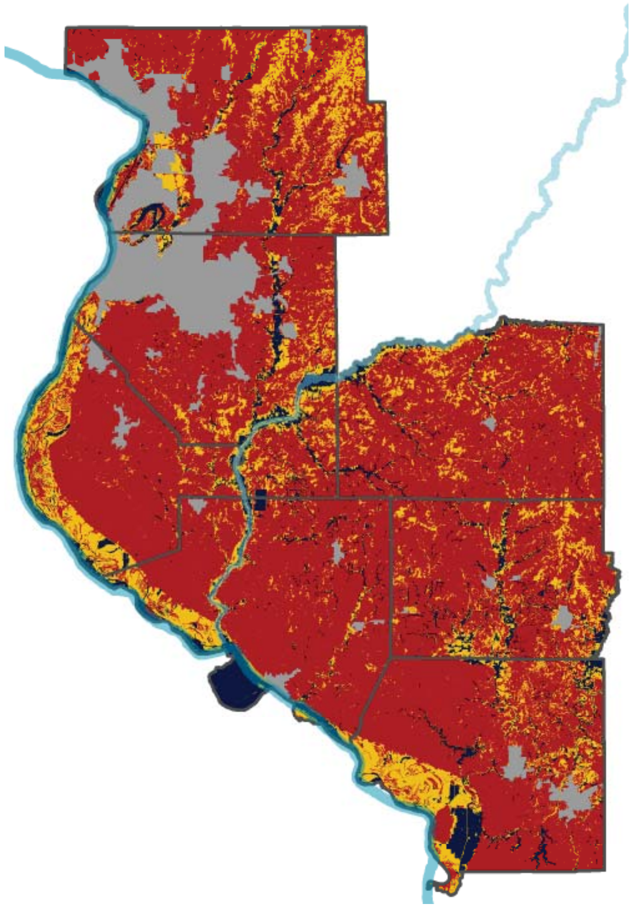
Lower slopes are more suitable for wetlands to allow pooling, and discourage drainage (MARC, 2008). No specific slope is ideal for wetlands, so slope ranges were based on the ability of a given slope to allow water collection. The flatter the slopes, the more likely the water will stand. Slopes 0%-8% are highly suitable, 8.01%-20% are moderately suitable, and 20.01%-25% are least suitable. According to the Manual of Best Management Practices for Stormwater Quality (MARC, 2008), the maximum slope a wetland can exist on is 25%. For the suitability analysis, all slopes 25% and above were considered not suitable. Excluding 25% and higher slopes primarily excluded the bluffs. The seven counties are mainly green shown on the map, which means slopes are primarily 0%-8% (Figure 4.13).

Slope suitability received a 10% weight in the final weighted overlay.

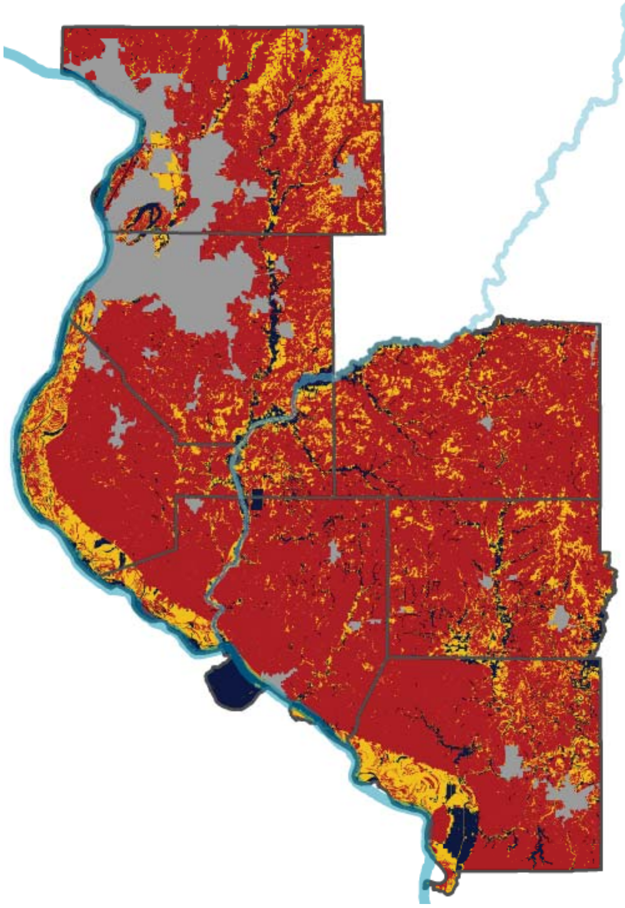
Overall suitability

Hydric soils and proximity to hydrologic features had the largest influence on the analysis (Figure 4.15) by having the most weight in the weighted overlay. All three results maps are extremely similar, especially palustrine and lacustrine. Map similarity is due to the similar factors analyzed, with hydrology being the differentiating factor.

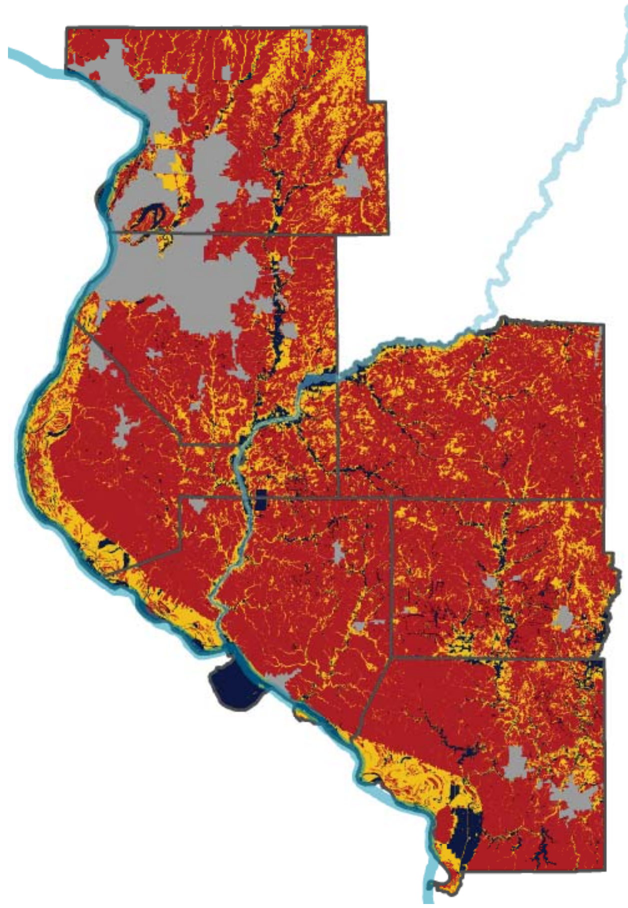
All highly suitable areas for each wetland type were closely located to existing wetlands and were small in size. Highly suitable areas for palustrine wetlands were found along the Kaskaskia River and the eastern portion of Perry and Jackson County, seen in Figure 4.16. Suitable lacustrine wetland locations were found in the eastern portion of Perry and Jackson County, along the southwestern edge of Jackson County near the Mississippi, and southwestern Madison County near the Mississippi and East St. Louis development, seen in Figure 4.17. Found in Figure 4.18, the highly suitable areas for riverine wetlands occurred primarily along the Kaskaskia River and the Mississippi floodplain in Randolph County. Overall, the most suitable areas for each wetland type were similar in location; along the Kaskaskia River, portions of the Mississippi River floodplain, and the eastern portion of Perry and Jackson County.



Palustrine suitability



Lacustrine suitability



Riverine suitability

Figure 4.15: Comparison of suitability for wetland types.
(by Author, 2013)

Legend

County boundary
Mississippi River
Kaskaskia River

Suitability
High
Moderate
Low
Not suitable
(Developed areas)
Not suitable
(Existing wetlands)

0 37,500 75,000 150,000 Feet

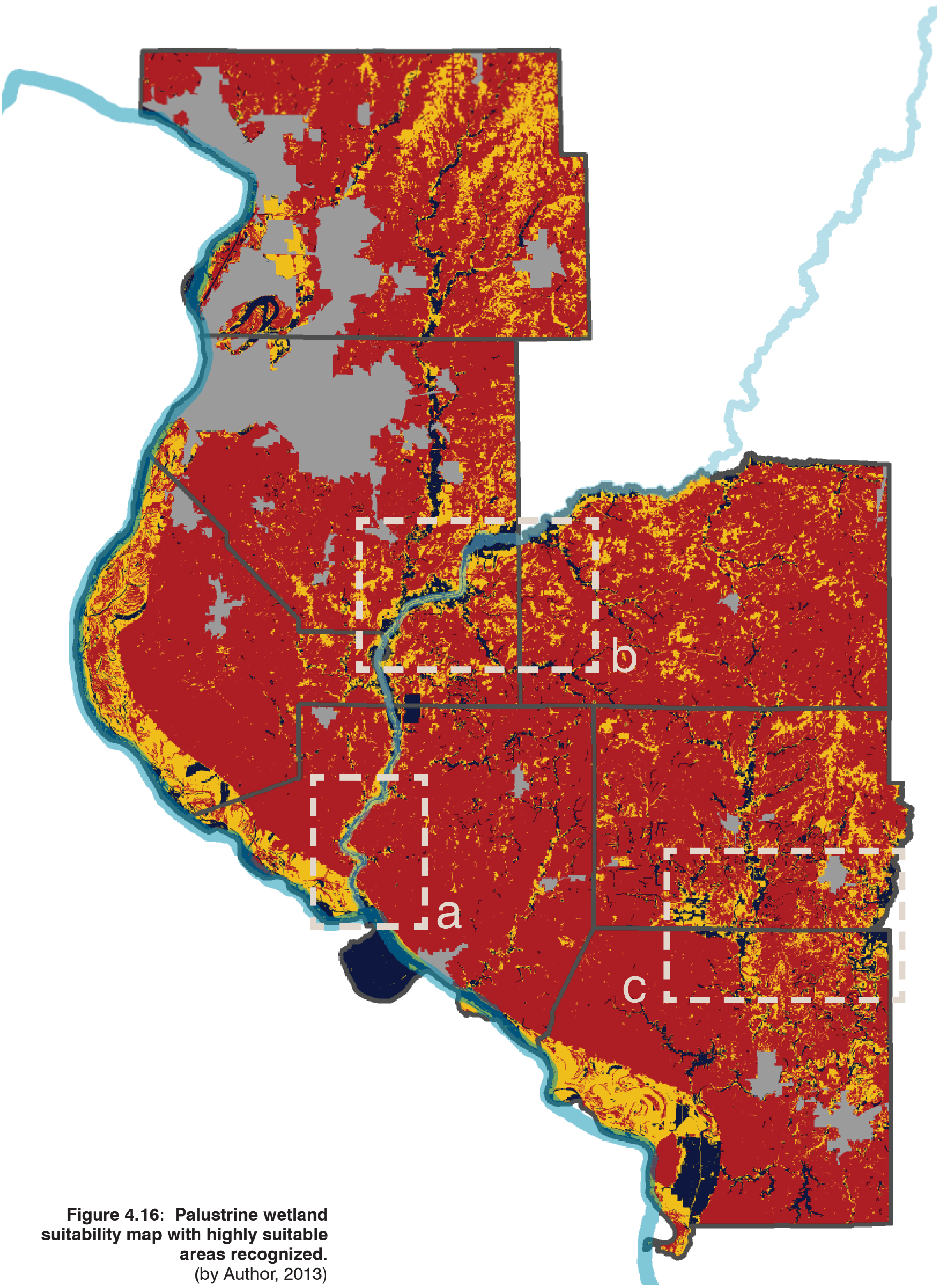
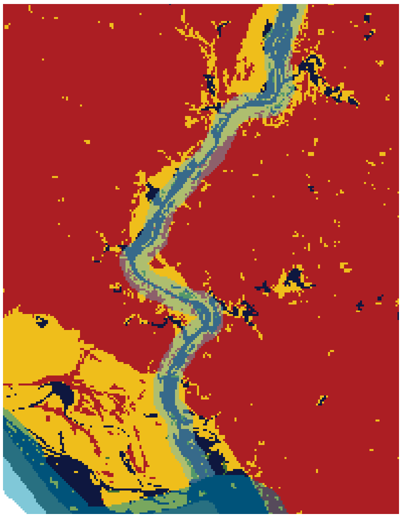
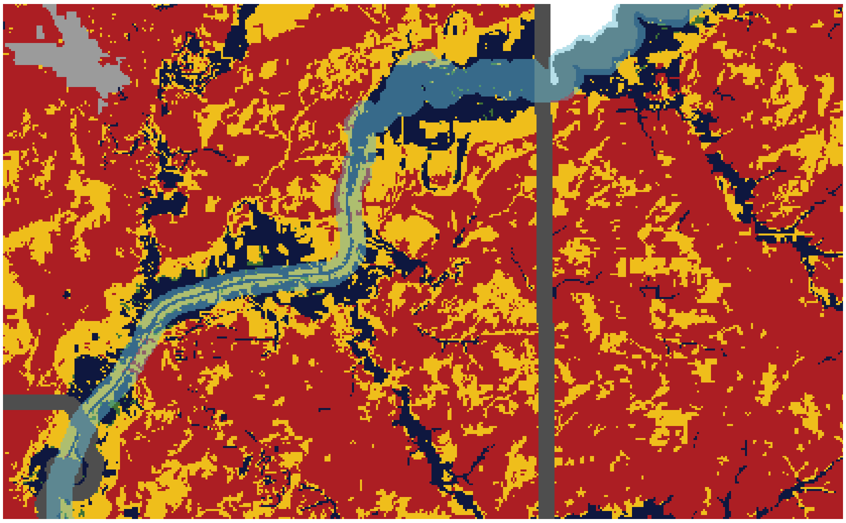


Figure 4.16: Palustrine wetland suitability map with highly suitable areas recognized.
(by Author, 2013)

Areas of high suitability



a



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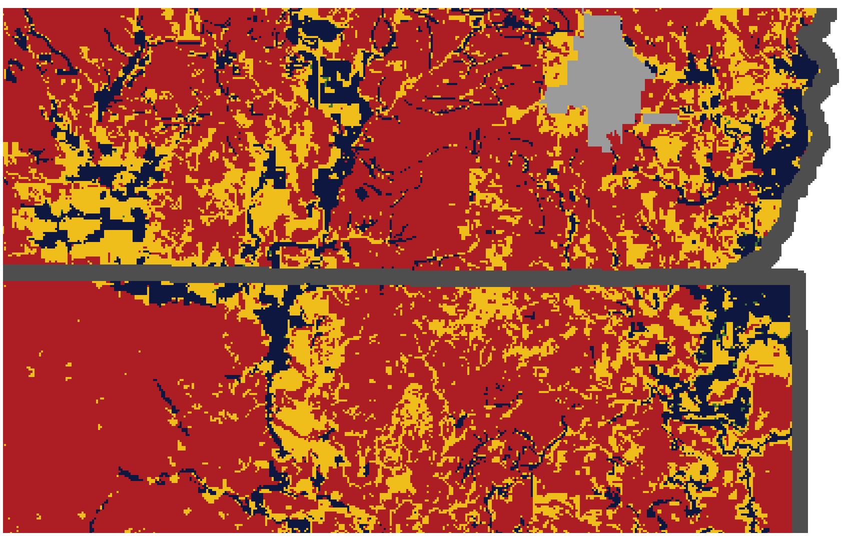

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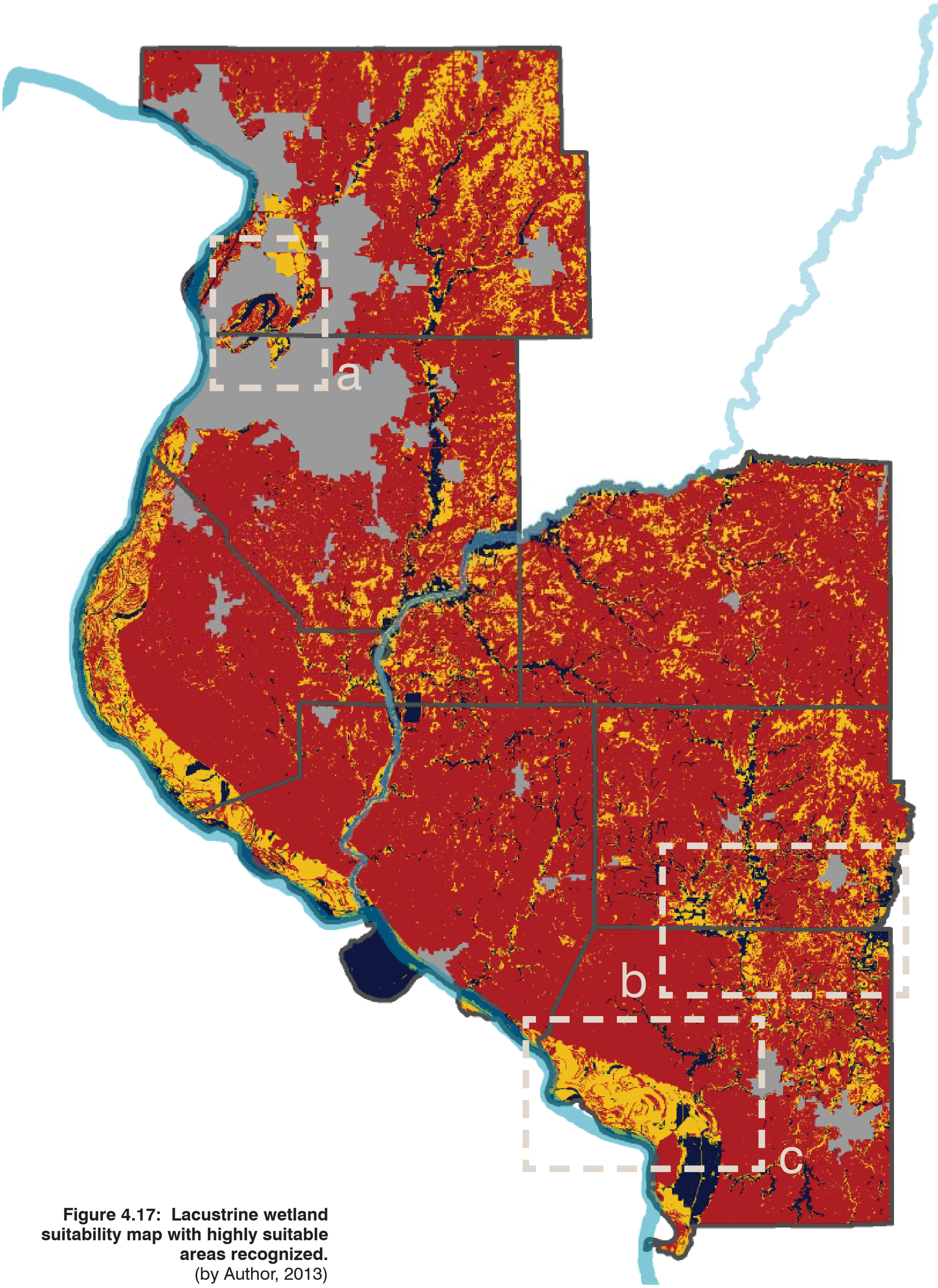
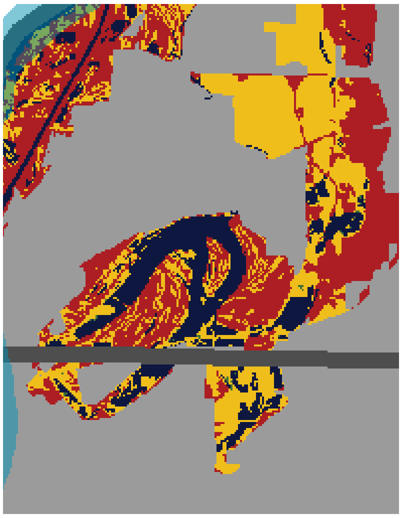


Figure 4.17: Lacustrine wetland suitability map with highly suitable areas recognized.
(by Author, 2013)

Areas of high suitability



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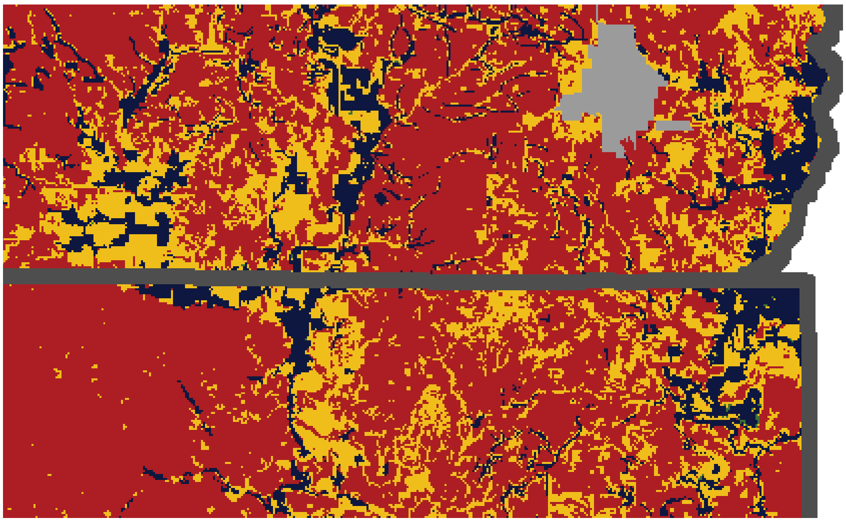

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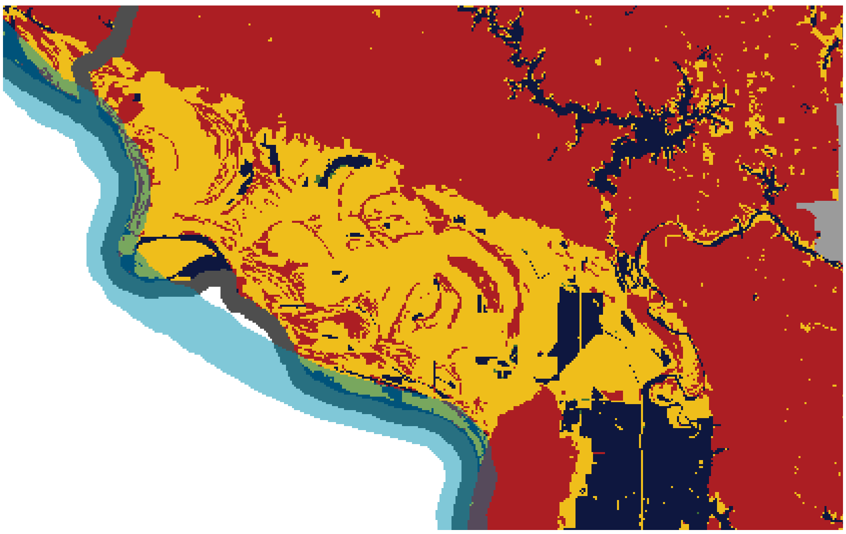

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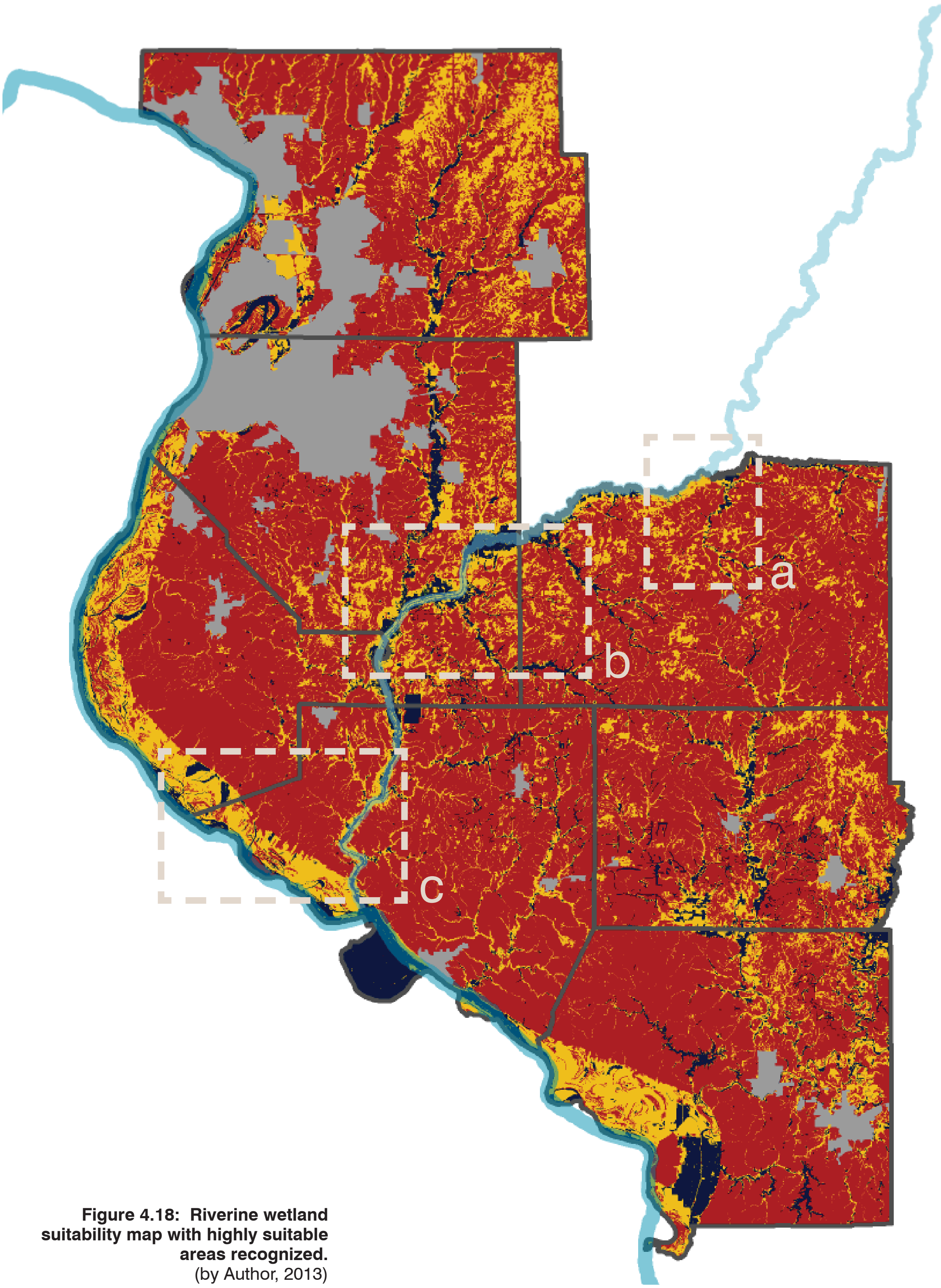
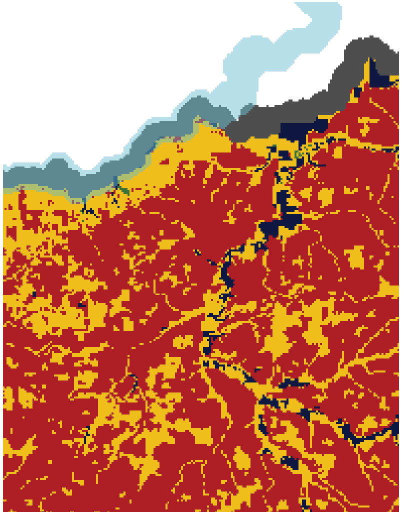
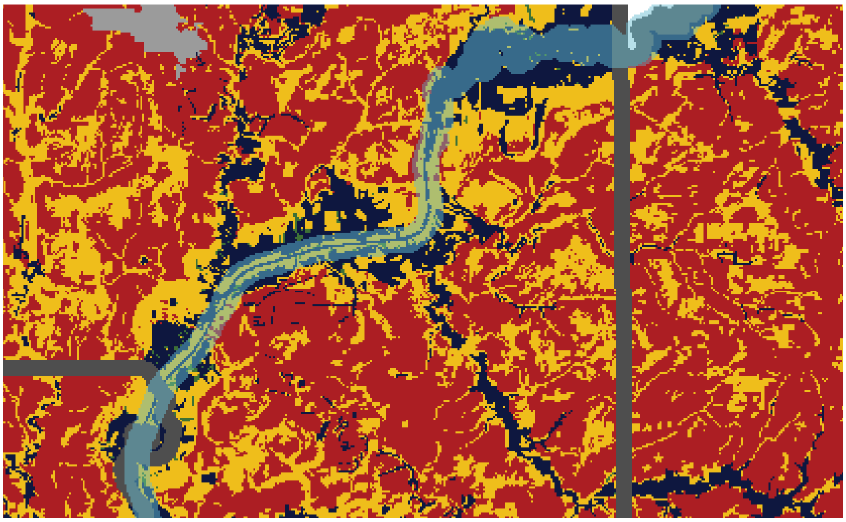


Figure 4.18: Riverine wetland suitability map with highly suitable areas recognized.
(by Author, 2013)

Areas of high suitability



a



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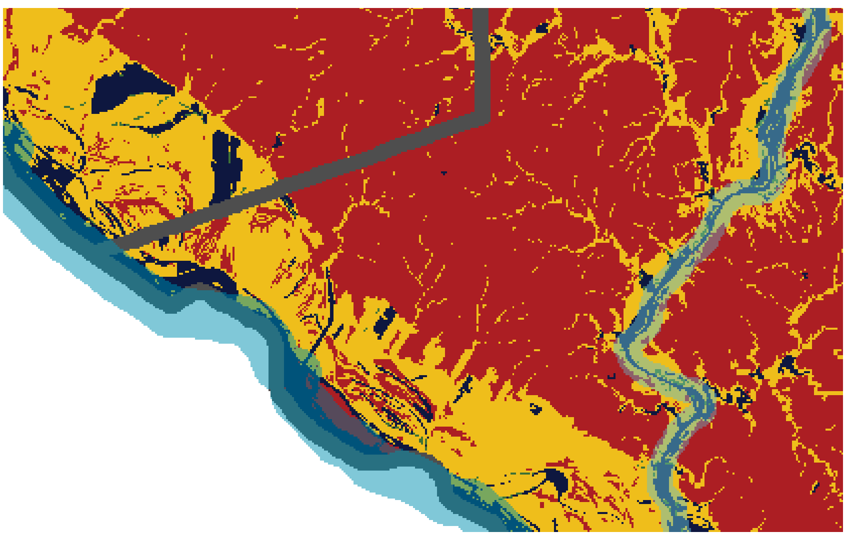


c

Conclusions + limitations + recommended actions

[5]

Highly suitable areas + existing wetlands

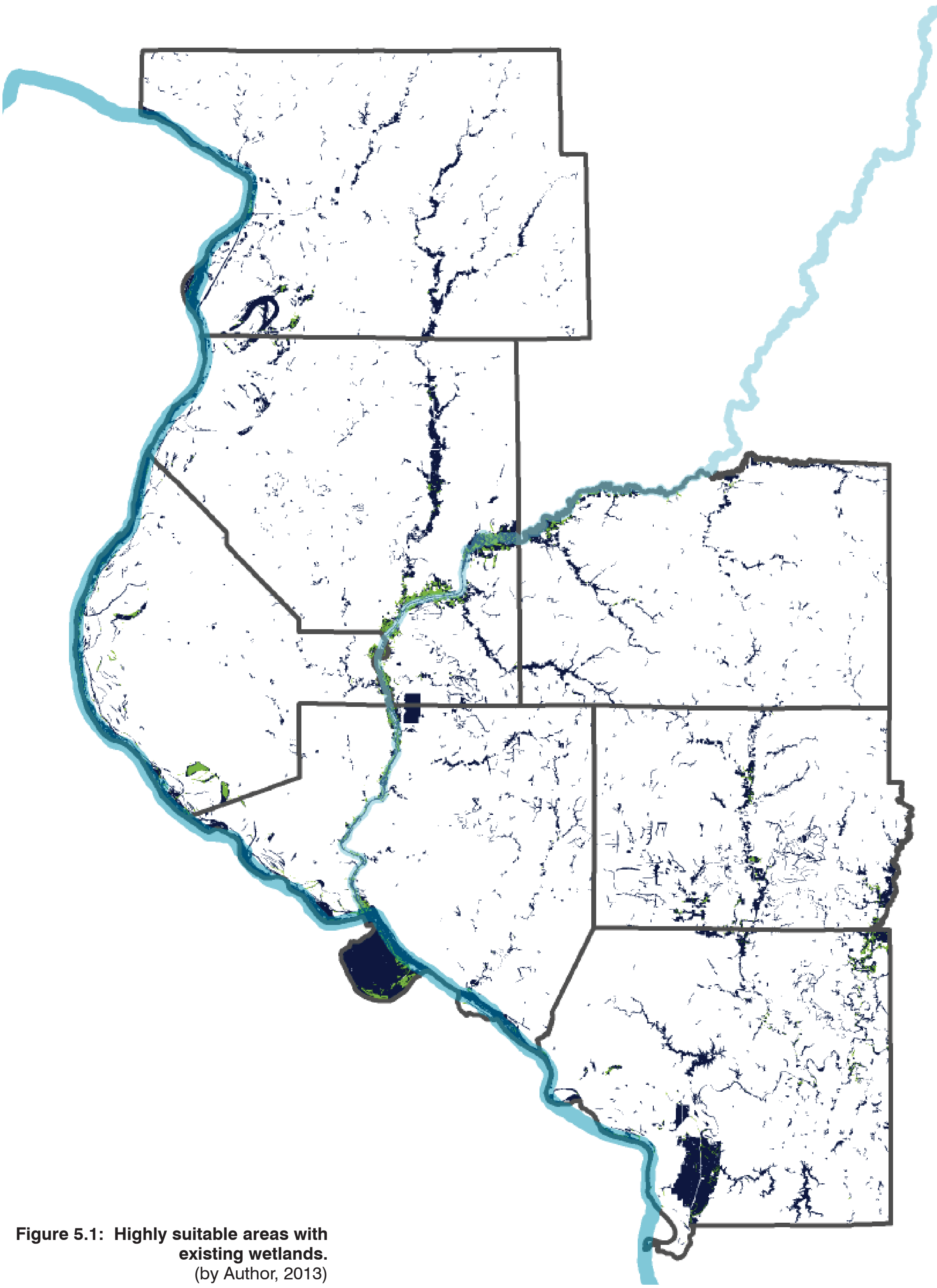
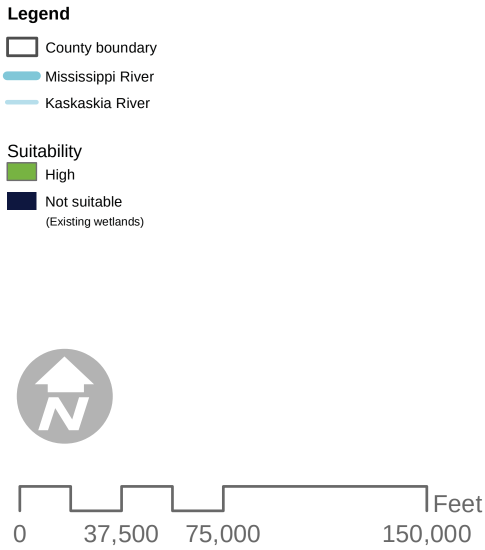


Figure 5.1: Highly suitable areas with existing wetlands.
(by Author, 2013)



Conclusions + results explained

Much of Southwest Illinois, according to the results maps, are low or moderately suitable for wetlands. Low suitability results were not expected in such high quantity. Nonetheless, there are several precise areas located in Southwest Illinois which are highly suitable for wetland rehabilitation.

By receiving a suitability ranking of "highly suitable", depicted in green, the delineated areas have ideal or most desirable conditions present for potential wetlands. Yellow areas, deemed as moderately suitable, are still valuable areas for potential wetlands. Moderately suitable indicates many of the qualities needed for a wetland are present, but factors negatively influencing wetland success are present as well. Least suitable areas, represented by red, could potentially be wetland areas, but would require more work and adjustment of conditions to make the area functional. Only developed areas should truly be avoided if the wetland's intent is to serve as wildlife habitat.

The analysis was effective in conveying the inputs prescribed in the analysis method. Figure 5.1 shows the highly suitable areas on top of the existing wetland areas. The highly suitable areas in Figure 5.1 are not apparent in the results maps because existing wetlands are excluded from the analysis. Figure 5.1 demonstrates the factors utilized in the analysis were appropriate for identifying potential wetland areas because the areas coincide with existing wetlands.

Even though larger highly suitable areas were expected, the analysis results are beneficial with specific green clusters. If the maps resulted in broad expanses of highly suitable areas, there would be no clear focus on where important areas were located to initiate rehabilitation or conservation efforts.

Project limitations

Several aspects limited the project. If vegetation were to be included in the analysis, the analysis could be structured to more accurately find suitable locations for each specific wetland type. To accurately decipher between vegetation types, site visits would be necessary with the assistance of a wetland specialist. Vegetation can be analyzed through aerial imagery, but aerial imagery analysis can allow large room for error. Site visits would be beneficial for general site inventory and analysis to support the digital site inventory and analysis. Photographs and notes documenting site characteristics would add to the validity of the digital analysis.

Using the Lower Kaskaskia watershed boundary would have been more logical than using county boundaries. The Lower Kaskaskia includes a large portion of the area of interest analyzed and would have focused on the water within one drainage system.

For this project, palustrine and lacustrine analyses could be combined because the factors analyzed were so similar. Factor similarity resulted in map similarity. If the analyses were extrapolated and applied to the remainder of Illinois, the wetland analyses should remain separate because the hydrology will differ from the hydrology analyzed in Southwest Illinois.

When the factors are combined in a weighted overlay, the system implies the factors are independent, when in reality they are related (Hopkins, 1977). The analysis model created has several compounding or related factors (Hopkins, 1977). Compounding factors should be avoided so more weight is not unintentionally given to one factor. For example, the analysis criteria created in this project uses floodplains and proximity to hydrologic features as individual factors, as well as hydric soils and soil drainage class. Both sets of factors are compounding. Proximity to hydrologic features could have combined the floodplain to create one factor analyzing proximity to hydrology. Hydric soils could be eliminated since hydric soils drain poorly and soil drainage class already ranks poorly draining soils as highly suitable. Because hydric soils and soil drainage class were both included, and hydric soils had double the weight, soils actually received an approximate 30 percent weight in the analysis.

Political boundaries and land ownership would influence the feasibility of land acquisition or state and private owner partnership. Number of land owners, type of land owner, and political boundaries crossed all raise potential hindrances to acquisition. Economic value determines whether the state can viably purchase the land. If the land is too costly, the owner could volunteer to allow the state to manage the land.

Time was another limiting factor. If time allowed, a closer dialogue with Pat Malone, the Illinois Department of Natural Resources water systems and wetland specialist, would greatly benefit the project and potential outcomes. This project will continue after its academic purposes are achieved, to be pushed in a direction that will benefit the state of Illinois and its citizens.

State limitations

Issues concerning Illinois as a whole affect Southwest Illinois and are important to recognize.

The current total of state or public owned land in Illinois is minimal (Conservation, 2009). The Illinois land and water report from 2005 states the total acreage for all properties was 497,439.668 acres (DNR, 2012a). The 2010 total acreage was 470,638.553 acreage (DNR, 2012b), which is a decrease of 16,685.141 acres. Of the total acreage in 2005 and 2010, roughly 40,000 acres are water acres both years (DNR, 2012b). Illinois has no national parks, and only one national forest (DNR, 2012d). State owned public places are heavily sided with parks, 73 total, rather than wildlife refuges and nature preserves and wildlife areas, which total 30 (DNR, 2012d). Illinois appears to have a substantial amount of state owned land potentially providing wildlife habitat, but in reality it's minimal, especially in comparison to other states. Many of the state-owned parks in Illinois were acquired in the early to mid-1900s, with infrequent acquisitions made in recent years (DNR, 2012a; DNR, 2012b; DNR, 2012d).

A lack of conservation efforts plagues the state of Illinois. Only one percent of land is protected, which is one of the lowest percentages of all of the states in the Midwest, with Iowa coming in just slightly lower (Conservation, 2009). The leader, Michigan, has 12.3% land protected (Conservation, 2009).

“Illinois has several land acquisition programs but they are not doing the job” (Conservation, 2009, p.11). The Open Space Land Acquisition exists, but is lacking funding (Conservation, 2009). Wetlands Reserve Program strives to conserve land, but it’s a public program that recruits private landowners to volunteer to commit to conserving their wetlands (Wetland, 2011). The land remains privately owned, but the program assists in protection, restoration, and enhancement of wetlands (Wetland, 2011).

Illinois has major funding issues; all departments are in a financial crisis with funds diminishing (Conservation, 2009). Department of Natural Resources (DNR) suffers from large General Revenue Fund cuts (Conservation, 2009). Illinois is one of the lowest ranked states for conservation, and because of current demands on land, catching up with other states ranked highly, is financially difficult (Conservation, 2009). Land is expensive because of the flat and farmable nature (Conservation, 2009). Land protected by the state costs $4453/acre compared to the national average of $1501/acre (Conservation, 2009). Little money is spent on conservation efforts when compared to other states from 1999-2004 (Conservation. 2009).

- Florida: $24.10 (billion)
- Maryland: $20.87
- New Jersey: $19.47
- Pennsylvania: $7.09
- Illinois: $2.67

Florida, Maryland, and New Jersey are all actively trying to conserve land before developers consume the majority (Conservation, 2009). Pennsylvania is more comparable economically and still spends more than Illinois (Conservation, 2009). Illinois did rank higher than Tennessee, Michigan, and Alabama, but only by a few hundred thousand dollars (Conservation, 2009). Funding in other states is set, and some of the methods include “…General Obligation bonds, property taxes, real estate transfer taxes, a deed or other document recording fee, state sales taxes including a dedication of a portion of the tax through changes to a state’s Constitution, a set-aside of estimated sales taxes paid on sporting goods, lottery proceeds, tipping fees on garbage disposal, cigarette taxes, license plate fees, oil and gas revenues, or simple annual general appropriations passed each year by the legislature” (Conservation, 2009, p.10). Illinois does not participate in any of these methods. Data shows that Michigan has the most conservation land set aside, yet Michigan has one of the least amounts of money spent on conservation (Conservation, 2009). Conservation efforts and funding have deviated and need significant improvement if Illinois wants to compete competitively, especially in eco-tourism.

Figure 5.2: Kidd Lake Marsh, Monroe County, an INAI area.
(courtesy of Sherry Mayer, 2013)

Recommended actions

The report was intended to be applicable to parties who found interest in its content, so the targeted audience was kept vague. Ultimately, the report is best suited for the state of Illinois and conservation organizations working with Illinois land.

Loss of wetlands equates to loss of habitat (Conservation, 2009). Depletion of wetlands equates to loss of water storage area and natural flood control (Conservation, 2009). If the state could purchase the flood plain area, development could be prevented and would prevent unnecessary spending on repair costs after a damaging flood event (Conservation, 2009). The cost of maintenance and building-up on levees is expensive (Conservation, 2009). Using wetlands as flood control would give water a place to go, and save on levee expenses (Conservation, 2009). Utilizing wetlands' ability to clean and filter would be advantageous with pollutants and toxins from runoff (Conservation, 2009). Goods and foods could be produced in wetland areas (Knight, 1997; Maltby, 1986). Crops and fish can be grown and harvested from wetlands (Knight, 1997).

Many endangered and threatened species (Appendix B) specific to Southwest Illinois inhabit one or several of the seven counties being analyzed; another reason to conserve natural areas. Land acquisition does not always have to come from the state. Organizations like Ducks Unlimited, National Wildlife Federation, and The Nature Conservancy work to acquire land to protect wildlife and threatened landscapes. The Florida Forever Program is Florida's conservation of natural resources effort (FDEP, 2013). Under this program, Florida has acquired and preserved millions of acres of wetlands (FDEP, 2013). The program has an Acquisition and Restoration Council which reviews proposals, evaluates need, determines project boundaries and priority ranking, and produces an annual work plan. Illinois could use the Florida Forever Program as a model and benefit from establishing a reliable funding source as well as a more focused entity promoting conservation efforts.

Similar to Frederick Law Olmsted's Emerald Necklace in Boston, Southwest Illinois could have a network of linked conserved areas providing habitat to wildlife and accessible open space for passive recreation. New wetlands could be linked to local and regional preserves, like the Shawnee National Forest located in southern Illinois. A connected chain of conserved areas could be economically beneficial once established, attracting tourists and nature enthusiasts, but also locals.

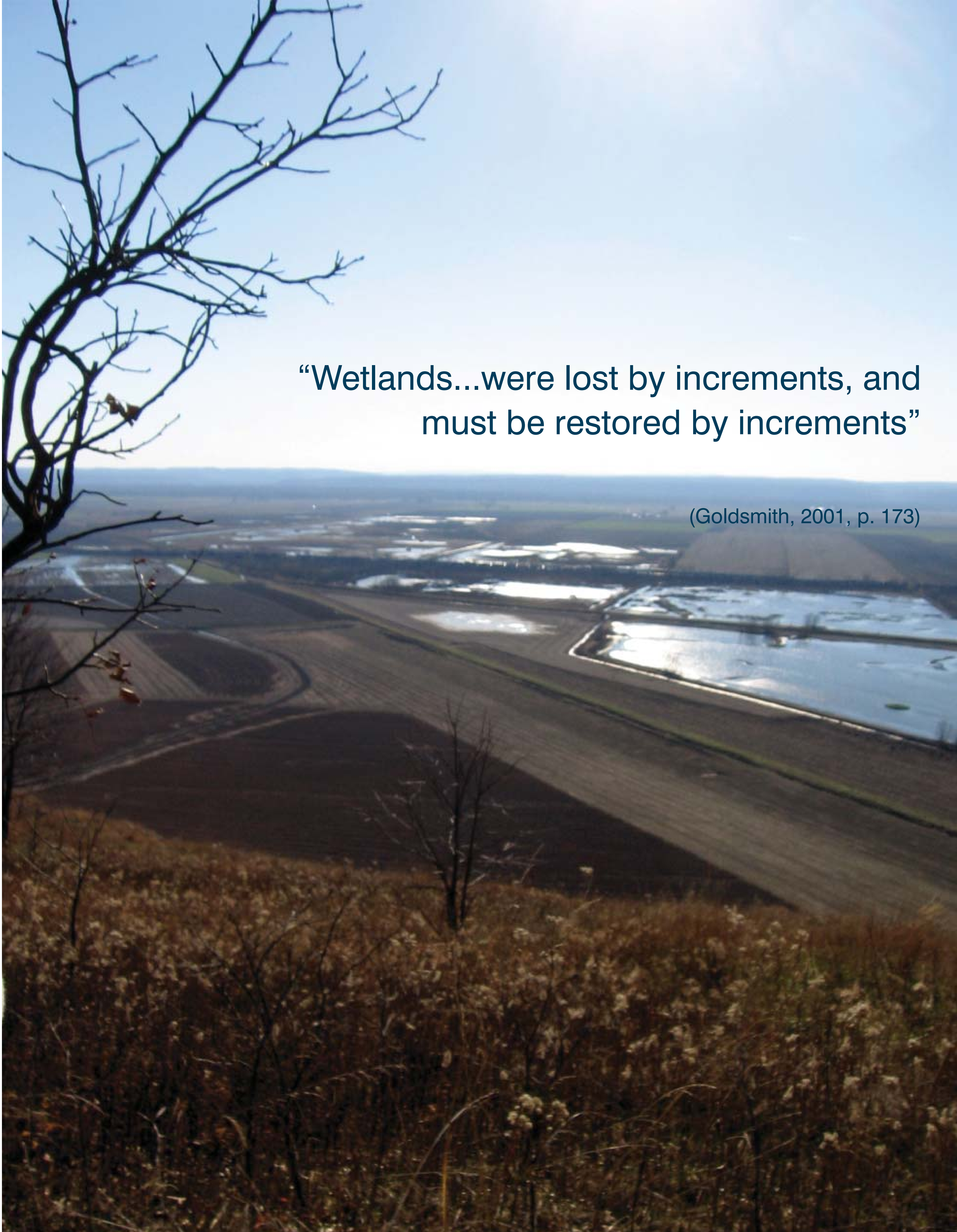
While investigating Southwest Illinois and collecting data, I discovered several protected natural areas within the seven counties I did not realize existed, even though I have lived in Monroe County my entire life. Public awareness of the natural spaces needs to be improved, as well as establishing a clear public access route if the area is intended to benefit the public. Nature is one of the greatest educators, and individuals should have the opportunity to experience nature without the impact of humans and society. Experiencing nature in its naturally occurring state is critical. Too many parks and open spaces have "museumified" nature; signs, descriptions, labels, directions to tell the visitor how he or she is supposed to experience the space. Minds develop ideas and thoughts voluntarily when allowed the freedom.

Importance

The wetland suitability analyses can be extrapolated and applied to the remainder of the state to identify potential wetland areas. An extensive analysis can build a strong foundation for in-depth design. An informed decision on site selection could impact how successful a design becomes, especially landscapes designed to provide wildlife habitat.

Understanding the concepts of natural systems and ecology are imperative to the landscape architecture profession, and are often over-looked. How can we design and manipulate the landscape without knowing what we are affecting? This project begins to look at the importance and benefits of a wetland ecosystem and the critical components that comprise a wetland.

This project incorporates the beginning phases of design, inventory and analysis, and the political parties and policies responsible for the management of the land. This project is the intersection design and policy, demonstrating how design is affected by policy, and policy is affected by design.



“Wetlands...were lost by increments, and must be restored by increments”

(Goldsmith, 2001, p. 173)

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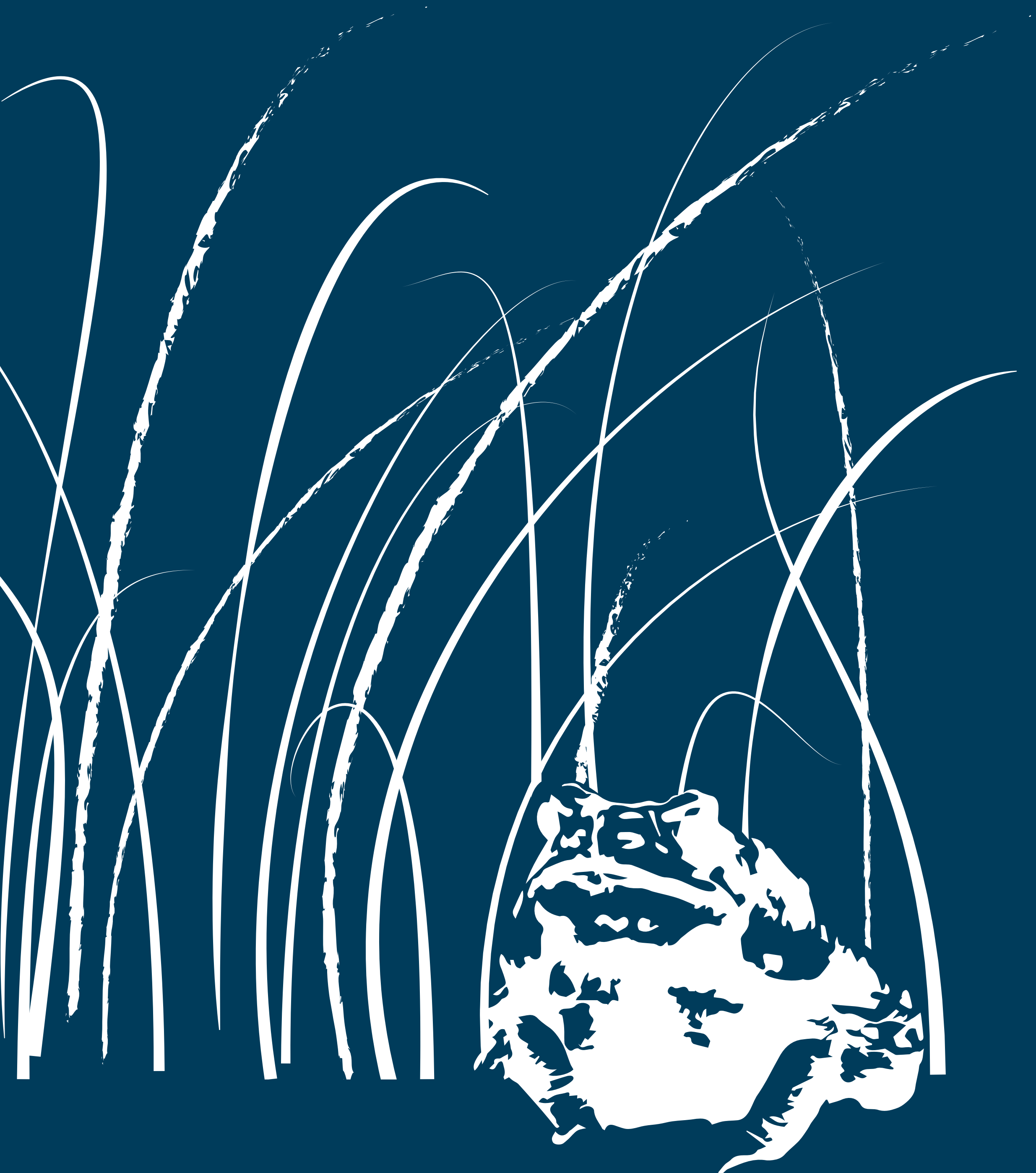

Appendices

[8]

Appendix A

Defined terms

Sustainable – economically, social equitably, and environmentally valuable and proficient (Cox, Ewald, Kisler, Mayer, & Wood, 2013)

Community – a group or association of people or organisms, with similar interests or objectives defined by geography, place, and location (Cox, Ewald, Kisler, Mayer, & Wood, 2013)

Amenity – tool, asset, enhancement that satisfies the necessity of economic, social equity, and environmental value and provide a common good for a member of a community (Cox, Ewald, Kisler, Mayer, & Wood, 2013)

Wetland – "…land that has a predominance of hydric soils (soils which are usually wet and where there is little or no free oxygen) and that is inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances does support, a prevalence of hydrophytic vegetation (plants typically found in wet habitats) typically adapted for life in saturated soil conditions. Areas which are restored or created as the result of mitigation or planned construction projects and which function as a wetland are included in this definition even when all three wetland parameters are not present" (DNR, 2013).

Natural wetland – "…areas wherein, at least periodically, the land supports predominantly hydrophytes and the substrate is predominantly undrained hydric soil or the substrate is non-soil and is saturated with water or covered by shallow water at some time during the growing season of each year. Natural wetlands have and continue to support hydric soils and wetland flora and fauna" (Hammer, 1997, p.11).

Restored wetland – "…areas that previously supported a natural wetland ecosystem but were modified or changed, eliminating typical flora and fauna and used for other purposes but then subsequently altered to return poorly drained soils and wetland flora and fauna to enhance life support, flood control, recreational, educational, or other functional values. Natural and restored wetlands are "waters of the U.S." and are subject to regulation under the 404 permitting process" (Hammer, 1997, p. 11)

Created wetland – "…formerly had well-drained soils supporting terrestrial flora and fauna but have been deliberately modified to establish the requisite hydrological conditions producing poorly drained soils and wetland flora and fauna to enhance life support, flood control, recreational, educational, or other functional values" (Hammer, 1997, p.12). (some other stuff about mitigation wetlands and section 404)

Constructed wetland – "...consist of former terrestrial environments that have been modified to create poorly drained soils, wetland flora and fauna for the primary purpose of contaminant or pollutant removal from wastewater. Constructed wetlands are essentially wastewater treatment systems and are designed and operated as such though many systems do support other functional values" (Hammer, 1997, p.12).

Appendix B

Endangered + threatened species of Southwest Illinois

Scientific Name	Common Name	State Protection	Jackson	Madison	Monroe	Perry	Randolph	St. Clair	Washington
Acipenser fulvescens	Lake Sturgeon	Endangered		X					
Ammocrypta clarum	Western Sand Darter	Endangered	X	X			X		
Apalone mutica	Smooth Softshell	Endangered	X						
Asio flammeus	Short-eared Owl	Endangered				X	X	X	
Asplenium bradleyi	Bradley's Spleenwort	Endangered	X				X		
Berberis canadensis	Allegheny Barberry	Endangered	X						
Boltonia decurrens	Decurrent False Aster	Threatened		X				X	
Botaurus lentiginosus	American Bittern	Endangered			X	X			
Botrychium biternatum	Southern Grape Fern	Threatened	X						
Buchnera americana	Blue Hearts	Threatened		X					
Bumelia lanuginosa	Wooly Buckthorn	Endangered			X				
Caecidotea spatulata	Isopod	Endangered						X	
Carex physorhyncha	Bellows Beak Sedge	Endangered	X				X		
Carex plantaginea	Plantain-leaved Sedge	Endangered	X						
Carex willdenowii	Willdenow's Sedge	Threatened	X						
Centruroides vittatus	Common Striped Scorpion	Endangered			X		X		
Cimicifuga rubifolia	Black Cohosh	Threatened	X						
Circus cyaneus	Northern Harrier	Endangered				X	X	X	
Coccyzus erythropthalmus	Black-billed Cuckoo	Threatened			X				
Corynorhinus rafinesquii	Rafinesque's Big-eared Bat	Endangered	X						
Crotalus horridus	Timber Rattlesnake	Threatened	X	X	X	X	X		
Cumberlandia monodonta	Spectaclecase	Endangered		X					
Cynosciadium digitatum	Cynosciadium	Endangered	X						
Dendroica cerulea	Cerulean Warbler	Threatened	X		X				
Dodecatheon frenchii	French's Shootingstar	Threatened	X						
Draba cuneifolia	Whitlow Grass	Endangered			X		X		
Egretta caerulea	Little Blue Heron	Endangered		X				X	
Egretta thula	Snowy Egret	Endangered						X	
Ellipsaria lineolata	Butterfly	Threatened		X					
Erimystax x-punctatus	Gravel Chub	Threatened			X				
Euphorbia spathulata	Spurge	Endangered			X				
Falco peregrinus	Peregrine Falcon	Threatened		X					
Fontigens antroecetes	Hydrobiid cave snail	Endangered			X			X	
Fusconaia ebena	Ebonyshell	Threatened		X					
Galium virgatum	Dwarf Bedstraw	Endangered			X				
Gallinula chloropus	Common Moorhen	Endangered	X	X	X	X	X	X	
Gammarus acherondytes	Illinois Cave Amphipod	Endangered			X			X	
Gastrophryne carolinensis	Eastern Narrowmouth Toad	Threatened	X		X		X		
Glyceria arkansana	Manna Grass	Endangered	X						
Heliotropium tenellum	Slender Heliotrope	Endangered			X				
Hexalectris spicata	Crested Coralroot Orchid	Endangered	X		X		X		
Huperzia porophila	Cliff Clubmoss	Threatened	X						
Hydrolea uniflora	One-flowered Hydrolea	Endangered	X						
Hyla avivoca	Bird-voiced Treefrog	Threatened	X						
Ictinia mississippiensis	Mississippi Kite	Threatened	X	X	X		X		
Ixobrychus exilis	Least Bittern	Threatened	X	X	X	X		X	
Lanius ludovicianus	Loggerhead Shrike	Endangered	X		X	X	X	X	X

Ligumia recta	Black Sandshell	Threatened		X					
Limnothlypis swainsonii	Swainson's Warbler	Endangered	X						
Lonicera dioica var. glaucescens	Red Honeysuckle	Endangered	X						
Lonicera flava	Yellow Honeysuckle	Endangered	X				X		
Macrhybopsis gelida	Sturgeon Chub	Endangered	X						
Masticophis flagellum	Coachwhip	Endangered			X		X		
Matelea decipiens	Climbing Milkweed	Endangered	X		X				
Melanthium virginicum	Bunchflower	Threatened	X						
Melothria pendula	Squirting Cucumber	Threatened	X						
Myotis grisescens	Gray Bat	Endangered	X		X				
Myotis sodalis	Indiana Bat	Endangered	X		X	X		X	
Neotoma floridana	Eastern Wood Rat	Endangered	X						
Notropis boops	Bigeye Shiner	Endangered	X	X			X		
Nyctanassa violacea	Yellow-crowned Night-Heron	Endangered		X	X			X	
Nycticorax nycticorax	Black-crowned Night-Heron	Endangered		X	X			X	
Ochrotomys nuttalli	Golden Mouse	Threatened	X						
Orconectes placidus	Bigclaw Crayfish	Endangered	X						
Oryzomys palustris	Rice Rat	Threatened	X			X			
Oxalis illinoensis	Illinois Wood Sorrel	Endangered	X						
Pantherophis emoryi	Great Plains Ratsnake	Endangered			X		X		
Pinus echinata	Shortleaf Pine	Endangered	X		X		X		
Plantago cordata	Heart-leaved Plantain	Endangered	X						
Platanthera flava var. herbiola	Tubercled Orchid	Threatened				X			X
Poa alsodes	Grove Bluegrass	Endangered	X						
Pseudacris illinoensis	Illinois Chorus Frog	Threatened		X	X				
Ptilimnium nuttallii	Mock Bishop's Weed	Endangered	X				X		
Pygmarrhopalites madonnensis	Madonna Cave Springtail	Endangered			X				
Quercus montana	Rock Chestnut Oak	Threatened	X						
Rallus elegans	King Rail	Endangered				X			
Rhexia mariana	Dull Meadow Beauty	Endangered	X						
Rudbeckia missouriensis	Missouri Orange Coneflower	Threatened			X		X		
Scaphirhynchus albus	Pallid Sturgeon	Endangered		X					
Scleria pauciflora	Carolina Whipgrass	Endangered					X		
Silene regia	Royal Catchfly	Endangered		X					
Sistrurus catenatus	Eastern Massasauga	Endangered		X					
Spiranthes vernalis	Spring Ladies' Tresses	Endangered		X					
Sternula antillarum	Least Tern	Endangered					X		
Synandra hispidula	Hairy Synandra	Endangered	X						
Talinum calycinum	Fameflower	Endangered			X		X		
Tantilla gracilis	Flathead Snake	Threatened			X		X		
Terrapene ornata	Ornate Box Turtle	Threatened		X			X		X
Tomanthera auriculata	Ear-leafed Foxglove	Threatened	X						
Torreyochloa pallida	Grass	Endangered	X						
Tradescantia bracteata	Prairie Spiderwort	Threatened		X					
Trifolium reflexum	Buffalo Clover	Threatened	X					X	X
Trillium viride	Green Trillium	Endangered						X	
Tropidoclonion lineatum	Lined Snake	Threatened		X					
Tyto alba	Barn Owl	Endangered	X			X	X	X	X
Xanthocephalus xanthocephalus	Yellow-headed Blackbird	Endangered		X					
Total species for each county			50	26	32	12	26	17	5

Endangered Species Protection Board : Illinois Endangered Species Protection Board. (n.d.). Retrieved September 18, 2012, from http://www.dnr.illinois.gov/espb/Pages/default.aspx

Appendix C

Process