GREEN INFRASTRUCTURE METRICS: MEASURING RESILIENCE

MID-AMERICA REGIONAL COUNCIL - 2020

ACKNOWLEDGMENTS

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I. EXECUTIVE SUMMARY

APPROACH

Green infrastructure solutions are living systems and when carefully integrated, can provide a wide array of benefits to people and nature. The following maps and metrics highlight factors that contribute to the vulnerability of the region as well as opportunities to implement green infrastructure solutions. These metrics guide our region to increased resilience in the categories of Flood Risk, Water Quality, Habitat & Climate, and Public Health. Each category is evaluated through the lens of social vulnerability. The purpose of this study is to provide data to decision-makers that can inform equitable regional investment based on an understanding of the greatest needs and opportunities to benefit people and nature while becoming a more resilient region.

GOALS AND MEASURES

High level goals to increase resilience are:

- Local Flood Risk Reduction: Improve the health of the floodplain to protect communities.
- Water Quality Improvement: Increase the number of stream miles with protected, managed, and restored stream buffers.
- Habitat Improvement and Climate Protection: Increase the number of stream miles with contiguous riparian habitat and increase canopy coverage.
- Public Health Improvement: Increase access to parks, trails, and bike infrastructure.

Key metrics that indicate progress on resilience include:

- Percent of impervious surface in the floodplain
- Percent of housing units in the floodplain
- Percent of socially vulnerable housing units in the floodplain
- Percent of the 300' stream buffer that is riparian habitat
- Miles of streams in the highest and lowest quartiles of riparian health
- Percent of region covered by tree canopy
- Percent of floodplain covered by tree canopy
- Percent of riparian habitat that is contiguous
- Population more than ¼ mile from parks or MetroGreen trails
- Socially vulnerable population more than ¼ mile from parks or MetroGreen trails

This study establishes the baseline measurement for each metric and how often the calculations should be updated to test progress. In addition, widely adopted policies such as Complete and Green Street ordinances, and Stream Buffer ordinances are highlighted as key opportunities to influence increased implementation of green infrastructure related to water quality improvement, habitat improvement, climate protection, and public health improvement. Some areas of the region have additional policies that can be leveraged for green infrastructure implementation such as Forestry ordinances and Climate Action Plans. Additional policy measures that focus coordinated efforts on flood risk reduction and resilience would benefit the communities of this region as well as communities downstream.

CONCLUSIONS AND NEXT STEPS

Through this study, a few key opportunities for implementation of Green Infrastructure solutions emerged that have benefits across multiple resilience categories:

- Focus flood risk reduction and access to parks and trails in socially vulnerable tracts.
- Focus environmental conservation and restoration activities on the floodplain and contiguous riparian habitat.
- Use the widely adopted Complete and Green Streets policy to increase implementation of green infrastructure solutions to decrease runoff, increase canopy cover, identify strategies to maintain habitat connectivity, and provide more equitable access to parks and trails.
- Use the widely adopted Stream Buffer policy to increase protection and restoration of streams and riparian habitat through adaptive management of the land in the buffer area.
- Determine ecosystem service values for riparian habitat, contiguous riparian habitat, and canopy cover to establish mitigation bank values for offset credits and to provide cost-benefit analysis for green infrastructure implementation.

Through the focused efforts of the Mid-America Regional Council, local governments, and numerous agencies working to protect people and restore the environment, these metrics will show progress toward becoming a more resilient region.

2. PROJECT CONTEXT

Green infrastructure metrics are designed to evaluate the status of systems related to the resilience of our region. The purpose of this evaluation is three-fold. First, to provide data and measurement that supports advocacy and persuasion to change course. Second, key measurements show changes over time and provide a way to set targets for progress and success. And finally, metrics can be used to show a nexus of benefits and costs to influence investment in green infrastructure solutions.

BUILDING ON PAST REGIONAL GREEN INFRASTRUCTURE WORK

This current phase of work on green infrastructure metrics is built on the foundation of previous regional green infrastructure work products. The development of a Regional Green Infrastructure Framework was the first in the series of projects focused on increasing the understanding of the role green infrastructure can play in creating multi-benefit solutions to enhance communities' resilience. The next phase was the creation of a Playbook of site-based multi-benefit solutions. The two regional projects selected for the Playbook were the Rock Island Corridor and Shawnee Mission School District. Both of these projects were selected for the broad applicability they represent. Each project went through a suitability analysis to determine a pilot project area that met the criteria for highest impact - socially, environmentally, and educationally.

The third phase of regional green infrastructure work was a process to study policy and identify priority updates for implementation. More than 50 policy and planning recommendations were developed and prioritized by community stakeholders. The three priority recommendations that had the most support were:

1. Develop a suite of model ordinances related to trees, weeds, landscaping, invasive species, and planning and zoning updates using an inclusive stakeholder engagement process linking several communities interested in adopting these updates and revisions into their codes.
2. Update existing engineering standards and planning guidelines, rooted in the approach articulated within the Green Infrastructure Framework to benefit both upstream and downstream communities with greater ability to meet needs for rainwater, riparian health, and reduction of the heat island effect in addition to equitable economic development. A multidisciplinary, cross-sector stakeholder process would be implemented to fund, scope, develop and adopt amended engineering standards and planning guidelines.
3. Fully integrate green infrastructure conservation and restoration goals into the regional transportation plan, capital improvement plans, policies, programs, performance measures and evaluation criteria.

THE ROLE OF MID-AMERICA REGIONAL COUNCIL

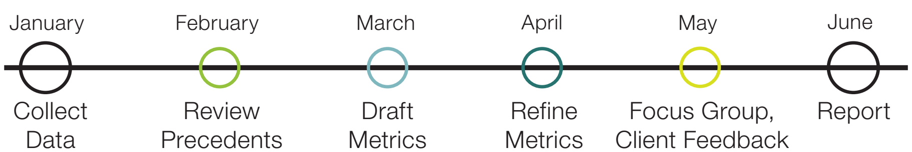
The Mid-America Regional Council (MARC) promotes regional cooperation between nine member counties and 119 member cities. MARC develops innovative solutions through leadership, planning and action. A major portion of MARC's budget from federal, state and private grants is passed through to local governments and other agencies for programs and services.

The development of the Green Infrastructure Framework, Playbook, Policy, and Metrics has been championed by the Environmental Programs division of the Transportation and Environment Department. Guidance from the Transportation and Land Use staff, Research Services staff, Public Affairs staff, and Community Development staff have assured that the suite of tools is widely applicable for multiple departments as they convene regional partners, provide technical support to local leaders, advocate for regional issues, and allocate resources for regional systems.

The engagement of cross-sector stakeholders throughout the region to develop the Green Infrastructure Framework, Playbooks, and Policy guidance resulted in a set of tools that have wide buy-in and the potential for application across multiple jurisdictions and partner organizations.

3. APPROACH AND PROCESS

The six-month process to determine a set of Regional Green Infrastructure metrics was built on the foundation of previous green infrastructure work. The general process followed is described in the timeline below.



DATA

The parameters established to guide the development of Green Infrastructure Metrics hinged on using readily available data maintained by MARC. The ease of updating the measurement calculations over time is a key factor in the value and usefulness of the metrics. The frequency of updates and expectations for a timeframe of change were also factors considered in determining the metrics selected to measure change. In each step of the process the team vetted methodologies and assumptions to display the data in ways that would be replicable, defensible, and widely usable between departments. In a few cases supplementary metric data was sourced and included if it fit MARC's standards for reliability, quality, frequency of updates, and accessibility (i.e. Social Vulnerability datasets as defined by the Centers for Disease Control and Prevention). Following is a list of datasets used.

MID AMERICA REGIONAL COUNCIL, RESEARCH SERVICES:

Riparian Health (based on the 2016 Stream Health Assessment Report)
Natural Resource Inventory
Ecological Value
Floodplains
Roads and Highways
Parks
MetroGreen
Mobility Hubs
Activity Centers
Housing Tracts
Public Health
Ordinance Adoption
Public Assets
Public Health Trends

I-TREE:

Tree Canopy and Impervious Surface
Tree Value

CENTER FOR DISEASE CONTROL:

Social Vulnerability Index (2018 U.S. ACS Data)
Physical Inactivity Health Care Costs

US GEOLOGICAL SURVEY:

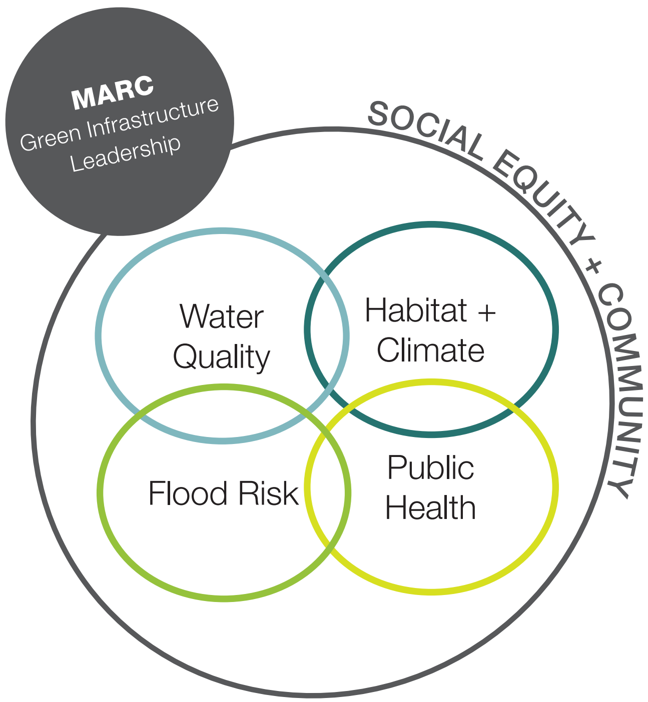
HUC 12 Watersheds

ENVIRONMENTAL PROTECTION AGENCY:

303d Stream Impairments

STRUCTURE

The organizational concept for Regional Green Infrastructure Metrics started with the primary goals for Air, Water, and Land from the Regional Green Infrastructure Framework and the layers of benefits described in the Playbook.



Next, the metrics were organized by regional resilience categories. The lenses of social vulnerability and equity were elevated to prioritize communities facing the greatest challenges in each category of resilience. The preliminary metrics were developed by comparing available data sets with framework goals and multi-benefit solutions identified in the Playbook. As the data analysis progressed and precedents were studied (see Appendix p. 56), the categories were refined to:

- Local Flood Risk Reduction
- Water Quality Improvement
- Habitat Improvement and Climate Protection
- Public Health Improvement

Mapping and measurements in each category include a focus on impact to socially vulnerable people.

The team studied the data to understand metrics that can contribute to achieving high level goals in each resilience category:

- Local Flood Risk Reduction: Improve the health of the floodplain to protect communities.
- Water Quality Improvement: Increase the number of stream miles with protected, managed, and restored stream buffers.
- Habitat Improvement and Climate Protection: Increase the number of stream miles with contiguous riparian habitat and Increase canopy coverage.
- Public Health Improvement: Increase access to parks, trails, and bike infrastructure.

Some of the metrics provide context and a baseline of conditions but do not change rapidly, while others are measures within specific areas of MARC's influence that have the potential to change more rapidly.

POLICY

The Regional Green Infrastructure Policy Framework (2019) identified three overarching policy recommendations; 1. Development of a package of model, local green infrastructure-friendly ordinances; 2. Updates to local stormwater management planning guidelines and engineering standards; 3. Integration of conservation and transportation at the plan, program and project levels.

The resilience goal for flood risk reduction is one that requires regional coordination for meaningful progress. This aligns with the policy framework strategy recommendation for a formalized collaborative, cross-sector regional forum to convene connected policy, planning and funding needs.

The two most widely adopted ordinances that are relevant to green infrastructure are Complete Streets and Stream Setbacks. The most populous municipalities have adopted both, with over 63% of the regional population in cities that have Complete Streets ordinances and over 69% in areas that have adopted Stream Setback ordinances. The cities that have adopted Complete Streets ordinances equate to 57% of the incorporated land area of the region and those that have adopted Stream Setback ordinances cover almost 60% of the incorporated land area of the region.

The Complete Streets **Policy** and **Handbook** were updated in 2015 and 2018 respectively to incorporate green infrastructure. Complete and Green Streets are designed and operated with the consideration of needs and safety of all travelers on the public right of way. This includes all who may be walking, biking, driving, using transit, and freight shippers. Green infrastructure solutions are designed to enhance the local context and may include increased canopy cover to reduce heat island effects, bioswales to capture and filter rain events, and other site solutions that allow the streets, sidewalks, highways and bridges to provide a wider array of benefits to people and the environment. The Complete Street Handbook guides the integration of policy processes and implementation of Complete and Green Streets projects.

Different communities throughout the region are at different stages of implementation. With this report and the Handbook, communities can be strategic about implementation and the benefits of these projects for their communities.

MARC has also provided a model Stream Setback ordinance used by local communities as well as a Tool Kit for adopting and implementing stream buffers and preserving or restoring natural resources in stream corridors. Another model resource is the **Stream Corridor Protection and Adaptive Management Manual** prepared for Independence, MO. Management includes mitigating invasive species and restoring, protecting, and enhancing the corridors to maximize the benefits provided such as:

- Reduce flood damages by limiting streamside construction.
- Reduce the impact of stormwater runoff by trapping sediment and sediment-bound pollutants.
- Slow and disperse stormwater flows over a wide area, helping to protect city infrastructure, human health, and property from potential damage.
- Preserve stream bank stability by reinforcing the soil with root systems.
- Create recreation opportunities with walking and running trails.
- Protect habitat and wildlife corridors.

The data and maps provided in this study help to identify regional opportunity areas to focus implementation of buffer management.

COMPLETE STREET AND STREAM SETBACK ORDINANCE

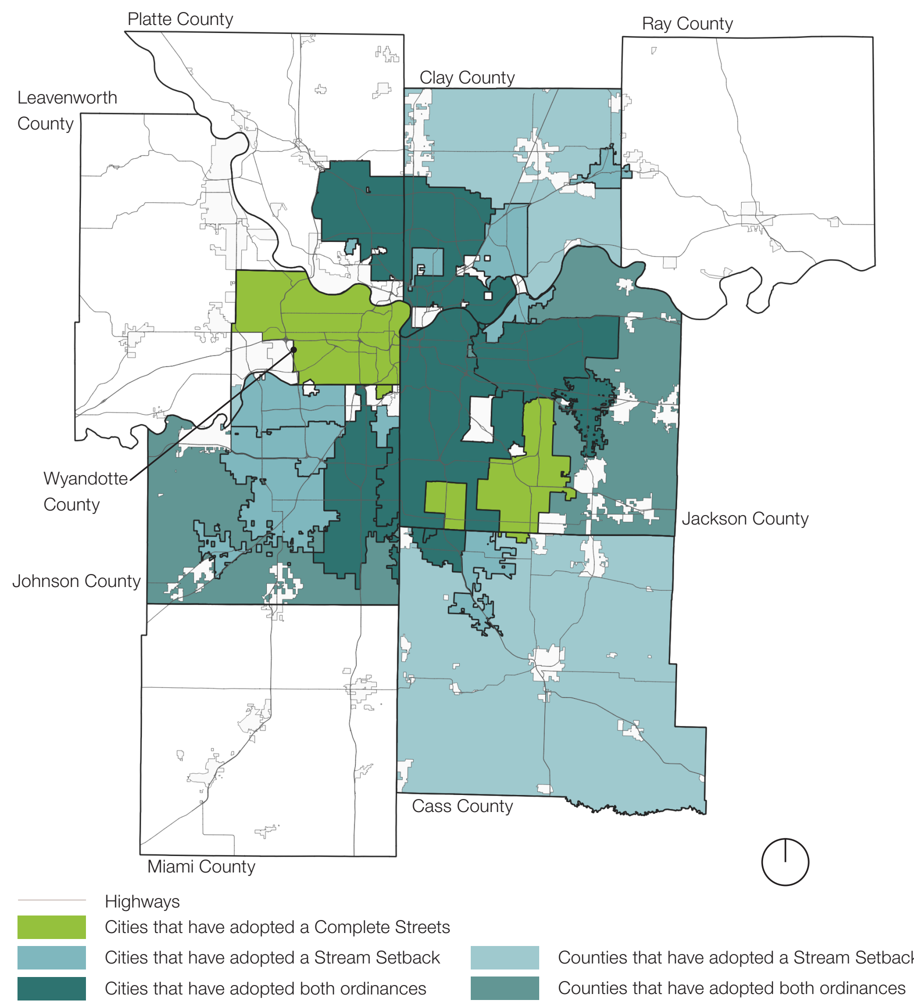


Figure 3.1 Complete Street and Stream Setback ordinances.

4. HOW TO USE THIS DOCUMENT

This report provides regional-scale data. The hope is that regional partners in public, private, and non-profit sectors will put it to use and inform its future development. The following examples provide scenarios for applying this information and data at local scales:

STEPS TO FOLLOW IN GENERAL...

- Start with the Matrix on p. 15 for the overall organization of benefit categories and metrics
- Identify your organization's goals related to the resilience categories: Flood Risk Reduction, Water Quality, Habitat Improvement, Climate Change Protection, and Public Health. [See the summary spreadsheet of metrics p. 50-51]
- Select the metrics that are most helpful to achieving your goals, and see the related Measurable Resilience sub-chapter for description of analysis, maps, findings and opportunities. (p. 16-47)
- If there are datasets described that would be helpful for you to use differently, see the Appendix for more information on accessing the data and focusing on the right place or scale for you. (p. 58-61)

IF YOU WORK ON TRANSPORTATION-RELATED ISSUES...

In addition to the general process described, you could ask additional questions to see how the prioritized projects of your agency intersect with opportunities in each of the resilience categories. For example:

- How can your projects include enhanced pedestrian and bike infrastructure in areas where Public Health mapping shows that it would have the greatest impact?
- Where can you implement green infrastructure solutions in your Complete and Green Streets projects with bioswales and canopy cover in areas that have low riparian health (see Water Quality mapping p. 28-32) and low canopy cover (see Habitat and Climate mapping p. 36-38)?
- Do you have the local information you need to leverage increased funding for your projects through using a green infrastructure benefit-cost equation (see examples p. 54)?

IF YOU WORK ON ENVIRONMENTAL CONSERVATION-RELATED ISSUES…

Additional considerations as you use this information may include:

- Many of the Water Quality, Habitat and Climate maps showing riparian health, riparian buffer, connected riparian buffer, and canopy cover are analyzed by watershed.
- How does the watershed-based analysis provide you a better understanding of your organization's priorities?
- Where does this direct your geographic focus on key restoration or conservation needs in our region?
- How does this provide a way for you to connect your work to the interrelated resilience categories of benefit?
- Which potential cross-sector partners working to achieve related benefits in Public Health, Water Quality, Flood Risk, and Climate Protection does this bring to mind?

IF YOU WORK ON POLICY, ADVOCACY, OR EDUCATION RELATED TO THE BENEFIT CATEGORIES...

Additional questions to consider as you use this information may include:

- Given the state of health shown in each category and your organizations' priorities, what are the potential policies that could shift the state of health in each category over time?
- How can your organization use this information to advance equity-based policy and protect the region's most vulnerable?
- How can this information assist ongoing education and research programs?

5. MEASURABLE RESILIENCE

Metrics were assessed in four categories of resilience:

1. Local Flood Risk Reduction
2. Water Quality Improvement
3. Habitat Improvement + Climate Protection
4. Public Health Improvement

The following sub-chapters take a deeper look into factors of the four categories of resilience in our region to show how they relate to green infrastructure implementation.

The diagram on the following page shows the components and scales of analysis in each category. The following sub-chapters focus on describing the regional and watershed scales of analysis in each category. Each sub-chapter has the following organizational flow:

- Resilience Category Introduction
- Analysis
    - Measurement Questions
    - Evaluating Data
    - Mapping and Measurements
- Summary of Findings and Opportunities

See Conclusions and Examples, Chapter 6, for a summary of the relationships between the four categories and the Appendix pp 54-55 for suggestions on evaluating quantifiable costs and benefits for varying scales of projects.

RESILIENCE CATEGORIES

1. LOCAL FLOOD RISK REDUCTION

Goal
- Improving the health of the floodplain to protect communities

Baseline Metrics
- Impervious in 500-year floodplain
  - % and miles of roads and highways in the floodplain
- Housing in the floodplain
  - Socially vulnerable housing in the floodplain

Local Measurement
- Observe conditions of impervious, social vulnerability and ecological value at project sites in floodplain
- Risk cost analysis (road replacement v design to protect floodplain)

Related Policy
- Increase opportunities to coordinate floodplain restoration efforts to increase regional resilience.

2. WATER QUALITY IMPROVEMENT

Goal
- More stream miles with protected and managed buffers

Baseline Metrics
- Streams impaired
- Riparian health ranked below average (watersheds in lowest quartile and miles of streams)
- Ranked above average (watersheds in lowest quartile and miles of streams)
- % of stream buffer that is riparian

Local Measurement
- Value of land with riparian habitat
- Cost of gray treatment v green treatment

Related Policies
- Implement Stream buffer land management

4. PUBLIC HEALTH IMPROVEMENT

Goal
- Increase access to parks, trails and bike infrastructure

Baseline Metrics
- Population and density > 1/4 mile from parks
  - Socially vulnerable > 1/4 mile from a park
- Population and density > 1/4 mile from MetroGreen or bike trail
  - Socially vulnerable > 1/4 mile from MetroGreen or bike trail

Local Measurement
- Observe conditions of social vulnerability and disconnection from parks and trails at project sites in the floodplain
- Health care $ associated with physical inactivity compared with $ of additional parks and maintenance

Related Policies
- Implement Complete and Green Streets ordinance to prioritize an increase in equitable access to parks and trails
- Coordinate with Public Health policy

3. HABITAT IMPROVEMENT + CLIMATE PROTECTION

Goal	• More contiguous riparian habitat	• More acres of canopy coverage
Baseline Metrics	• % of riparian stream buffer that is contiguous	• Canopy Cover • Social vulnerability relationship to canopy cover
Local Measurement	• Observe conditions of riparian habitat, social vulnerability and ecological value at sites in the floodplain	• Observe conditions of canopy cover, social vulnerability and ecological value at sites in the floodplain • Tree $ value in climate benefits
Related Policies	• Implement stream buffer land management • Implement Forestry ordinance • Implement Green Infrastructure ordinance	• Implement Forestry ordinance • Implement The Climate Action Plan

blue = mapped by watershed green = mapped by regional datasets

5.1 FLOOD RISK REDUCTION

GOAL: IMPROVING THE HEALTH OF THE FLOODPLAIN TO PROTECT COMMUNITIES

INTRODUCTION

Local Flood Risk Reduction includes factors of public safety that are controlled by local, state and federal government agencies. The KC Metro region has seven levee units covering 60 miles of levees and floodwalls in Kansas and Missouri. Green infrastructure solutions such as floodplain restoration and reconnection including wetland enhancement, increased canopy cover, and regional scale retention basins are a few ways to increase the performance of natural systems and support the engineered systems in place. Severity of storm events and the amount of annual rainfall is increasing and is predicted to continue to increase over the coming decades. Returning acreage along our streams and rivers to functional ecosystems that reduce flooding in place rather than displacing flooding downstream is an important consideration to any hazard mitigation plan.

When the team began to analyze regional data associated with flood risk we started with FEMA floodplain data to create a regionally recognizable and accepted footprint of impact. Given predictions of increased flooding, and to err on the side of conservative evaluation, we used the 500-year floodplain boundary to map related regional factors. (Also see section 5.3, Habitat Improvement + Climate Protection (p. 34-41) data, mapping, and resources on contiguous riparian habitat, a primary indicator of reducing flood risk.)

ANALYSIS

Measurement Questions

The questions we stepped through to evaluate flood risk included:

- Where is the most impervious surface in the floodplain?
- How much of the impervious surface in the floodplain is roads and highways?
- How much housing is in the floodplain?
- How much of the housing in the floodplain is inhabited by socially vulnerable populations?
- Where are the majority of wetlands and hydric soils?
- Is there opportunity to protect and restore additional acreage of wetlands and hydric soils?
- Are there opportunities to reduce impervious surface or increase regional scale retention basins to capture overland flow?
- What new policy or enhanced existing policy can support the goal to reduce local flood risk?

EVALUATING THE DATA

Data evaluation began with the set of data provided by MARC and found through other reputable and regularly updated sources (USGS, CDC, iTree). In this category datasets used includes:

- Impervious surfaces (iTree, MARC)
- Roads (MARC)
- 500-year floodplain (MARC, FEMA)
- National Resource Inventory (NRI) (MARC)
- Healthcare Assets (MARC)
- Schools (MARC)
- Wastewater Treatment Facilities (MARC)
- Housing and Social Vulnerability (CDC, ACS)
- Complete Street ordinances (MARC)

These data sets were selected because of the relevance to the subject matter and because the majority of them are owned and maintained internally by MARC. Many of the measurements in this category provide an understanding of assets to plan for and protect. Existing housing, healthcare assets, schools, wastewater treatment facilities, and roads are major infrastructure elements that will remain until replacements are required in the future. It is recommended that this dataset is updated every five years. Complete and Green Streets ordinances are not currently a part of a regularly maintained database, however, since they are widely adopted and seem to be a primary method for implementation of green infrastructure, it is recommended to update this record of adoption and implementation every two years. Impervious surface data can be manually updated through the iTree Canopy software and it is recommended that this data is captured every two years. The CDC's Social Vulnerability data is updated through the ACS, with new estimates available yearly. Based on the frequency of updates in this category, it is assumed that change in metric percentages will be seen in two to five year increments.

The goal of the mapping and measurements in the Flood Risk Reduction category is to understand the assets that are at risk in our region and proactively plan for their protection. It is important to note that the 500-year floodplain is the basis for our measurements because while it is a conservative estimate, in many cases it is the most comprehensive regional-scale flood risk assessment available.

IMPERVIOUS SURFACE IN THE FLOODPLAIN

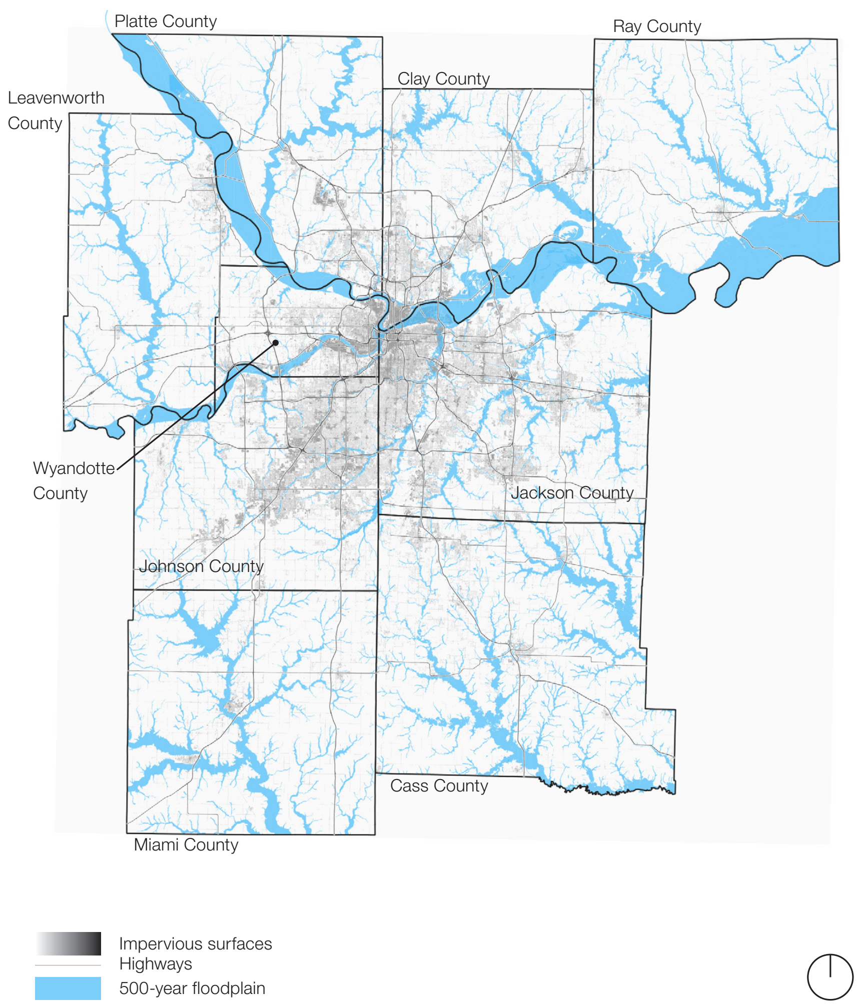


Figure 5.1.1 Approximately 9% of the Mid-America Regional Council boundary is impervious surface. In the 500-year FEMA designated floodplain 3.28% of the area is impervious.

ROADS IN THE FLOODPLAIN

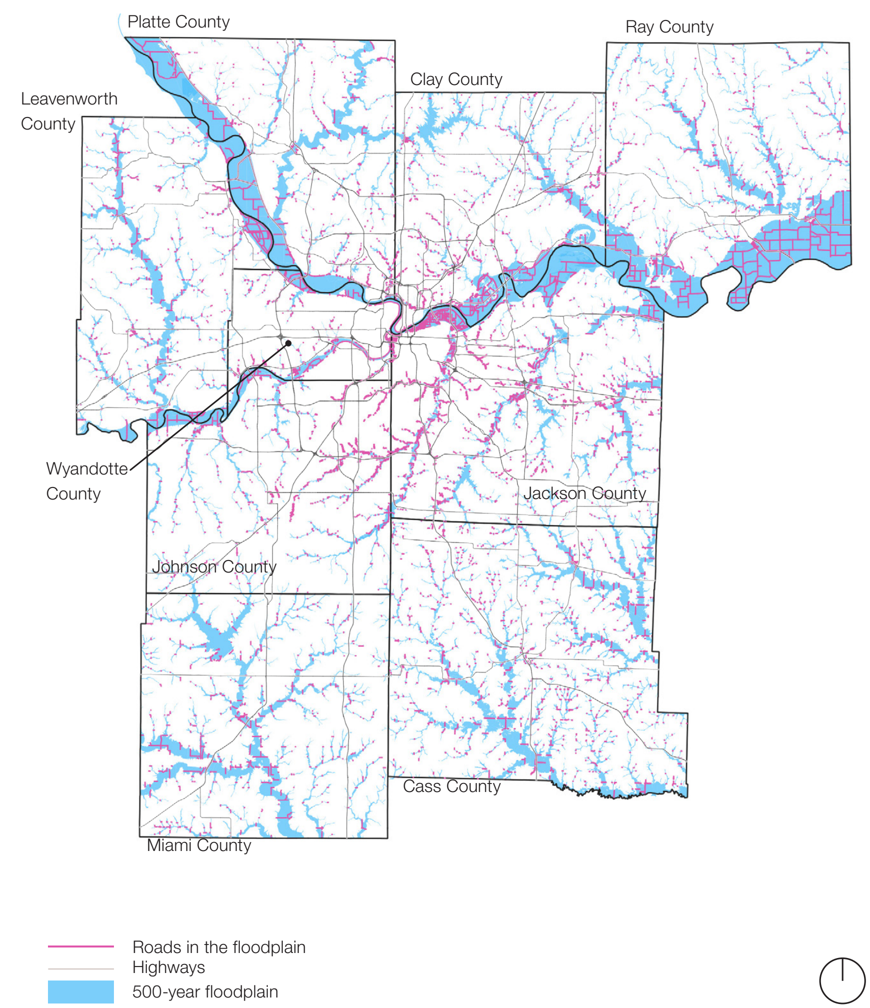


Figure 5.1.2 There are a total of 1312 miles of road in the 500-year FEMA designated floodplain which accounts for almost 7% of our region's roads. While levees and engineered flood protection measures are in place, assets in the floodplain face heightened risk of being damaged in flood events; these roads present key opportunities to employ green infrastructure to protect public and private investments.

HYDRIC SOILS AND WETLANDS

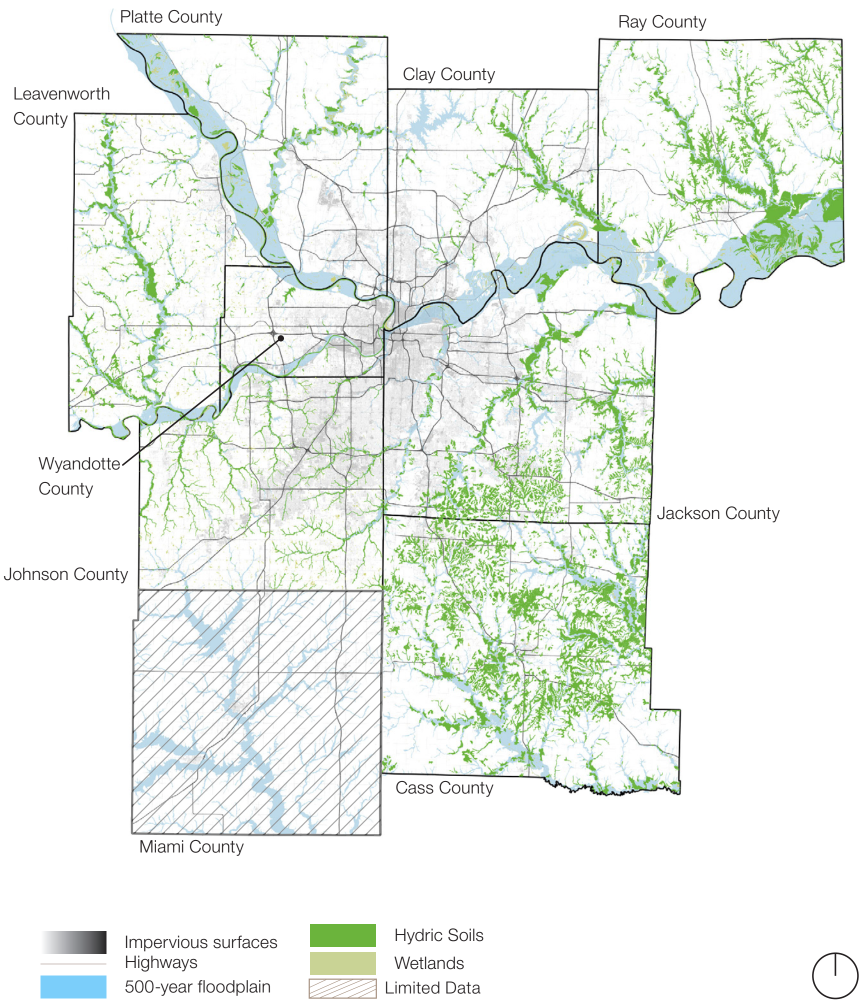


Figure 5.1.3 Hydric soils and existing wetlands point to prime areas for conservation and ecological value for floodplain protection. Existing data does not include Miami County, KS. The region has 252,756 acres of hydric soil and 40,804 acres of existing wetlands. Existing wetlands land cover data was extracted from the Natural Resource Inventory (NRI) data and include the following categories: forested wetlands, forested wetlands (urban), lowland hardwood forest and woodland (hydric), marsh and wet herbaceous vegetation, other wetland (urban), sand/gravel bar wetland.

HEALTH CARE ASSETS IN AND NEAR THE FLOODPLAIN

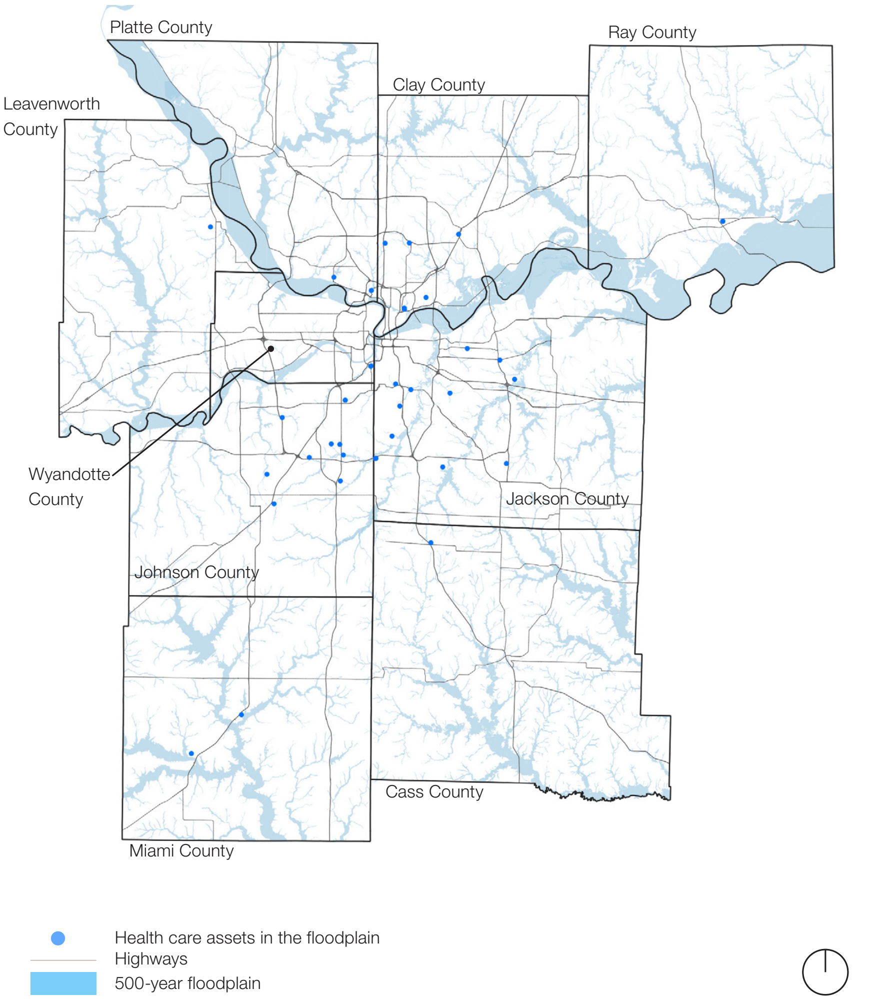


Figure 5.1.4 There are 39 total health care assets within a quarter mile of the floodplain. This includes health clinics, health departments, hospitals, mental health facilities, and safety net clinics. Of these 39 facilities, 19 are hospitals.

SCHOOLS IN AND NEAR THE FLOODPLAIN

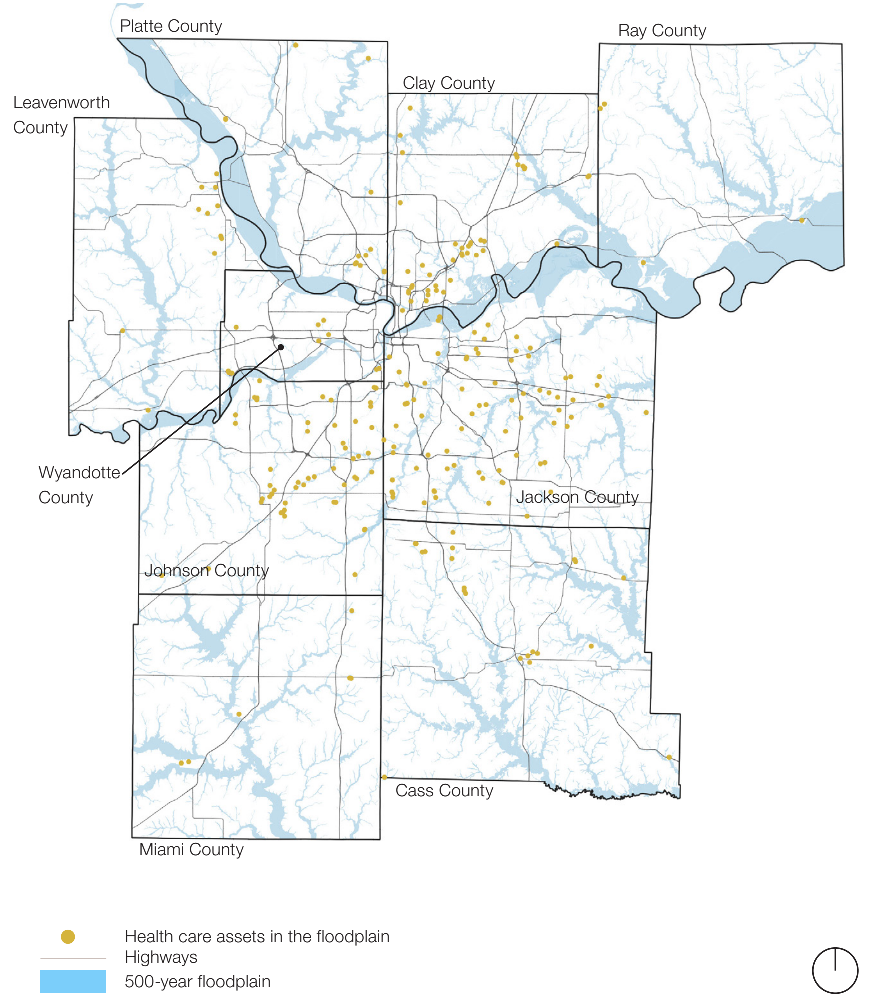


Figure 5.1.5 There are 255 schools within a quarter mile of the floodplain. In total, these schools educate just over 100,000 K-12 students, about 33% of whom receive free or reduced lunch.

WASTE WATER TREATMENT SITES IN THE FLOODPLAIN

Figure 5.1.6 In total, there are 90 wastewater treatment sites in the floodplain. These locations can be described as either facilities or ponds, for our purpose we are focused on facilities. There are 38 total facilities in the floodplain.

HOUSING UNITS IN THE FLOODPLAIN

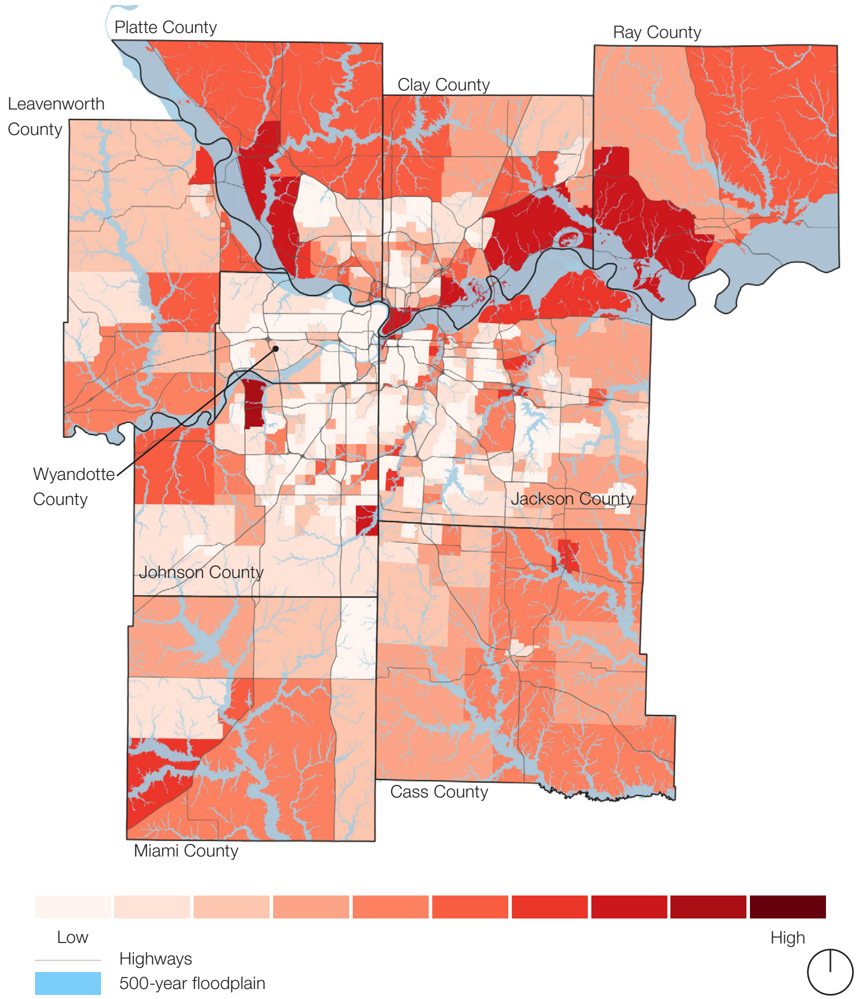


Figure 5.1.7 Regionally, just over 75,000 housing units can be found in the floodplain. This map shows the census tracts where those homes are located.

HOUSING DENSITY IN THE FLOODPLAIN

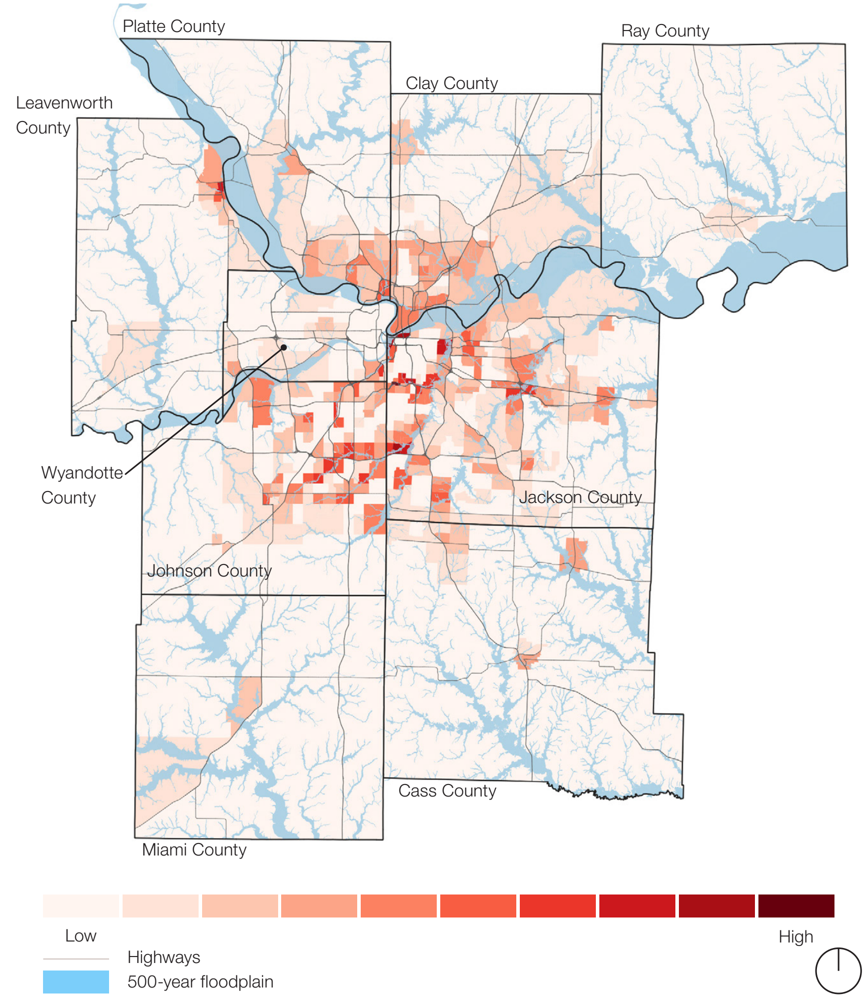


Figure 5.1.8 Similar to housing units in the floodplain, housing density in the floodplain provides a snapshot of where the highest number of homes per square mile (population density) are located in the floodplain. With this map we have the opportunity to see areas where solutions oriented towards remediating flood risk would have the most impact.

SOCIALLY VULNERABLE HOUSING UNITS IN THE FLOODPLAIN

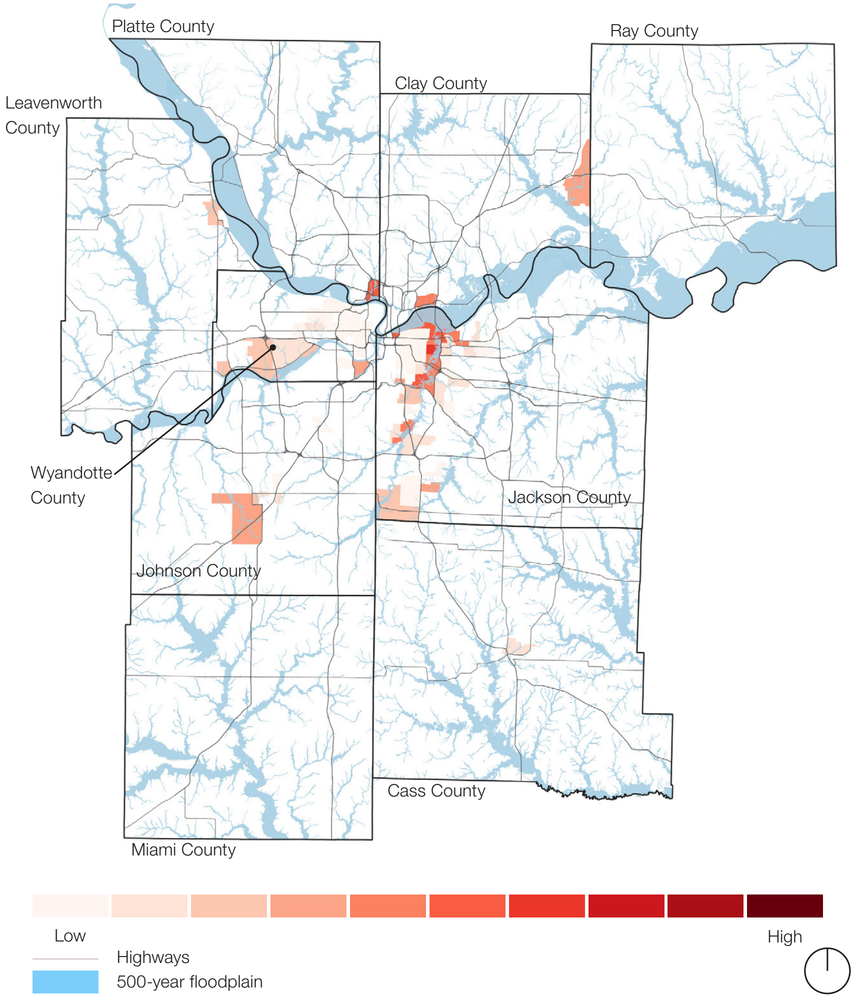


Figure 5.1.9 The tracts visualized in this map represent locations in the floodplain that are considered most socially vulnerable, according to analysis by the CDC. In these tracts, there are approximately 8,180 housing units in the 500-year floodplain.

COMPLETE AND GREEN STREET ORDINANCES

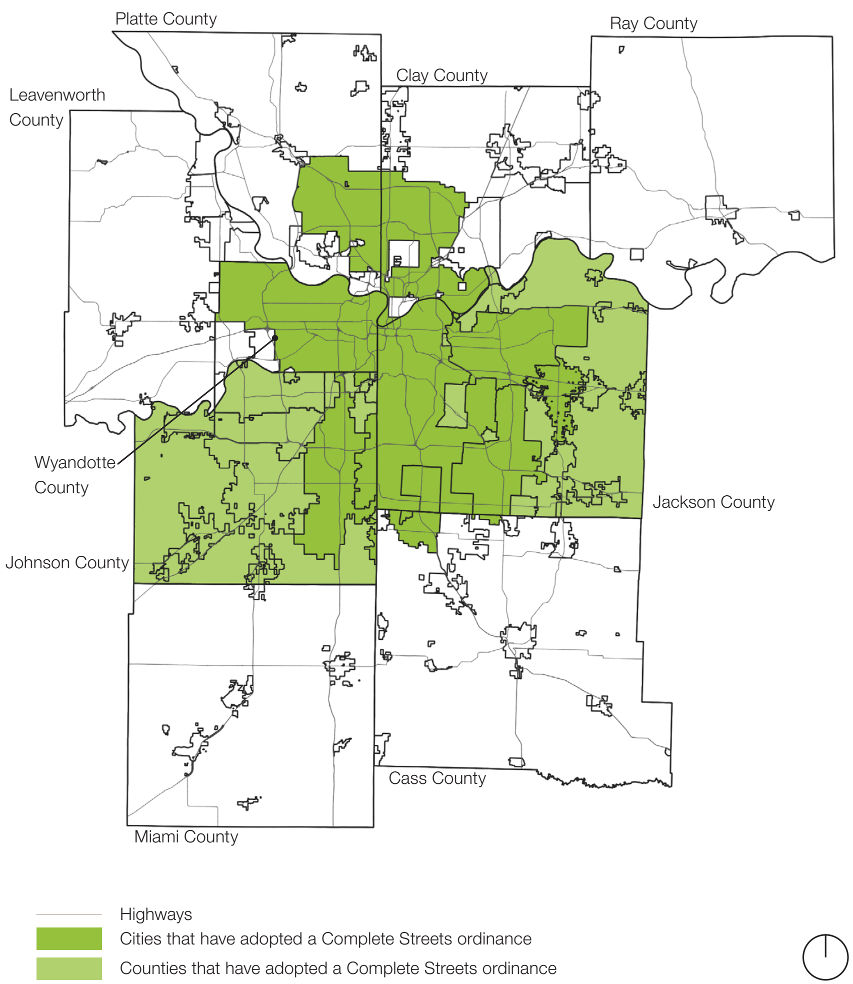


Figure 5.1.10 Complete and Green Street ordinances have been adopted in 2 out of 9 counties in the region and by 10 of 119 municipalities. Complete and Green Street ordinances cover 57% of the region's municipal land and over 63% of residents live in areas that have Complete Street ordinances in place.

SUMMARY OF FINDINGS AND OPPORTUNITIES

The goal of flood risk reduction is to improve the health of the floodplain to protect communities.

Impervious surface accounts for nine percent of the region's land cover. Over three percent of the 500-year floodplain is impervious and seven percent of the region's roads (1,312 miles) are in the 500-year floodplain. This development and infrastructure represents investment, jobs, homes, and a transportation network in the floodplain that require protection and maintenance.

Upwards of 75,000 housing units are located in the floodplain, about 8,000 of those are in socially vulnerable tracts. The residents residing in the floodplain face an increasing risk, and local governments can use this data to focus policy and investment on protecting existing housing in the floodplain and assuring that new housing units are not constructed in the floodplain.

Understanding where crucial community assets such as health care facilities (39 in the floodplain), schools (255 in the floodplain), and wastewater treatment facilities (38 in the floodplain) exist in or near the floodplain helps local governments to focus investments on protection and enhancement of flood risk precautions. This can include green infrastructure features such as regional scale retention basins or adaptive landscape design including bioswales with deep rooted native plants to increase soil health, water retention, micro weather patterns, and carbon sequestration.

OPPORTUNITIES:

- Identify areas in the floodplain for large scale restoration and management
    - Short term: Geographic Identification of focus areas and partner identification
    - Long term: Implementation
- Develop flood risk reduction criteria as a part of affordable housing policy, planning and development policy, and transportation policy
    - Short term: Criteria development
    - Long term: Policy implementation

GOAL: IMPROVING THE HEALTH OF THE FLOODPLAIN TO PROTECT COMMUNITIES

5.2 WATER QUALITY IMPROVEMENT

GOAL: INCREASE THE NUMBER OF STREAM MILES WITH PROTECTED, MANAGED, AND RESTORED STREAM BUFFERS

INTRODUCTION

Water quality of our region's streams and rivers is directly related to human and environmental health. Monitoring compliance with the Clean Water Act is administered by the US Environmental Protection Agency, however monitoring responsibilities are shared by Federal, State, and local agencies. In our region, factors that contribute to water quality challenges include pollutant runoff from roads, herbicide and pesticide runoff from cultivated land, fertilizer runoff from residential, institutional, and commercial properties, as well as combined sewer and stormwater runoff. Changes in velocity and flow patterns cause erosion of stream banks which increases the sediment load of the streams and impacts the ability to support the life of many species of flora and fauna.

Green infrastructure solutions to increase water quality involve stabilizing stream buffers with healthy riparian habitat to filter and slow runoff from surrounding land uses. Capturing runoff from roads, bridges, and developed and cultivated land are site-based solutions that require design and maintenance by a variety of public and private partners. Potential outcomes of increasing water quality also include water focused tourism such as fishing, swimming, and canoing which provide opportunities for more people to explore the natural environment and learn about the history of the region.

ANALYSIS

Measurement Questions

The questions we stepped through to evaluate factors of water quality included:

- Which watersheds have above average riparian health?
- Which watersheds have below average riparian health?
- Which watersheds have the most riparian habitat in their stream buffers?
- Where are there adopted Stream Buffer ordinances?
- What new policy or enhanced existing policy can support the goal to increase riparian health?
- How do we best assess the value of existing habitat, restored habitat and designed green infrastructure features?

EVALUATING DATA

Data evaluation began with the set of data provided by MARC and found through other reputable and regularly updated sources (USGS, CDC, iTree). In this category datasets used includes:

- Riparian health (MARC) (based on the 2016 Stream Health Assessment Report)
- Riparian habitat (from Natural Resource Inventory (NRI))
- Population and Social Vulnerability (CDC/ACS)
- Impervious surfaces (iTree, MARC)
- Tree canopy cover (itree, MARC)
- Stream Buffer Ordinances (MARC)
- 303d Stream Impairments (EPA)

These data sets were selected because of the relevance to the subject matter and because the majority of them are owned and maintained internally by MARC. Riparian health data is based on a study conducted in two parts and does not have an anticipated date for update. Riparian health is based on NRI data which was last updated in 2013. A description of which NRI categories are considered riparian habitat can be found on p. 60 of this document. Population and social vulnerability is updated yearly based on estimates from American Fact Finder. Impervious surfaces and tree canopy cover data can be manually updated through the iTree Canopy software and it is recommended that the data is captured yearly. Stream Buffer ordinances are not currently a part of a regularly maintained database, however, since they are widely adopted and implementation improves riparian habitat in the region, it is recommended to maintain a record of adoption and implementation status every two years. Stream Impairments from the EPA were last updated in 2012; ideally they would be updated every five or ten years.

Based on the frequency of updates in this category, it is assumed that change in percentage will be seen in five to ten year increments.

The goal of the mapping and measurements in the Water Quality Improvement category is focused on understanding where water quality is at its best, at its worst, and regional opportunities for improvement. As a part of the analysis, regional correlation between riparian health and impervious surfaces, and riparian health and canopy cover were assessed. At a regional watershed scale neither variable had a strong correlation with riparian health, but it is likely a correlation would become more clear at a local scale.

PERCENT OF STREAMS OF ABOVE AVERAGE RIPARIAN HEALTH

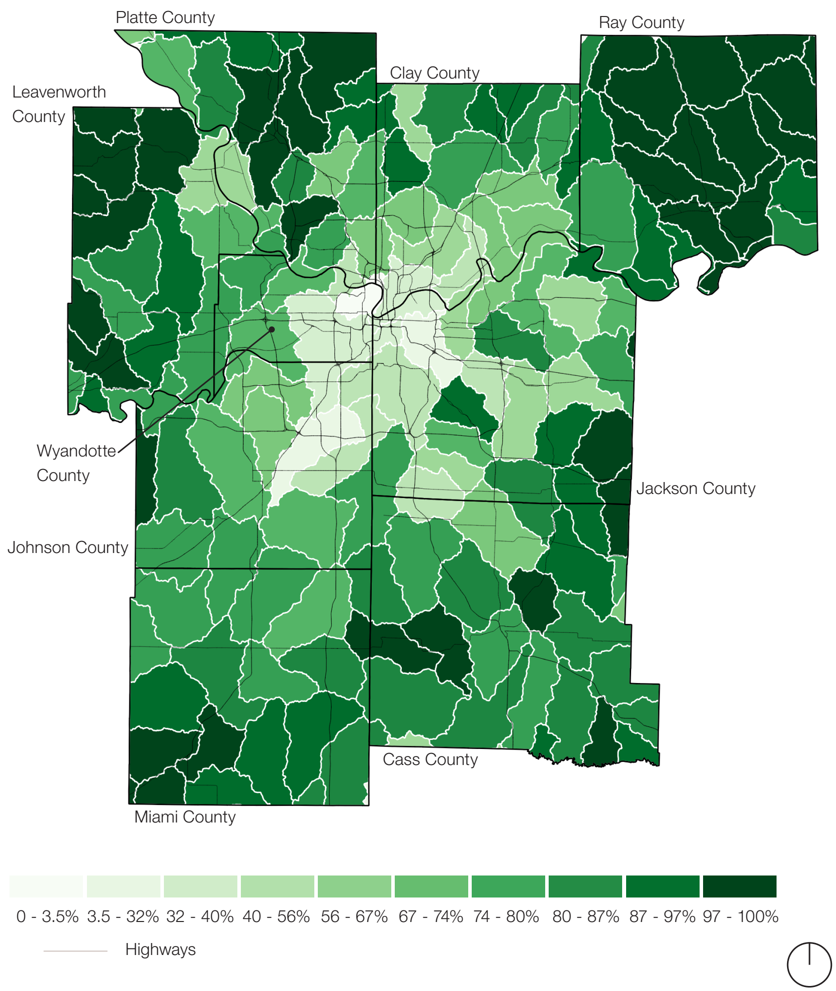


Figure 5.2.1 Based on a riparian health analysis completed in 2005, this study aggregated riparian health data to HUC 12 watersheds to show where a high percentage of above average health streams can be found.

PERCENT OF STREAMS OF BELOW AVERAGE RIPARIAN HEALTH

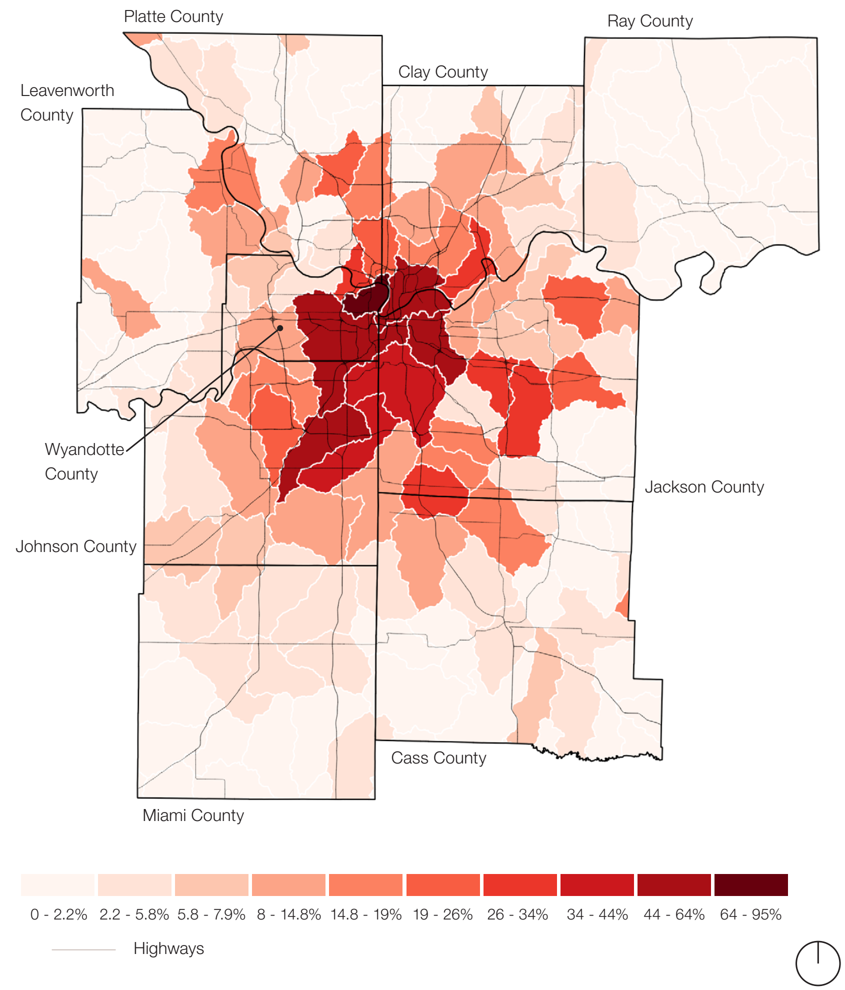


Figure 5.2.2 Based on a riparian health analysis completed in 2005, this study aggregated riparian health data to HUC 12 watersheds to show where a high percentage of below average health streams can be found.

PERCENT STREAMS IN THE TOP QUARTILE BELOW AND ABOVE AVERAGE RIPARIAN HEALTH

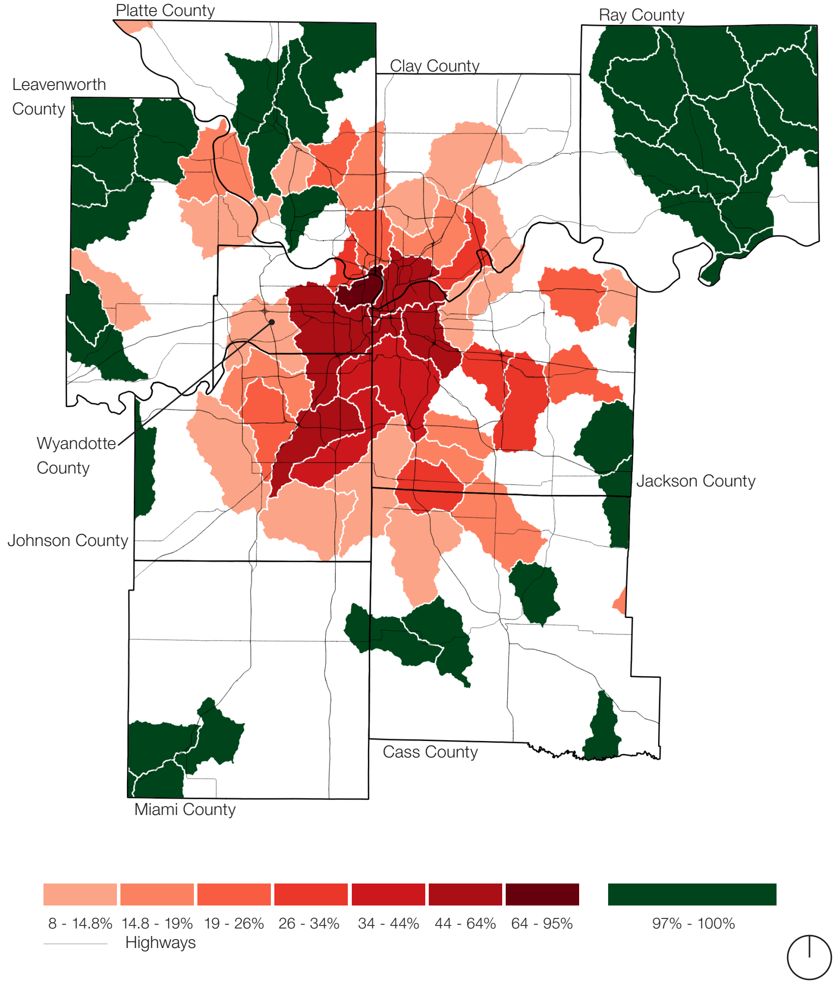


Figure 5.2.3 This map combines the highest and lowest quartiles of HUC 12 watersheds both below and above average riparian health. Combining measures of both high and low riparian health help to show more clearly where our region's streams are healthiest and where they are suffering the most challenges.

PERCENT OF RIPARIAN HABITAT

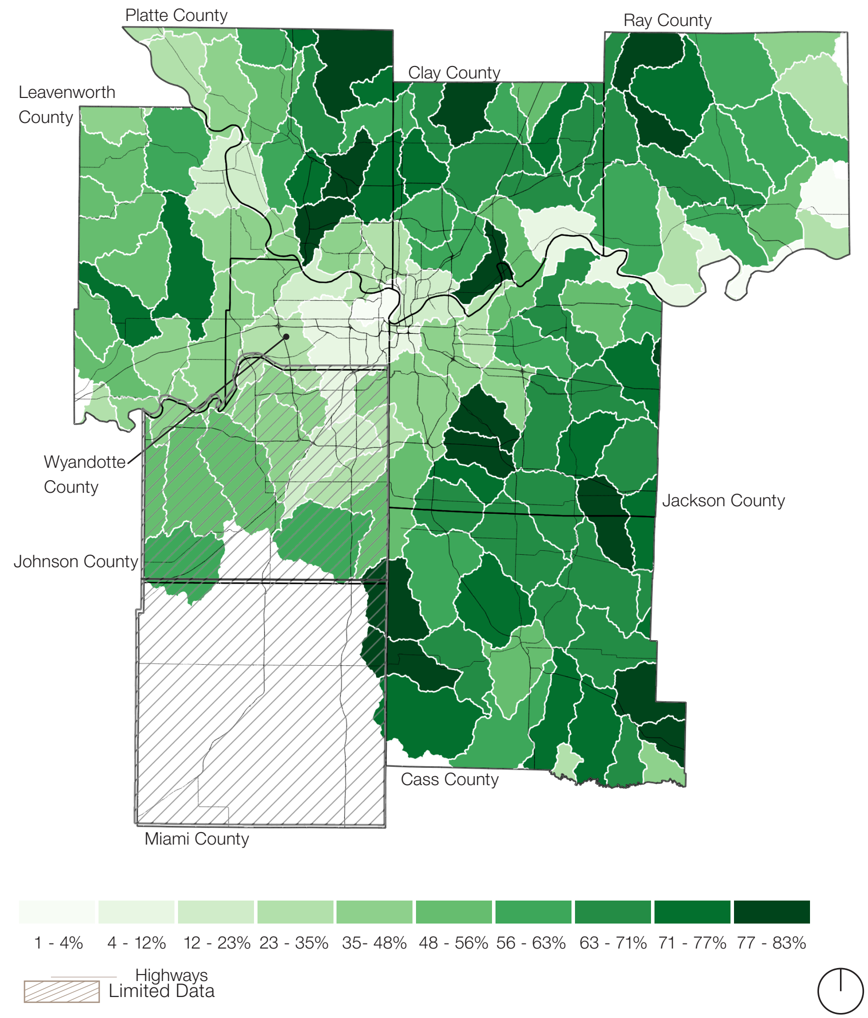


Figure 5.2.4 This map measures the total percentage of riparian habitat in the 300ft buffer around streams and then aggregates totals to the HUC 12 watershed level. Data was unavailable in Miami County and frequently uncategorized in Johnson County making assessments in those watersheds less reliable.

PERCENT OF STREAMS IN THE TOP QUARTILE OF BELOW AND ABOVE AVERAGE RIPARIAN HEALTH, MOST SOCIALLY VULNERABLE TRACTS

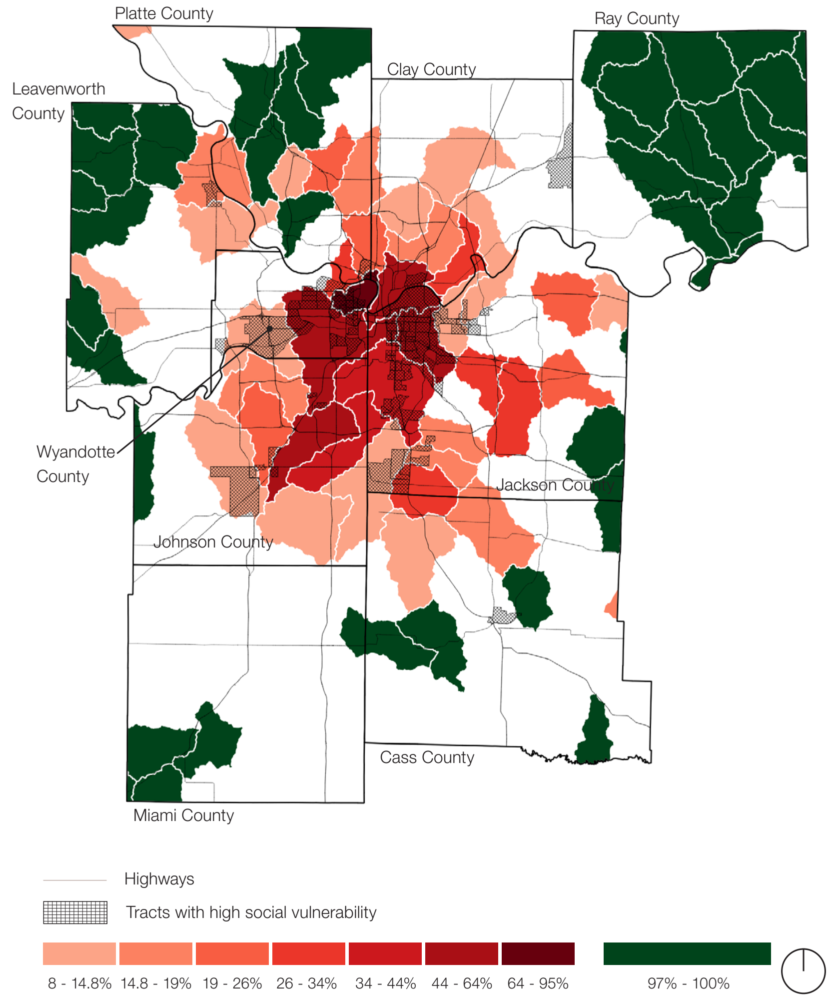


Figure 5.2.5 Socially Vulnerable tracts are overlaid here with the top quartile of high and low riparian health averages. Many tracts with high social vulnerability are located in areas with below average riparian health.

PERCENT OF STREAMS IN THE TOP QUARTILE OF BELOW AND ABOVE AVERAGE RIPARIAN HEALTH, 303D IMPAIRED STREAMS

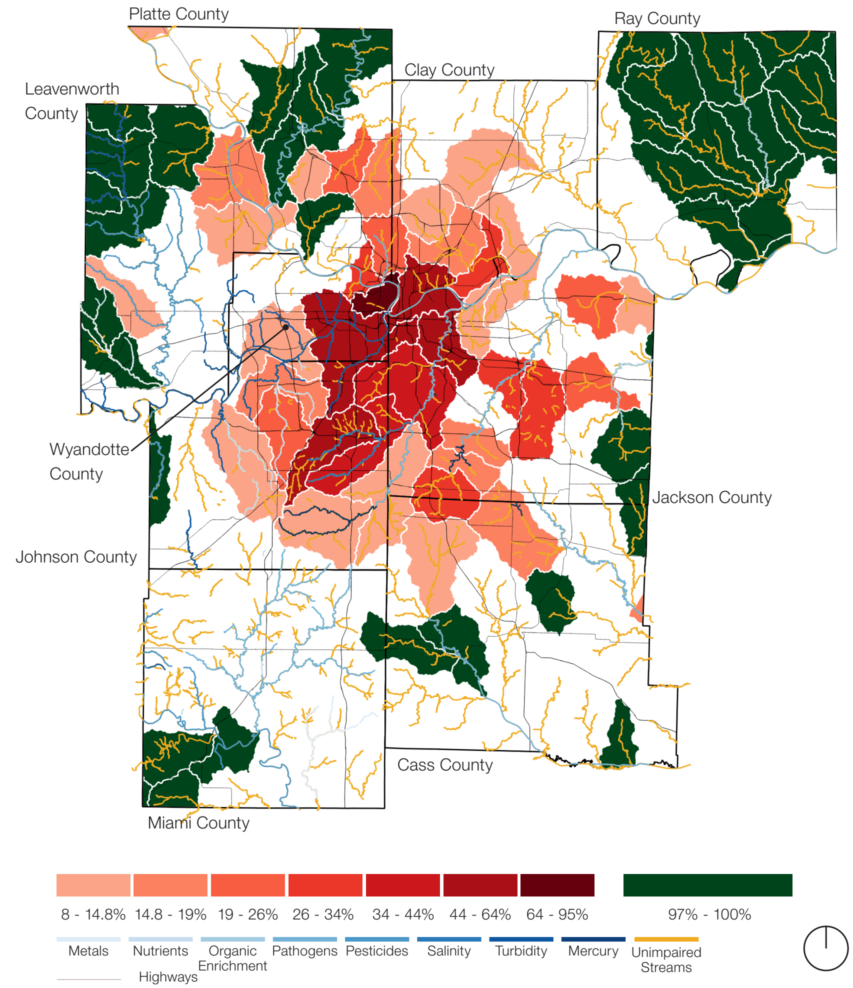


Figure 5.2.9 In this map the streams with 303D impairments and unimpaired streams (in yellow), are overlaid on top of riparian health.

303D IMPAIRED STREAMS

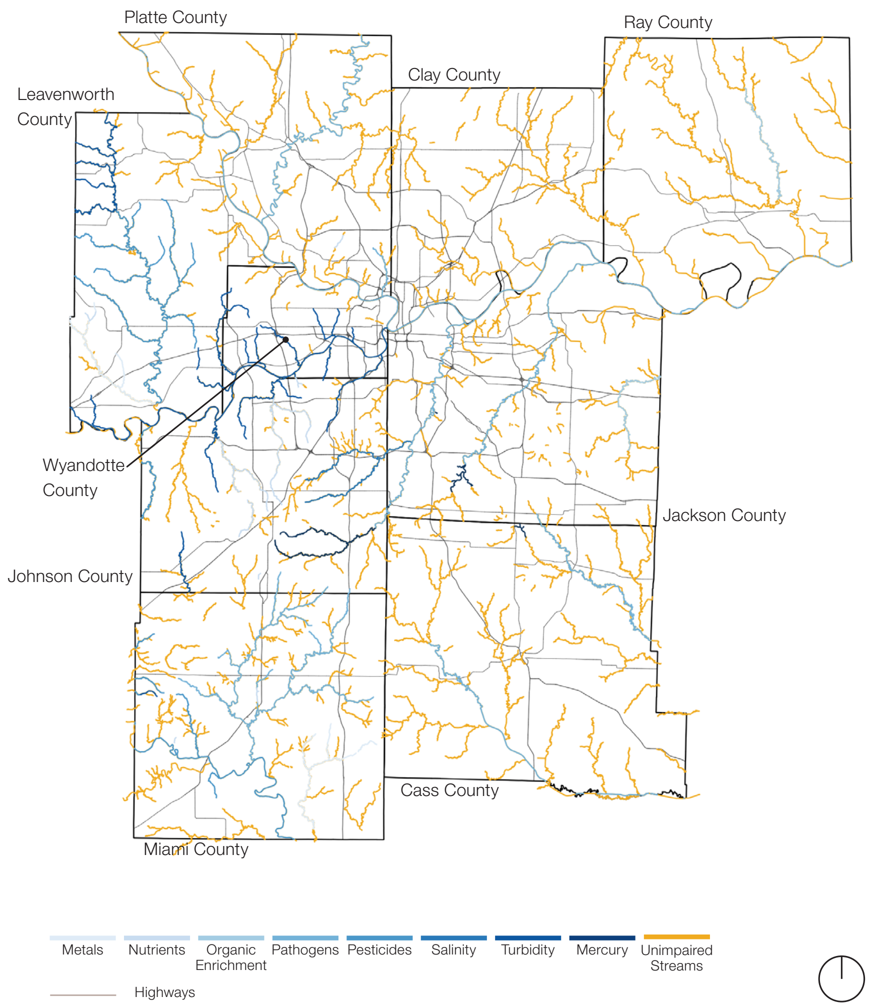


Figure 5.2.10 This map shows the many types of 303D impairments found in the region's streams including metals, nutrients, organic enrichment, pathogens, pesticides, salinity, turbidity, and mercury. Unimpaired streams are also visualized in yellow.

STREAM BUFFER ORDINANCES

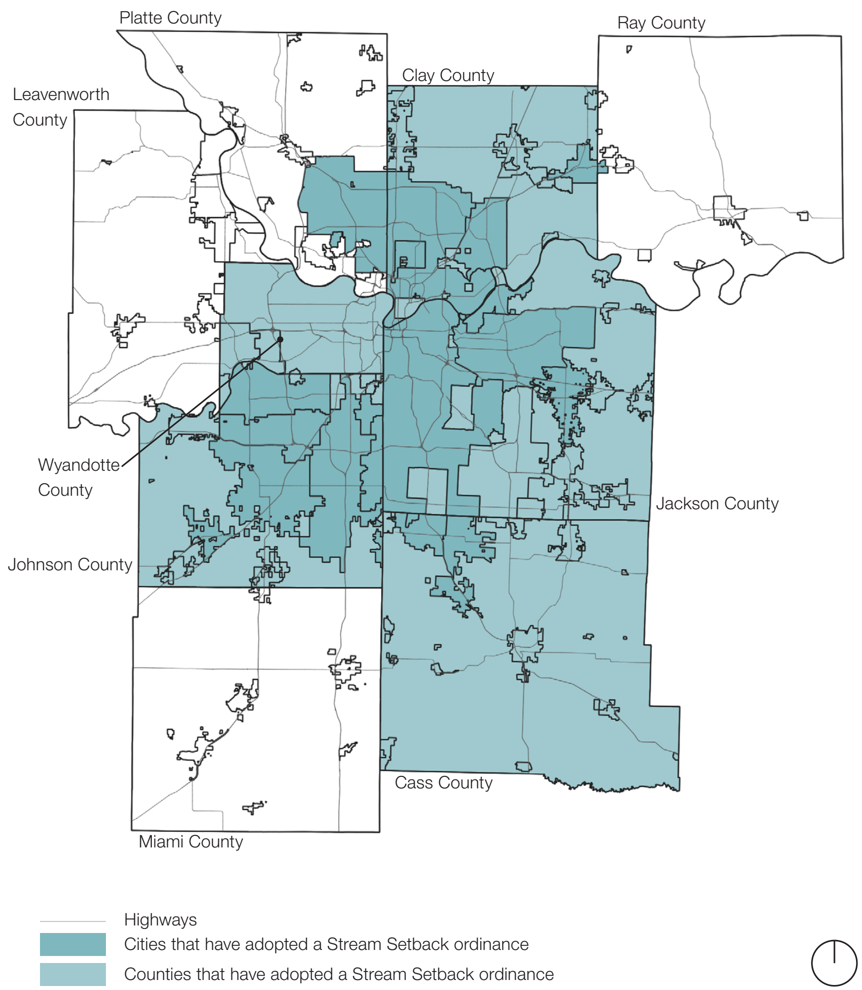


Figure 5.2.11 Stream Buffer ordinances have been adopted in 4 out of 9 counties in the region and by 18 of 119 municipalities. In the region, about 70% of residents live in municipalities with Stream Setback ordinances and 57% of incorporated land has a Stream Setback ordinance.

SUMMARY OF FINDINGS AND OPPORTUNITIES

The goal of Water Quality Improvement is to increase the number of stream miles with protected and managed buffers.

Over 5,684 miles of streams are in watersheds in the bottom quartile of riparian health. Through focusing restoration efforts in the watersheds with the lowest percentages of riparian habitat, regional partners can positively impact water quality. Understanding which impairments are predominant in different watersheds helps to tailor riparian restoration and pollution mitigation strategies to the streams and surrounding land uses.

OPPORTUNITIES:

- Focus implementation of riparian restoration practices and adaptive land management in watersheds with low percentages of riparian habitat and below average riparian health.
    - Short term: identification of areas and partners
    - Long term: implementation
- Identify riparian restoration practices to mitigate specific water quality impairments.
    - Short term: identification of specific practices
- Support and advocate for implementation of adaptive stream buffer land management in all municipalities and unincorporated areas that have adopted the Stream Buffer ordinance.
    - Short term: communication and education campaign
    - Long term: management implementation

GOAL: INCREASE THE NUMBER OF STREAM MILES WITH PROTECTED, MANAGED, AND RESTORED STREAM BUFFERS

5.3 HABITAT IMPROVEMENT+CLIMATE PROTECTION

GOAL: INCREASE THE NUMBER OF STREAM MILES WITH CONTIGUOUS RIPARIAN HABITAT AND INCREASE CANOPY COVERAGE

INTRODUCTION

Monitoring the health of plant communities and the animals they support is critical in understanding change in climate and pollution. Resilient ecosystems are reliant on maintaining, or increasing biodiversity. Land use, land cover, and mitigation of invasive plant species are additional factors that must be addressed to maintain or increase biodiversity.

Based on the recent research of Dr. Stacey Hutchinson, a scholar at Kansas State University in Biological and Agricultural Engineering, contiguous riparian habitat is seen not only as an indicator of biodiversity, but also a primary indicator of reducing flood risk (Hutchinson, McDonough, Stanton, & Thomas, 2020). (See Appendix page 60 for the description of riparian habitat land cover used in this study).

Trees provide numerous ecosystem service benefits including the important role of reducing carbon dioxide in the atmosphere and storing carbon. Trees planted in and around urban areas provide natural air pollution control, habitat for urban wildlife, and help reduce heat-island effect. Native trees are also part of a healthy riparian habitat. Some native tree species, such as Hazelnuts, can be cultivated as a specialty crop that can have a positive effect on reducing climate change by reducing carbon dioxide, long term carbon storage, low energy requirements (no tillage), and shell potential for biomass fuel.

The analysis that follows shows baseline conditions of all riparian habitat, contiguous riparian habitat, and canopy cover as well as relationships to other types of land cover and areas of high social vulnerability.

ANALYSIS

Measurement Questions

The questions we stepped through to evaluate factors of habitat health and climate change protection included:

- Which watersheds have the most riparian habitat in their stream buffers?
- Of the riparian habitat, where does the most uninterrupted, or contiguous, riparian habitat exist?
- Are there more opportunities to increase contiguous habitat through cultivated land cover?
- Which watersheds have the most canopy cover?
- How much canopy cover is in areas of social vulnerability?
- Where are there adopted stream buffer ordinances and complete streets ordinances?
- What new policies or enhanced existing policies can support the goals to increase contiguous healthy habitat and canopy cover in urban areas?

EVALUATING DATA

Data evaluation began with the set of data provided by MARC and found through other reputable and regularly updated sources (USGS, CDC, iTree). In this category analysis was focused on:

- Natural Resource Inventory (NRI) (MARC)
- Canopy cover (iTree)

NRI data was last updated in 2013. Ideally updates happen every five years so change can be measured at regular intervals. Canopy cover data can be measured using iTree at any interval and it is recommended that reassessment would be done annually. Canopy cover data developed from iTree is updated with Google maps satellite imagery meaning the analysis can be updated easily every year. Riparian habitat data is from NRI and is not updated frequently, this is an established baseline that will require alternate data for future land cover analysis.

The goals of mapping and measurements in the Habitat Improvement and Climate Protection section are to understand and strengthen our region's riparian habitat, to assess opportunities for increasing habitat connectivity, and to understand opportunities for increasing canopy coverage in the region. The NRI dataset was used to assess the riparian buffer of our region's streams and to analyze the connectivity of riparian habitat (see p. 60 for the description of riparian habitat land cover used in this study).

PERCENT RIPARIAN HABITAT

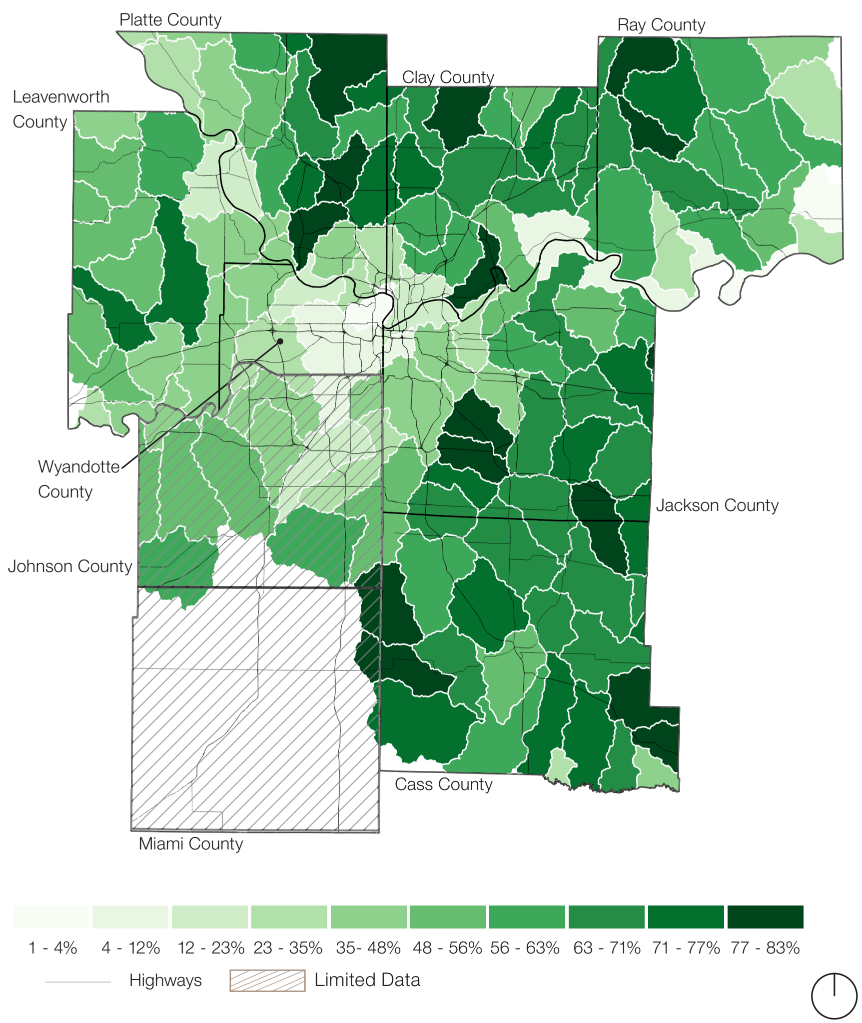


Figure 5.3.1 Riparian habitat is based on NRI data clipped to a 300 ft buffer. This map displays the percent of those buffers that are riparian habitat rather than agricultural or cultivated areas, developed land, unclassified land, or open water. Data was unavailable in Miami County and frequently uncategorized in Johnson County making assessments in those watersheds less reliable.

PERCENT CONNECTED RIPARIAN HABITAT

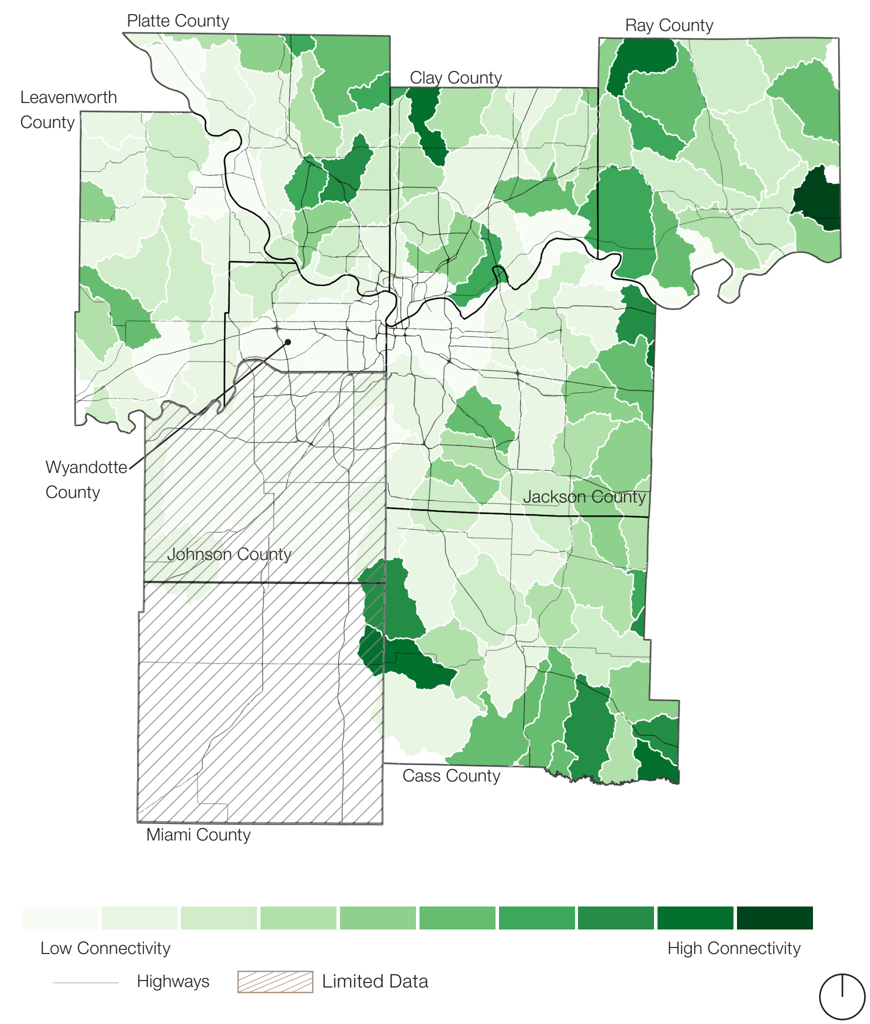


Figure 5.3.2 Connected riparian habitat was assessed using a methodology called Effective Mesh [See the appendix description of Effective Mesh p. 60]. Data was unavailable in Miami County and frequently uncategorized in Johnson County making assessments in those watersheds less reliable.

PERCENT CONNECTED RIPARIAN HABITAT, 300FT RIPARIAN BUFFER LAND COVER

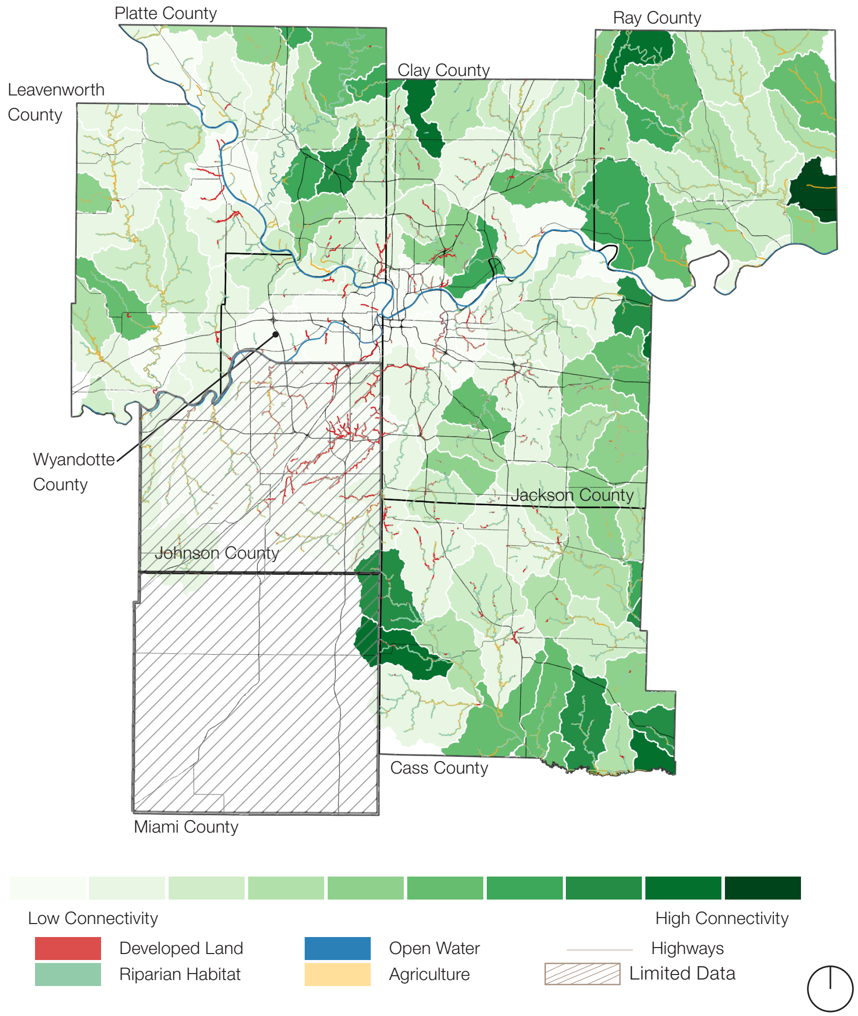


Figure 5.3.3 This map shows land cover from the NRI data set clipped within the 300 ft buffer around streams in the region. Each of the watersheds was assessed based on the land cover around the streams. (Also compare with stream impairments map, Figure 5.2.10)

300FT RIPARIAN BUFFER CULTIVATED LAND COVER

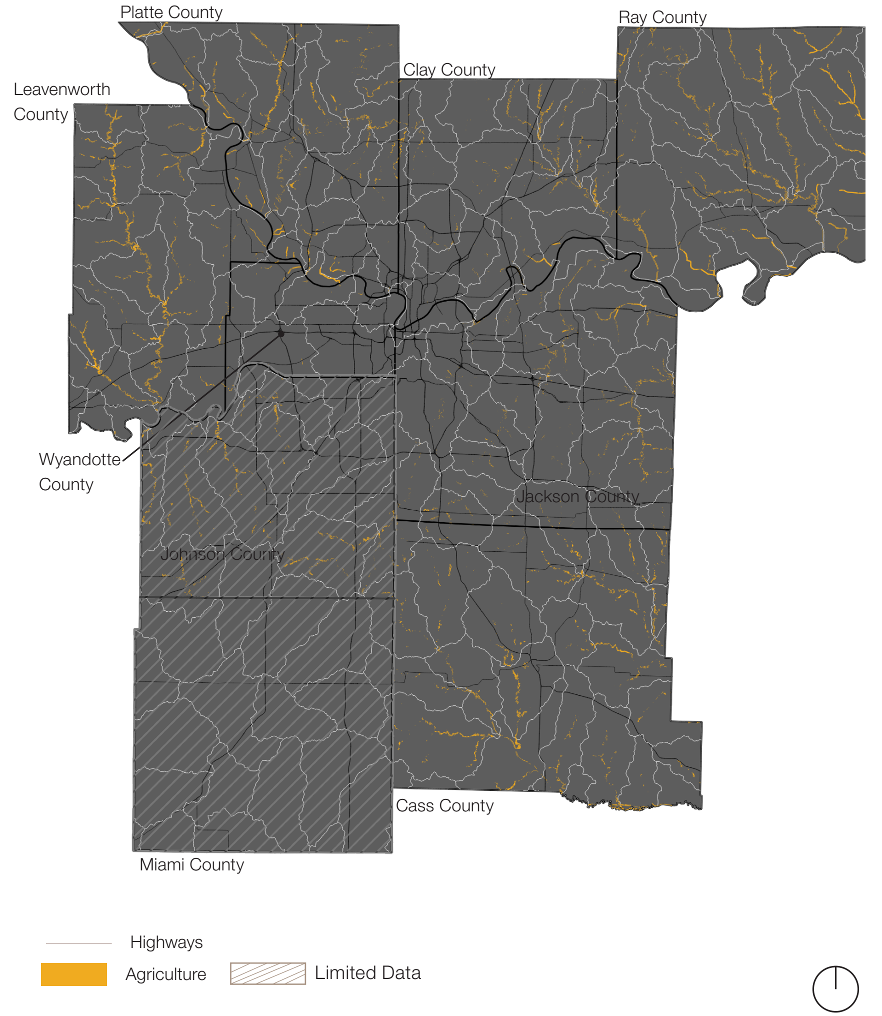


Figure 5.3.4 In this map, agricultural land in the 300 ft. stream buffer can be seen in yellow. This map is meant to highlight the potential for improving the riparian buffer through a buffer management approach in collaboration with agricultural use. This could provide a key opportunity for connecting riparian habitat in our region's more rural areas. (Also compare with stream impairments map, Figure 5.2.10)

PERCENT CANOPY COVER

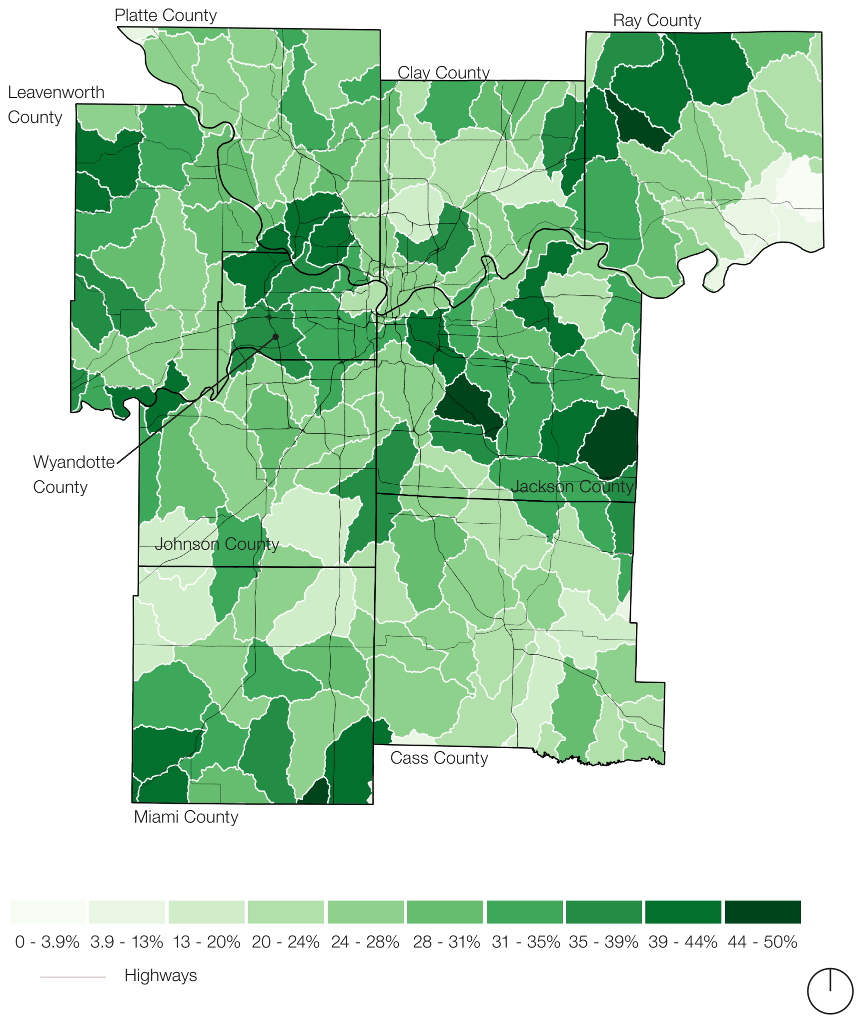


Figure 5.3.5 Using iTree, canopy cover was assessed for each of the watersheds in the MARC region.

CANOPY COVER AND SOCIALLY VULNERABLE TRACTS

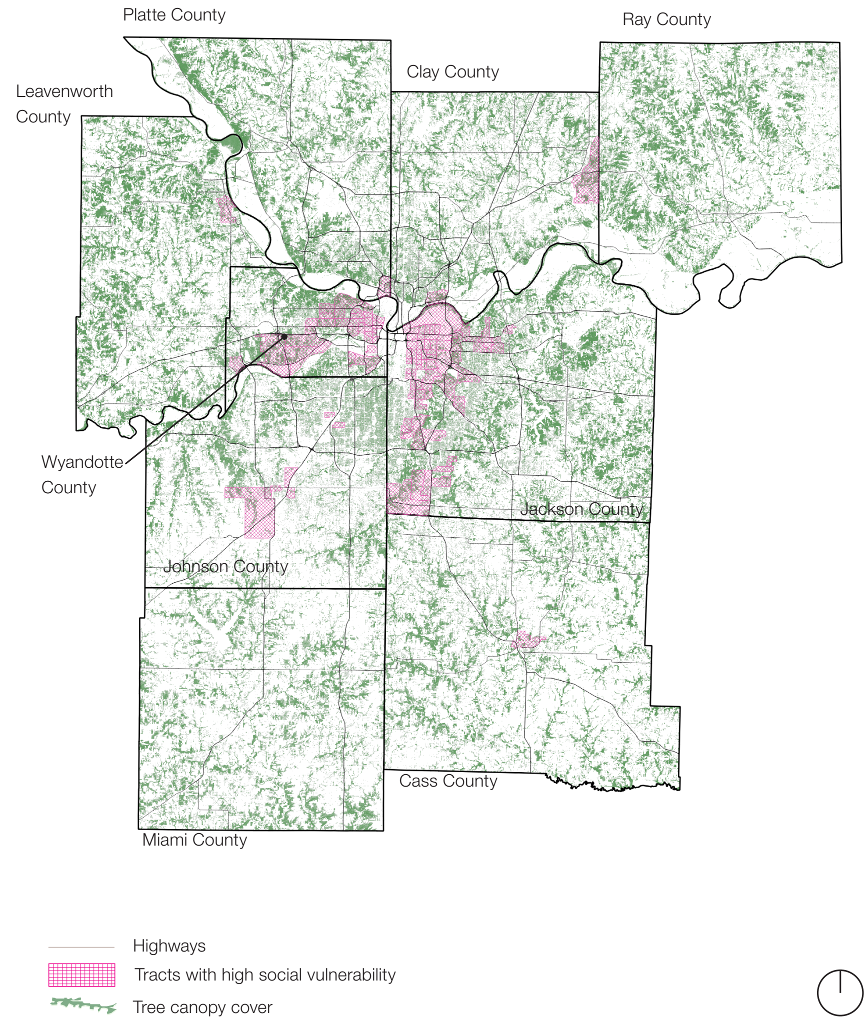


Figure 5.3.6 This map combines a visualization of where the tree canopy cover is located in the region with where the most socially vulnerable tracts are located. Oftentimes more canopy coverage is associated with more affluent areas, but in some cases in our region the socially vulnerable tracts have more canopy coverage. One factor creating this condition may be Swope park, an 1,800 acre park that

exists among some of the most socially vulnerable tracts. Other elements contributing to higher canopy cover include a high number of vacant lots and topographic challenges leading to land being underdeveloped.

SUMMARY OF FINDINGS AND OPPORTUNITIES

The goals of Habitat Improvement and Climate Protection are to increase the number of stream miles with contiguous riparian habitat and to increase canopy coverage.

While 56% of our region's stream buffers could be considered riparian habitat (rather than developed or cultivated land), based on an effective mesh assessment of that same buffer, regionally there is only a 0.08% chance that those riparian habitats are connected. Increasing habitat connectivity is an essential step towards improving diverse habitat conditions, increasing water quality, and mitigating flood risk.

In the region, 27% of the area is covered by tree canopy. In the floodplain, 25% of the area is covered by tree canopy. In the floodplain, the canopy sequesters 164 kT of carbon which is equivalent to 603 kT of CO_2 annually. The annual value of this sequestration is over $14M. This canopy coverage in the floodplain also removes over 4,100 tons of air pollutants at a value of over $1M annually. This also accounts for 804 Kgal of avoided runoff.

Strategically addressing areas to increase canopy coverage and connect riparian habitat can strengthen the resilience of our region with increased biodiversity, carbon sequestration, and air quality improvements.

OPPORTUNITIES:

- Focused habitat restoration in areas with high percent of riparian habitat to connect riparian patches into contiguous corridors
    - Short term: prioritize restoration areas
    - Long term: implement restoration and maintenance/land management
- Explore adaptations to buffer management on cultivated land to increase connected habitat
    - Short term: Identify management practices and land owners interested in implementing these practices
- Identifying strategies for transportation corridors to maintain habitat connectivity
    - Short term: Identify best practices
    - Midterm: Implement best practices during scheduled maintenance and construction processes
- Support and advocate for implementation of stream buffer management in all municipalities and unincorporated areas that have adopted the Stream Buffer ordinance.
    - Short term: Communication and education campaign
- Implement the widely adopted Complete and Green Streets ordinances in all projects in the public right of way for increased canopy cover as appropriate.
    - Midterm: Implement during scheduled maintenance and construction processes

GOAL: INCREASE ACREAGE OF CANOPY COVER IN URBAN AREAS,
MORE STREAM MILES WITH PROTECTED AND MANAGED BUFFER

5.4 PUBLIC HEALTH IMPROVEMENT

GOAL: INCREASE ACCESS TO PARKS, TRAILS AND BIKE INFRASTRUCTURE

INTRODUCTION

The priority of public health is a cross cutting issue that includes factors of access to healthcare, environmental health, equity, access to outdoor recreation, quality housing, and public policy, among others. Socially vulnerable populations have greater prevalence of asthma, diabetes, heart disease, and obesity due to less access to healthy food, quality housing, and nearby access to safe outdoor recreation options. Increased physical activity has well-documented quantifiable benefits related to health care costs. As a Metropolitan Planning Organization (MPO), MARC is the federally mandated and funded transportation policy-making organization for the region. The indicators of public health improvement most related to green infrastructure and MARC's areas of influence are focused on increasing connections between areas of high social vulnerability and access to parks, trails and bike infrastructure.

ANALYSIS

Measurement Questions

The questions we stepped through to evaluate factors of public health related to physical activity included:

- Where are the parks and MetroGreen trails throughout the region?
- Where are the most people who live more than ¼ mile (10 minute walk) from a park or trail?
- Where are the most socially vulnerable people who live more than ¼ mile from a park or trail?
- Where are there adopted Complete and Green Streets ordinances?
- What new policies or enhanced existing policies can support the goal to increase physical activity through equitable and safe access to parks, trails and bike infrastructure.
- What is the medical cost of physical inactivity? And what does it cost to build and maintain parks and trails to fill gaps in walkability?

EVALUATING DATA

Data evaluation began with the same set of data provided by MARC and found through other reputable and regularly updated sources (USGS, CDC, iTree). In this category analysis includes:

- Parks (MARC)
- MetroGreen (MARC)
- Population (ACS)
- Social Vulnerability (CDC)

Parks and MetroGreen data is updated based on MARC's discretion. Ideally a biennial update would provide a holistic image of progress for the region and measure change over time. The population data and the Social Vulnerability data based on the ACS population data are updated at yearly intervals.

The goals of mapping and measurements in the Public Health Improvement section are to understand where people have walkable access to parks and other outdoor opportunities for physical activity. This section provides maps showing where future trails have been planned and where the most people could benefit from those trails being built out.

Future expansion of the Public Health Improvement section could look at more specific health outcomes such as asthma rates, diabetes, or obesity.

PARKS, METRO GREEN, PLANNED METRO GREEN

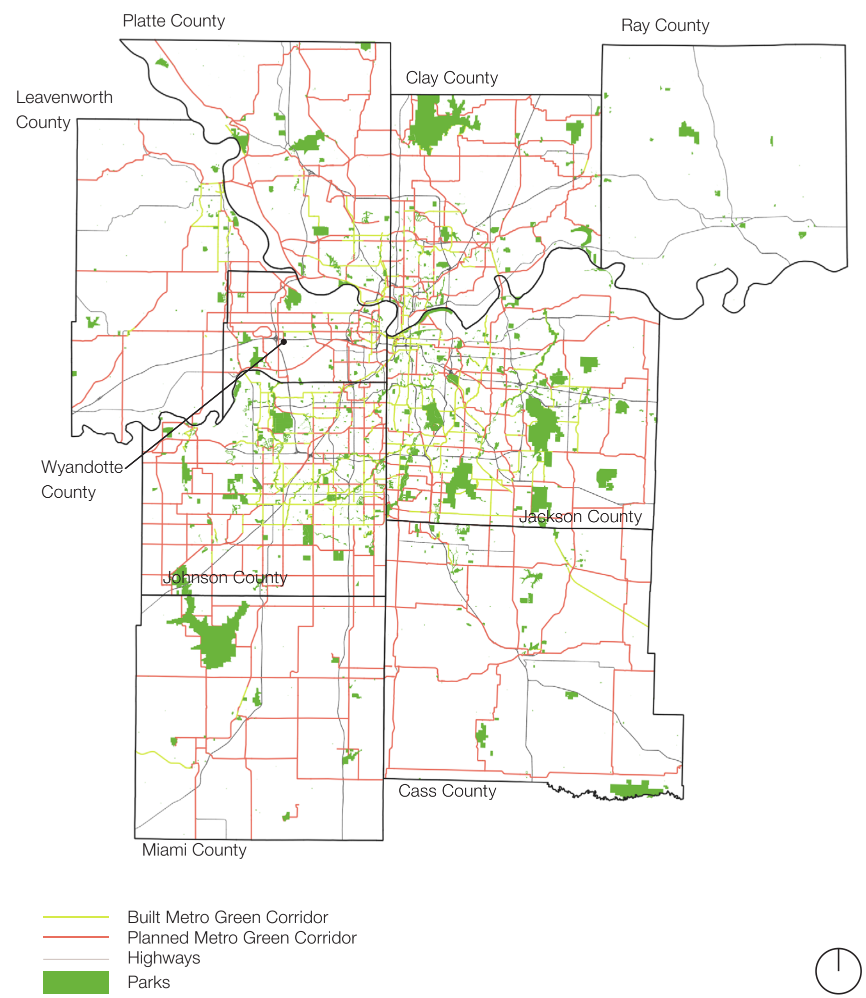


Figure 5.4.1 This map provides orientation to the existing public parks (municipal, county, special district, and state), existing MetroGreen trails, and planned MetroGreen trails throughout the region.

POPULATION DENSITY MORE THAN A QUARTER MILE FROM PARKS, SOCIAL VULNERABILITY

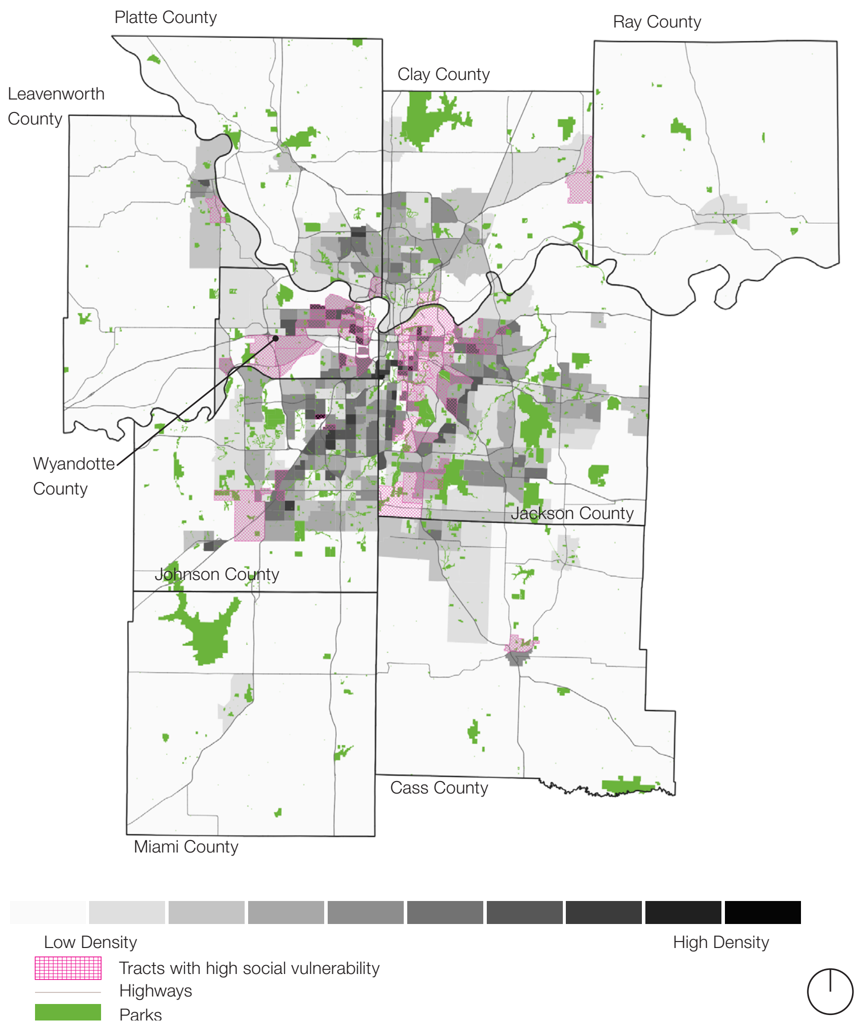


Figure 5.4.2 This map shows where the highest population density tracts are more than ¼ mile from a park (10-minute walk) in relation to socially vulnerable populations. The dark gray patches with overlapping pink hatch pattern highlight locations currently lacking parks that have the potential to increase equitable access and provide for the highest number of users in each new park in these census tracts.

POPULATION COUNT MORE THAN A QUARTER MILE FROM PARKS, SOCIAL VULNERABILITY

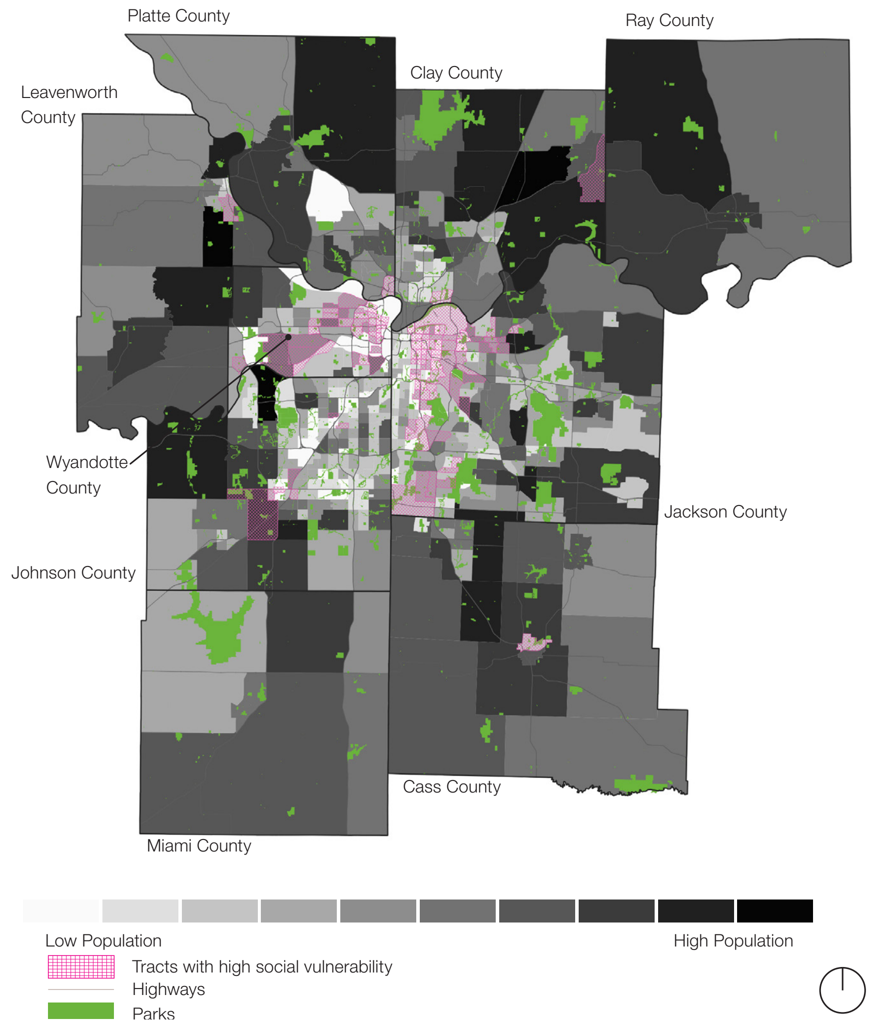


Figure 5.4.3 This map shows the total population by census tract that is more than ¼ mile (10-minute walk) from a park. Throughout the region, 1.2M people (55.5% of total population) and 134,689 people in socially vulnerable tracts (43.4% of population in SV tracts) live farther than ¼ mile from a park. Converse to the previous map, this map highlights the rural tracts where most people are not in walking distance of a park.

POPULATION DENSITY MORE THAN A QUARTER MILE FROM METROGREEN, SOCIAL VULNERABILITY

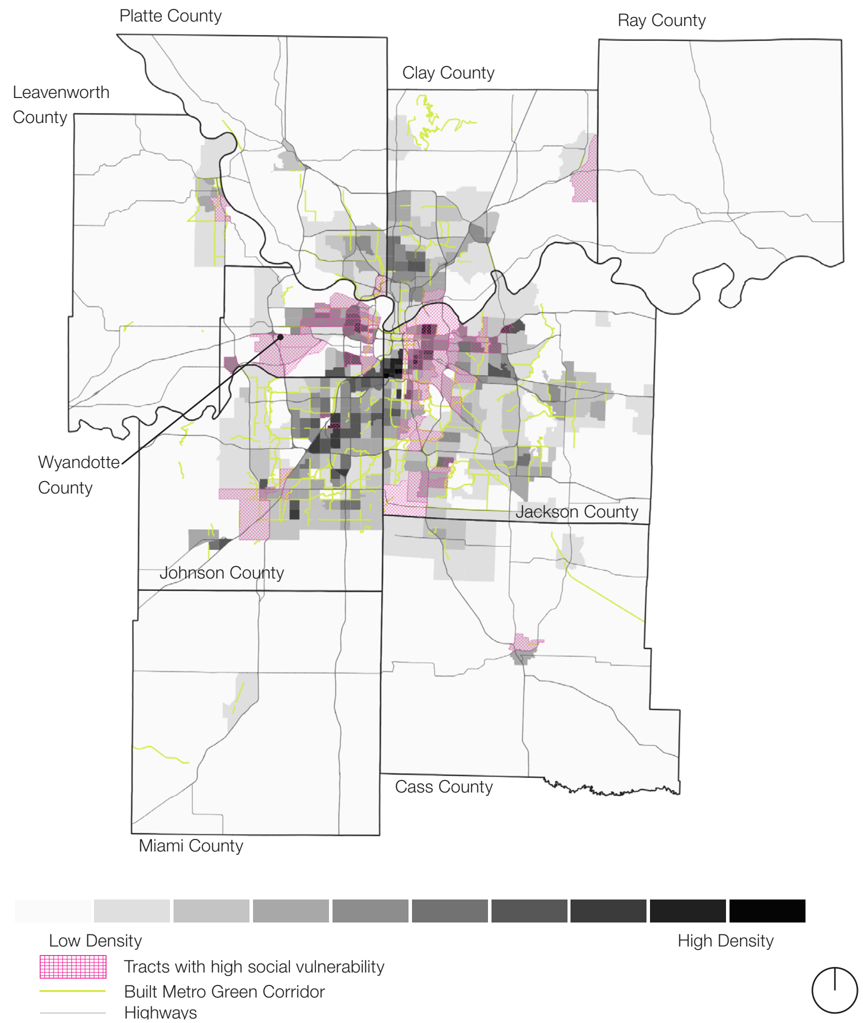


Figure 5.4.4 Similar to Figure 5.4.2, this map shows where the highest population density of people are more than ¼ mile from a MetroGreen trail in relation to socially vulnerable populations. Dark gray patches with overlapping pink hatch pattern highlight locations lacking MetroGreen trails that could increase equitable access and provide the highest number of users walkable access to new trails.

POPULATION COUNT MORE THAN A QUARTER MILE FROM METROGREEN, SOCIAL VULNERABILITY

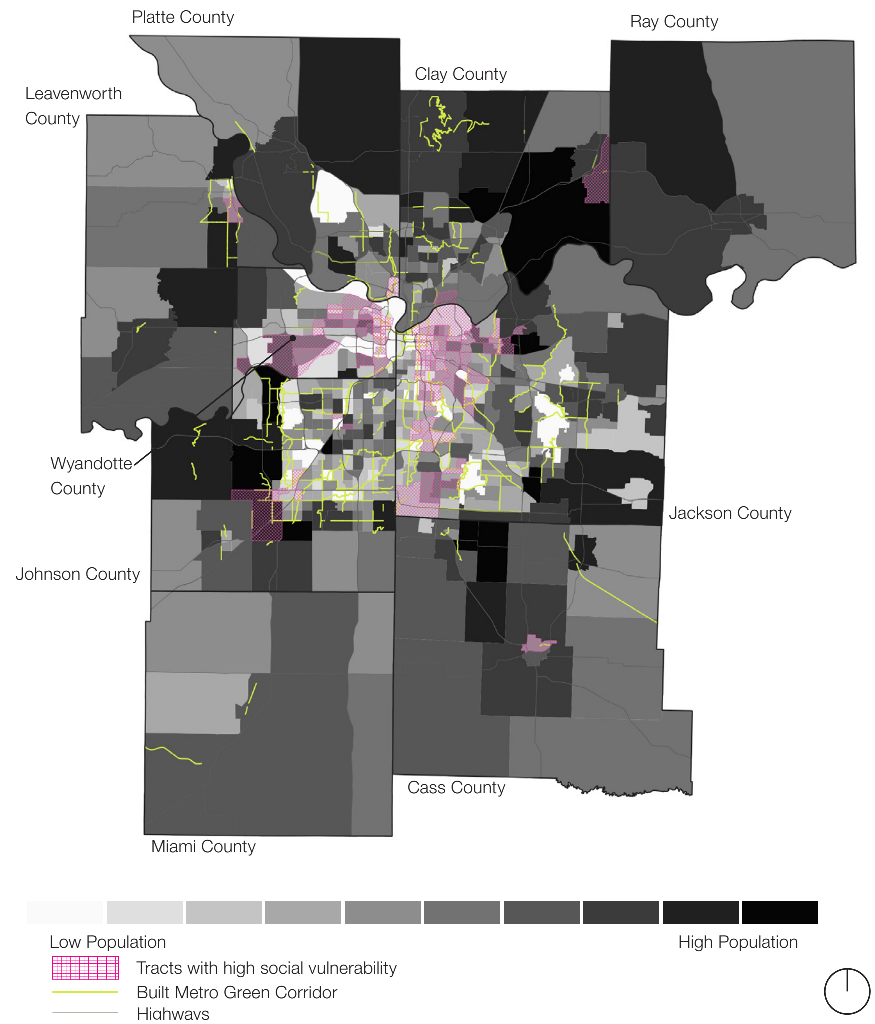


Figure 5.4.5 Similar to Figure 5.4.3, this map shows the total population by census tract that is more than ¼ mile from a MetroGreen trail. Throughout the region, 1.6M people (76% of total population) and 217,549 people in SV tracts (70% of population in SV tracts) live farther than ¼ mile from a MetroGreen trail. The dark gray patches in this map show the populations that are disconnected from the MetroGreen.

POPULATION DENSITY MORE THAN A QUARTER MILE FROM PARKS AND METROGREEN, SOCIAL VULNERABILITY

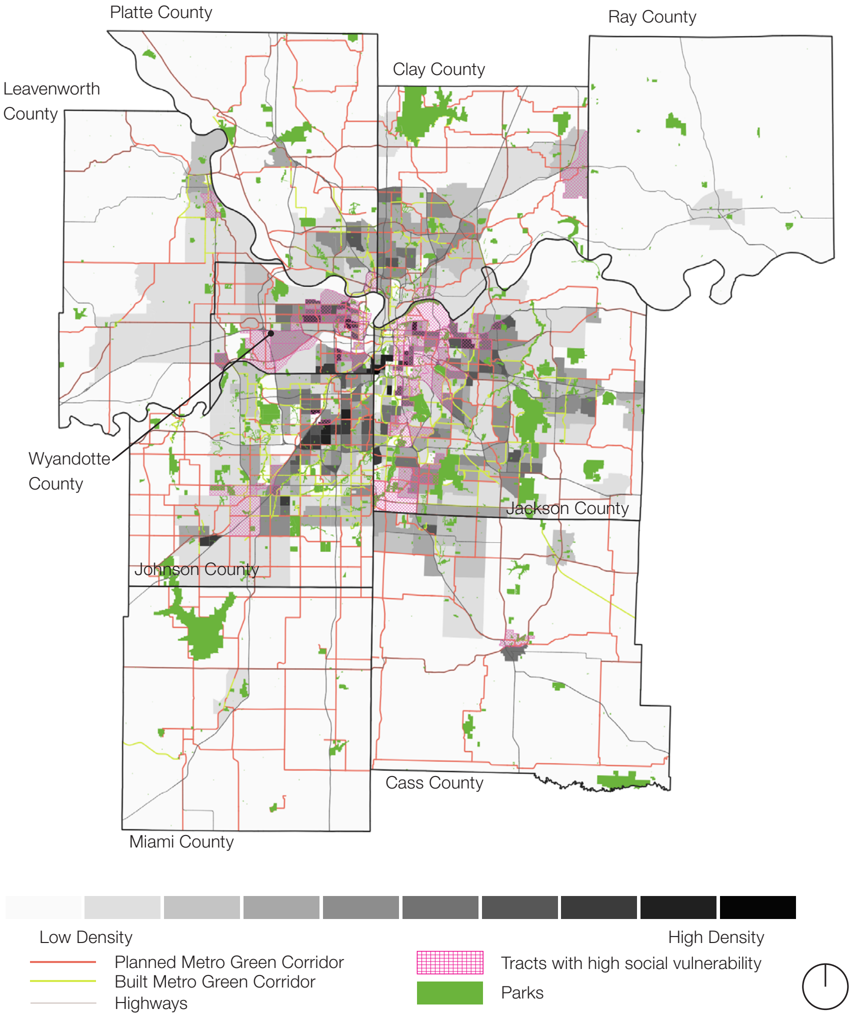


Figure 5.4.6 The maps on this page combine parks, current MetroGreen trails, and the planned MetroGreen network to provide a picture of access, needs, and opportunities. Similar to the previous maps in the Public Health Improvement category, this one shows where the population density of people is more than a ¼ mile from a park or current MetroGreen trail in relation to vulnerable populations.

POPULATION COUNT MORE THAN A QUARTER MILE FROM PARKS AND METROGREEN, SOCIAL VULNERABILITY

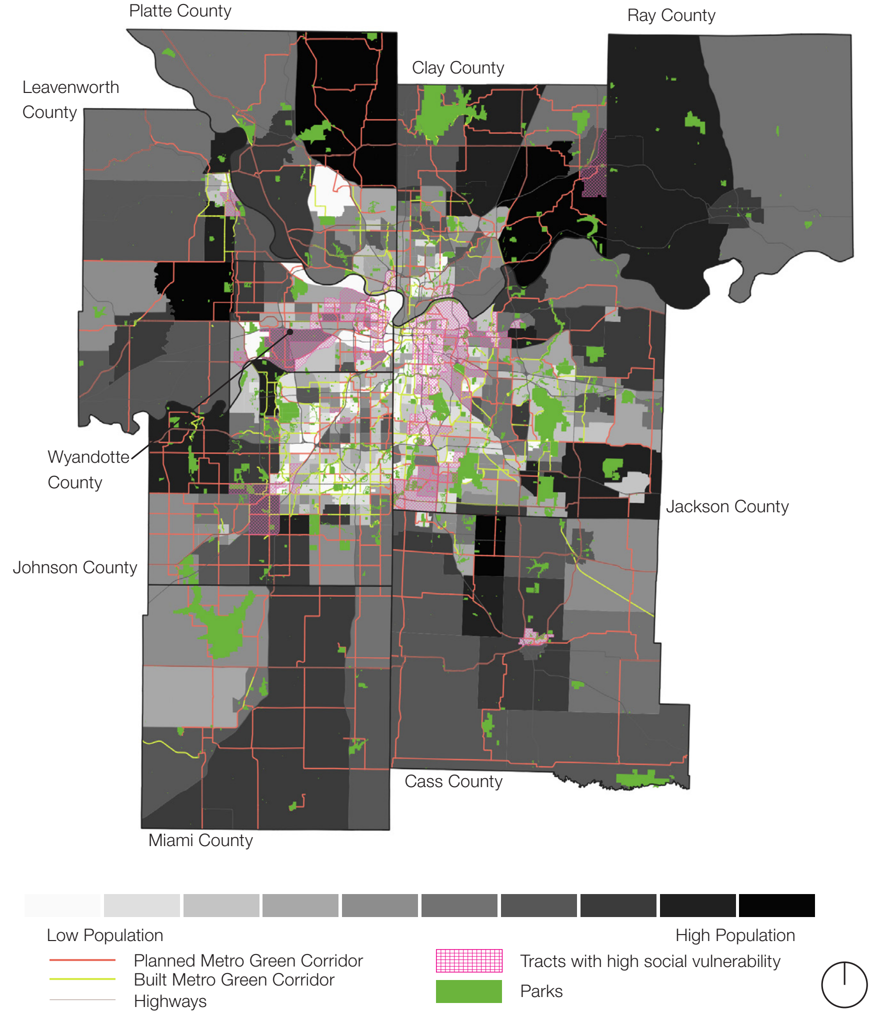


Figure 5.4.7 This map shows the total population by census tract that is more than ¼ mile from a park or current MetroGreen trail. Throughout the region, 1M people total (47% of total pop) and 105,574 socially vulnerable tracts (34% of pop in SV tracts) live farther than ¼ mile from a park, current MetroGreen trail. The dark gray patches in this map also show the population that are not in walking distance of public parks and trails.

SUMMARY OF FINDINGS AND OPPORTUNITIES

The goal of Public Health Improvement is to increase physical activity through access to parks, trails, and bike infrastructure.

About 47% of the metro's residents, approximately 1 million people, are more than a quarter mile from both MetroGreen trails and parks. Of that number, 105,574 live in socially vulnerable tracts. The Center for Disease Control associates access to opportunities for physical activity to reduced health care costs. The mapping in this section shows key areas to address gaps in access to parks and trails for the region.

OPPORTUNITIES:

- Identify gaps in the park and trail system for all residents and especially for socially vulnerable populations and areas with high population density.
    - Short term: Equity and gap assessment for opportunities for safe physical activity.
    - Midterm: Construction and management plan for infill parks and trails.
- Connect public health policy to Complete and Green Streets policy and implementation
    - Short term: Update ordinances and formalize departmental collaboration.
- Implement the widely adopted Complete and Green Streets ordinances in all projects in the public right of way and prioritize connections to parks, trails, and other opportunities for communities to engage in physical activity.
    - Midterm: Prioritize municipal bond funding for these improvements and implement during scheduled maintenance and construction processes.

GOAL: INCREASE PHYSICAL ACTIVITY THROUGH ACCESS TO PARKS, TRAILS AND BIKE INFRASTRUCTURE

6. CONCLUSIONS

REGIONAL GREEN INFRASTRUCTURE METRICS

When we look at the all of the resilience categories together there are a number of mutually beneficial opportunities to advance the high level goals and implement Green Infrastructure solutions:

- Focus efforts in socially vulnerable tracts. Protect homes and community services through regional scale flood mitigation strategies, and create policy and criteria to locate future projects out of the floodplain (Flood Risk Reduction).
- Identify gaps in parks and trails systems and increase equitable access to places that stimulate physical activity for reduced health care costs (Public Health).
- Use the widely adopted Complete and Green Streets policy to increase implementation of green infrastructure solutions that decrease runoff, increase canopy cover (Climate Protection), identify strategies to increase habitat connectivity (Habitat), and provide more equitable access to parks and trails (Public Health). This policy could also have formalized connections to Urban Forestry policy, Climate Action policy and Public Health policy throughout the region.
- Use the widely adopted Stream Buffer policy to protect and restore Water Quality and Habitat through adaptive management of the land in the buffer area. Management practices may include invasive species eradication, replanting native species of trees, shrubs and understory plants to mitigate runoff of surrounding land use, and maintenance of a healthy biodiverse riparian habitat to protect the land and water, as well as the plant and animal species.
- Determine ecosystem service values for riparian habitat (Water Quality), contiguous riparian habitat (Habitat), and canopy cover (Climate Protection) to establish mitigation bank values for offset credits in carbon sequestration.

One of the next steps for applying metrics to projects region-wide is creating funding criteria that reference green infrastructure goals and quantified objectives for public projects. MARC's Transportation Department plans to be the first to model this process.

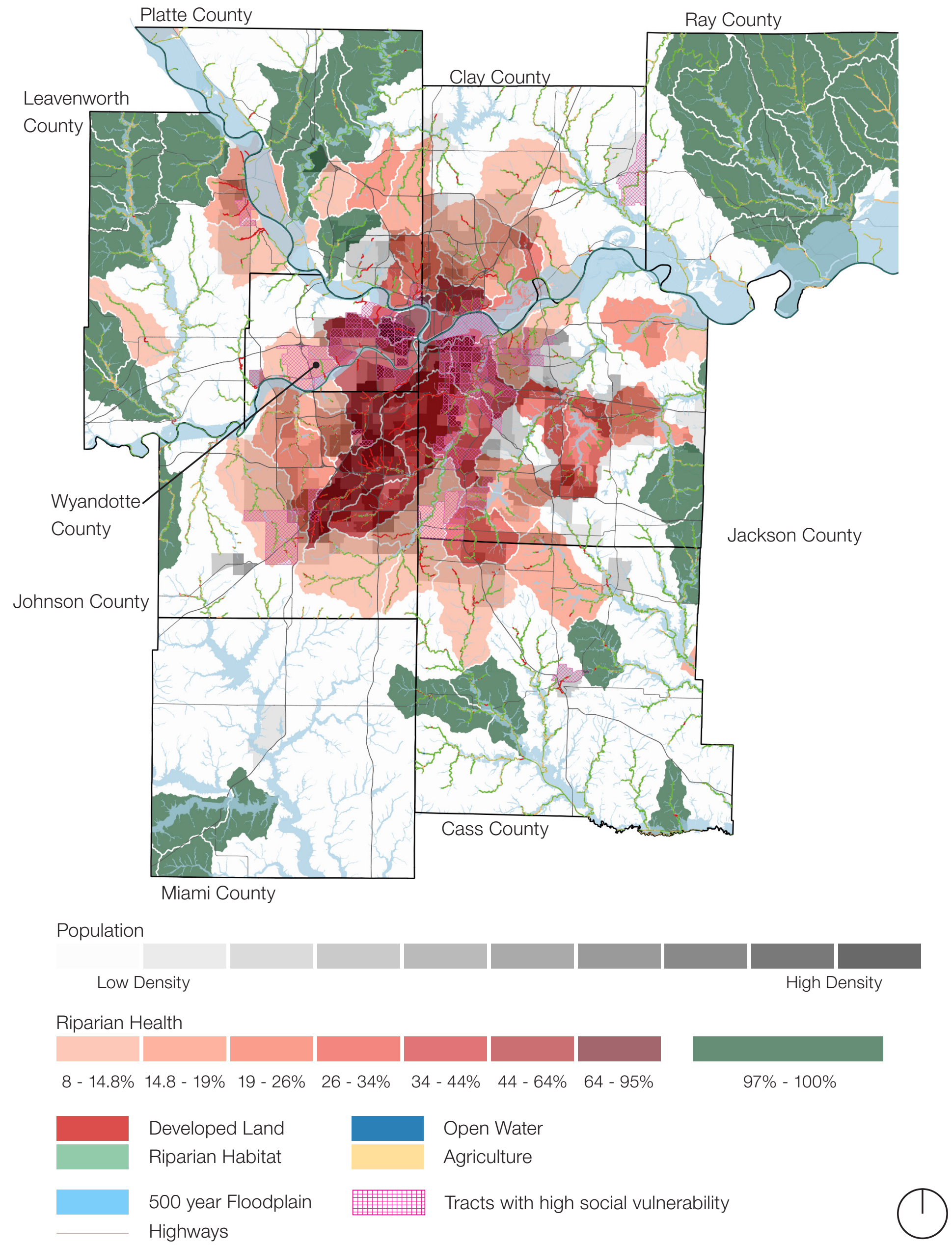
Another step needed to provide "fuel to the fire" of approval and funding for green infrastructure projects is collecting additional local quantified benefit and cost figures for ecosystem services and avoided costs. (See Appendix p. 54-55 for examples of local figures and application at a Mobility Hub scale)

It is important to note that the metrics assessed in this study provide a snapshot in time. The ability to see change in the data at a regional scale will take several years. As noted in the description of data in each resilience category, the recommended updates to track change range greatly. From annual updates to census data and social vulnerability, biennial updates to policy changes, impervious surface, canopy cover and transportation projects, to 5-year updates to housing and community assets, land cover, and stream health data. This frequency will allow for some changes in planning and policy to be seen in 2 year increments and for measurable changes in resilience to be seen in five to ten year increments based on the premise that changes in policy, planning, and design implementation are made.

The hope is that this set of metrics provides a starting point for measuring the state of health, the importance of connected systems, and the state of protection for the people and ecosystems of our region. The following map shows a combined group of factors including floodplains, watersheds with healthy streams, watersheds with unhealthy streams, stream buffer land cover, and population density and social vulnerability.

While far from comprehensive, these layered factors tell a story of a region with multiple opportunities to impact positive change with a focus on protecting the people and ecosystems that are the most vulnerable and helping them become more resilient.

Contact Tom Jacobs (tjacobs@marc.org), Environmental Program Director, with questions and requests for data and maps.



MARC GREEN INFRASTRUCTURE METRICS

For reference, the population of the MARC region is **2,153,620** and the total number of people living in the most socially vulnerable tracts in the region is **310,570**.

FLOOD RISK REDUCTION

MEASURES			GOAL
Figure 5.1.1	Acres of impervious surface in the floodplain	12,716	
	Percent of impervious floodplain	3.28%	↓
Figure 5.1.2	Miles of road in the floodplain	1,312.17	
	Percent of roads in the floodplain	6.98%	↓
Figure 5.1.2	Miles of interstate in the floodplain	28.76	
	Percent of interstate in the floodplain	4.20%	↓
Figure 5.1.7	Housing units in the floodplain	75,226	
	Percent of housing units in the floodplain	8.17%	↓
Figure 5.1.9	Socially vulnerable housing units in the floodplain	8,183	
	Percent of SV housing units in the floodplain	5.65%	↓
ASSETS			
Figure 5.1.4	Health care assets (quarter mile buffer) in the floodplain	39	—
Figure 5.1.5	Schools (quarter mile buffer) in the floodplain	255	—
Figure 5.1.6	Waste water treatment facilities (quarter mile buffer) in the floodplain	38	—
RELATED POLICIES			
	Increase opportunities to coordinate floodplain restoration efforts to increase regional resilience.	**Improving the health of the floodplain to protect communities**	

WATER QUALITY IMPROVEMENT

MEASURES			GOAL
Figure 5.2.4	Percent of the 300ft stream buffer that is riparian	56.36%	↑
Figure 5.2.3	Miles of stream in watersheds in the top quartile of riparian health	1,827	↑
Figure 5.2.3	Miles of stream in watersheds in the lowest quartile of riparian health	5,684	↓
RELATED POLICIES			
	Implement Stream Setback ordinance strategies.	**Increase the number of stream miles with protected, managed, and restored stream buffers**	

HABITAT IMPROVEMENT AND CLIMATE PROTECTION

MEASURES			GOAL
Figure 5.3.5	Percent of the region covered by tree canopy	27%	↑
Figure 5.3.6	Percent of socially vulnerable tracts covered by tree canopy	36%	↑
	Percent of the floodplain covered by tree canopy	25.7%	↑
Figure 5.3.2	Percent of the riparian 300ft stream buffer that is contiguous	0.08%	↑

RELATED POLICIES

Implement Stream Setback ordinances and strategies including forestry ordinances, Conservation ordinance, and The Climate Action Plan.

Increase the number of stream miles with contiguous riparian habitat and Increase canopy coverage

HEALTH IMPROVEMENT

MEASURES			GOAL
Figure 5.4.2 & 3	Population more than a 1/4 mi from parks	1,196,060	↓
Figure 5.4.2 & 3	Socially vulnerable population more than 1/4 mi from parks	134,689	↓
Figure 5.4.5 & 6	Population more than a 1/4 mi from MetroGreen or bike trail	1,641,850	↓
Figure 5.4.5 & 6	SV Population more than a 1/4 mi from MetroGreen or bike trail	217,549	↓
Figure 5.4.7 & 8	Population more than a 1/4 mi from MetroGreen, bike trail, park	1,016,060	↓
Figure 5.4.7 & 8	SV Population more than a 1/4 mi from MetroGreen, bike trail, park	105,574	↓

RELATED POLICIES

Implement Green and Complete Streets ordinance to prioritize an increase in equitable access to parks and trails. Coordinate this effort with Public Health Policy.

Increase access to parks, trails, and bike infrastructure

APPENDIX

MID-AMERICA REGIONAL COUNCIL - 2020

LOCAL COST-BENEFIT APPLICATION

The following quantified costs and benefits were collected to provide examples of how to compose a scalable cost-benefit analysis of green infrastructure projects that meet Water Quality, Climate and Public Health goals.

LOCAL COSTS:

Restoration of riparian habitat	Land cost $/acre $3,500/acre invasive mitigation (in areas with canopy cover) $4,200/acre for replanting
Maintenance	$750/acre/year

Source: Heartland Conservation Alliance, Habitat Architects (for Municipal Farm restoration in KCMO)

Construction of GI features	
Less than 10,000 sf	$42/sf
50,000-100,000 sf	$19/sf
Regional retention basin	$14.50/sf
Maintenance	$1.50/sf/year
Workforce training maintenance	$8.25-$9.50/sf/year

Source: KCMO Water Department and Green Stewards Program

Construction of new park/trail facilities	
1 mile walking trail	$150,000 construction
Maintenance	$20,000/year

Source: NC State Extension analysis on park facilities to promote physical activity

LOCAL BENEFITS:

Canopy Cover Value:

Description	Removal Rate (lb/ac/yr)	Monetary Value ($/lb/yr)
CO removed	0.902	$0.04
NO2 removed	4.917	$0.01
O3 removed	48.968	$0.07
> PM 2.5 removed	16.403	$0.15
< PM 2.5 removed	16.403	$2.99
SO2 removed	3.098	$0.0037
	Removal Rate (gal/ac/yr)	**Monetary Value ($/gal/yr)**
Avoided runoff	105	$0.603
	Sequestration Rate (T/ac/yr)	**Monetary Value ($/T)**
C Sequestered	1.365	$170.55
CO2 Sequestered	5.005	$46.51

Value ($) of Canopy Cover:

(x) acres * removal rate * monetary value = total

Source: i-Tree

Health care cost due to physical inactivity: $355/person/year in socially vulnerable tracts. Cost could be avoided by 25% if parks and trails systems expanded to assure access within ¼ mile of all socially vulnerable tracts (compare with construction and maintenance costs of new facilities)

Local example: Surrounding Truman Sports Complex, 6,769 people live in socially vulnerable tracts farther than 1/4 mi from a public park or trail = $600,749 in annual health care costs.

1 mile trail = $150,000 construction, $20,000 yearly maintenance

10 year costs = $350,000 cost for a new trail to be added vs. $6M in health care costs

Sources: Center for Disease Control and US Census

Source: NC State Extension analysis on park facilities to promote physical activity

MOBILITY HUB APPLICATION:

The map on the following page shows priority regional mobility hubs located in the floodplain as key opportunity areas for Green Infrastructure solutions. Each mobility hub has different site-based factors, and the acreage would not allow for full scale flood risk mitigation projects, however these are highly visible places for potential Green and Complete Streets projects that model water quality, climate, and public health goals.

OTHER LOCAL COST AND BENEFIT QUANTITIES THAT CAN HELP MAKE THE CASE FOR GREEN INFRASTRUCTURE

Costs:

- Floodplain restoration and maintenance, $/mi
- Cost of offset credits to mitigation bank, $/acre or $/mi

Benefits:

- Floodplain ecosystem service values, $/acre or $mi
- Contiguous riparian habitat ecosystem service values, $/acre
- Riparian habitat ecosystem service values, $/acre
- Road replacement/repair costs and O&M avoided, $/mi
- Treatment of water supply avoided, $/Kgal
- Recreation and tourism income, $/mi of healthy streams
- Property value, adjacent to restored green space, $/acre
- Energy savings from canopy cover, $/acre in highest population density

MOBILITY HUBS IN THE FLOODPLAIN

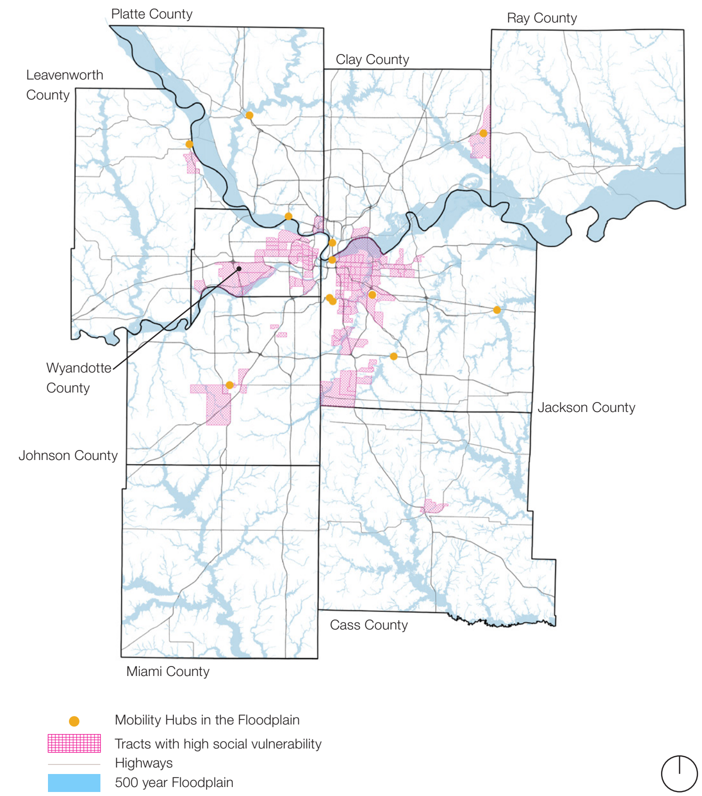
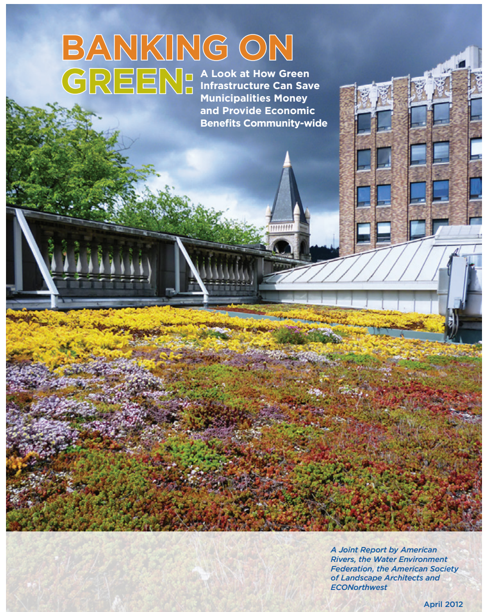


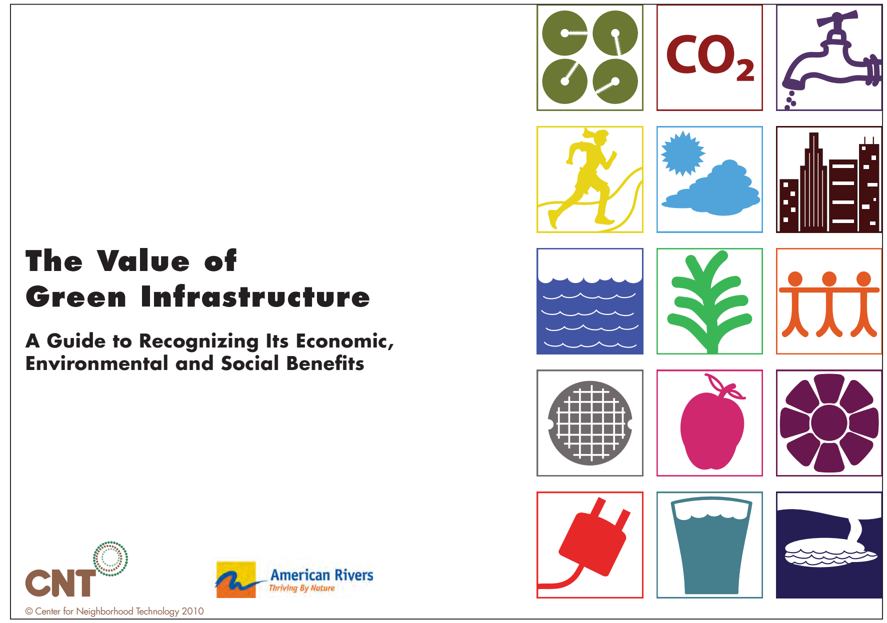
Figure 6.1 Regional mobility hubs in the floodplain

Name	Type	Phase
Plaza	Destination	1
View High/Rocak Island	Gateway	3
Excelsior Springs	Local	3
Platte City	Local	3
UMKC	Junction	1
Grain Valley	Local	3
Downtown Olathe	Gateway	1
Downtown Parkville	Gateway	3
Leavenworth	Local	1
Truman Sports Complex	Junction	3
3rd and Grand	Destination	1
North Kansas City	Destination	1

PRECEDENTS AND RESOURCES

PRECEDENTS





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MASTER DATA LIST AND METHODOLOGIES

DATA SUMMARY

The data summary spreadsheet is a digital asset and central location where the methodology and detailed tables associated with the metrics in this study are compiled. It provides a description of analysis completed and some of the datasets developed as a part of the Green Infrastructure Metrics Process.

Official Data Summary

Measures	Data	Notes
Flood Risk Reduction		
Acres of impervious surface in the 500-year FEMA Floodplain	12716	iTree
Percent of impervious 500-year FEMA Floodplain	3.28%	iTree
Miles of non-interstate in the Floodplain	1312.17	MARC roads shapefile clipped to FEMA 500yr Floodplain
Percent of non-interstate roads in the Floodplain	6.98%	MARC roads shapefile clipped to FEMA 500yr Floodplain
Miles of interstate road in the Floodplain	28.76	MARC roads shapefile clipped to FEMA 500yr Floodplain
Percent of interstate roads in the Floodplain	4.20%	MARC roads shapefile clipped to FEMA 500yr Floodplain
number of housing units in the floodplain	75226	SV layer, FP using the overlap analysis tool, multipy the resulting percent by .01 and then multiply that by the number of housing units in the tract.
Percent of housing units in the floodplain	8.17%	
number of SV housing units in the Fp	8183	
percent of SV housing units in the FP	5.65%	
Assets in the Floodplain		
Hospitals	39	.25 mile buffer around MARC's hospitals shapefile, select the buffers that fall within the
Schools	255	.25 mile buffer around MARC's schools shapefile, select the buffers that fall within the fl
Waste Water Treatment Facilities	38	.25 mile buffer around MARC's Waste Water Treatment Facilities shapefile, select the b

Summary | Roads and Highways in the Floodplain | Housing in the Floodplain | Assets in the Floodplain | 30

ROADS AND HIGHWAYS IN THE FLOODPLAIN (FLOOD RISK REDUCTION)

This chart breaks down the number of miles and percentage of road and interstate length in the region and the floodplain. The data was derived from the roads layer provided by MARC. The layer was clipped to the 500-year floodplain boundary. Interstate numbers were found by selecting the segments labeled “interstate” from the “streetcode” column.

HOUSING IN THE FLOODPLAIN (FLOOD RISK REDUCTION)

Housing in the floodplain was determined using the overlap analysis tool. This tool produced a percentage cover by which features from the input layer (a layer of tracts with data on housing, population, and other measurements of people), are overlapped by features from an overlay layer, in this case the floodplain. This produced two outputs, the total area of overlap, and the percentage of the overlap. The output was multiplied by .01 and then by the number of housing units in the tract. This equation produced a number that was representative of the number of housing units in the floodplain in the tract. This methodology was repeated on data for total population count.

ASSETS IN THE FLOODPLAIN (FLOOD RISK REDUCTION)

Three assets were selected for assessment in this project: Hospitals, schools, and wastewater treatment facilities. To assess which assets are in the floodplain, a .25 mile buffer was placed around each of the facilities. This was used to select the buffers that fall within the floodplain.

303D TMDL (WATER QUALITY IMPROVEMENT)

The TMDL breakdown shows the most frequent TMDLs in the MARC region by number of stream segments, KM, and Miles of stream. The most frequent TMDL in the region is Pathogens. Other TMDLs are Mercury, Metals, Nutrients, Organic Enrichment, Pesticides, Salinity, and Turbidity.

RIPARIAN HEALTH BY WATERSHED (WATER QUALITY IMPROVEMENT)

As a part of Green Infrastructure metrics analysis, Riparian Health was broken down by watershed. This sheet shows stream length, length above and below average, and percent above and below average by watershed.

RIPARIAN CONNECTIVITY/EFFECTIVE MESH (HABITAT IMPROVEMENT/ CLIMATE PROTECTION)

Please see appendix p. 60 for a step-by-step breakdown of the Effective Mesh analysis.

ITREE BY WATERSHED (HABITAT IMPROVEMENT/CLIMATE PROTECTION)

This section includes tree canopy cover and impervious surface area determined by watershed through iTree analysis. Through this study, iTree analysis was done on every watershed in the region to create an accurate understanding of the watersheds in the region.

POPULATION NEAR PARKS (HEALTH IMPROVEMENT)

Population near parks breaks down the key metrics associated with proximity to parks, MetroGreen, and the combination of parks and MetroGreen. The majority of the data collected here is displayed in the summary sheet.

ORDINANCES

The ordinances spreadsheet shows a breakdown of the population in areas with complete streets and stream setback ordinances and how much land area each of those ordinances cover in the region.

RIPARIAN HABITAT CONNECTIVITY ANALYSIS : EFFECTIVE MESH

1. Clip NRI data to a 300ft boundary around stream centerlines
2. Add a field to recategorize the clipped data into categories. For this analysis there are 5 groups:

    a. Riparian Habitat (1)
        -Includes: Oak Woodland and Savana, Mixed Evergreen, Mixed Evergreen Urban, Marsh, Cultural Grassland, Deciduous Forest, Woodland and Immature Forest, Urban Forest, Forested Wetland, Grassland, Lowland Hardwood Forest
    b. Open Water (2)
    c. Developed Land (3)
    d. Cultivated Land (4)
        -Includes: Agriculture, Cultivated Land
    e. Unclassified (0)

3. Dissolve the buffer data by feature, resulting in 5 attributes, one for each category.
4. Use the multi-part to single part tool to separate the areas within each attribute that are disconnected.
5. Clip the buffer to the HUC 12 watersheds using the clip tool, run a batch process and make sure the watersheds are each in their own layer.
6. Join attributes by location for each of the newly clipped layers and the combined HUC 12 Watershed boundary. Input is the clipped layers, join layer is the HUC12 Watersheds. Use the “contains” geometric predicate. You only need to add the category called “HUC 12” and “Name”
7. Merge clipped pieces of the buffer back together.
8. Open the attribute table of the combined file and recalculate the “Acres” with the field calculation “$area”
9. Export the layer to a csv and continue in excel
10. In excel separate the data into two sections by their recategorized numbers (one page for Green/Native Habitat (1), another for the rest of the categories (0, 2-4)
11. Now calculate the total area for the two categories in each watershed
12. Calculate meff by using the following equation:

$(\text{Segment 1})^2+(\text{Segment 2})^2+(\text{Segment 3})^2 = \text{Acres Riparian Squared}$

meff = Acres Riparian Squared/Total Acres in the Stream Buffer

average percent riparian connectivity = m_{eff}/Total Acres in the Stream Buffer

RIPARIAN HEALTH ASSESSMENT

Stream Health Assessment Report — December 2016

Introduction and Summary

This project predicts stream quality in the Kansas City region with 1) field-sampled stream data and 2) regional environmental, land use, and other data. Variables were developed and tested to find a valid regression model that could predict stream quality. A valid model was used to determine variables to predict stream quality throughout Greater Kansas City. Predictions of stream quality may be used to prioritize streams for management and remediation strategies.

Stream Inventory Data

In 2005, Patti Banks Associates (PBA, now known as Vireo) conducted a stream assessment for the City of Kansas City, MO (KCMO). The purpose was to assess and classify the relative condition of all streams within the city, and provide baseline natural resource conditions for sustainable storm water management and land use planning recommendations. Assessment criteria included erosion indicators, bed and bank composition, aquatic habitat features, tree canopy and understory coverage and composition, and indirect water quality indicators. These criteria were assigned individual weighted scores to create a composite score of stream quality at each location and a relative ranking of stream quality throughout the watershed. The assessment was designed to produce generalized results rather than site-specific data.

289 sample locations were selected along streams in KCMO with about .75 mile between sample locations. Only natural streams were selected for sampling, not channelized or piped streams. Surveys were conducted from May through November, with 5 scoring components in each of four categories: stream stability (STAB_SC_SU in table 1 below), aquatic habitat quality (AQTC_SUM), terrestrial habitat quality (TERR_SUM), and water quality (WQ_SUM). Not all component scores could be determined at each site because of site conditions. Aquatic scoring components were omitted for all ephemeral and dry intermittent streams. Each of the 20 components have a potential score of 10, providing a maximum score of 50 for each of the four categories, with a possible total score (RAW) of 200. The final stream quality score was calculated by dividing the total site score by the number of components scored (N). The final scores (TOTAL_SC) ranged from 0, indicating poor stream conditions, to 10, indicating optimal stream conditions.

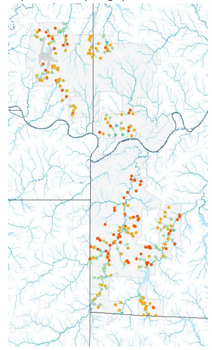
Streams were classified by stream type (STR_TYPE) so that Type 2 stream scores fell one standard deviation above or below the mean score, Type 3 stream scores fell within two standard deviations above or below the mean, etc.' Stream types are described as: Type 1, Highest quality; Type 2, high quality; Type 3, restorable; Type 4, low quality; and Type 5, lowest quality. The classification was assigned relative to the sample population of surveyed streams, rather than applying an absolute score.

Table 1: Sample of stream assessment data

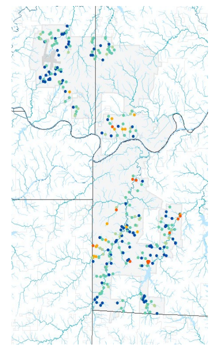
SAMP_LOC	WTRSHD	DATE	STAB_SC_SU	AQTC_SUM	TERR_SUM	WQ_SUM	RAW	N	TOTAL_SC	STR_TYPE
tod18	Todd Creek	9/21/2005	43.5	46	42	31	162.	20	8.125	1
tod17	Todd Creek	9/21/2005	49	42	44	25	160	20	8	2
pra05	Prairie Creek	9/27/2005	47	46	46	19	158	20	7.9	2
nbr09	N Brush Creek	9/9/2005	39	48	42	28	157	20	7.85	2
RBC05	Rocky Branch Creek	8/24/2005	50	44	36	25	155	20	7.75	2
RBC09	Rocky Branch Creek	8/24/2005	36.5	44	42	32	154.	20	7.725	2
nbr13	N Brush Creek	9/9/2005	41	46	40	27	154	20	7.7	2
LBR31	Litlle Blue River	10/3/2005	37	44	38	35	154	20	7.7	2
BEC04	Buckeye Creek	8/31/2005	39	38	42	35	154	20	7.7	2
RCC06	Rock Creek	8/30/2005	35	48	46	25	154	19	8.105263	1
BLR53	Blue River	10/7/2005	35	46	42	30	153	20	7.65	2
tod12	Todd Creek	9/21/2005	39	46	46	21	152	20	7.6	2
nbr02	N Brush Creek	9/6/2005	44	42	42	24	152	20	7.6	2
RUC04	RUSH CREEK	8/17/2005	28	46	46	32	152	20	7.6	2
BLR19	Blue River	9/9/2005	39.5	44	42	25	150.	20	7.525	2

1

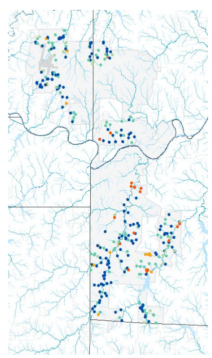
Maps 1-4: Scores by category for KCMO stream data samples



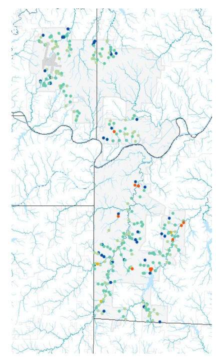
Water Quality



Terrestrial Habitat



Aquatic Habitat Quality



Stream Stability

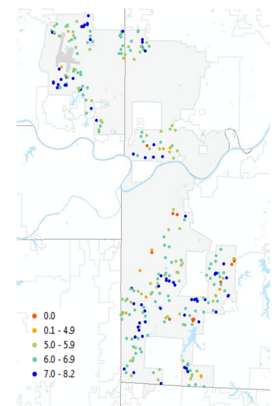
- 0 - 9
- 10 - 19
- 20 - 29
- 30 - 39
- 40 - 50

Score per category

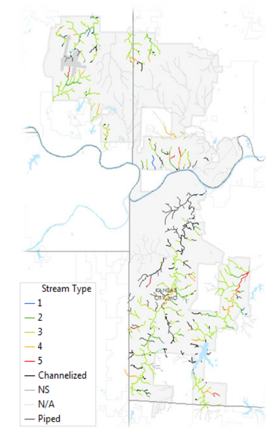
2

PBA analysis indicated that terrestrial habitat scores showed the greatest correlation with overall stream quality. The other three general assessment factors (stream stability, aquatic habitat quality, and indirect water quality indicators) did not strongly correlate with overall stream quality. However, when PBA narrowed the analysis to sample locations where all 20 components were scored, the water quality component correlated strongly with overall stream condition. PBA found some high-quality streams in urbanized areas and low-quality streams in agricultural areas. PBA also noted that grouping watersheds into generalized land use classes did not produce useful results, which was consistent with various negative impacts to stream quality observed in urban, agricultural, and mixed use areas.

Maps 5-6: Results of KCMO stream assessment: Final score and stream type



Final score (=Total component score/N)



Stream type

3

DATA WISHLIST

- Established benchmarks for targeting and tracking outcomes over a period of time
- 10-year updates to regional land cover data and aerials being more frequently updated
- Annual infrastructure costs for flooding repairs
- Infrastructure value in floodplain
- Historic Flood Damage/Property Damage
- Region-wide hydrological models for flood forecasting
- Scoring criteria for future projects
- Canopy cover at mobility hubs
- Future targets and past trend lines on transportation investments
- Complete and green street network assessment (where are they currently, where are they planned)
- Historic Flood Damage/Property Damage
- Hydrological models for flood forecasting
- Detailed regional impervious surface layer
- Walkability Index Scoring throughout the region
- Health: Asthma and Diabetes for the region at a more detailed scale
- Atmospheric Climate Data
- Assessment of stream health by stream order
- Consistent riparian habitat data for full region
- Regional soil health data
- Outfalls and point source discharge
- Water treatment cost
- Endangered species and key habitat corridors
- Regional biodiversity index