Suitability Analysis for Champaign County

PREPARED BY

Matt Yoder

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Executive Summary

This study analyzes the suitability of land in Champaign County, Illinois for development based on four environmental criteria: slope, soil, surface water and green infrastructure. It identifies regions of high, medium and low suitability for each of these criteria and uses these to create a composite suitability map, which appears at the right.

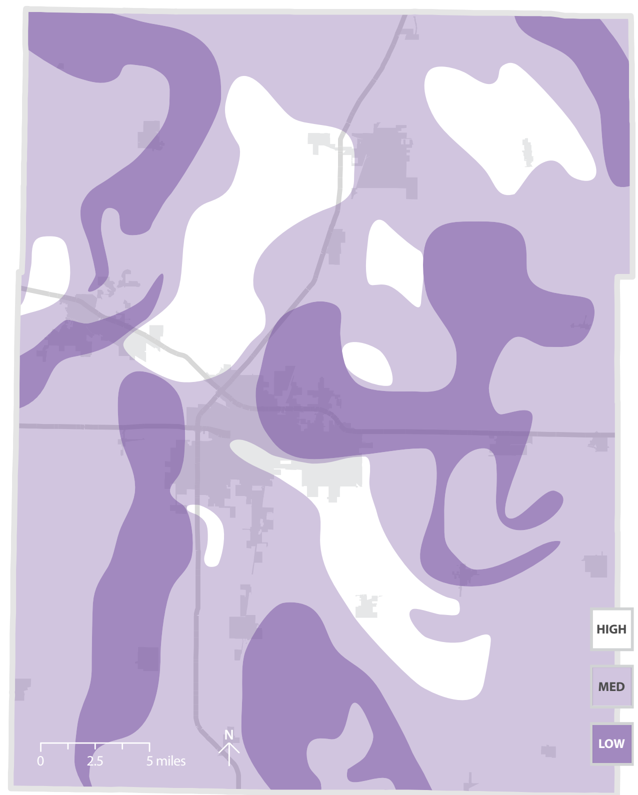
Slope varies little throughout the county, ranging from 0% to 3.04%. Because of this narrow range, it does not factor prominently in the final analysis.

Of the nine soil types present in Champaign County, one is highly suitable for development, four more are moderately suitable, and four are unsuitable. The moderately suitable soils may require stabilization, particularly for roads.

The county is home to significant surface water resources, which must be protected from runoff using riparian buffers. These buffers, along with federally-designated floodzones, are classified as unsuitable for development.

The green infrastructure analysis identifies three natural hubs and three recreational hubs, which are currently connected by two natural links. It proposes extending this system with three additional recreational links.

The composite suitability map suggests that urban expansion should be directed south of Urbana, west of Rantoul and east of Mahomet. Of these proposed vectors, however, only the last one reflects current growth trends.



A NOTE ABOUT MAPS

The suitability maps in this report follow certain conventions in their placement of elements:

- The colors representing high, medium and low suitability appear on the lower right side of the map. The lightest color is always the most suitable.
- Most maps include a background layer containing municipal boundaries and interstates to provide context.
- Any other background elements are identified in a legend that extends off the bottom of the map.

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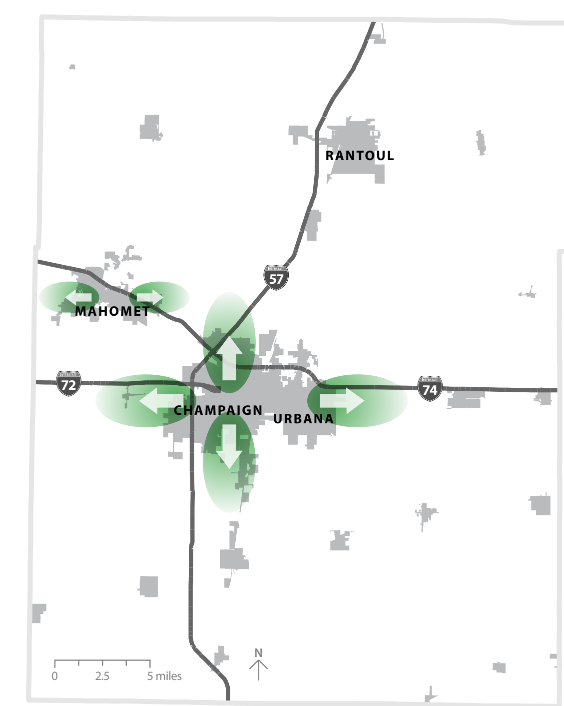
INTRODUCTION

Growth in Champaign County is currently taking place along these vectors:

- East and west of Mahomet
- North, west and south of Champaign
- East of Urbana

The purpose of this study is to determine which, if any, of these vectors are most suitable for development and to recommend additional areas that may be more suitable. Suitability is determined by considering the interaction of four environmental factors: slope, soil, surface water and green infrastructure. The suitability of all of these factors contributes to the composite suitability analysis.



Slope

Suitability Analysis

One of the most fundamental considerations in development is the slope of the site. Slope refers to the rate of elevation change across the surface of the land, or the ratio of "rise" to "run." Very flat land is said to have a low slope, while steep surfaces have a high slope value. Slope is most often expressed as a percent grade, with 0% being completely flat and 90% completely vertical.

Slope affects development along three primary axes: drainage, construction cost and safety.[1] In the first of these, low slope is the primary concern. When precipitation falls on land with slopes below 0.5%, it tends to pool on the surface instead of draining into the watershed.[2] These pools of surface water can lead to severe flooding and damage to structures, particularly in areas prone to heavy precipitation.

The other concerns—cost of construction and safety—relate to areas with high slope. Starting at about 8%, development becomes progressively more expensive as slope increases, particularly for large buildings such as industrial and commercial structures.[3] Similarly, winter roads become difficult for trucks to traverse safely at slopes above 7%.[4] Very little development is possible above 15% grade because of these concerns.[5]

SLOPE IN CHAMPAIGN COUNTY

Figure 1 maps slope in Champaign County. The slope calculations are based on 5-meter contour lines, which are shown as a background layer in the map. Close contour lines indicate steeper slope, while widely-spaced lines indicate a flatter surface. The map lays out slope areas according to the categories defined in **Table 1**.

> **Slope affects development along three primary axes: drainage, construction cost and safety.**

The slope analysis of Champaign County reveals that the majority of the county's land has a slope of less than 0.5%. This extreme flatness makes that land unsuitable for most development because of poor drainage. Surface grading of the sites in this category can improve drainage, but it also introduces significant expense. Artificial drainage systems, like storm sewers and retention ponds, can help to mitigate flood risks, but they also add to the cost of development.

A substantial portion of the county's land falls in the 0.5% to 1% slope category. Land in this category is moderately suitable for development, but like the previous category, it may require measures like retention ponds to capture storm water and prevent flooding.

Four small areas of the county have a slope between 1% and 3.04%—the maximum slope in the county. These regions require no additional flood mitigation and constitute the best candidates for development based on slope. However, because of the small size of these areas, it is unlikely that most new development will occur within them.

Since so much of the county's land falls in areas with less-than-ideal slope—and since the overall range of slope values is so narrow—slope is given the lowest weight of any factor in the final suitability analysis. Still, the slope analysis can serve as a useful reference for developers looking to minimize development costs by taking advantage of the land's natural drainage properties.

TABLE 1: Slope Categories and Development Constraints
Slope areas in Champaign County can be divided into three categories. This table displays a visual representation of these categories and lists relevant development concerns.

Slope Categories Found in Champaign County		
Slope	Visual Representation	Development Constraints
Less than 0.5%		Most development requires surface grading to increase slope and artificial systems to improve drainage.
0.5% to 1%		Drainage problems increase costs for most types of development. Areas in this category are suitable for farming outside of flood plains.
1% to 3.04%		No significant development constraints exist in this slope category.

Data Source: Anderson, Chapter 3

FIGURE 1: Slope Suitability Map for Champaign County
Slope in Champaign County varies between 0% and 3.04%. Slopes above 1% are the most suitable, and slopes between 0.5% and 1% can support development with drainage improvements. *Data Source: U.S. Geological Survey*

Flat Farmland in Champaign County
This farmland, located just south of Urbana, demonstrates the low slope found throughout the county. The property is being marketed for future development, but like much of the county, it falls in an area of medium suitability based on slope.
Image Source: Butler Busby Hicks[6]

Soil
Suitability Analysis

Like slope, soil type is a significant factor in determining where development can and should occur. Soils are composed of particles of varying sizes. From largest to smallest, these particles are categorized as gravel, sand, silt and clay.[7] The soil type, or series, depends on the proportions of these particle types. Soil series that frequently occur together are grouped into associations. In these associations, the first name listed is the dominant series.[8]

The composition of soil types determines their engineering characteristics and makes them more or less suitable for development. Common development concerns include:

- **Wetness:** The soil is too damp for development.
- **Shrink-swell:** The soil increases in volume when wet, damaging building foundations and roads.[9]
- **Ponding:** The soil has limited permeability, resulting in standing water.[10]
- **Low strength:** Soils composed of sand and gravel have the highest bearing strength. Some other soils can be stabilized by adding cement or hydrated lime.[11]
- **Frost action:** The water in the soil is susceptible to freezing and thawing, damaging roads and building foundations.[12]
- **Too clayey:** The slipping and swelling of clay in the soil makes it unsuitable for development.[13]

TABLE 2: Soil Associations Found in Champaign County
This table classifies the soil associations found in Champaign County according to their suitability for development. Highly suitable soils raise no severe development concerns for buildings or streets, while moderately suitable soils raise no severe concerns for buildings. Soils with low suitability have severe concerns for both buildings and streets.

Soil Association	Suitability	Concern by Type of Development		Concern by Effect					
		Dwellings and Commercial	Local Streets	Wetness	Shrink-Swell	Ponding	Low Strength	Frost Action	Too Clayey
Bryce- Swygert	Low	Severe	Severe	Slight	Severe	Severe	Severe	Severe	Severe
Drummer-Plano-Elburn	Low	Severe	Severe	Slight	Slight	Severe	Severe	Severe	Slight
Flanagan-Drummer-Catlin	Low	Severe	Severe	Severe	Severe	Slight	Severe	Severe	Slight
Swygert-Bryce-Mokena	Low	Severe	Severe	Severe	Severe	Slight	Severe	Severe	Slight
Catlin-Dana-Tama	Moderate	Moderate	Severe	Moderate	Moderate	Slight	Severe	Severe	Slight
Morley-Blount-Beecher	Moderate	Moderate	Severe	Moderate	Moderate	Slight	Severe	Slight	Moderate
Morley-Markham-Ashkum	Moderate	Moderate	Severe	Moderate	Moderate	Slight	Severe	Slight	Moderate
Varna-Elliott-Ashkum	Moderate	Moderate	Severe	Moderate	Moderate	Slight	Severe	Severe	Moderate
Miami-Strawn-Hennepin	High	Moderate	Moderate	Slight	Moderate	Slight	Moderate	Moderate	Slight
Source: Soil Survey of Champaign County, IL		**Concern Levels:** • Slight • Moderate • Severe							

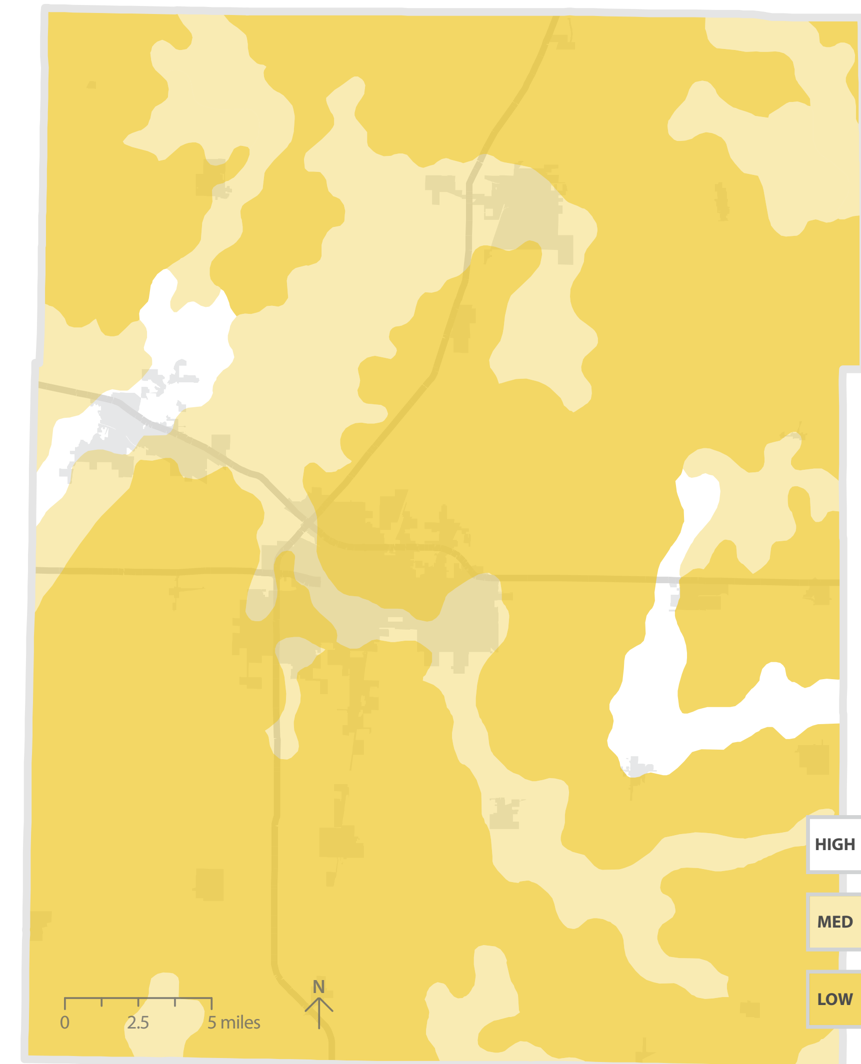


FIGURE 2: Soil Suitability Map for Champaign County
Only one soil association in Champaign County is ideal for development, but four additional associations can support development with soil improvements. *Data Source: Soil Survey of Champaign County, IL*

SOILS IN CHAMPAIGN COUNTY

Table 2 summarizes the development characteristics and suitability of the soil associations present in Champaign County. Of the nine soil associations found in the county, only one—Miami-Strawn-Hennepin—is classified as highly suitable for development with no severe concerns for dwellings, commercial buildings or streets.

Four additional associations are classified as moderately suitable for development. They have no severe development concerns for dwellings and commercial buildings, but the low strength and frost action of these soils may pose challenges for the construction of streets and roads. As a result, development in the moderately suitable regions likely will require additional stabilization, making it more expensive.

Four soil associations have severe development concerns for both buildings and streets, making them unsuitable for development. Development on these soils is possible, as evidenced by the current development in the central and southern parts of the county. Still, building on unsuitable soils creates substantial additional costs in site preparation and foundation reinforcement.

Figure 2 shows the spatial distribution of high-, medium- and low-suitability soils. The distribution of highly and moderately suitable soil largely mirrors the slope patterns previously described. Since soil characteristics vary more widely than slope, however, soil type receives more weight than slope in the final suitability analysis.

A Sample of the Miami Soil Series
Miami soils, such as the Miami-Strawn-Hennepin association found in Champaign County, have no severe development concerns. They are highly suitable for building foundations and roads.
Image Source: U.S. Department of Agriculture[14]

Water
Suitability Analysis

Surface water is perhaps the most notable topographical feature, and it has clear implications for the suitability of a site for development. Surface water considerations fall into two broad categories: flood prevention and water resource preservation.

Flooding occurs when streams and rivers rise during periods of heavy precipitation, inundating surrounding low-lying areas. In most communities in the United States, areas prone to flooding are defined using data provided by the Federal Emergency Management Agency (FEMA).

For communities that have joined its flood insurance program, FEMA produces a Flood Insurance Rate Map (FIRM) that designates Special Flood Hazard Areas (SFHA), or floodplains. These are areas in which the annual probability of a flood is 1% or greater.[15]

In addition to flooding, water resource preservation is a significant concern that impacts suitability for development. Precipitation that is not absorbed by the soil enters the watershed as runoff. It caries with it pollutants and nutrients that damage aquatic ecosystems.

The amount of runoff produced is determined by soil type, topography, land cover and area of impervious surfaces, among other factors.[16] The effects of runoff can be mitigated using riparian buffers, which are areas

Flooded Streets in Champaign City
Flood waters inundate the intersection of Washington and Russell Streets in northern Champaign. This area is on the edge of the medium suitability zone that covers the west side of the city. *Image Source: City of Champaign*[17]

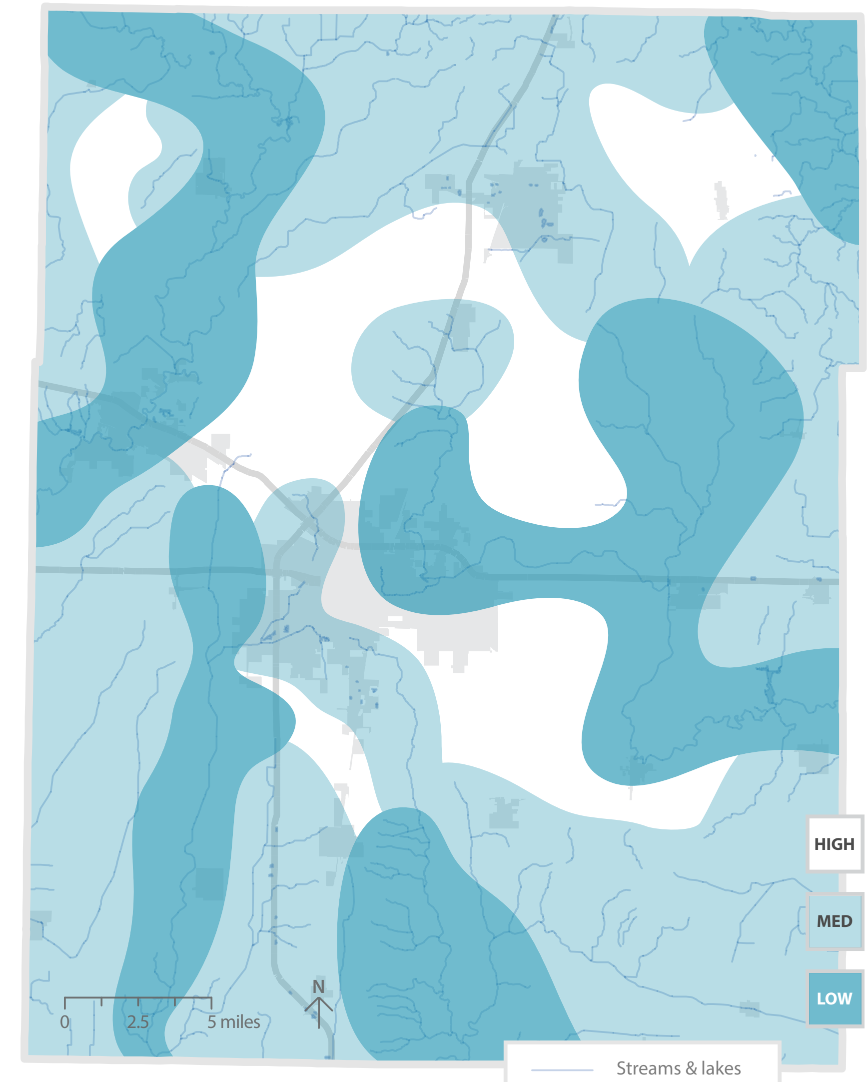


FIGURE 3: Water Suitability Map for Champaign County
Champaign County is rich in water resources that must be protected. For a map of flood zones, riparian buffers and water flow, see ***Appendix A***.
Data Source: U.S. Geological Survey

of undeveloped land adjacent to streams and rivers. Often covered in forest or grasslands, riparian buffers help to absorb runoff before it reaches the watershed.

SURFACE WATER IN CHAMPAIGN COUNTY

Figure 3 displays the results of the water suitability analysis as areas of high, medium and low suitability for development. The analysis considers several factors, including land cover, riparian buffers and flood zones. Slope also contributes to flooding and runoff, but it is considered in a separate analysis.

The developable area excludes lands within the riparian buffer and flood zones. This exclusion area is comprised of three categories of land that are unsuitable for development:

- **A 100-meter buffer on both sides of streams, rivers and lakes.** A survey of the literature on riparian buffers conducted at the University of Georgia concluded that a 100-meter buffer provides optimal protection for wildlife and ecosystems.[18]
- **Forested lands adjacent to streams, rivers and lakes.** These areas of dense vegetation provide a natural riparian buffer, preventing runoff and erosion.
- **Areas within the floodplain on FEMA's Flood Insurance Rate Map (FIRM).** These areas are subject to inundation during floods, and as a result, development within them is cost-prohibitive.

These features—as well as watershed boundaries and the general direction of water flow in the county—are visible on the full water suitability map found in ***Appendix A***. Water flow information is particularly useful in determining how new development may impact surrounding ecosystems through runoff and the release of pollutants.

Surface water features are important resources that need to be protected, and flood mitigation can be costly. As a result, the water study receives the highest weight in the final suitability analysis.

Green Infrastructure

Suitability Analysis

Green infrastructure is a network of recreational and open spaces that provides ecosystem services and sustains human life. These services include water and air filtration, carbon sequestration and climate regulation.

The green infrastructure network is usually described as an interconnected series of hubs and links. Hubs are centers of wildlife habitat and ecological systems. They include parks, nature preserves, wildlife refuges and forests.[19]

Links are linear open spaces that connect hubs and facilitate movement within the green infrastructure network. Types of links include greenways, greenbelts and "conservation corridors," which often follow the paths of rivers and streams.[20]

Together, hubs and links provide valuable ecosystem services. Some of these services can be reproduced artificially—for example, a water purification plant can substitute for natural filtration—but doing so is often expensive. As a result, protection of green infrastructure often relies on describing its value, or the cost of its replacement, in monetary terms.

GREEN INFRASTRUCTURE IN CHAMPAIGN COUNTY

Figure 4 shows the location of existing and proposed green infrastructure in Champaign County and its implications for development. Several features are considered, including land cover, streams, lakes, trails, parks and nature preserves. (A detailed map of these features appears in ***Appendix B***.) Land cover types contributing to green infrastructure include forest, prairie and grasslands, both natural and urban.

Based on the location of these features, two types of hubs and three types of links emerge:

- **Natural hubs:** These hubs include reserves of forest, prairie and grasslands. They act as a riparian buffers and provide wildlife habitat.
- **Recreational hubs:** These hubs are identified by a high concentration of parks, trails and nature preserves.
- **Natural links:** Like natural hubs, these links are formed by chains of naturally-occurring land cover such as forest and grasslands. They connect natural hubs to recreational green spaces.
- **Recreational links:** These links represent a proposed addition to the system of trails already in place. They would connect existing parks and green spaces, using existing railroad right-of-way where possible.

TABLE 3: Economic Value of Carbon Sequestration
The following table summarizes the economic value provided by the carbon sequestered by two types of land cover. Preserving these areas, which represent valuable green infrastructure, offers the county an economic benefit.

Value Provided by Carbon Sequestration			
Land Cover	Total Acres	Value Per Year: Low Estimate	Value Per Year: High Estimate
Forest	9,617	$21,637	$454,382
Buffers and conservation areas	34,248	$25,685	$231,171
Total	**43,865**	**$47,322**	**$685,553**

FIGURE 4: Green Infrastructure Map for Champaign County
Champaign County contains a network of parks, trails and open spaces that provides ecosystem services. This infrastructure should be leveraged by adding recreational links. For a detailed map of existing parks, trails and open spaces, see ***Appendix B***.
Data Source: U.S. Geological Survey

The natural hub in the northeast corner of the county is not connected by links to any other hubs in Champaign County. It could, however, be connected to hubs within neighboring Ford and Vermilion Counties.

CARBON SEQUESTRATION

Though the green infrastructure in Champaign County provides numerous ecosystem services, carbon sequestration is among the most difficult to reintroduce once it has been disrupted. Table 3 summarizes the economic value of carbon sequestration based on existing land cover. It uses estimates produced by the EPA that suggest that reforestation sequesters 0.3 – 2.1 metric tons of carbon per acre per year and that buffers and conservation areas sequester 0.1 – 0.3 metric tons of carbon per acre per year.[21] These carbon estimates are converted into dollar values using low and high values of $7.50 and $22.50 per metric ton of carbon respectively, conversion rates calculated by Robert Stavins and Kenneth Richards.[22]

The resulting valuations range from $47,322 to $685,553, a range that reflects the difficulty in assigning precise monetary values to green infrastructure. Variables that impact the true value include the type of soil and specific species of vegetation present.

If the proposed rail and recreational links were constructed, they would further contribute to carbon sequestration. Initially, however, the value of that sequestration likely would be offset by construction costs.

Green infrastructure provides valuable ecosystem services that can be delivered artificially, but only at great expense. Therefore, green infrastructure concerns receive a medium weight in the final suitability analysis.

Composite
Suitability Map

Landscape architect Ian McHarg pioneered a method for considering multiple environmental factors in a single suitability analysis. McHarg described the technique in his book *Design with Nature*. In it, he laid out a system where each factor under consideration is represented by a transparent layer that is shaded according to suitability. Dark areas are the least suitable for development, while areas that are completely transparent are the most suitable. The range of values used in each layer determines its weight in the composite analysis.

Figure 5 demonstrates the application of this process to the four factors considered in this analysis: slope, soil, water and green infrastructure. Because of its potential for flood damage and the cost of restoring aquatic ecosystems, the water layer is given the most weight.

Soil and green infrastructure are given medium weight because they represent significant development impacts. While less costly to modify than water systems, improving poor soil and rebuilding green infrastructure both represent significant expenses.

Slope is given the least weight in the analysis because it varies little among areas in Champaign County.

In McHarg's method, each factor under consideration is represented by a transparent layer that is shaded according to suitability. Dark areas are the least suitable for development, while areas that are completely transparent are the most suitable.

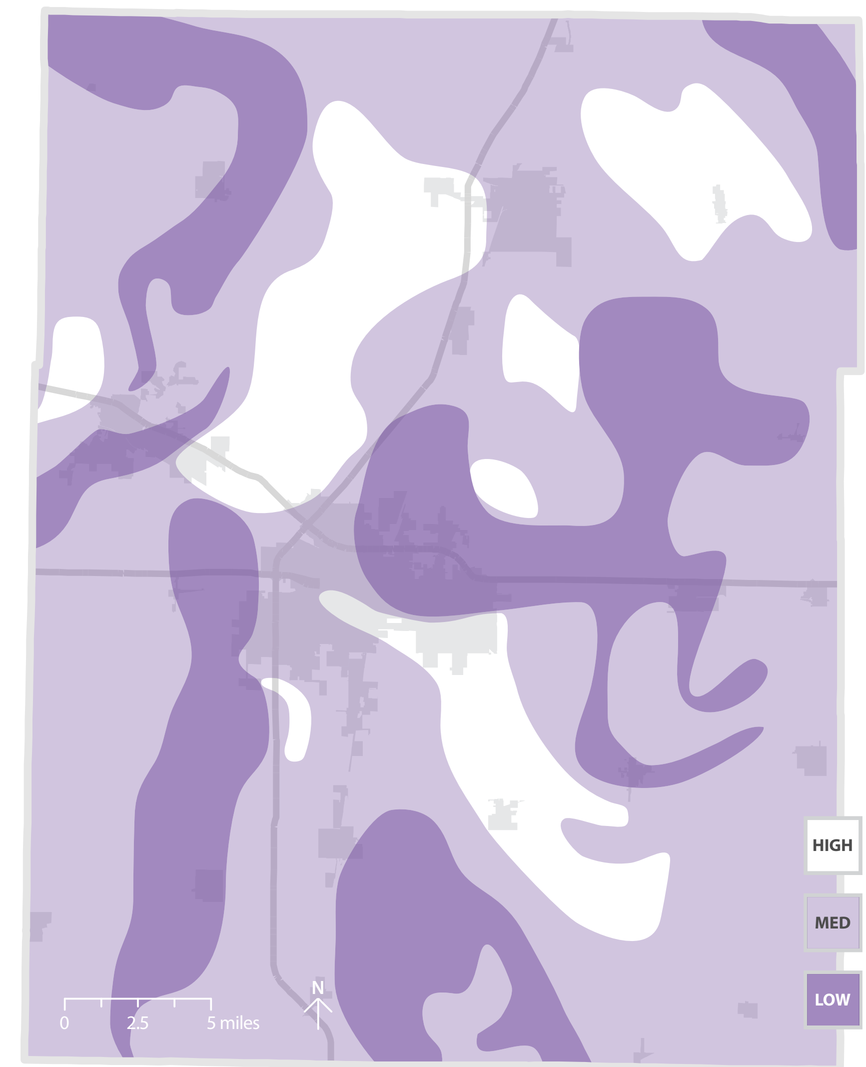


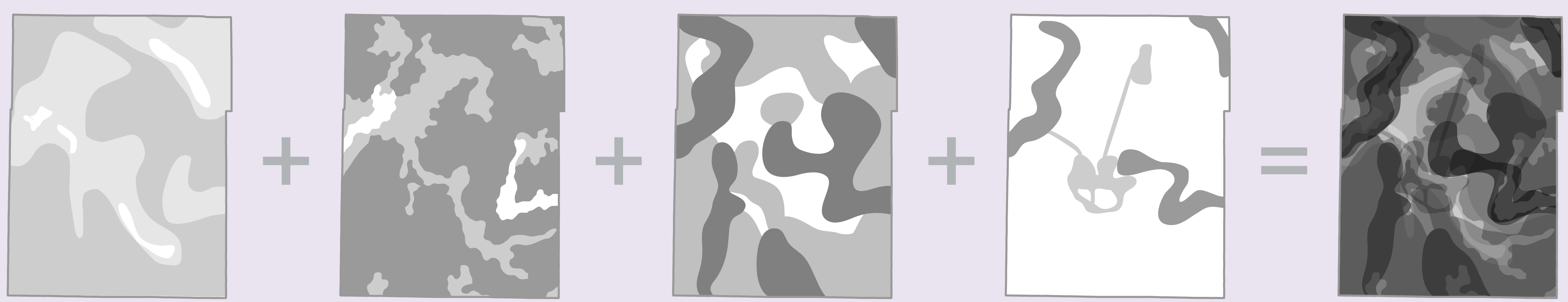
FIGURE 6: Composite Suitability Map for Champaign County
When the slope, soil, water and green infrastructure layers are compiled, several areas emerge as the most suitable for development.

COMPOSITE SUITABILITY FOR CHAMPAIGN COUNTY

The overall suitability map presented in **Figure 6** summarizes the results produced by overlaying the four transparent layers. It classifies areas with a composite opacity of 75% or higher as having low suitability for development and areas with a composite opacity of 50% to 75% as having medium suitability. Since there are no fixed standards for suitability aggregates, these ranges could be adjusted to fit the demand for developable land in the county.

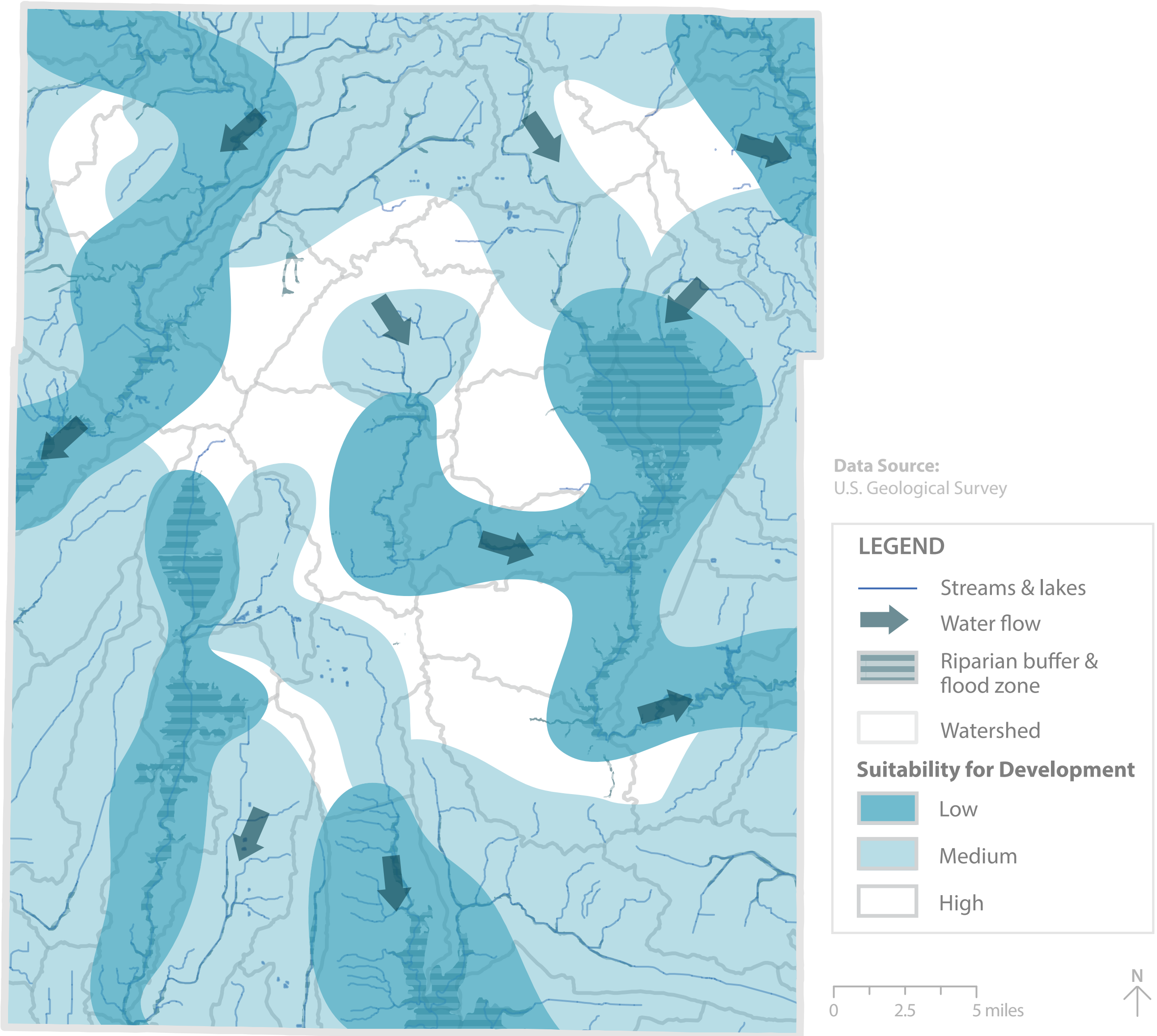
Of the current growth vectors, only the area east of Mahomet falls in an area of high suitability. Though they are not reflected in current growth trends, the areas south of Urbana and west of Rantoul also hold promise as areas highly suitable for urban expansion. Building in these areas will allow the county to accommodate growth while preserving its natural resources.

FIGURE 5: The McHarg Method
This suitability analysis uses a technique developed by Ian McHarg where weighted transparent layers are compiled to determine overall suitability. These images show the weighted layers and list the opacity of the medium and low suitability categories. Larger numbers indicate greater importance.

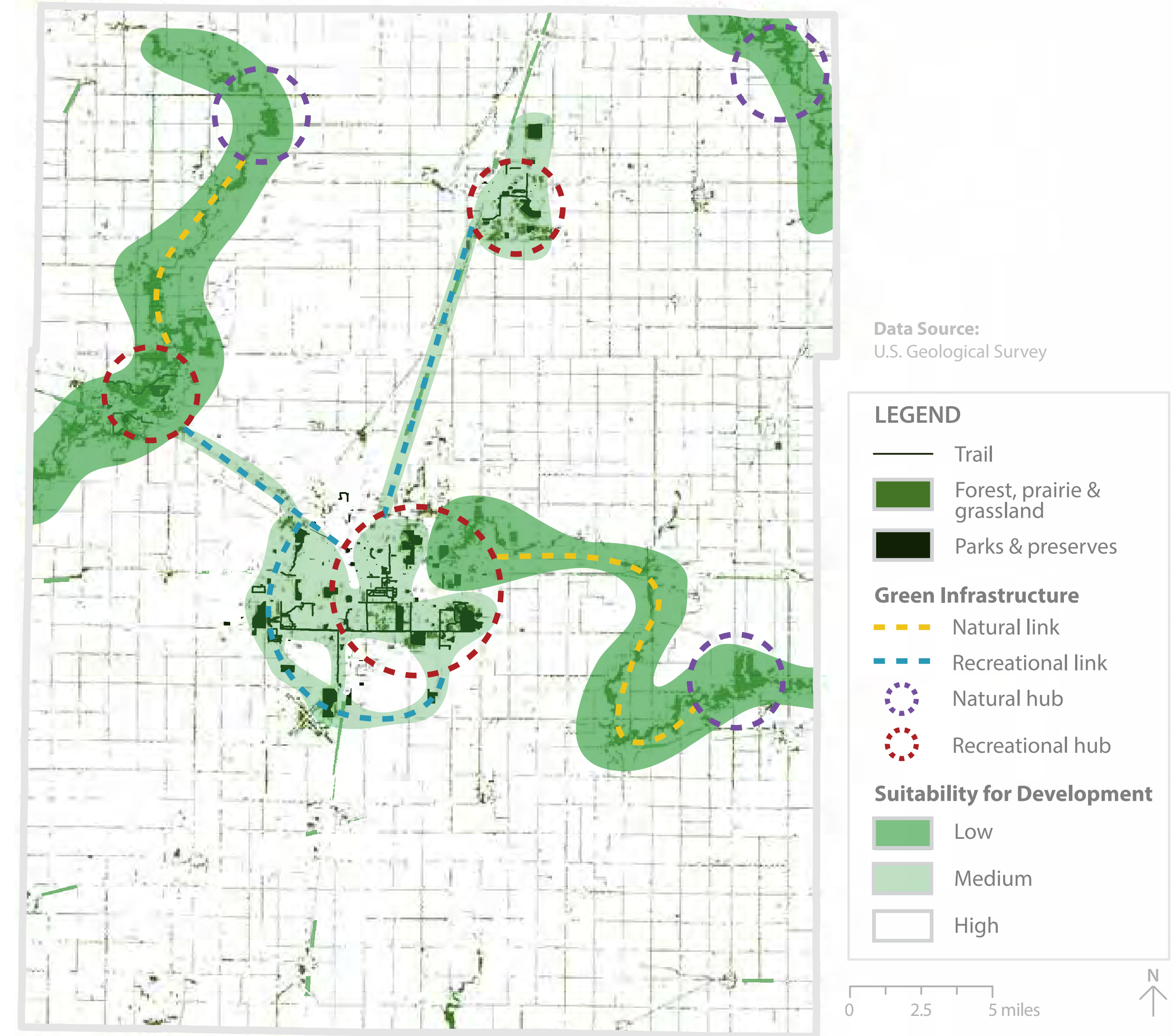


Slope *Med: 10% Low: 20%*
Soil *Med: 20% Low: 40%*
Water *Med: 25% Low: 50%*
Green Infrastructure *Med: 20% Low: 40%*
Composite *Med: 50% Low: 75%*

Appendix A: Water Suitability in Champaign County



Appendix B: Green Infrastructure in Champaign County



[1] Larz T. Anderson, "Chapter 3: The Constraints of Slope on Land Development," in *Planning the Built Environment* (Chicago: American Planning Association, 2000), 22-32.

[2] Anderson, "Chapter 3," 25.

[3] Anderson, "Chapter 3," 25.

[4] Anderson, "Chapter 3," 25.

[5] Anderson, "Chapter 3," 25.

[6] http://www.bbhland.com/Craverprop.html

[7] Kevin Lynch and Gary Hack, "Appendix A: Soils," in Site Planning, Third Edition (Cambridge, MA: MIT Press, 1984), 379.

[8] "Soil Taxonomy: A Basic System of Soil Classification for Making and Interpreting Soil Surveys," United States Department of Agriculture, (Washington, DC: USDA, 1999), Second edition, 10, accessed September 27, 2012, ftp://ftp-fc.sc.egov.usda.gov/NSSC/Soil_Taxonomy/tax.pdf.

[9] Tonie J. Endres, "Soil Survey of Champaign County, Illinois," United States Department of Agriculture, (Washington, DC: USDA, 1999), 168, accessed September 27, 2012, http://preprod.nrcs.usda.gov/Internet/FSE_DOCUMENTS/16/nrcs143_017853.pdf.

[10] Endres, "Soil Survey," 167.

[11] Lynch and Hack, "Appendix A," 384.

[12] Endres, "Soil Survey," 163.

[13] Lynch and Hack, "Appendix A," 382-84.

[14] http://www.il.nrcs.usda.gov/technical/soils/soil-regions/miami.html

[15] "Floodplain Management in Illinois: Quick Guide," *Illinois Department of Natural Resources*, (Springfield, IL: Illinois DNR, 2001), 7, accessed October 20, 2012, http://www.dnr.illinois.gov/WaterResources/Documents/Resman_ILFPMQuickGuide.pdf.

[16] Larz T. Anderson, "Chapter 6: Storm Drainage," in *Planning the Built Environment* (Chicago: American Planning Association, 2000), 66.

[17] http://ci.champaign.il.us/departments/public-works/residents/stormwater-management/stormwater-and-erosion-control/

[18] Seth Wenger, "A Review of the Scientific Literature on Riparian Buffer Width, Extent and Vegetation," Institute of Ecology, University of Georgia, last modified March 5, 1999, http://www.rivercenter.uga.edu/service/tools/buffers/buffer_lit_review.pdf.

[19] Mark A. Benedict and Edward T. McMahon, "Green Infrastructure: Smart Conservation for the 21st Century," *The Conservation Fund*, (Washington, DC: Sprawl Watch Clearinghouse, 2001), 7.

[20] Benedict and McMahon, "Green Infrastructure," 8.

[21] "Representative Carbon Sequestration Rates and Saturation Periods for Key Agricultural & Forestry Practices," United States Environmental Protection Agency, last modified June 22, 2010, http://www.epa.gov/sequestration/rates.html.

[22] Robert N. Stavins and Kenneth R. Richards, "The Cost of U.S. Forest-Based Carbon Sequestration," Pew Center on Global Climate Change, January 2005, http://www.c2es.org/docUploads/Sequest_Final.pdf.