Flood susceptibility indexes for northeastern Illinois 2026

Chicago Metropolitan Agency for Planning

Acknowledgements

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Contents

Introduction

Flooding is one of the most significant and persistent climate challenges facing northeastern Illinois. Over the past decade, the region has experienced many floods that damaged homes and businesses, disrupted daily life, and put people's safety at risk. These impacts are already widespread, and climate change is expected to further intensify flooding in the coming decades.

In a continued effort to help the region tackle current and future flooding challenges, CMAP updated the region's urban and riverine flood susceptibility indexes (FSIs). First created in 2017, the FSIs identify large-scale priority areas across the region where to focus stormwater management and flood resilience planning activities. Areas ranked higher on the indexes' susceptibility scales exhibit characteristics that may make them more likely to experience flooding than other parts of the region.

Since the FSIs were published, they have become widely used data tools. They inform CMAP's planning as well as various efforts by regional partners. CMAP has used the indexes in local plans to identify areas of further study as well as where flood mitigation and stormwater management investments might be most beneficial at a community level.[1] CMAP has also used them alongside critical facility and at-risk population data to inform community vulnerability assessments.[2] The Metropolitan Water Reclamation District of Greater Chicago (MWRD) used the urban FSI as a preliminary screening tool to inform their stormwater master planning work. It has also been used in prioritization mapping tools, such as the Greater Chicago Watershed Alliance's Natural Solutions Tool.[3]

Updated with new and more accurate data, the 2026 FSIs enable CMAP, partners, and other stakeholders to better advance regional stormwater mitigation activities. They serve as tools to help identify high-level priority areas for stormwater management and flood resilience investments.

Overview

The flood susceptibility indexes identify developed areas within northeastern Illinois that are most likely to experience flooding impacts. Susceptibility is scored on a scale of 1 to 10, with 1 being the lowest susceptibility and 10 being the highest.

There are two indexes:

- **Urban FSI:** illustrates flood susceptibility caused when precipitation and stormwater exceed the capacity of an area's stormwater infrastructure system
- **Riverine FSI:** illustrates flood susceptibility caused by water overflowing the banks of nearby waterways.

Together, the two indexes provide an understanding of flood susceptibility across the region.

The sections below provide an overview of the geographic scope and methodology used in the 2026 FSIs. See the Detailed methodology section for more information on updates that were made from the 2017 indexes.

Timeline

Phase 1: Scoping

This phase involved understanding how the 2017 FSIs were previously used, learning about new and better approaches to susceptibility mapping, choosing a methodology, identifying flood-related factors, and scoping the work.[4] The project team also conducted interviews with previous FSI users to inform the scope of the update. See Appendix A for a list of stakeholders who were interviewed as part of this phase and Appendix B for a list of other flood-related factors that were considered.

Phase 2: Update

This phase involved finalizing data, screening the flood-related factors, conducting the frequency ratio analysis, creating the 2026 FSIs, and publishing the data and this supplemental report.

Geography

The 2026 FSIs cover the seven-county CMAP region: Cook, DuPage, Kane, Kendall, Lake, McHenry, and Will. The urban FSI analyzes susceptibility for all developed areas both within and outside of floodplains, while the riverine FSI only analyzes susceptibility for developed areas within the floodplain. The floodplain is defined as areas within the 500-year Federal Emergency Management Agency (FEMA) floodplain or the 500-year MWRD inundation area (Table 1).

Table 1. Data extent of the 2026 flood susceptibility indexes

Index	Data extent
Urban	All developed areas within and outside of floodplains
Riverine	Developed areas located within the 500-year FEMA floodplain or the 500-year MWRD inundation area*

* The 500-year FEMA floodplain and 500-year MWRD inundation area is an area that has a 0.2 percent (or a 1 in 500) chance of flooding each year. The 500-year floodplain is more commonly used to illustrate areas at increased risk of riverine flooding resulting from more extreme precipitation due to climate change.

Source: CMAP, 2026.

Approach

The FSIs were created with the frequency ratio approach — a statistical method based on the relationship between the distribution of reported flooding locations and flood-related factors inherent in the landscape.[5] This approach was used to create the 2017 FSIs and is still widely viewed as a well-grounded and acceptable approach for measuring flood susceptibility, particularly given the ease and speed at which it can be performed.[6] Using the same approach offers more consistency across the two versions, making it easier for current users to integrate the updated data in existing tools and applications.

Each index uses a unique combination of flood-related factors that account for environmental, landscape, and infrastructure conditions that influence flooding. Table 2 provides an overview of each factor and whether it was used in the urban index, riverine index, or both. See the Detailed methodology section for more details on the flood-related factors.

Table 2. Flood-related factors used in the 2026 flood susceptibility indexes

Flood-related factor	Reason for inclusion	Urban FSI	Riverine FSI
Age of development	Areas built before stormwater management requirements were first enacted are more likely to flood	✓	✓
Catchment runoff rate	Areas are more likely to flood due to peak runoff flows reaching the catchment's outlet shortly after a storm event, or a lack of a defined flow path for runoff to drain	✓	✓
Combined sewer service areas	Areas have a greater chance of flooding due to a connection to a combined sewer system	✓	
Flow accumulation	Areas along overland flow paths or near flow paths with significant flow have a greater chance of flooding	✓	
Impervious cover	Areas with greater impervious cover prevent rainfall from soaking into the ground and increase surface runoff, which can contribute to an increased chance of flooding	✓	✓
Low-lying areas near floodplains	Areas near waterways have a greater chance of flooding when they are at or near the base flood elevation and/or have a sewer connection to the waterway	✓	
Potential future flooding	Areas where runoff is most likely to pond and cause increased flooding due to climate change	✓	✓
Precipitation	Areas that could flood as a result of historically experiencing higher amounts	✓	

	of rainfall from common severe storm events than other parts of the region		
Soil infiltration	Areas that could flood and/or increase runoff volumes caused by poorly drained soils		✓

Source: CMAP, 2026.

Results

This section summarizes key findings at the county scale, based on average urban and riverine FSI scores, alongside an analysis of which flood-related factors have a greater influence on the average scores. The following takeaways describe where flooding poses some of the greatest challenges and highlight the drivers of flood susceptibility across the region.

Many communities experience both urban and riverine flooding. While these results are summarized by flood type, communities should reference both indexes to understand their flood susceptibility. See the Detailed methodology section for more details on the analysis and how the results were validated and indexed.

The indexes are also rescaled to each county and include maps in Appendix C. Countywide rescaled index results. Rescaled maps depict flood susceptibility relative to the individual county rather than the seven-county region. Measuring susceptibility within a smaller geography allows for greater nuance in the scores, which can be helpful for counties with large areas that have minimal variability in their scores at the regional level, such as Cook County. These maps may also be helpful for county stormwater engineers and planners interested in identifying areas for further study or investment within a single county.

Urban FSI

The urban FSI measures susceptibility to urban flooding across all the region's developed areas. Susceptibility is scored on a scale of 1 to 10, with 1 being the lowest and 10 being the highest. After averaging scores across each county, Cook County has the highest susceptibility to urban flooding and McHenry County has the lowest (Table 3).

Table 3. Average urban FSI score by county, 2026

County	Average urban FSI score
Cook	7.8
DuPage	5.2
Kane	4.2
Kendall	3.5
Lake	4.1
McHenry	3.1
Will	4.2

Source: CMAP, 2026.

Key findings

Older, dense communities are more susceptible

Areas throughout the region that are most susceptible to urban flooding tend to be built-out communities that have high levels of impervious cover, use combined sewer systems, and were developed before stormwater requirements were put in place. Most of Chicago and Cook County fall into this category, as well as Aurora, Elgin, Joliet, and Waukegan.

Heavier precipitation has significant influence on urban flood susceptibility in Cook County

Some portions of the region historically have received more rain than others. Analysis by the National Oceanic and Atmospheric Administration (NOAA) shows higher rainfall occurring across the northwest and southeast parts of Cook County.[7] These patterns are consistent with many of the major storms that have impacted Cook County communities since 2020.

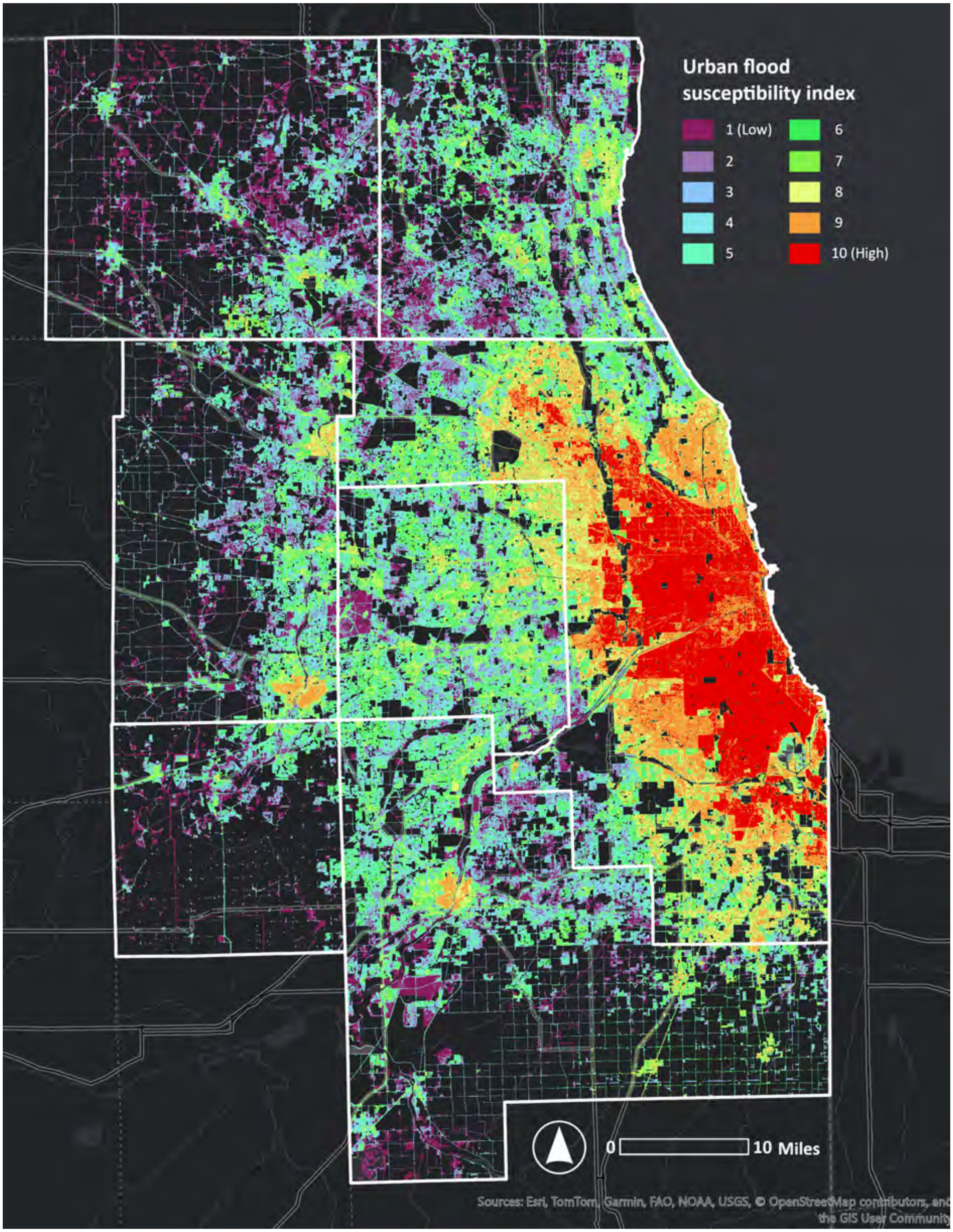
Flow accumulation and low-lying areas near floodplains are stronger drivers of urban flood susceptibility in counties surrounding Cook

In Kane, Lake, and Will counties, flow accumulation and low-lying areas near floodplains are the most influential factors. In DuPage, Kendall, and McHenry counties, they are the second or third most influential factors. More moderate slopes in these areas can lead to overland flow paths with significant runoff volumes. The slopes also create more low-lying areas where runoff can collect and pond. Together, these factors leave many developed areas throughout these counties more susceptible to urban flooding.

In less-developed counties, urban flood susceptibility is more influenced by the potential future flooding factor

The modeling effort to create this factor provides a high-level understanding of where flooding could occur by mid-century as a result of climate change. For Kane, Kendall, Lake, McHenry, and Will counties, this indicates that urban flooding could become a greater issue future as storms become more frequent and severe.

Figure 1. Urban flood susceptibility index, 2026



Source: CMAP, 2026.

Urban FSI results by county

This section:

- Summarizes urban flood susceptibility for each county or grouping of counties
- Describes general patterns and areas of the county with higher susceptibility
- Identifies the top flood-related factors that contribute to urban flood susceptibility across each county

The result shows how susceptibility varies across counties and municipalities depending on development patterns and landscape characteristics.

Cook

Cook County has high susceptibility to urban flooding, scoring an average of 7.8. Within the county, Chicago has some of the highest susceptibility scores, along with inner-ring suburbs to the south, west, and northwest. This is due to various factors, such as being home to the oldest and most dense communities in the region, the majority of which rely on combined sewers. Northwest and southeast Cook also tend to receive more precipitation.[8] While precipitation does not fall equally or in the same pattern across all storm events, these areas closely mirror those hit the hardest by the region's most recent flooding disasters.[9]

DuPage

DuPage County has moderately high susceptibility to urban flooding, including northeast and north central parts of the county, scoring an average of 5.2. Urban flooding is largely driven by high impervious cover, overland flow accumulation, and development in low-lying areas. DuPage is also home to older communities that were built before stormwater requirements, which increases flood susceptibility.

Kane, Lake, and Will

Kane, Lake, and Will counties have moderate susceptibility to urban flooding, scoring 4.2, 3.5, and 4.1, respectively. Susceptibility is generally driven by overland flow accumulation, followed by development located in low-lying areas and increases in precipitation due to climate change. However, these counties are also home to some of the region's largest cities, like Aurora, Elgin, and Joliet, which have high flood susceptibility. In these areas, urban flooding is largely driven by combined sewers and older communities that were developed without stormwater management.

Kendall and McHenry

Kendall and McHenry counties have lower susceptibility to urban flooding, scoring 3.1 and 4.2, respectively. Kendall County's susceptibility is driven by development located in low-lying areas, followed by overland flow accumulation and the area's potential for future flooding. In McHenry County, urban flood susceptibility is more influenced by catchment runoff rate.[10] This indicates that there are catchment areas throughout the county, including Cary, Crystal Lake, and Woodstock, that may experience higher peak runoff based on the length of flow paths relative to its contributing area. Low-lying areas and overland flow accumulation are two other prominent drivers of urban flood susceptibility for McHenry County.

Riverine FSI

The riverine FSI measures susceptibility to riverine flooding in developed areas within FEMA's 500-year floodplain and the MWRD's 500-year inundation areas. Susceptibility is scored on a scale of 1 to 10, with 1 being the lowest and 10 being the highest. After averaging scores across each county, Cook has the highest susceptibility to riverine flooding and Kendall has the lowest (Table 4).

Table 4. Average riverine FSI score by county, 2026

County	Average riverine FSI score
Cook	7.6
DuPage	6.6
Kane	4.3
Kendall	2.6
Lake	4.5
McHenry	3.3
Will	4.1

Source: CMAP, 2026.

Key findings

Older, developed areas along major rivers and streams are most susceptible to riverine flooding

The communities most susceptible to riverine flooding are those along the tributaries of the Des Plaines River in east DuPage and west Cook counties, the North Branch Chicago River system in Lake and Cook counties, and the Little Calumet River and tributaries of the Calumet-Saganashkee (Cal-Sag) Channel in south Cook County. Many of these communities were established before stormwater requirements and are densely developed. Outside of Cook County, communities around the upper reaches of the Des Plaines River in Lake County and its lower reaches in Will County are also susceptible.

Soil infiltration influences riverine flooding in most counties

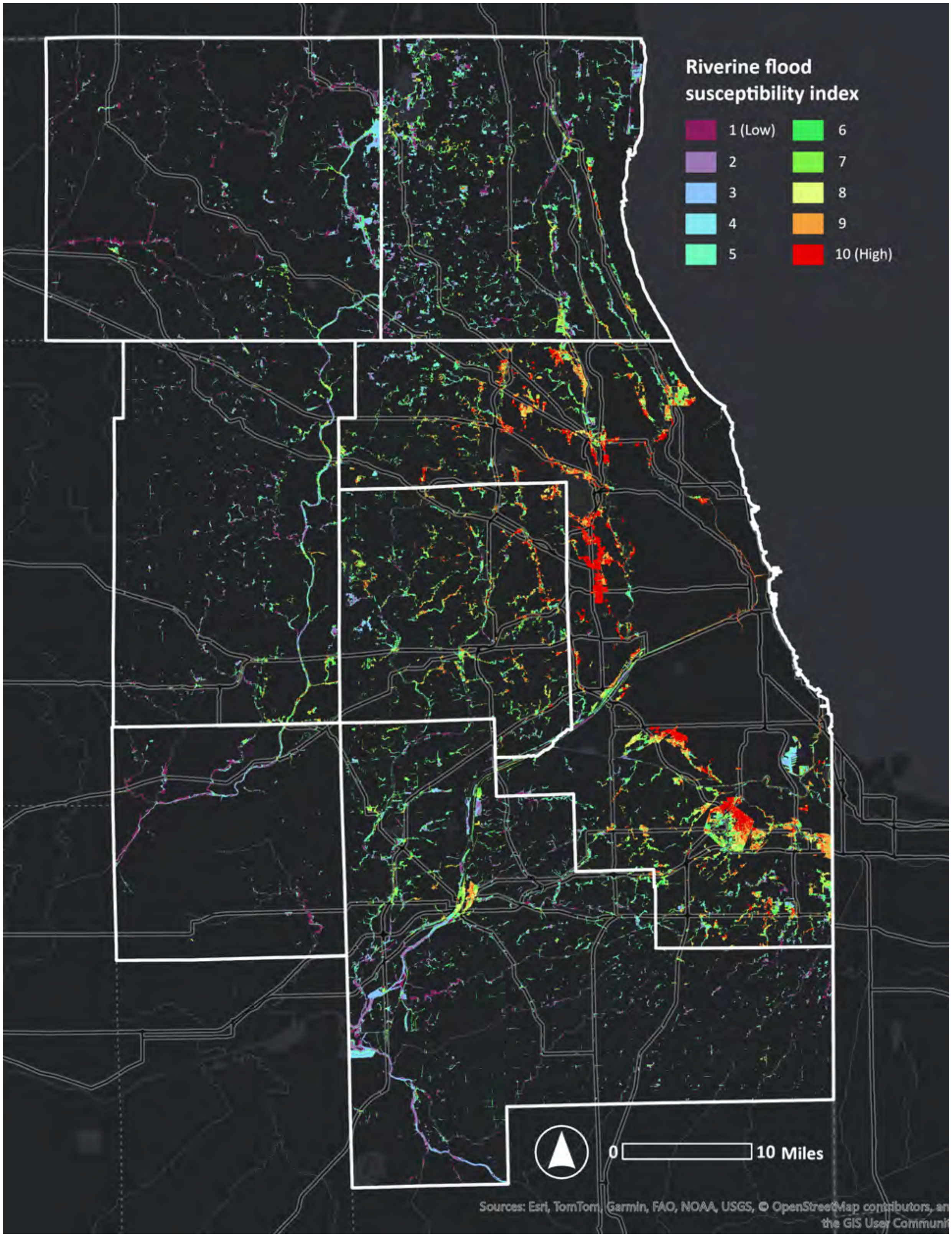
In nearly all counties, the soil infiltration layer is among the top three factors contributing to riverine flood susceptibility. Many of the areas with higher susceptibility have soils with either slow or very slow infiltration ratings, or mixed soils with underlying soils that are slow draining. While hydrological soil group data is missing in large parts of Cook County (including most of

Chicago), it is well known that this area is covered by urban fill or sandy clay loam, which also have slow infiltration rates.

In counties surrounding Cook and DuPage, riverine flood susceptibility is more influenced by the potential future flooding factor

While decades of investment have reduced riverine flooding, climate change is increasing the frequency and severity of major storm events. This means that developments in the current 500-year FEMA floodplain could be at greater risk of flooding in the future than they have been in the past. For some counties, including Lake, McHenry, and Will, potential future flooding is the top factor contributing to riverine flood susceptibility.[11]

Figure 2. Riverine flood susceptibility index, 2026



Source: CMAP, 2026.

Riverine FSI results by county

This section:

- Summarizes riverine flood susceptibility for each county or grouping of counties
- Describes general patterns and areas of the county with higher susceptibility
- Identifies the top flood-related factors that contribute to riverine flood susceptibility across each county

The result shows how susceptibility varies across counties and municipalities depending on development patterns and landscape characteristics.

Cook and DuPage

Cook and DuPage counties have higher susceptibility to riverine flooding (an average of 7.6 and 6.6, respectively). This is particularly true along the tributaries of the Des Plaines River in east DuPage and west Cook counties, the North Branch Chicago River in north Cook, and the Little Calumet River and tributaries of the Cal-Sag Channel in south Cook County. Susceptibility is largely driven by the presence of denser, older developments that predate stormwater management requirements. Poor soil infiltration is also a primary factor across Cook and much of DuPage.

Lake, McHenry, and Will

Lake, McHenry, and Will counties have moderate susceptibility to riverine flooding with an average of 4.5, 3.3, and 4.1, respectively. Areas that stand out with moderate to high susceptibility include parts of the Des Plaines River in Will County, parts of the Fox River and its tributaries in McHenry County, and the upper reaches of the Des Plaines and North Branch Chicago rivers in Lake County. Susceptibility is driven by the area's potential future flooding and catchment runoff rate. This means that riverine flooding could become an increasing threat in the future, as the region experiences more severe and frequent storms resulting from climate change. Having catchments with higher runoff rates indicates that some areas could experience higher peak flows resulting in a greater chance of flooding.

Kane and Kendall

On average, Kane and Kendall counties have lower susceptibility to riverine flooding, with an average of 4.3 and 2.6, respectively. However, some parts of Kane County along the Fox River and its tributaries — Blackberry, Ferson, Indian, Norton, and Poplar creeks — have moderate susceptibility. Susceptibility is primarily driven by the catchment runoff rate factor. Like the other less populated counties, there are catchment areas receiving higher peak runoff flows, which can result in a greater chance of flooding.

In Kane, the second highest contributing factor is older development built before stormwater requirements. This is apparent in communities along the Fox River such as Batavia, Carpentersville, Elgin, Geneva, and St. Charles. In Kendall, the second highest factor is soil infiltration. While soils surrounding the lower Fox River and its tributaries have moderate infiltration and drainage characteristics, there are many other floodplain areas that have soils with slower infiltration rates.

Comparison with 2017 FSIs

While both the 2017 and 2026 FSIs used the same statistical approach for measuring susceptibility, the 2026 FSIs cover a larger geography and use different flooding locations, flooding factors, and methods for indexing the raw scores. Many of these improvements could contribute to differences in the scores between 2017 and 2026.

The 2026 average county susceptibility scores for both FSIs increased compared to average scores from 2017. At the same time, the ranking of the seven counties relative to their average county scores did not change between the urban FSIs but shifted slightly between the riverine FSIs, particularly for counties with moderate to low riverine susceptibility.

The 2026 urban FSI shows more parts of the region with a maximum score of 10. In 2017, Cook was the only county to receive an urban FSI score of 10. This increase in scores at the local level led to increases in county averages for nearly all counties except Kendall and Will, which remained the same (Table 5).

Table 5. Average urban FSI score and relative ranking by county, 2026 and 2017

County	2026	2026 relative ranking	2017	2017 relative ranking
Cook	7.8	1	7.6	1
DuPage	5.2	2	4.8	2
Kane	4.2	4	4.1	4
Kendall	3.5	6	3.5	6
Lake	4.1	5	3.8	5
McHenry	3.1	7	3.0	7
Will	4.2	3	4.2	3

Source: CMAP, 2026.

While the flood-related factors used in the 2026 FSIs differ from those used in 2017, several consistently contribute to urban flood susceptibility across the two versions. For Cook County, age of development, combined sewers, impervious cover, and precipitation all remain the greatest contributing factors. The remaining counties saw low-lying areas near floodplains (previously known as elevation differential between property and nearest Base Flood Elevation) as a consistent contributor to urban flood susceptibility in both versions.

In 2026, Cook, DuPage, Kendall, Lake, and McHenry saw increases in riverine susceptibility. At the same time, their relative ranking remained the same, except for Lake County, whose ranking increased by two, making it the third-most susceptible county to riverine flooding

(Table 6). Kane and Will counties saw decreases in their 2026 average scores, and their relative ranking also dropped by one.

Table 6. Average riverine FSI score by county, 2017 and 2026

County	2026	2026 relative ranking	2017	2017 relative ranking
Cook	7.6	1	7.4	1
DuPage	6.6	2	6.5	2
Kane	4.3	4	4.6	3
Kendall	2.6	7	2.4	7
Lake	4.5	3	4.1	5
McHenry	3.3	6	3.1	6
Will	4.1	5	4.3	4

Source: CMAP, 2026.

Changing the geographic extent for the 2026 riverine FSI increased the footprint of the index in all counties. Cook County saw the largest increase, with the riverine extent more than doubling within its boundary. DuPage, Kane, Kendall, and McHenry counties also saw substantial increases in the riverine footprint of nearly 50 percent or more. This provides a more accurate depiction of flood susceptibility for areas in the region that were previously excluded from the riverine FSI.

Detailed methodology

This section documents the methodology used to create the 2026 FSIs, including the data inputs, process, and changes that were made.

The team selected the frequency ratio approach — the same method used to create the 2017 indexes. This method uses an equation to quantify the relationship between observed flood locations (represented as points) and flood-related factors (represented as raster grids) across a defined study area (geographic extent). Using the same approach created consistency across the two versions.

While the approach used to create the indexes remained the same, there were two significant updates:

- **Methodology refinements.** The 2026 FSI analyses cover more geography to better reflect flooding conditions under climate change impacts. They also involve more rigorous testing of flood-related factors, exploration of different classifications and groupings for the factors, and strengthened steps for validating and indexing the results. The analyses also refined past scripts and documents to make the process more efficient.

- **Data updates.** The project used the most up-to-date information on both known flooding and landscape and infrastructure conditions in the frequency ratio analysis, offering a more accurate and comprehensive outlook on flood susceptibility across northeastern Illinois.

Geographic extents

Both the urban and riverine indexes cover a larger geography than in 2017. This change aims to better reflect the impacts of climate change, acknowledge the difficulty in distinguishing clean boundaries within which urban and riverine flooding occur, and increase applicability among regional stakeholders.

The riverine FSI was expanded to cover developed areas within FEMA's 500-year floodplain and the MWRD's 500-year inundation layer (Table 7).[12] FEMA's floodplain mapping is widely known to be an outdated snapshot in time that does not take climate change into account. As such, its 500-year floodplain is considered more representative of the 100-year floodplain (areas with a 1 percent annual chance of flooding), as the frequency and intensity of precipitation events have increased across the region.[13]

The urban FSI extent was expanded to include all developed areas in the CMAP region — even those within the 100-year floodplain or 100-year inundation area — to acknowledge that even developed areas within floodplains can experience urban flooding (Table 7).

Although the 2026 urban and riverine FSIs now overlap, each uses a different set of flood-related factors to conduct the susceptibility analysis for each flooding type (see the Flood-related factors section).

Table 7. Differences in geographic extents between the 2017 and 2026 flood susceptibility indexes

FSI	2017 geographic coverage	2026 geographic coverage
Riverine	FEMA's 100-year floodplain and MWRD's 100-year inundation layer	FEMA's 500-year floodplain and MWRD's 500-year inundation layer
Urban	Developed areas outside FEMA's 100-year floodplain and MWRD's 100-year inundation layer	All developed areas (including floodplain/inundation areas)

Source: CMAP, 2026.

Flood locations

With continued assistance from FEMA, counties, the City of Chicago, and other regional partners, the 2026 FSIs' flooding location count nearly doubled, increasing to over 312,000 unique locations from more than 20 sources (Table 8). Notably, the updated flood location data included 7 more years of data from FEMA's National Flood Insurance Program and 10 more years of individual assistance claims. Expanding the number of uniquely documented flooding locations improves the indexes' accuracy and reliability.

Unlike the 2017 analysis, flood locations were not classified by flood type. They were randomly split into two datasets. One encompasses 70 percent of the points for the frequency ratio analyses, while the second covers the remaining 30 percent to validate the results. This change is due to the challenges distinguishing the difference between urban and riverine flood events, particularly given the expanded geographies for both indexes.

Table 8. Reported flood locations used in the 2026 FSIs

Source	Time period	Data status	Unique locations
City of Chicago 311 water in basement locations[a]	2020-2024	New	24,239
CMAP other[b]	2020-2021	New	229
Center for Neighborhood Technology Urban Flooding Baseline Project	2021--2022	New	1,285
Cook County Department of Emergency Management and Regional Security[b]	2013	New	91
Cook County Department of Transportation and Highways[b]	2018-2022	New	19
Chicago Transit Authority (via the Regional Transportation Authority)[b]	2011-2016	New	532
DuPage County Division of Transportation[b]	Unspecified	New	9
DuPage County Stormwater Management Department[c]	2013	Used in 2017	2,521
FEMA Discovery Data	2013-2015	Used in 2017	3,161
FEMA individual assistance claims[d]	2007-2024	Updated – 10 years of additional data	242,293
FEMA National Flood Insurance Program claims[d]	1978-2023	Updated – 7 years of additional data	13,904
Illinois Department of Transportation[b]	1990-2024	New	1,546
Kane County Department of Environmental and Water Resources[b]	1996-2023	New	149
Kendall County Planning, Building and Zoning Department	2008-2013	Used in 2017	261

Lake County Division of Transportation[b]	2015-2020	New	233
Lake County Stormwater Management Commission	2013-2024	Updated – 1 year of additional data	21,633
McHenry County Division of Transportation[b]	Unspecified	New	31
MWRD detailed watershed plans	2009-2011	Used in 2017	31
Pace[b]	Unspecified	New	26
Will County Division of Transportation[b]	Unspecified	New	13

[a] The City of Chicago's 311 calls for standing water related to mosquito abatement were not used given the more relevant basement back-up data that has become available in more recent years.

[b] Data collected as part of CMAP's *Transportation Resilience Improvement Plan*.

[c] Associated with the April 2013 floods that were recognized in a presidentially declared disaster (DR-1416).

[d] All FEMA claims or reports were included regardless of payment.

Source: CMAP, 2026.

Flood-related factors

There are several environmental, geographic, and infrastructure characteristics that contribute to or influence flooding. Given the different causes and contributing factors associated with urban and riverine flooding, each index uses a different set of flood-related factors (Table 9). Unless otherwise specified, the factors below were used and created as part of the 2026 update.

Age of development

Nationally, floodplains were first recognized in development regulations in 1968, while stormwater management ordinances were introduced in the region starting in 1972.[14] However, large portions of the region were developed before these requirements were enacted and could be more likely to experience flooding. In addition, older developments may be more susceptible to flooding due to greater maintenance demands over time.

CMAP created this layer in 2017 using the U.S. Geological Survey (USGS) National Water-Quality Assessment Wall-to-Wall Anthropogenic Land Use Trends 1974-2012 land cover datasets to create groupings of development trends over time.

Catchment runoff rate

Hydrographs are often used to understand how a catchment area responds to rainfall — how much accumulates and how quickly it moves through the catchment. One way to understand this dynamic is to calculate a ratio of the natural drainage to the catchment area. A higher ratio indicates higher peak runoff flows and a greater chance of experiencing flooding within the catchment. A ratio of zero indicates an area without a natural path for drainage to flow, which could also contribute to flash flooding.[15]

CMAP used catchments and flowlines from the USGS National Hydrography Dataset Plus High Resolution to create these ratios for the region.[16]

Combined sewer service areas

Areas with combined sewers have long been recognized as more susceptible to flooding since they collect both stormwater and sewage in the same pipe. When the sewers reach capacity, these areas are more likely to experience basement backups and combined sewer overflows.

CMAP created this layer in 2017 with data assistance from the MWRD and various communities.[17]

Flow accumulation

Knowing where overland flow accumulates can help identify locations that are more prone to experience urban flooding. Flow accumulation mapping represents how surface runoff accumulates and flows across the landscape. Areas with high flow accumulation have an increased risk of stormwater inundation — even outside of mapped rivers and streams.

CMAP used the flow accumulation raster from the USGS National Hydrography Dataset Plus High Resolution dataset.[18]

Impervious cover

Impervious surfaces — such as roads, rooftops, and parking lots — prevent rainwater from soaking into the ground and generate stormwater runoff. Areas with higher impervious cover generate greater volumes of runoff at faster rates. As a result, these areas are more reliant on stormwater management systems to store and convey runoff. Development in these areas could experience flooding in the form of surface ponding, overwhelmed catch basins, or basement backups due to overloaded sewers.

CMAP used the 2023 National Land Cover Dataset's Fractional Impervious Surface to identify the percent of impervious cover.[19]

Low-lying areas near floodplains

Development that is outside of the 100-year floodplain but is nearby and at a similar surface elevation is considered more likely to experience urban flooding. The 2019 Cook County Hazard Mitigation Plan identified that the majority of repetitive loss properties located outside of FEMA's 100-year floodplain had basements below the base flood elevation (BFE).[20] Called "elevation differential between property and nearest base flood elevation" in the 2017 FSIs, CMAP created this layer by calculating the mean parcel elevation for properties within 1,500 feet of the nearest BFE and identified those parcels with an elevation within six feet. CMAP updated this layer in 2026 using more recent elevation and BFE data.[21]

Potential future flooding

Recognizing that flooding is a growing concern and expected to worsen over time, rainfall and flooding projections under future climate scenarios can offer more clarity on the potential impacts across the region.

Through CMAP's *Transportation Resilience Improvement Plan* (TRIP), Geosyntec created a future flood inundation model using HEC-RAS 2D.[22] It modeled the impacts from a 500-year storm by mid-century under a high-emissions global warming scenario (SSP5-8.5).[23] CMAP used the output raster to account for potential future flooding, thus identifying areas where flooding could occur if sewers and structures (bridges and culverts) reached capacity.

However, there are limitations that prevent the data from supporting detailed analyses. For example, the model does not include hydraulic structures (bridges and culverts) or other aspects of the region's complex river system. It also excludes information on existing separate and combined sewer system infrastructure, which is essential for developing a better understanding risk.

Precipitation

Some areas of the region have historically seen higher amounts of precipitation that contribute to flooding.

CMAP used precipitation data from the NOAA Atlas 14, 25-year, 2-hour storm event to account for the variation that can influence an area's susceptibility to urban flooding. This represents a change from the 2017 FSIs, which relied on data for a 10-year, 2-hour storm event. Given the impacts of climate change, CMAP selected the larger, 25-year storm to represent the magnitude of storms that are increasingly more common in the region.

Soil infiltration

Water's ability to soak into soil can be an indicator of how much stormwater runoff may be generated. Areas with soils that cannot soak up or that retain water, like clay, may be more likely to flood.

Soil infiltration rates are best represented by the USDA Natural Resources Conservation Service's (NRCS) hydrologic soil groups. Soils are grouped A through D, with A characterizing high infiltration rates and D characterizing low rates. CMAP used the NRCS Soil Survey Geographic Database (SSURGO) to compile hydrologic soil groups for the region.[24]

Table 9. Flood-related factors by FSI type

Flood-related factor	Description	Urban FSI update	Riverine FSI update
Age of development[a]	Categorizes the age of development, by decade, based on developed land classes[b]	✓	✓
Catchment runoff rate	Catchments (small basins) across the region with ratios representing the rate at which runoff flows through it	✓	✓
Combined sewer service areas	Identifies areas served by a combined sewer system	✓	
Flow accumulation	Measures where stormwater runoff accumulates and flows across the landscape	✓	
Impervious cover	Measures different amounts of impervious cover, such as roads, rooftops, and parking lots, within a given area	✓	✓
Low-lying areas near floodplains	Identifies areas that are outside of FEMA's 100-year floodplain but are nearby and at a similar elevation	✓	
Potential future flooding	Measures potential flood depths from a forecasted, mid-century 500-year flood event under a high emissions scenario	✓	✓
Precipitation[c]	Estimates the amount of rainfall the region receives from a 25-year, 2-hour storm, based on historic rainfall data	✓	
Soil infiltration	Identifies soil types based on their ability and rate at which water can soak into the ground		✓

[a] In 2017, this factor was referred to as "Age of first development."
[b] Developed USGS classes: Major transportation, commercial/services, industrial/military, high density residential, and low-medium density residential.
[c] In 2017, this factor was referred to as "Precipitation variation."

Source: CMAP, 2026.

Factor screening

CMAP conducted a rigorous screening process to identify the most relevant factors for both the urban and riverine frequency ratio analyses. Although there is no single agreed-upon set of factors for flood susceptibility mapping, screening and testing are widely recognized as essential steps in factor selection.

To select the flood-related factors, CMAP applied a combination of qualitative and quantitative screening methods, including a list of factors based on their unique contributions to flooding risk, data availability, and processing capacity.

A subset of factors was then evaluated using a series of statistical tests to assess both pairwise relationships (collinearity) and relationships among multiple variables within a group (multicollinearity).[25] Given that the flood-related factors of interest were both continuous and categorical datasets, different tests were used based on their applicable data type (Table 10).[26] Continuous factors were tested using Spearman's Rho and logistic regression. Categorical factors were tested using Cramer's V and General Variance Inflation Factor.[27]

Table 10. Statistical screening tests used in the 2026 FSI update

Screening test	Data type	Description
Cramer's V	Categorical	Measures the strength of association between two categorical factors
Generalized Variance Inflation Factor	Categorical	Measures whether two or more variables are highly linear (i.e., collinear) across all factors
Logistic regression	Continuous	Measures how relevant continuous variables are at predicting flooding, both individually and when accounting for one another
Spearman's Rho	Continuous	Measures the strength of association (i.e., correlation) between two continuous factors

Source: CMAP, 2026.

Conducting the frequency ratio analysis

To conduct the analysis for both indexes, each flood-related factor was clipped to the corresponding geographic extent (urban or riverine), transformed into a raster (if originally in a different data format), and resampled based on the factor with the highest resolution. For both analyses, the spatial resolution of each factor was defined by the potential future flooding factor that has a 10-foot by 10-foot resolution.

Each flood-related factor was then divided into bins to identify which factor characteristics are most strongly associated with reported flood locations. Categorical factors were binned according to their underlying classifications, while continuous factors were divided into deciles (i.e., 10 groups of equal size). For each bin within a given factor, the proportion of reported flood locations occurring within the bin was compared to the proportion of the study area represented by that same bin (Figure 3). This comparison results in a frequency ratio that indicates whether flooding has occurred more or less frequently in areas with specific factor characteristics.

Figure 3. Frequency ratio analysis equation

$$\frac{\textit{Percent of flood events in factor bin}}{\textit{Percent of study area in factor bin}} = \textit{Frequency ratio}$$

Tables 11 and 12 provide the frequency ratios for each flood-related factor for both urban and riverine flooding study areas, respectively. The tables also present two data points used to derive the frequency ratio: the percent of the study area that corresponds with each factor bin and the percent of flood locations that occurred within each factor bin. A frequency ratio value of one (highlighted in light blue in Tables 11 and 12) means that flood locations occur in a bin at the same rate as the bin's share of the study area. Values greater than one indicate that flood locations are overrepresented within the bin, suggesting a stronger association with flooding. Values less than one indicate underrepresentation and a weaker association.

CMAP conducted numerous iterations of the frequency ratio analysis and consulted with experts to finalize which factors and factor groupings should be included in either analysis.[28] This allowed for testing different categorical groupings and determining which factors were appropriate to use. Factors were included if they had frequency ratios scores near, at, or above one, and presented a clear pattern or "story" across the factor bins.

Table 11. Flood-related factors, bins, and frequency ratios for the 2026 urban FSI

Flood-related factor	Data input	Bins	Percent of study area	Percent of flooding locations	Frequency ratio
Age of development	USGS 1974-2012 land use trends dataset, using developed land classes	Prior to 1974	40.53%	83.73%	2.07
		1982	5.32%	2.93%	0.55
		1992	3.25%	0.99%	0.30
		2002	4.81%	1.44%	0.30
		2012	4.46%	0.91%	0.20
		Undeveloped/	41.61%	9.99%	0.24

		post-2012			
Catchment runoff rate	Catchments with corresponding ratios comparing the size of the catchment to the total length of its natural drainage path	0	4.22%	26.44%	6.27
		0.01 - 0.04	5.78%	1.63%	0.28
		0.041 – 0.06	10.00%	2.75%	0.27
		0.061 – 0.09	10.00%	7.29%	0.73
		0.091 - 0.11	10.00%	4.64%	0.46
		0.111 - 0.14	10.00%	9.09%	0.91
		0.141 - 0.17	10.00%	7.76%	0.78
		0.171 - 0.24	10.00%	7.23%	0.72
		0.241 - 0.35	10.00%	9.43%	0.94
		0.351 - 0.59	10.00%	10.04%	1.00
		> 0.59	10.00%	13.67%	1.37
Combined sewer service areas	Combined sewer service area boundaries, received from MWRD and municipalities	Present	15.30%	67.85%	4.44
		Absent	84.70%	32.15%	0.38
Flow accumulation	Flow accumulation layer from the USGS National Hydrography Dataset Plus High Resolution dataset	0 - 0.16	10.00%	9.88%	0.99
		0.17 - 0.65	10.00%	8.62%	0.86
		0.66 - 1.27	10.00%	8.42%	0.84
		1.28 - 2.19	10.00%	8.44%	0.84
		2.20 - 3.58	10.00%	8.33%	0.83
		3.59 - 5.88	10.00%	8.72%	0.87
		5.89 - 10.36	10.00%	9.45%	0.94
		10.37 - 21.88	10.00%	10.83%	1.08
		21.89 - 74.23	10.00%	13.09%	1.31
		> 74.24	10.00%	14.18%	1.42
Impervious cover	Percent impervious cover from 2023 National Land Cover Dataset	No impervious cover	9.18%	0.14%	0.02
		0.01 - 12.72%	9.08%	0.83%	0.09
		12.73 - 21.73%	9.08%	1.87%	0.21

	Fractional Impervious Surface	21.74 - 30.47%	9.08%	3.31%	0.36
		30.48 - 38.64%	9.08%	5.14%	0.57
		38.65 - 46.53%	9.08%	8.00%	0.88
		46.54 - 54.08%	9.08%	11.66%	1.28
		54.09 - 61.52%	9.08%	16.79%	1.85
		61.53 - 69.64%	9.08%	29.27%	3.22
		69.65 - 81.57%	9.08%	19.72%	2.17
		81.58 - 100 %	9.08%	3.27%	0.36
Low-lying areas near floodplains	Difference in mean parcel elevation calculated from a 10-foot regional digital elevation model and FEMA BFE lines for parcels within 1,500 feet of the nearest BFE	Not within 1,500 feet/non-parcel	76.62%	84.81%	1.11
		< -6	0.20%	0.06%	0.28
		-6 to -4	0.11%	0.05%	0.44
		-4 to -2	0.22%	0.23%	1.06
		-2 to 0	0.76%	1.10%	1.45
		0 to 2	1.90%	3.09%	1.63
		2 to 4	2.36%	2.80%	1.19
		4 to 6	2.26%	1.91%	0.85
		> 6	15.56%	5.94%	0.38
Potential future flooding	Potential flood depth of a forecasted mid-century 500-year flood event under a high emissions scenario from TRIP	0 - 0.08 feet (1 inch)	49.67%	32.07%	0.65
		0.09 - 0.49 feet	13.05%	19.11%	1.46
		0.5 - 0.99 feet	12.02%	17.52%	1.46
		1 - 1.99 feet	12.84%	16.96%	1.32
		2 or more feet	12.42%	14.30%	1.15
Precipitation	Precipitation amounts (inches) for the 25-year, 2-hour storm from NOAA Atlas 14	2.62 - 2.73	10.00%	2.49%	0.25
		2.74 - 2.76	10.00%	2.50%	0.25
		2.77- 2.80	10.00%	2.65%	0.27
		2.81 - 2.84	10.00%	4.93%	0.49
		2.85 - 2.86	10.00%	2.20%	0.22
		2.87 - 2.88	10.00%	1.49%	0.15

		2.89 - 2.90	10.00%	1.92%	0.19
		2.91 - 2.93	10.00%	12.12%	1.21
		2.94 - 2.96	10.00%	26.23%	2.62
		2.97 - 3.04	10.00%	43.43%	4.34

Source: CMAP, 2026.

Table 12. Flood-related factors, bins, and frequency ratios for the 2026 riverine FSI

Flood-related factor	Data input	Bins	Percent of study area	Percent of flooding locations	Frequency ratio
Age of development	USGS 1974-2012 land use trends dataset, using developed land classes	Prior to 1974	27.40%	62.13%	2.27
		1982	3.37%	4.20%	1.24
		1992	2.01%	3.31%	1.65
		2002	2.64%	3.16%	1.20
		2012	2.83%	0.92%	0.33
		Undeveloped/ post-2012	61.75%	26.28%	0.43
Catchment runoff rate	Catchments with corresponding ratios comparing the size of the catchment to the total length of its natural drainage path	0	0.96%	0.13%	0.14
		0.01 - 0.04	9.04%	8.08%	0.89
		0.041 - 0.06	10.00%	6.33%	0.63
		0.061 - 0.09	10.00%	4.04%	0.40
		0.091 - 0.11	10.00%	4.52%	0.45
		0.111 - 0.14	10.00%	7.74%	0.77
		0.141 - 0.17	10.00%	11.55%	1.16
		0.171 - 0.24	10.00%	9.16%	0.92
		0.241 - 0.35	10.00%	12.37%	1.24
		0.351 - 0.59	10.00%	18.98%	1.90
		> 0.59	10.00%	16.89%	1.69
Impervious cover	Percent impervious cover from 2023	No impervious cover	31.39%	1.45%	0.05
		0.01 - 12.72%	6.86%	1.40%	0.20

	National Land Cover Dataset Fractional Impervious Surface	12.73 - 21.73%	6.86%	2.01%	0.29
		21.74 - 30.47%	6.86%	3.37%	0.49
		30.48 - 38.64%	6.86%	6.34%	0.92
		38.65 - 46.53%	6.86%	9.17%	1.34
		46.54 - 54.08%	6.86%	11.31%	1.65
		54.09 - 61.52%	6.86%	15.59%	2.27
		61.53 - 69.64%	6.86%	21.21%	3.09
		69.65 - 81.57%	6.86%	22.59%	3.29
		81.58 - 100 %	6.86%	5.58%	0.81
Potential future flooding	Potential flood depths of a forecasted mid-century 500-year flood event under a high-emissions scenario from TRIP	-2 - 0 feet	8.16%	3.79%	0.46
		0 - 2 feet	21.99%	34.36%	1.56
		2 - 4 feet	26.76%	32.20%	1.20
		4 - 6 feet	20.20%	19.38%	0.96
		> 6 feet	22.89%	10.06%	0.44
Soil infiltration	Hydrologic soils groups from NRCS SSURGO database	A	0.93%	0.18%	0.19
		B	7.39%	6.22%	0.84
		C	12.42%	11.04%	0.89
		D	9.16%	20.37%	2.22
		A/D	11.06%	5.59%	0.51
		B/D	29.69%	17.74%	0.60
		C/D	22.66%	19.85%	0.88
		No data/missing	6.47%	18.80%	2.91

Source: CMAP, 2026.

Validating and indexing results

To create the flood susceptibility indexes, the frequency ratios of the flood-related factors were aggregated and indexed into 10 bins. In 2017, CMAP added the frequency ratios across all flood-related factors and split the summed ratios into 10 equally sized bins. In 2026, CMAP conducted several iterations of aggregating and indexing the frequency ratios and used a more robust validation method to determine the most accurate method. The final method chosen multiplies the frequency ratios and splits the products into 10 equally sized bins (deciles).[29]

CMAP tested iterations of both indexes against a random sample of flood points that were set aside prior to performing the frequency ratio analysis.[30] The accuracy of each index was determined with two validation methods: a correlation analysis and a receiver operating characteristic (ROC) curve & area under the curve (AUC) analysis. The correlation analysis, which was also performed in 2017, counts the number of validation flood locations within each value of the index. The ROC/AUC analysis is a more robust validation method added to the 2026 FSI process that determines how well the index distinguishes between flood points and non-flood points. CMAP chose the aggregation and indexing method that produced the strongest correlation and the highest AUC.

Table 13 shows the correlation analysis results of the chosen aggregation and indexing method. In both indexes, there is a strong positive correlation between known flood locations and the highest index values. This means the indexes correctly assign high susceptibility to areas with more known flood locations.

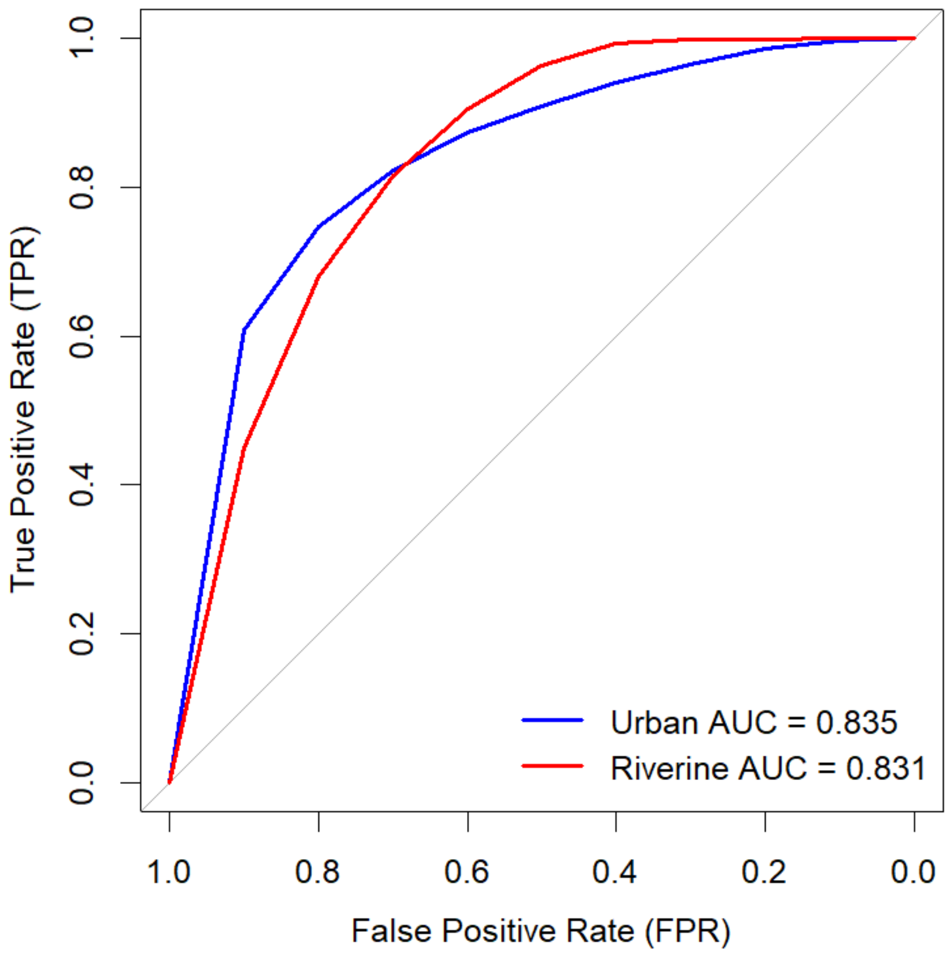
Table 13. Correlation by index level for 2026 urban and riverine FSIs

Index value	Share of validation flooding locations	
	Urban FSI	Riverine FSI
1	0.24%	0.02%
2	1.20%	0.03%
3	1.97%	0.16%
4	2.56%	0.53%
5	3.07%	2.86%
6	3.60%	5.79%
7	5.11%	9.09%
8	7.45%	13.45%
9	13.90%	23.03%
10	60.89%	45.03%

Source: CMAP, 2026.

Figure 4 shows the ROC/AUC analysis results of the chosen method. The urban AUC is 0.835 and the riverine AUC is 0.831.[31] This means that 83 percent of the time, the urban and riverine FSIs assign a higher index value to a randomly selected flooding location than to a randomly selected non-flooding location.

Figure 4. ROC/AUC analysis for 2026 urban and riverine FSIs



Source: CMAP, 2026.

Limitations and future refinements

While creating the 2026 FSIs, the project team encountered multiple challenges and limitations associated with data availability and processing. The following section identifies these challenges and limitations as well as additional considerations for future index refinements that were otherwise deemed out of scope or could not be addressed within the 2026 update.

Flood location data

FEMA NFIP claims

One of the flood location data sources used to generate the FSIs was property-level claims data from FEMA's National Flood Insurance Program (NFIP) dating back to the 1970s. While this allowed for numerous accounts of unique flooding locations across the region, areas with claims recorded between the 1970s and 2000s (or later) may no longer experience flooding as a result of flood mitigation and stormwater infrastructure investments from past decades.[32] While accounting for all improvements is not feasible, it may be worthwhile to run the frequency ratio analysis without claims from past decades and test the performance of the results to determine whether the oldest claims are obscuring the results.

Crowdsourced data

The City of Chicago's water in basement 311 data and Center for Neighborhood Technology's Urban Flooding Baseline Project data are two crowdsourced datasets used to create the FSIs. While crowdsourcing can be a cost-effective way to gather information on flooding from a wide range of people and perspectives, it can be difficult to verify and may introduce bias.

These concerns were considered during the flood location data selection process; however, the project team ultimately chose to proceed with the two datasets. Chicago's basement flooding 311 data is widely used to analyze flooding within the city, and the Center for Neighborhood Technology's flooding location data included multiple attributes (including photos) that enabled the project team to verify if flooding occurred.

Flood data from Waze — a crowdsourced navigation and traffic application — was evaluated as a potential source for the analysis due to its broad geographic coverage and near-real-time reporting. However, it was not included because individual reports could not be reliably verified or filtered to isolate specific flood events.

Flood-related factors

Catchment runoff rate

The catchment runoff rate factor was developed using two features of the National Hydrography Dataset Plus high resolution (NHDPlus HR) dataset: catchments and flowlines. The project team found that some catchments throughout the region lack flowlines, resulting in catchment runoff rate ratios of zero. Catchments without flowlines in less developed areas, such as McHenry County, could have resulted from a more depressional landscape from karst-like geography that creates catchments without defined outlets.[33] Catchments without flowlines in more developed areas, like those in Cook County, could have resulted from an overly developed, flat landscape that makes it difficult to delineate a defined flowline.

Additionally, the project team recognizes that these results could be related to data processing of the catchment areas and/or flowlines, or data issues present in large datasets, such as the NHDPlus HR.[34] For example, there are documented issues with the NHDPlus HR dataset that impact catchments, particularly for the Great Lakes region (which includes a small sliver of the CMAP region along Lake Michigan's coastline).[35] While no dataset is perfect, the project team felt that these potential discrepancies did not warrant removing the factor from the analyses.

Low-lying areas near floodplains

This factor relies on base flood elevations (BFEs), which are a data feature within FEMA's national flood hazard layer dataset.[36] BFEs are cross-sectional lines representing the elevation at which flooding could occur within FEMA's 100-year floodplain. BFEs are located on waterways with mapped floodplains where detailed hydraulic analyses have been completed. These are often areas where development exists or where FEMA has identified the potential for future development.

However, there are areas throughout northeastern Illinois that lack BFEs. Several waterways near developed land in south central Will County, northwest Kendall County, and northwest McHenry County do not have associated BFEs. Much of the Chicago Area Waterway System also does not have associated BFEs. As a result, this flood-related factor does not fully capture all development near waterways and may be incomplete.

Potential future flooding

The modeling effort to create this factor provides a high-level understanding of potential future flooding at a regional scale. It relies on a raster output from a HEC-RAS 2D model created by Geosyntec for CMAP's *Transportation Resilience Improvement Plan*. The factor uses modeled inundation depths from a 500-year storm by mid-century under a high-emissions global warming scenario (SSP5-8.5).

There are limitations that prevent the data from supporting detailed analyses. For example, the model does not include hydraulic structures (bridges and culverts) or other aspects of the region's complex river system. It also excludes information on existing separate and combined sewer system infrastructure, which is essential for developing a better understanding of risk. In the future, there could be opportunities to refine the HEC-RAS model to better reflect conditions, including but not limited to hydraulically correcting the digital terrain model; accounting for bridge, culvert, and pipe flows; and calibrating the model to a particular storm event.

Future methodological approach: Geographically weighted regression

The frequency ratio approach is widely viewed as a well-grounded and acceptable method for measuring flood susceptibility, particularly given its ease and speed. However, CMAP may want to consider other approaches, pending available time and resources for future updates.

If the 2026 FSIs continue to provide value for both CMAP and regional partners, CMAP should consider measuring flood susceptibility using a methodology based on geographically weighted regression (GWR). Although it is a more advanced and resource-intensive approach, GWR has the potential to improve the accuracy of the FSI analysis.

A GWR approach uses a traditional regression framework that allows for spatial variability as an influencing factor, which can be important for events like flooding that vary geographically.[37]

GWR is based on Tobler's Law of Geography: "Everything is related to everything else, but near things are more related than distant things." Instead of a single regression model fit to known flood occurrences, represented as an individual inventory layer of known locations where flooding has occurred, GWR fits a regression model to every flood event (i.e., a documented flood location).

Fitting a model to every flood location enables flood-related factors to vary by locality. Observations closer to a reported flood location will have a stronger influence on the calculation. For example, the flood-related factors present in Lake County will have a stronger influence on flood susceptibility in that county than those present in Will County. GWR can also mix spatially variable (local) and fixed (global) coefficients, meaning it can include flood-related factors that apply to all parts of the region as well as factors that are unique to or only available for a particular area, such as data on the presence of basements available through the Cook County Assessor's Office. In addition to spatial variability advantages, GWR reduces spatial autocorrelation (i.e., the degree to which a group of features and their values are clustered together) and is good at identifying spatial anomalies, all of which can help improve results.[38]

Appendix

A. Stakeholders interviewed

The project team conducted interviews to learn how partners have used the FSI in the past, identify new flooding location data, solicit feedback on flood-related factors and methodological improvements to consider through the update process, and gather input on how the updated FSIs could become more useful and valuable to stakeholders across the region. Over 15 regional stakeholders were interviewed between October 2022 and February 2023. Stakeholders included stormwater experts, climate scientists, statisticians, modelers, and index users from county stormwater agencies, nonprofit organizations, and academic and research institutions.

County stormwater agencies

- DuPage County, Department of Stormwater Management
- Kane County, Department of Environmental and Water Resources
- Kendall County, Department of Planning, Building, and Zoning
- Lake County Stormwater Management Commission
- McHenry County, Water Resources Division
- Metropolitan Water Reclamation District of Greater Chicago
- Will County, Stormwater Management Planning Committee

Local and state institutions

- City of Chicago, Department of Public Health
- Illinois State Water Survey, Watershed Science Section

Non-profit organizations

- The Nature Conservancy
- Greater Chicago River Watershed Council (represented by the Friends of the Chicago River and Trust for Public Land)
- Center for Neighborhood Technology
- Metropolitan Planning Council

University and research institutions

- Illinois-Indiana Sea Grant
- Northwestern University / Northwestern Center for Water Research
- University of Illinois at Urbana-Champaign, Department of Atmospheric Science

- University of Illinois at Chicago, Division of Environmental and Occupational Health Sciences in School of Public Health

B. Other flood-related factors considered in Phase 1

The following are flood-related factors that CMAP considered in Phase 1 but decided to exclude from the flood-factor screening in Phase 2. The reasoning for exclusion varied across the flood-related factors (Table 14).

Table 14. Other flood-related factors considered for the 2026 FSIs

Category	Flood-related factor	Description	Reason for exclusion
Basin area	Basin size	A physical attribute linked to streamflow characteristics and water quantity.	Recommended to use layer as a geography to summarize other basin-related characteristics.
Erosion	Sediment transport index	A composite statistic that describes erosion and movement of sediment due to water movement.	Erosion is not directly associated with flooding.
Erosion	Stream power index	A composite statistic that describes the potential erosion power of a stream relative to specific watershed areas.	Erosion is not directly associated with flooding.
Flood elevation	Altitude	Height of floodwater relative to the usual water height reflects the potential energy of floodwater in the event of release.	More relevant for high-relief landscapes and dam management.
Flood elevation	Terrain / topographic roughness index	A composite statistic that measures the variability or irregularity in elevation in an area.	Insufficient variability in this measure across the study area. It also requires extensive regional digital elevation model (DEM) processing beyond current resources.
Flood elevation	Topographic position index	A composite statistic that compares the elevation of a DEM cell and the mean elevation of the neighboring	Requires extensive processing of regional DEM beyond current resources.

		cells to indicate relative position.	
Flood elevation	Topographic wetness index	A composite statistic that identifies flat areas with high flow accumulation where water is likely to pond, absent sewer capacity.	Although used in the 2017 urban FSI, pivoted to using the future flood inundation model, developed using HEC-RAS 2D under CMAP's TRIP.
Infiltration	Aspect	Identification of the compass direction that the downhill slope faces for each location. Impacts soil moisture, sun intensity, and rainfall infiltration.	Insufficient variability in this measure across the study area. It would also require extensive processing beyond current resources.
Infiltration	Average inverse relative permeability	A composite statistic of detailed soil characteristics and land use.	Data quality and applicability in developed areas are unknown and may have insufficient variability across the study area.
Infiltration	Circularity ratio	Expresses degree of "roundness" of basin shape, indicating poor infiltration.	Variable data quality for developed areas.
Peak runoff	Curvature	The second derivative of a surface or the "slope of the slope." Areas that have negative curvature are more prone to flooding and pooling water.	Requires extensive processing of DEM beyond current resources and technical capabilities.
Peak runoff	Drainage texture	A ratio represents the total number of stream segments, of all orders, in a basin to the basin's perimeter.	Requires extensive processing and it is difficult to calculate at the regional scale.
Peak runoff	Elongation ratio	A ratio that compares the radius of a minimum bounding circle to the radius of an inscribed catchment or basin area. It indicates peak runoff; runoff is more likely to travel a wider range of distances in more elongated basins to reach the basin's outlet.	Requires extensive processing beyond current resources and technical capabilities.

Peak runoff	Form factor	Represents the shape or outline of a watershed and provides information on its flow intensity. Higher values are related to more circular watersheds with greater discharge in short durations, while lower values are the opposite.	Requires extensive processing of DEM beyond current technical capabilities.
Peak runoff	Rainfall (average or maximum)	Precipitation observations that are summarized over a particular timestamp. Timestamps range from the average maximum annual rainfall per year to the average of the most extended period of consecutive days of rain per year.	No variability within the data across the region.
Peak runoff	Relief ratio	Overall steepness of watersheds and intensity of erosional processes. It can be an indicator of sudden peak discharge.	More relevant for high-relief landscapes.
Peak runoff	Time of concentration	The time required for runoff to travel from the hydraulically most distant point in a watershed to its outlet. It is used to predict discharge rate and volume.	Requires extensive processing. It is also likely to be redundant to other factors.
River flow	Number of streams	Count of stream segments with different orders. Faster peak flow and higher runoff potential are associated with larger stream numbers.	Requires extensive processing and it is difficult to calculate at the regional scale.
River flow	Stream frequency	Count of flow/drainage lines per square kilometer. Steep slopes and low infiltration capacity are typically associated with higher stream frequencies, facilitating greater surface flow and increasing flood potential.	Requires extensive processing and it is difficult to calculate at the regional scale.

River flow	Stream length	Length of streams of different orders within the watershed, which is an indicator of infiltration and runoff potential.	Requires extensive processing and it is difficult to calculate at the regional scale.
River flow	Stream order	The classification of streams according to Strahler's method where rivers with no upstream tributaries were assigned as first orders, and a higher order was given when equal order streams merged.	Requires some processing and was considered a low-priority factor. It could be included in the future if time and resources allow.
Riverine flooding	Basin relief	Relief describes the variation in features and heights across a landscape and directly informs stream gradient, landform development, and flooding patterns of the terrain.	Not applicable to the region. It is more relevant for high-relief landscapes.
Riverine flooding	Bifurcation ratio	Ratio that splits and compares the number of streams in one order and compares it to the number of streams in the next order within a drainage network. The ratio can indicate proneness to flooding. The higher the ratio, the greater the likelihood of flooding.	Requires extensive processing and it is difficult to calculate at the regional scale.
Riverine flooding	Distance from rivers and road	A measurement of how far rivers are from roads. Roads closest to rivers are more likely to experience riverine flooding.	The analysis is focused on developed areas susceptible to flooding, not specific structures/assets within the developed areas. See the Risk-based Vulnerability Assessment for information on road vulnerability to flooding.[a]
Riverine flooding	Drainage density	The closeness of channel spacing. Well-drained watersheds have density values of approximately 0.73, while poorly drained ones have values of about 2.74.	Requires extensive processing and it is difficult to calculate at the regional scale.

Riverine flooding	Elevation	Distance above sea level. Elevation impacts slope and the rate at which stormwater runoff flows through a landscape.	Elevation is captured in other flood-related factors. For riverine flooding specifically, Base Flood Elevation is a better indicator.
Riverine flooding	Geology	Quaternary geologic deposits represent important reservoirs of hydrologic, aggregate, and other resources. It can indicate historic riverine flooding (e.g., a stream overflows and leaves sediment deposits in a floodplain as it recedes).	Likely to have an insignificant relationship with current flooding.
Riverine flooding	Texture ratio	The ratio is a function of lithology, slope, climate, vegetation, and soil type. It is classified into four types: course <4 per km, intermediate (4-10 per km), fine (10-15 per km), and very fine (>15 per km). A coarser texture is less prone to flooding.	Same as drainage texture. Requires extensive processing and it is difficult to calculate at the regional scale
Riverine flooding	Wetlands	Ecosystems that are flooded or saturated by water. Wetlands help reduce flooding and associated losses because they hold, store, and slowly release accumulated runoff.	Considered redundant to floodplain areas.
Runoff	First Street Foundation flood hazard layers	Urban, riverine, and coastal hazard layers developed using climate data, hydrologic and hydraulic models, and probabilistic flooding scenarios.	Requires product to be purchased and cannot be directly shared with partners and stakeholders
Runoff	Impervious cover of watershed catchment[b]	Impervious cover summarized by watershed catchment areas. More developed catchments have the potential to generate more stormwater runoff that increases the risk of flooding.	Considered redundant to impervious cover as a flood-related factor. It could be included in the future if time and resources allow.

Runoff	Land use/land cover[b]	Land use identifies specific uses or management of land usage or activity. Land cover describes the land cover types, ranging from developed areas to vegetation and water. Different land use/cover types can influence runoff volume and rate.	The flood-related factor is likely redundant to the impervious cover flood-related factor.
Runoff	Ruggedness number	Depicts the structural complexity of the terrain (roughness or unevenness). Basins with gentle and higher infiltration rates will likely generate less runoff than basins with steep and varied slopes.	Requires extensive processing and derived from other flood-related factors that were not included (e.g., basin relief and drainage density).
Runoff	Slope	Gradient, or extent of an incline of the land's surface. Steep slopes increase the speed of the surface runoff and reduce the time available for the soil to absorb the water. It is an indicator of increased runoff and low infiltration rates.	The flood-related factor is redundant to flow accumulation.
Urban flooding	Depressions	An area that has a lower elevation than its surrounding region. It identifies low-lying areas where stormwater will pool.	Requires extensive processing beyond current resources and technical capabilities.
Urban flooding	Storage capacity	Measurement of a geographic unit's total volume relative to surface elevation. It can indicate how much stormwater can be temporarily held within a watershed.	Requires extensive processing beyond current resources and technical capabilities.

a. CMAP, "Risk-based Vulnerability Assessment," November 2024, https://cmap.illinois.gov/focus-areas/climate/climate-resilience/#h-transportation-resilience-improvement-plan.
b. Previously used in the 2017 riverine FSI.

C. Countywide rescaled index results

Urban FSIs rescaled to each county within northeastern Illinois

Figure 5. Urban FSI rescaled to Cook County

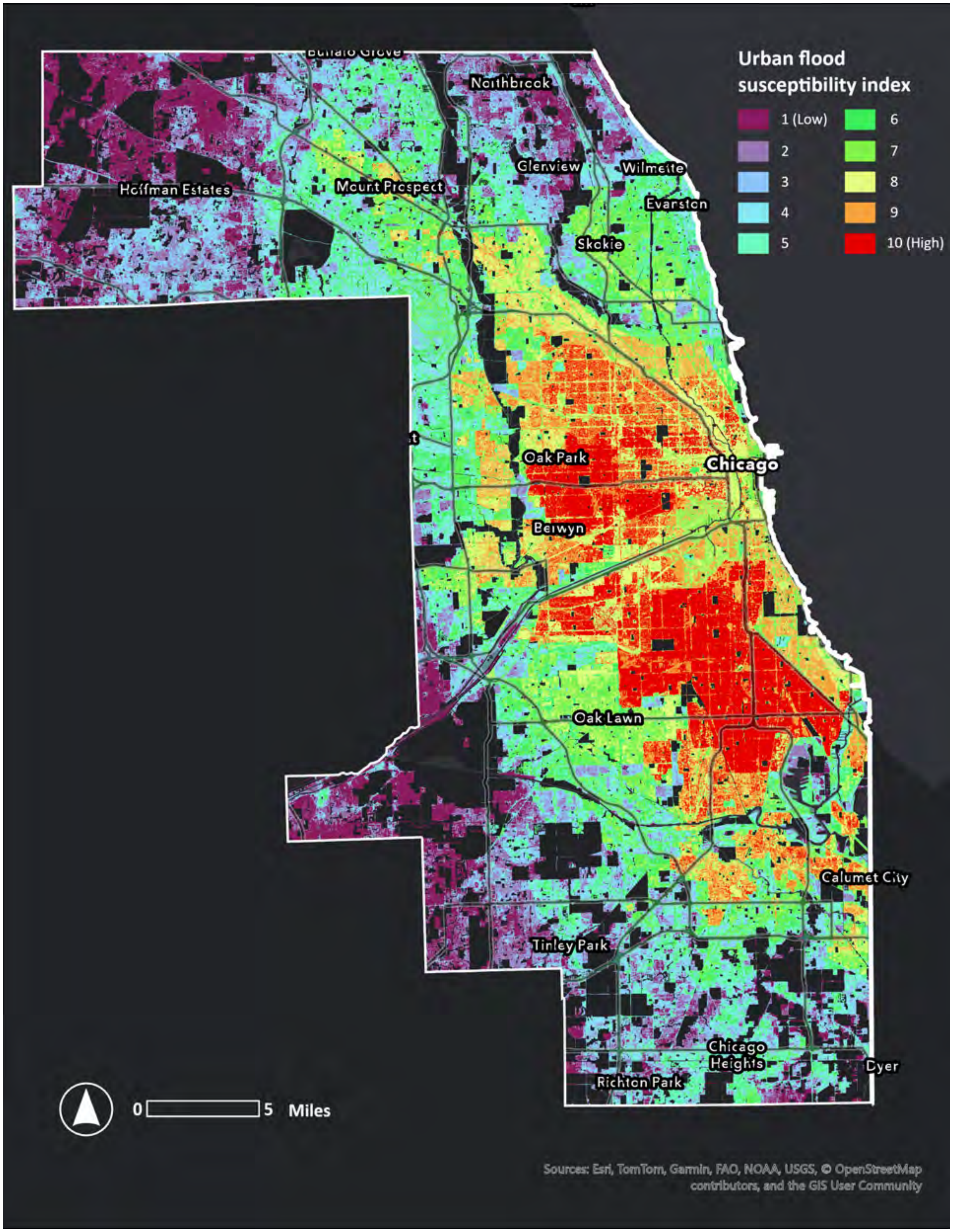


Figure 6. Urban FSI rescaled to DuPage County

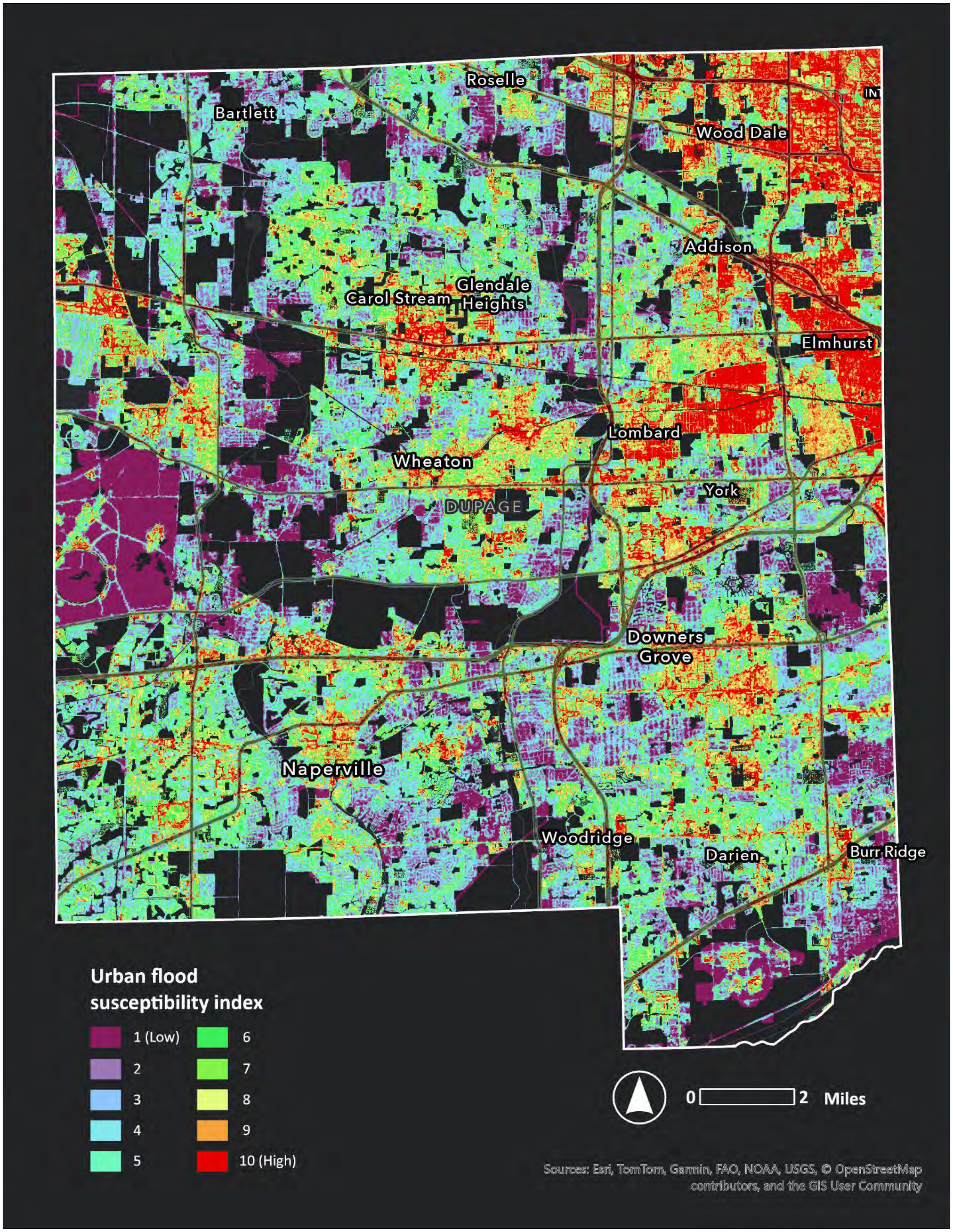


Figure 7. Urban FSI rescaled to Kane County

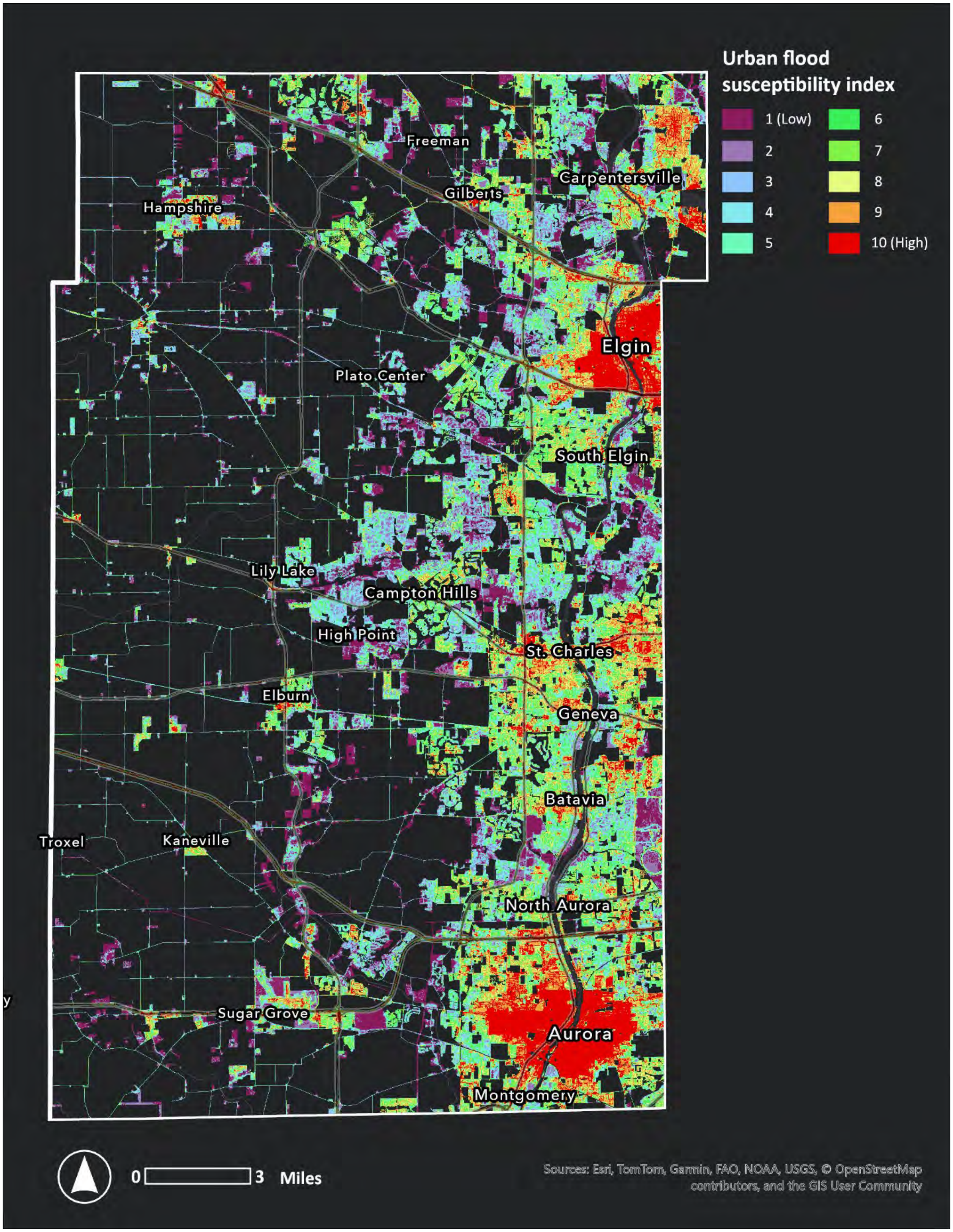


Figure 8. Urban FSI rescaled to Kendall County

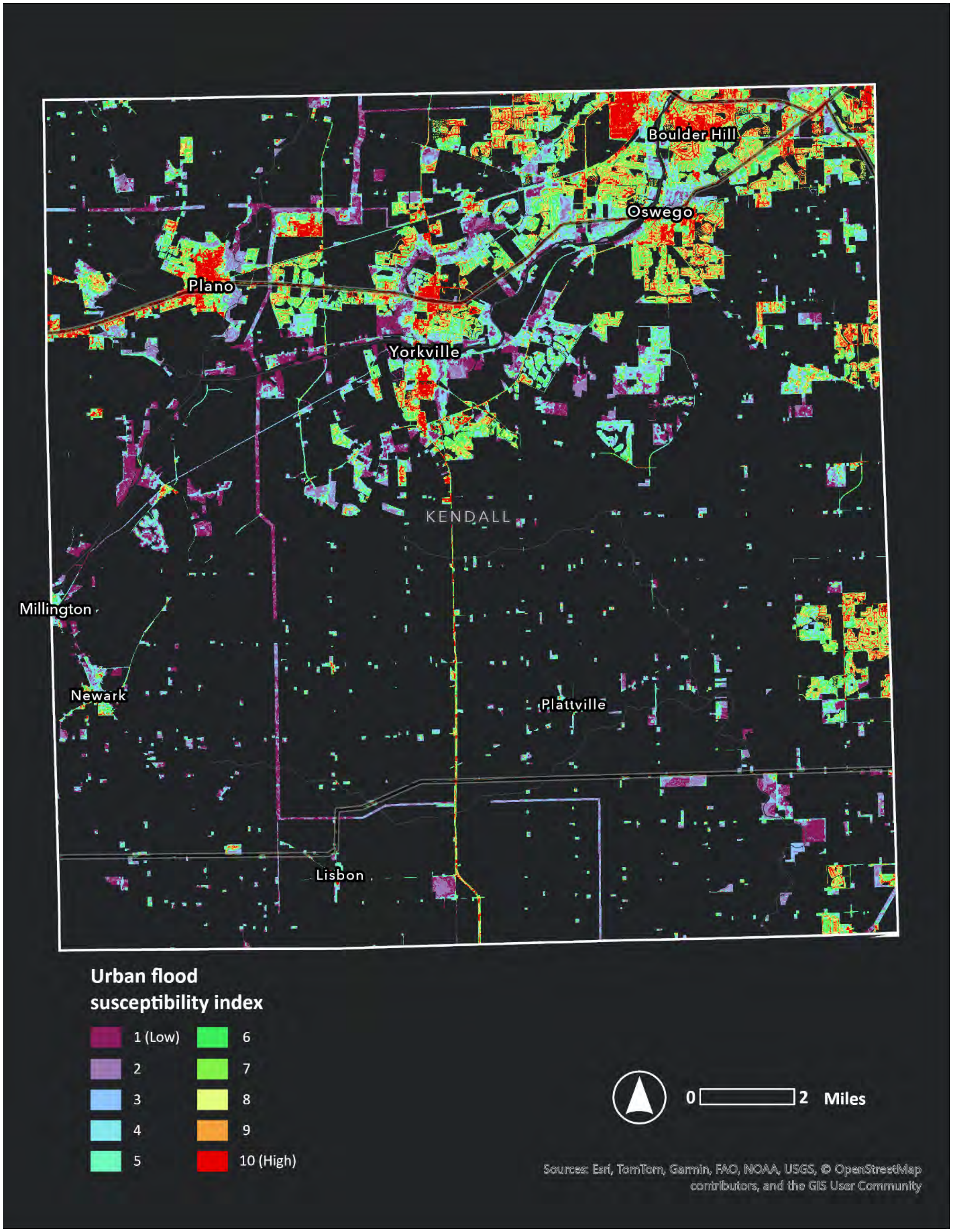


Figure 9. Urban FSI rescaled to Lake County

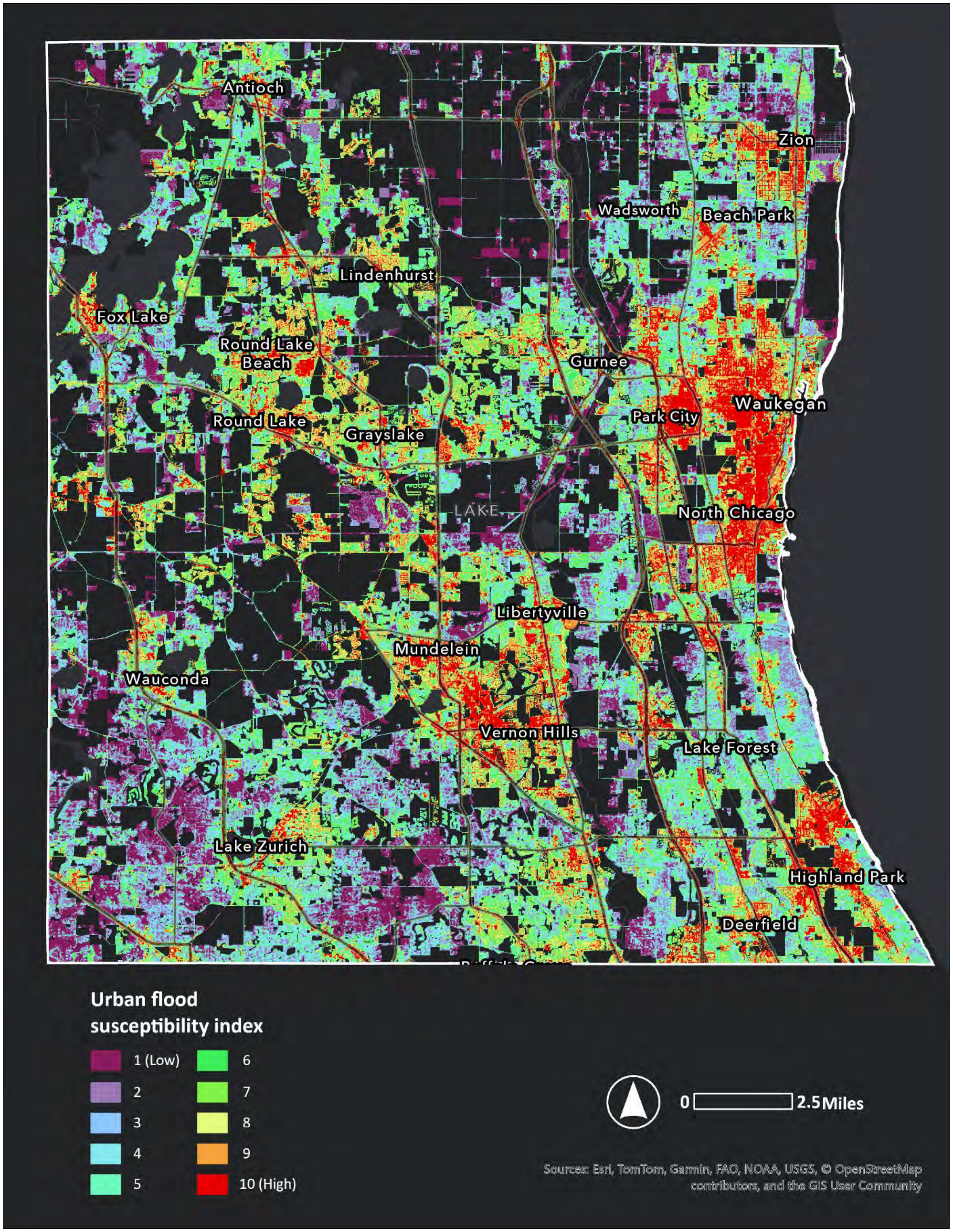


Figure 10. Urban FSI rescaled to McHenry County

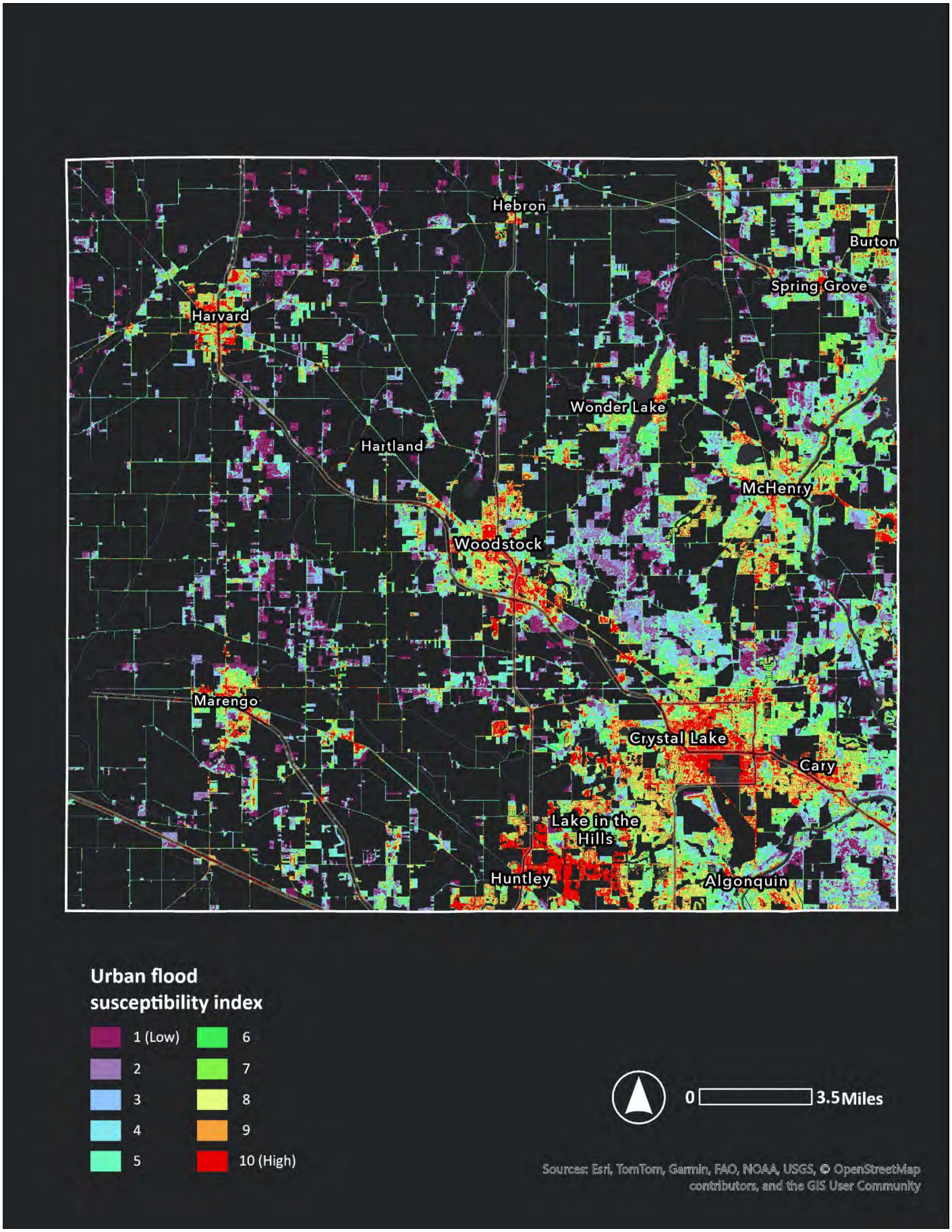
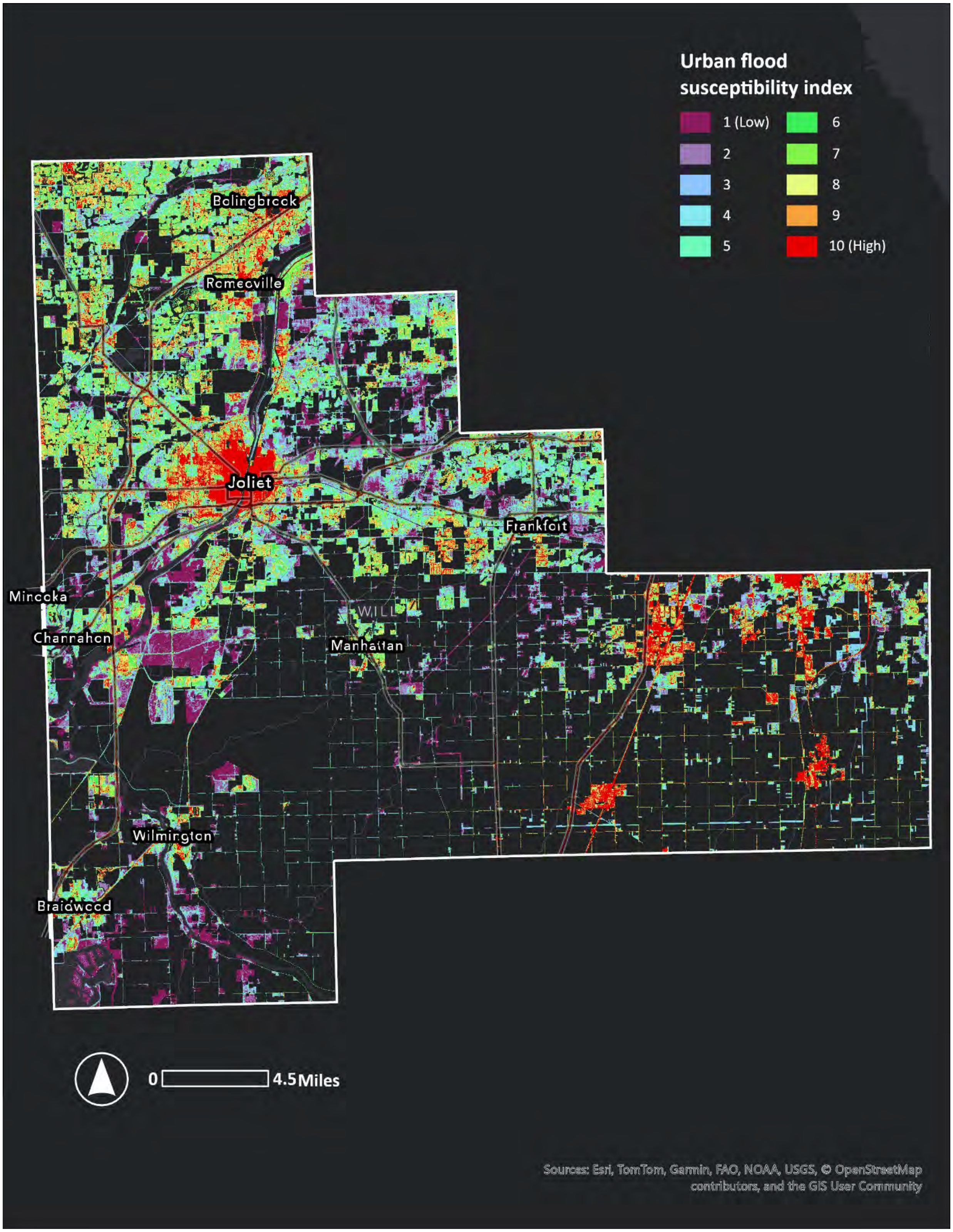


Figure 11. Urban FSI rescaled to Will County



Riverine FSIs rescaled to each county within northeastern Illinois

Figure 12. Riverine FSI rescaled to Cook County

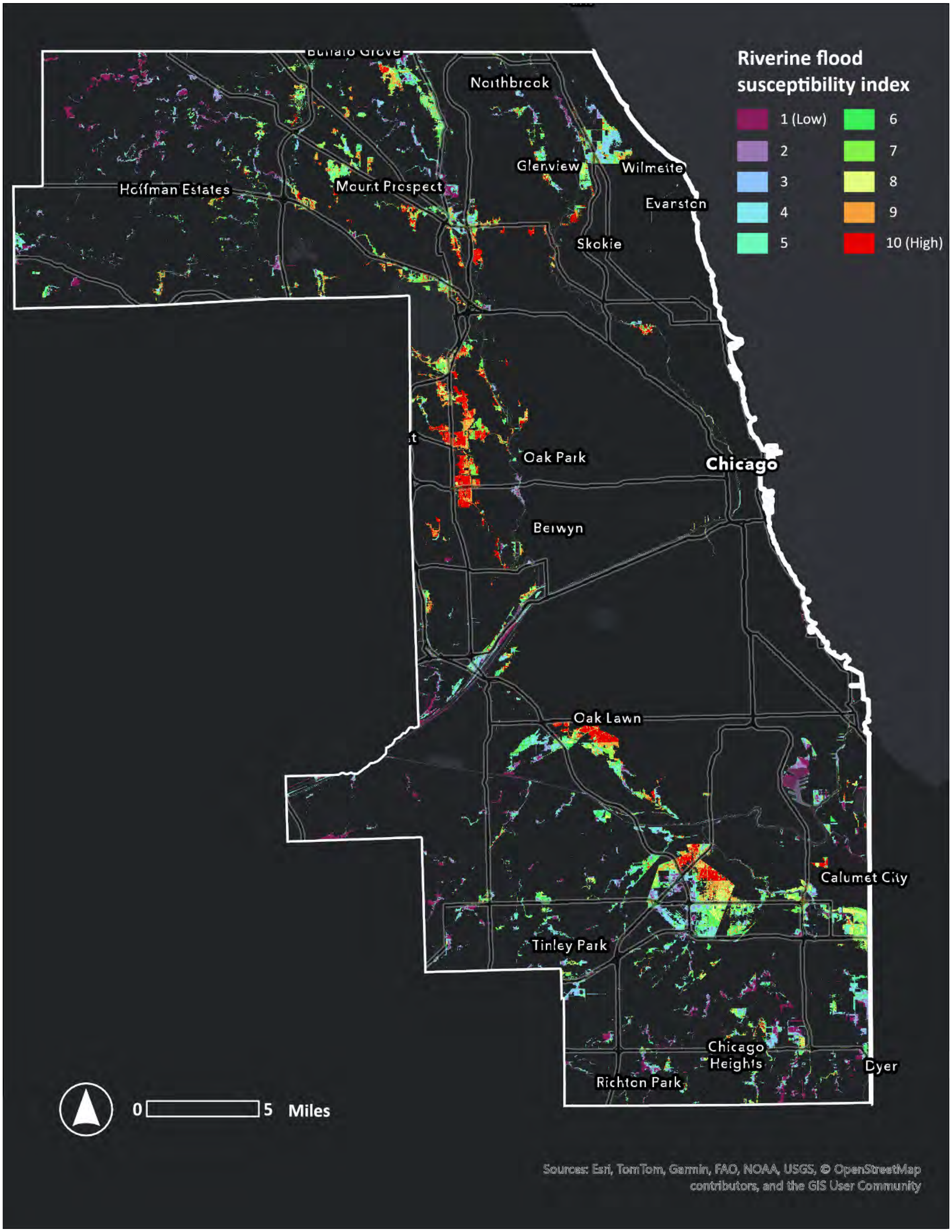


Figure 13. Riverine FSI rescaled to DuPage County

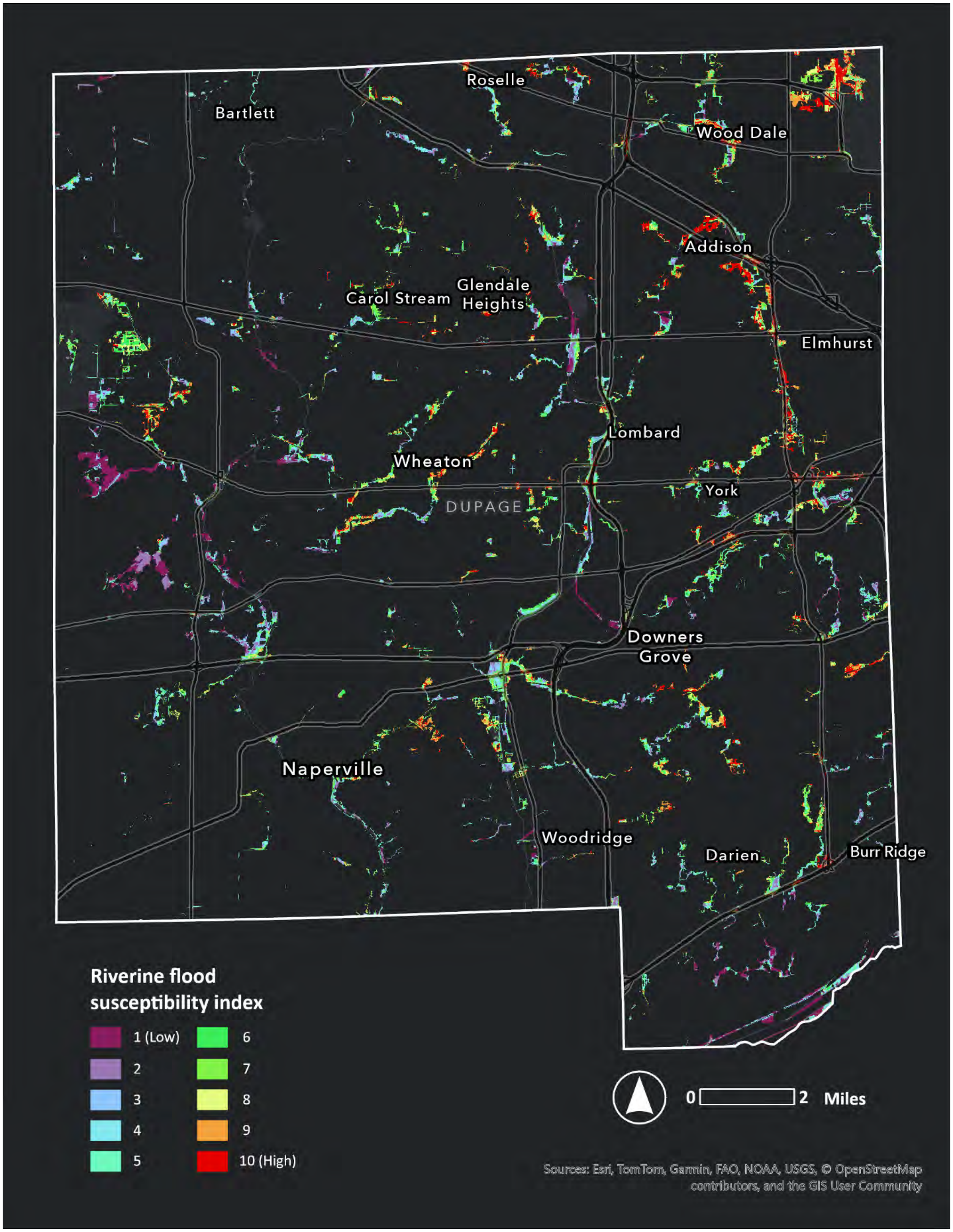


Figure 14. Riverine FSI rescaled to Kane County

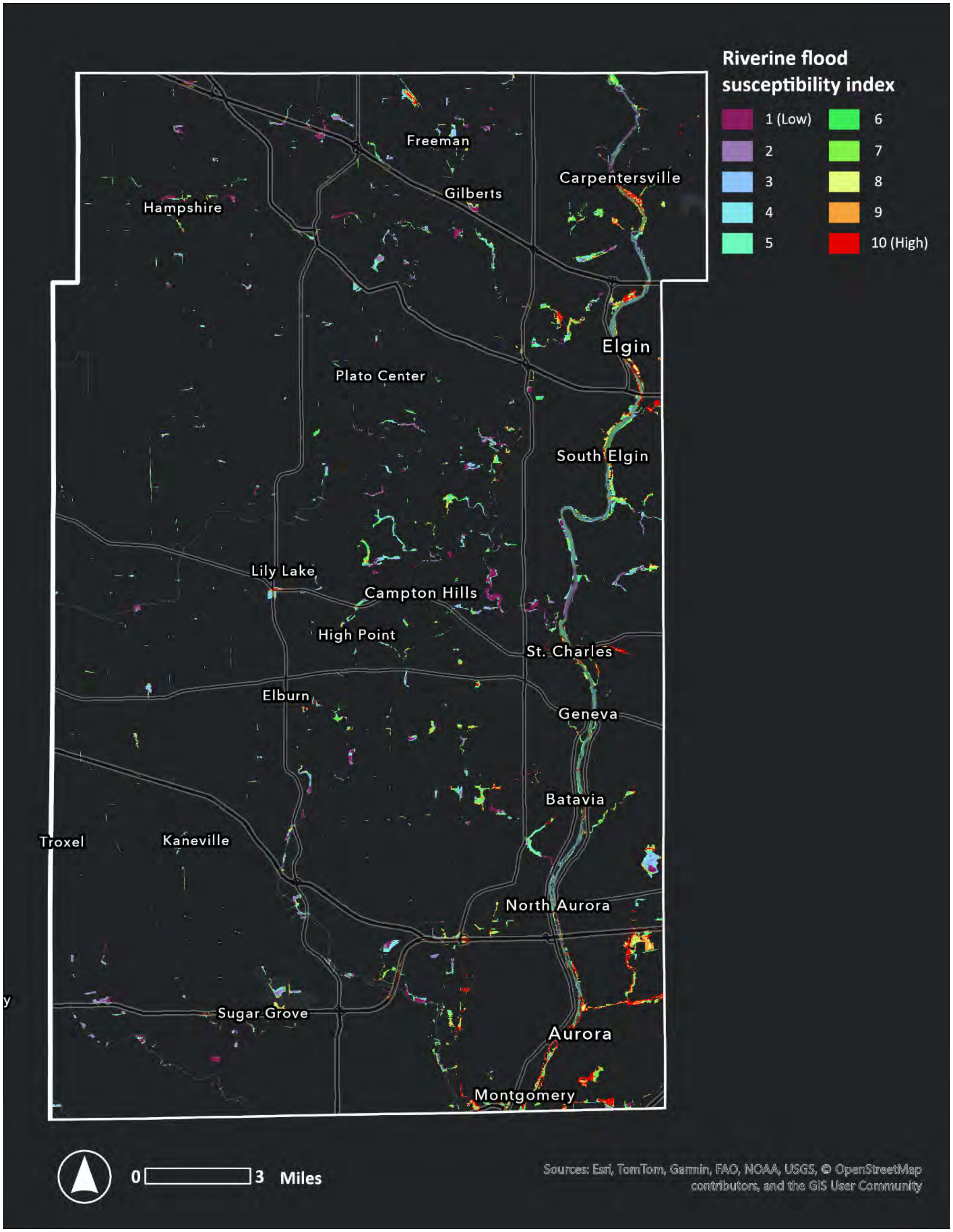


Figure 15. Riverine FSI rescaled to Kendall County

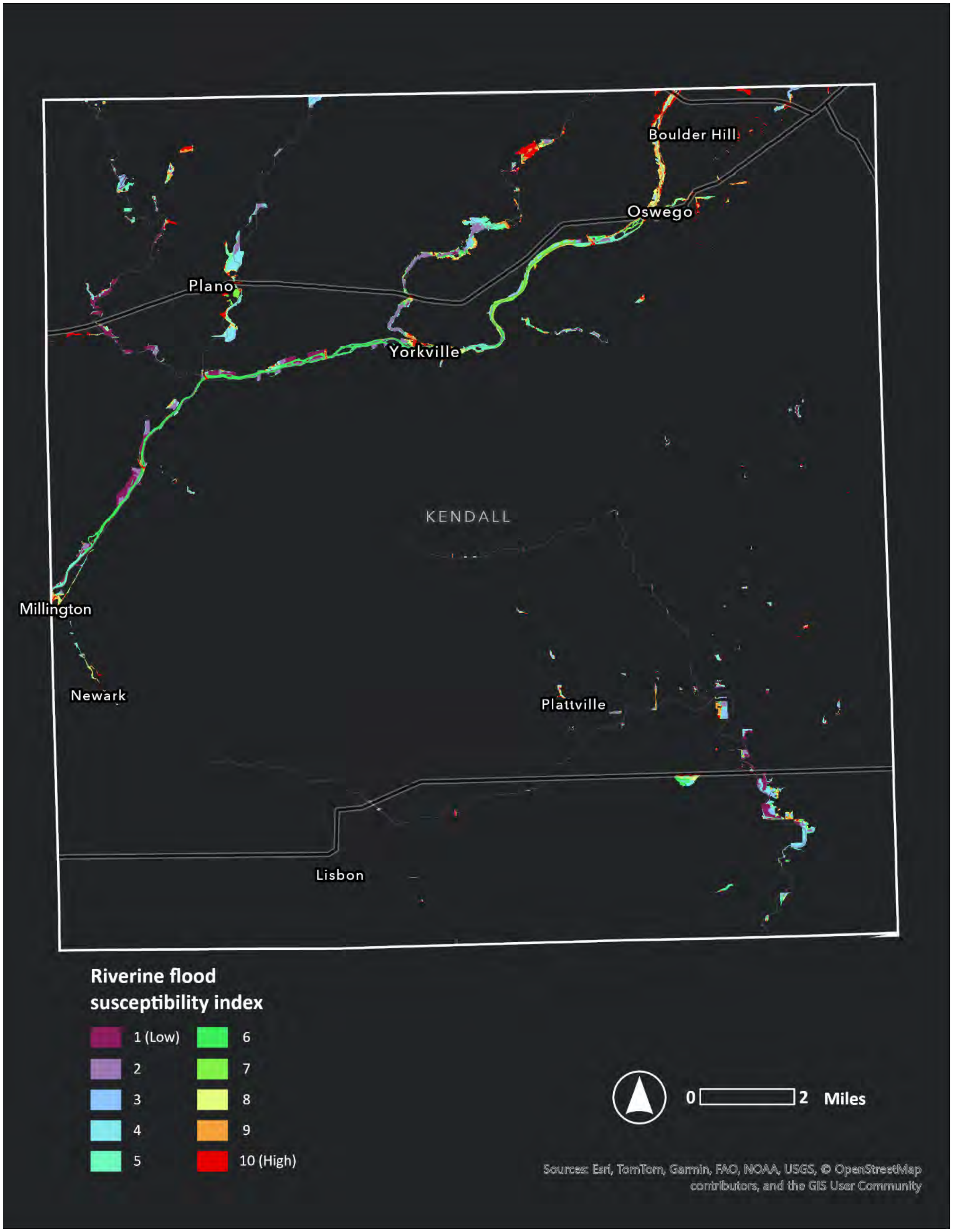


Figure 16. Riverine FSI rescaled to Lake County

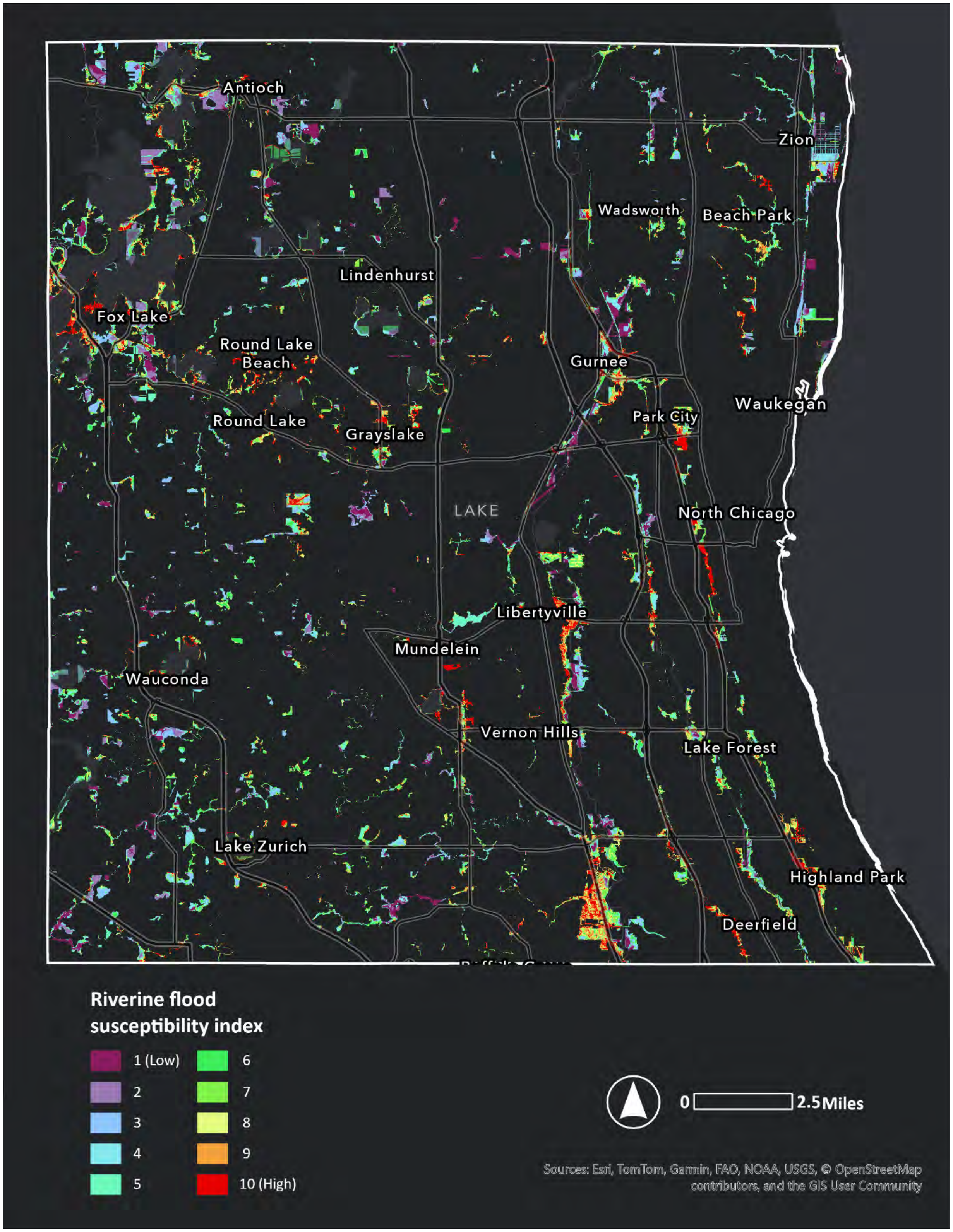


Figure 17. Riverine FSI rescaled to McHenry County

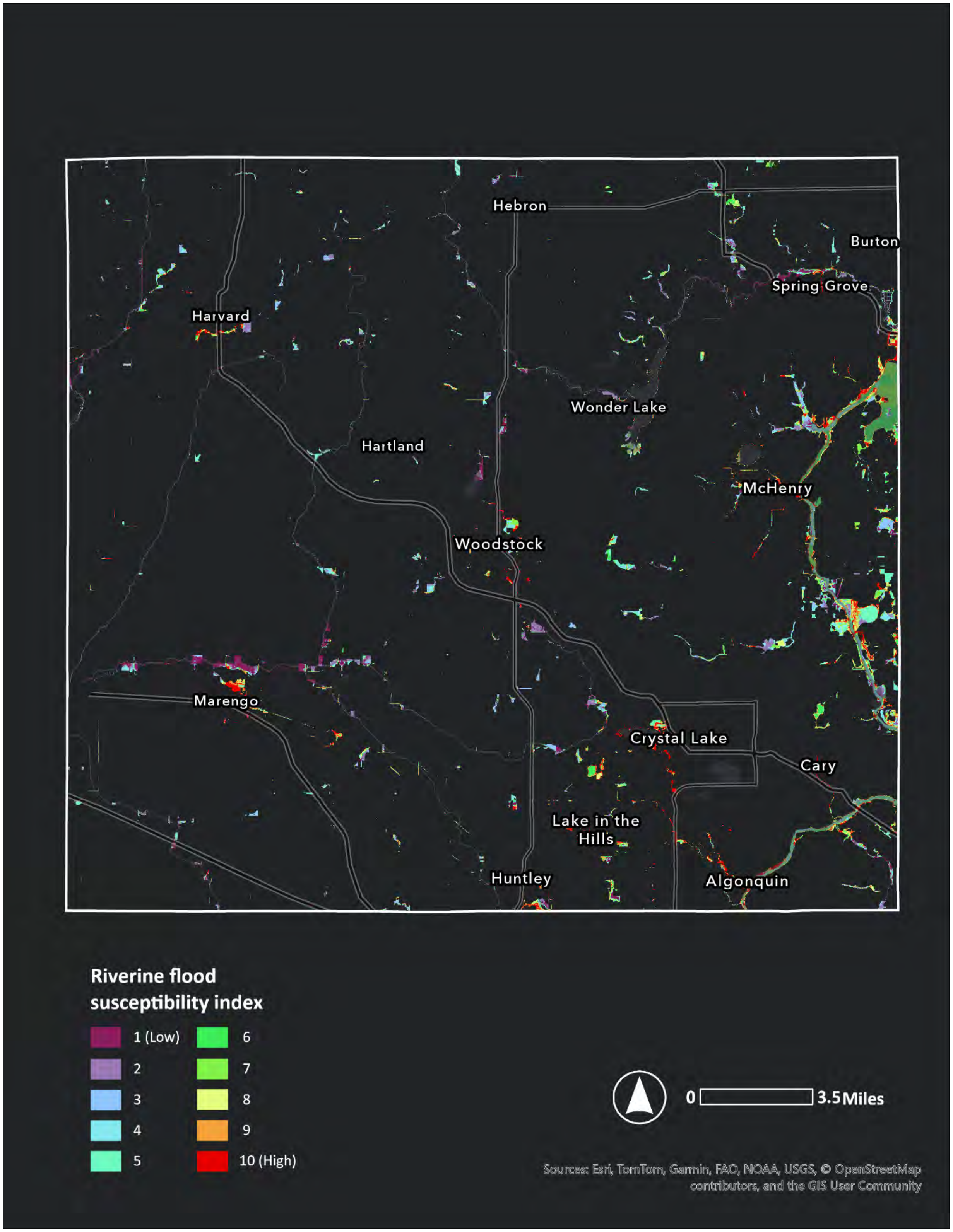
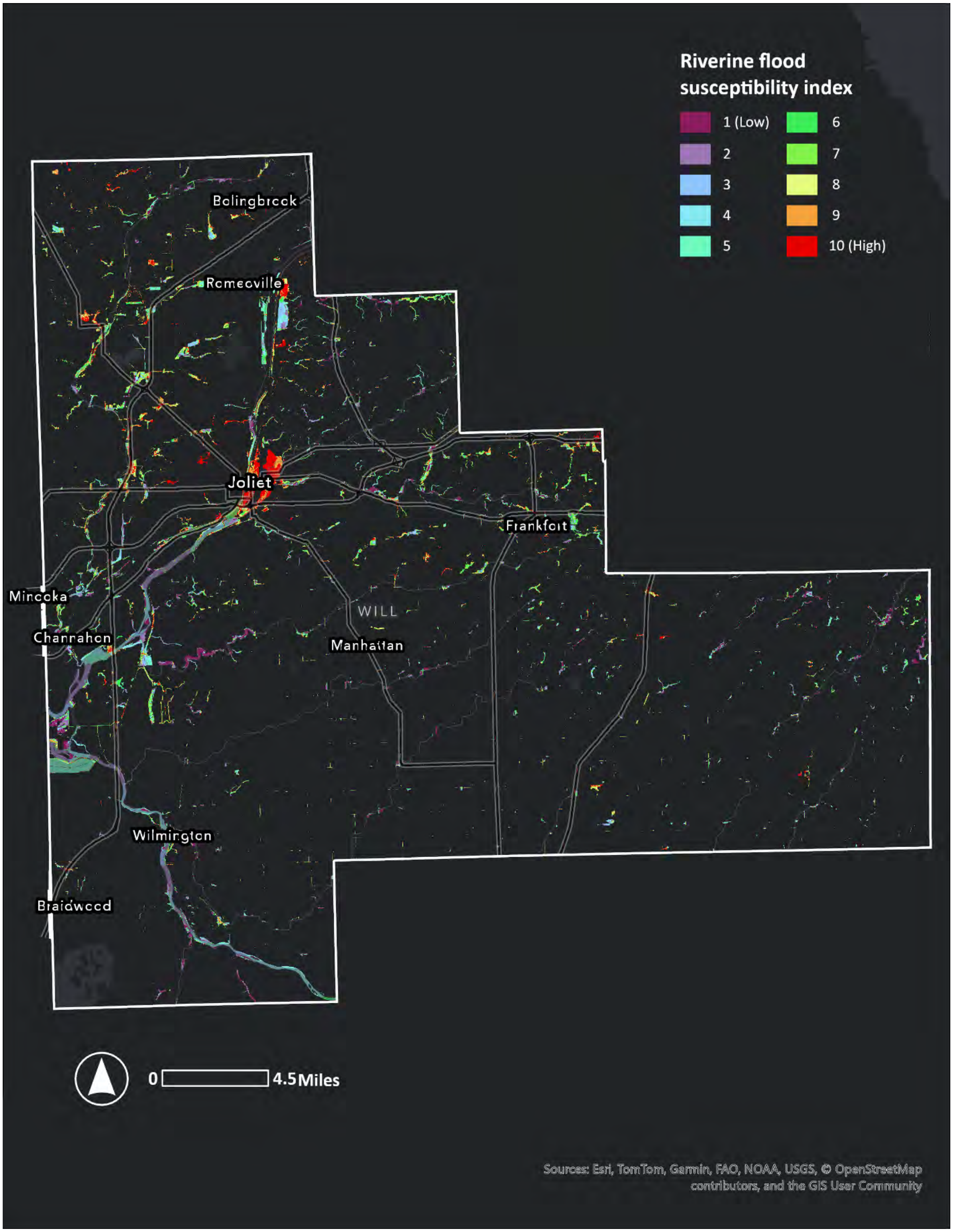


Figure 18. Riverine FSI rescaled to Will County



Endnotes

[1] CMAP, "Guide to Flood Susceptibility and Stormwater Planning," July 2018, https://cmap.illinois.gov/wp-content/uploads/FSSP_072318.pdf.

[2] American Planning Association and CMAP, "Using Climate Information in Local Planning: A Guide for Communities in the Great Lakes," October 2019, https://www.planning.org/publications/document/9188426/.

[3] Friends of the Chicago River, "Natural Solutions Tool," accessed February 13, 2026, https://www.chicagoriver.org/programs/public-policy-and-planning/natural-solutions-tool.

[4] During the first phase, staff reviewed existing literature on susceptibility mapping, conducted stakeholder interviews, obtained and processed data, evaluated different methodological approaches for index development, and selected an approach for updating the indexes.

[5] Given the lack of information to confidently categorize flooding events as either urban or riverine, the riverine analysis only uses flood locations that have occurred within either FEMA's 100-year floodplain or MWRD's 100-year inundation area.

[6] J.M. Lin and L. Billa, "Spatial prediction of flood-prone areas using geographically weighted regression," *Environmental Advances*, Vol 6, 2021, 100118, ISSN 2666-7657, https://doi.org/10.1016/j.envadv.2021.100118.; Ali R. Al-Aizari, Yousef A. Al-Masny, Ali Aydda, et al., "Assessment analysis of flood susceptibility in tropical desert area: A case study of Yemen," August 2022, accessed 2023, https://doi.org/10.3390/rs14164050.

[7] CMAP used precipitation estimates from the 25-year, 2-hour storm event from NOAA's Atlas 14 as a flood-related factor to identify precipitation variation within the region. The 25-year, 2-hour storm event (i.e., a 2-hour storm that has a 4 percent chance of occurring in a year) was selected as a common storm that could contribute to urban flooding. While the 2017 FSI used a 10-year, 2-hour storm event (a storm previously considered common and associated with infrastructure design standards for local drainage), the project team selected a larger storm to represent a size that is more commonly experienced in recent years as a result of climate change.

[8] Based on susceptibility scores averaged across a given county.

[9] Recent federally declared disasters in Illinois included DR-4819, DR-4749, and DR-4728.

[10] There may be limitations in the catchment runoff rates underlying data catchment and flowline data that may be influencing the FSI scores in McHenry County; see the NHDPlus High Resolution's Known Issues with NHDPlus HR Datasets: NHDPlus High Resolution.

[11] Based on susceptibility scores averaged across a given county.

[12] The geographic extent of the 2017 riverine FSI included FEMA's 100-year floodplain and MWRD's 100-year inundation area.

[13] Natural Resources Defense Council, "Accurate Floodplain Maps are Essential for Climate Adaptation," May 2024, https://www.nrdc.org/bio/rob-moore/accurate-flood-maps-are-essential-climate-adaptation; Thomas Frank and E&E News, "Studies Sound Alarm on "Badly Out-of-Date" FEMA Flood Maps," February 27, 2020, https://www.scientificamerican.com/article/studies-sound-alarm-on-badly-out-of-date-fema-flood-maps/; Evan Bush, "Under water: How FEMA's outdated flood maps incentivize property owners to take risks," NBC News, August 12, 2025, https://www.nbcnews.com/science/environment/water-femas-outdated-flood-maps-incentivize-system-risk-negotiable-rcna220529.

[14] Arlan Juhl, P.E., "History of Flood Control & Drainage in Northeastern Illinois," Illinois Department of Natural Resources, Office of Water Resources, https://dnr.illinois.gov/waterresources/historyoffloodcontroldrainageinnortheasternillinois.html.

[15] A ratio of 0 in less developed parts of the region may be a result of karst-like geography, which could create catchments without defined outlets.[15] A ratio of 0 in more developed parts of the region may be a result of an overly developed, flat landscape that makes it difficult to delineate a defined flowline. A ratio of 0 may also be a result of data processing limitations and errors in the NHDPlus HR dataset. See the 'Limitations and future refinements' section of this report for more details.

[16] U.S. Geological Survey, "NHD Plus High Resolution," https://www.usgs.gov/national-hydrography/nhdplus-high-resolution.

[17] CMAP sought to update this dataset for use in the 2026 FSIs but was informed by MWRD and other communities that no substantial updates were needed.

[18] U.S. Geological Survey, "NHD Plus High Resolution," https://www.usgs.gov/national-hydrography/nhdplus-high-resolution.

[19] U.S. Geological Survey, "Annual NLCD Fractional Impervious Surface," Earth Resources Observation and Science (EROS) Center, September 2024, https://www.usgs.gov/centers/eros/science/annual-nlcd-fractional-impervious-surface; Data downloaded through the Multi-Resolution Land Characteristics Consortium NLCD Viewer.

[20] Cook County Department of Homeland Security and Emergency Management, "Cook County Multi-Jurisdictional Hazard Mitigation Plan Volume 1 – Planning-Area-Wide Elements," July 2019, https://www.cookcountyemergencymanagement.org/sites/g/files/ywwepo281/files/document/file/2023-02/Cook%20County%20MJHMP%20Update%202019.pdf; the development of this flooding-related factor was also informed by FEMA Technical Bulletin 10: Ensuring that Structures Built on Fill in or Near Special Flood Hazard Areas are Reasonably Safe From Flooding, see https://www.fema.gov/media-library/assets/documents/3522.

[21] The updated elevation differential dataset was derived using more recent elevation data from the Illinois Height Modernization Project. Illinois Geospatial Clearinghouse, "Illinois Height Modernization (ILHMP): LiDAR Data," https://clearinghouse.isgs.illinois.edu/data/elevation/illinois-height-modernization-ilhmp. The updated elevation differential dataset was derived using the base flood elevation (BFE) lines from FEMA's National Flood Hazard Layer data (downloaded January 2025).

[22] CMAP, "Transportation Resilience Improvement Plan," March 2026, https://cmap.illinois.gov/wp-content/uploads/dlm_uploads/Transportation-Resilience-Improvement-Plan-2026.pdf.

[23] Emission scenarios represent projections of future greenhouse gas emissions based on varying assumptions on energy use, socioeconomic growth, and technological development. Shared socioeconomic pathways (SSPs) were developed as part of the framework used in the Intergovernmental Panel on Climate Change's Sixth Assessment Report. SSPs are used in combination with climate models to describe potential climate futures and guide mitigation and adaptation policies. SSP5-8.5 is a high-emissions scenario characterized by rapid economic growth, limited climate policy, and high energy demand (often considered as a worst-case scenario).

[24] U.S. Department of Agriculture Natural Resources Conservation Service, "Soil Survey Geographic Database (SSURGO)," accessed 2023, https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm.

[25] Tests were run on a sample dataset (i.e., 1 million random cells) of the factors extended across the region. Tests were also run prior to pre-processing factors for the frequency ratio analysis.

[26] Given that factors of interest were both continuous and categorical, not all tests could be used consistently across all factors.

[27] Tests that were explored but ultimately not used included Pearson's R for continuous factors and Chi-square for categorical factors. Spearman's Rho was used instead of Pearson's R because it was less sensitive to outliers, did not assume normality and did not assume a linear relationship across the variables. Similarly, Cramer's V was also considered to be a better alternative to the Chi-squared test because it is not influenced by sample size and

degrees of freedom. See H. Akoglu, "User's guide to correlation coefficients," Turkish Journal of Emergency Medicine, Vol 18, Iss. 3, 2018, ISSN 2452-2473, https://doi.org/10.1016/j.tjem.2018.08.001.

[28] Frequency ratio analysis iterations resulted in the project team removing a flood-related factor representing Lake Michigan flood inundation levels, as well as the soil infiltration factor used in the riverine FSI, from the urban FSI.

[29] The project team tested three other aggregation and indexing methods: adding the frequency ratios across all flood-related factors and normalizing the sums to a scale of 1-10; adding the frequency ratios and normalizing the sums to a scale of 1-5; and multiplying the frequency ratios and splitting the products into equally sized quintiles.

[30] Separate validation samples were set aside for the riverine and urban indexes. The urban validation sample was 30 percent of known flooding locations within the urban extent. The riverine validation sample consisted of known flooding locations within the 500-year floodplain exclusive of the 100-year floodplain.

[31] A perfect model — one that correctly assigns a higher index value to a randomly selected flooding location than a randomly selected non-flooding location 100 percent of the time — would have an AUC of one.

[32] Nearly half (48%) of the unique flooding locations that were from NFIP claims were from the years 1970-1990s. The remaining unique locations were from 2000-2020s.

[33] U.S. Geological Survey, "Karst Map of the Conterminous Unites States – 2020," May 2020, https://www.usgs.gov/media/images/karst-map-conterminous-united-states-2020.

[34] U.S. Geological Survey, "User's Guide for the National Hydrography Dataset Plus (NHDPlus) High Resolution," 2019, https://pubs.usgs.gov/of/2019/1096/ofr20191096.pdf.

[35] U.S. Geological Survey, "Known Issues with NHDPlus HR Datasets," April 2021, https://www.usgs.gov/national-hydrography/known-issues-nhdplus-hr-datasets.

[36] Federal Emergency Management Agency, "National Flood Hazard Layer (NHFL) Database," https://hazards.fema.gov/femaportal/NFHL/searchResult/.

[37] J.M. Lin and L. Billa, "Spatial prediction of flood-prone areas using geographically weighted regression."

[38] J.M. Lin and L. Billa, "Spatial prediction of flood-prone areas using geographically weighted regression."

FY27-0001

The Chicago Metropolitan Agency for Planning (CMAP) is the region's comprehensive planning organization. The agency and its partners developed and are now implementing ON TO 2050, a long-range plan to help the seven counties and 284 communities of northeastern Illinois implement strategies that address transportation, housing, economic development, open space, the environment, and other quality-of-life issues.

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