KANE COUNTY, ILLINOIS

ESTABLISHED JANUARY 16, 1836

Ground Cover, Heat Island and Carbon Sequestration Study

February 2023
Revised October 2023

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The true meaning of life is to plant trees, under whose shade you do not expect to sit.

Nelson Henderson

Introduction

The intent of this study is to support the Kane County in understanding the extent of Countywide tree canopy, grass, and impervious surface coverage and in establishing appropriate goals and strategies to improve the environmental impacts and opportunities of land coverage within the County. The findings of this report are to support establishment of goals, strategies, and actions for the County's Climate Action Plan. As a visionary planning document, the goals established for the County should be a "stretch" while also being achievable.

Why Study the County Wide Tree Canopy?

Trees play a central role in supporting community health, improving air and water quality, helping to reduce building energy use, and supporting heat island and climate mitigation.

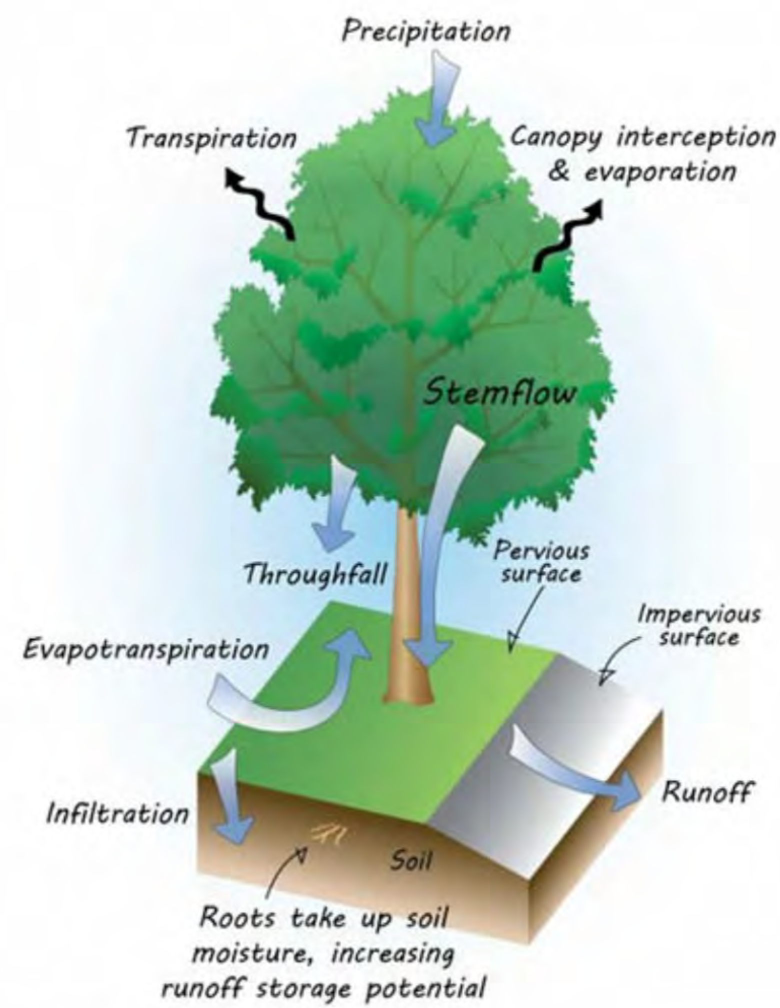
Community Health Benefit of Trees

Recent studies have shown that sometimes going to a park, or even looking at a single tree can significantly improve a person's health and stress levels. Our understanding of the value of trees has been expanded to include mental and physical health benefits.

Trees are critical in filtering air, removing harmful pollutants, such as Carbon Monoxide, particulate matter, and Ground-level Ozone - pollutants that can be toxic at high levels and which can cause asthma and other respiratory impacts.

Stormwater Management

Every tree catches the rain as it comes down, increasing the soil's capacity to retain water longer. A mature White Oak can intercept up to 12,010 Gallons of water in a single year. This water stays in the leaves until it's absorbed by the tree or evaporates to cool our air. Within an urban environment, this prevents that water from needing to be piped or treated by other stormwater infrastructure.



Source and Graphic:
United States Environmental Protection Agency

Introduction

Pollution Absorption

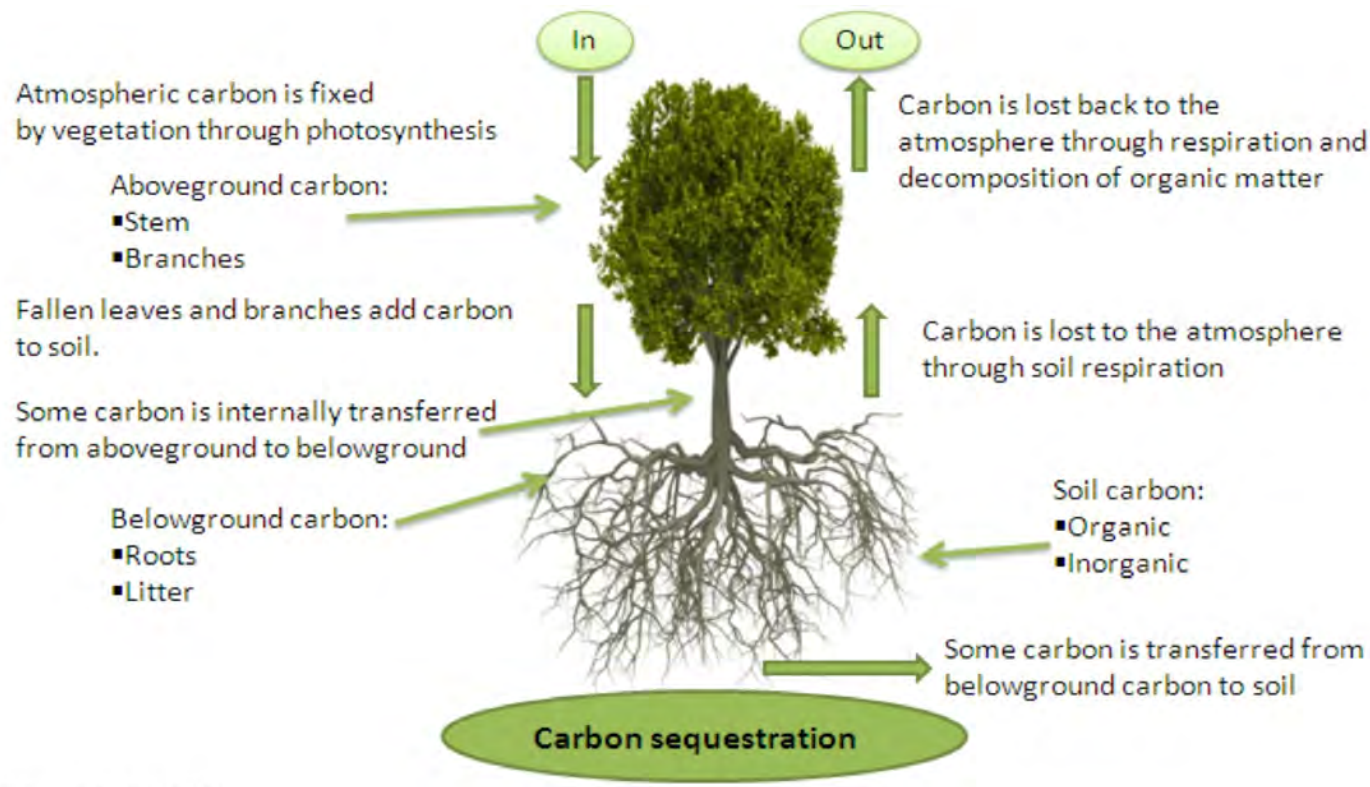
Trees remove gaseous air pollution primarily by uptake via leaf stomata, though some gases are removed by the plant surface. Once inside the leaf, gases diffuse into intercellular spaces and may be absorbed by water films to form acids or react with inner-leaf surfaces. Trees also remove pollution by intercepting airborne particles. (Source: USDA Forest Service)

Heat Island and Micro Heat Island Mitigation

Tree transpiration and tree canopies affect air temperature, radiation absorption and heat storage, wind speed, relative humidity, turbulence, surface albedo, surface roughness and consequently the evolution of the mixing-layer height. These changes in local meteorology can alter pollution concentrations in urban areas. Maximum mid-day air temperature reductions due to trees are in the range of 0.07 to 0.36 degrees F for every percent canopy cover increase. (Source: USDA Forest Service)

Carbon Sequestration

Through photosynthesis, trees take in carbon dioxide (CO_2) and release oxygen (O_2). Trees then transfer the remaining carbon to their trunks, limbs, roots, and leaves as they grow. When leaves or branches fall and decompose, or trees die, the carbon that has been stored will be released by respiration and/or combustion back to the atmosphere or transferred to the soil.



Source and Graphic:
Lal R. Soil carbon sequestration to mitigate climate change. Geoderma 2004;123 1-22.

Methodology

To arrive at recommended goals, this study looks at the existing extent of tree canopy, grass/shrub, and impervious surface coverage. Coverage for each category are established using aerial imagery and a random point technique using the USDA Forest Service's i-Tree Canopy Software tool. i-Tree Canopy is a quick and simple method to obtain statistically valid estimates for canopy cover and other land uses based on the point method. Further technical information on i-Tree canopy is included in Appendix 1

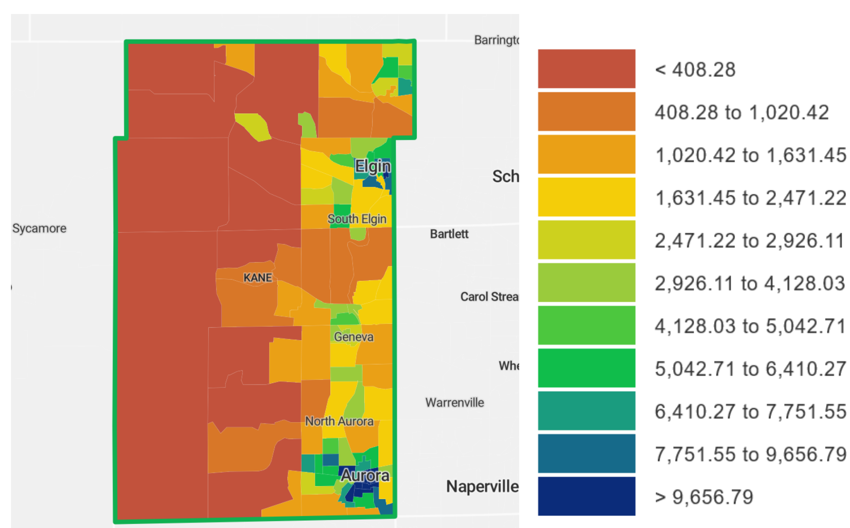
i-Tree Canopy was used to interpret aerial images across the community using 8,149 random points. This overall picture was built up by analyzing the 104 census tracts (see map below) that make up the Kane County. The point samples averaged 525 plots to each census tract, for a total of 58,539 until a satisfactory standard error for each land cover category was reached. The standard error (SE) achieved is typically between .2 and 2%.

Classification of coverage categories included Trees/Shrubs, Lawn, Prairie Grass, Agriculture, Water, Impervious Surface Light (buildings), Impervious Surface Light (pavement), Impervious Surface Dark (buildings), and Impervious Surface Dark (pavement). The land classes assigned and their descriptions are provided in the table below. Once statistically valid land cover calculations in these classifications were obtained for each neighborhood, calculations were created, by neighborhood, for Tree Canopy Benefits, Tree Canopy Values, and Baselines for community-wide Heat Island Contribution, Stormwater Runoff, and Carbon Sequestration. With these values established a range of potential goals and strategies to protect and improve the environmental benefits of the County's tree canopy and green infrastructure were identified and are included in the Recommendations Section of this report.

Land Coverage Categories Measured

Cover Class	Description
Agriculture / Crop	Cultivated crops, community garden, permaculture site
Dark Impervious - Building	Buildings with Dark Impervious Roof Surfaces
Dark Impervious - Pavement	Pavement with Dark Impervious Surfaces
Lawn	Maintained Grass Areas
Light Impervious - Buildings	Buildings with Light Impervious Roof Surfaces
Light Impervious - Pavement	Pavement with Light Impervious Surfaces
Prairie Grass/Wildflower	Wild, Native, and non manicured grass cover
Tree/Shrub	Trees and large shrubs
Water	Open Water, Lake, Pond, River, Wetland/Marsh

Population Density of Kane County Per Square Mile by County



Section 02

Land Coverage Characteristics

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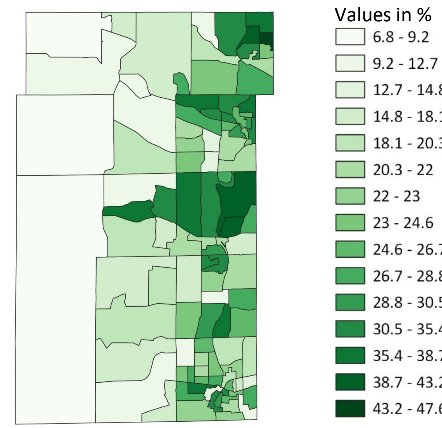
Classification of coverage categories included Tree Canopy, Grass, Water, Impervious Surface Light, and Impervious Surface Dark.

Tree Canopy Coverage

County Average: **16.9%**

County High: **47.6%**
Tract 8502.01

County Low: **6.8%**
Tract 8524.03

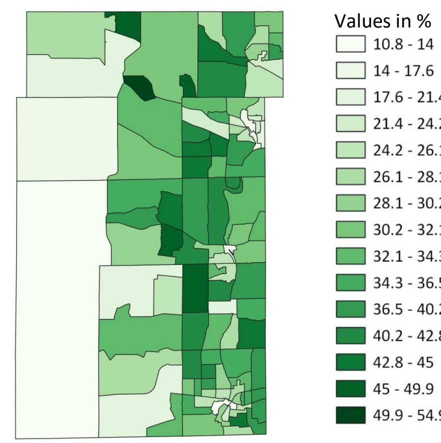


Lawn and Grass Coverage

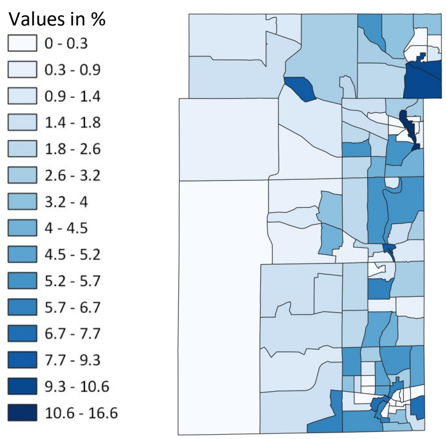
County Average: **26.5%**

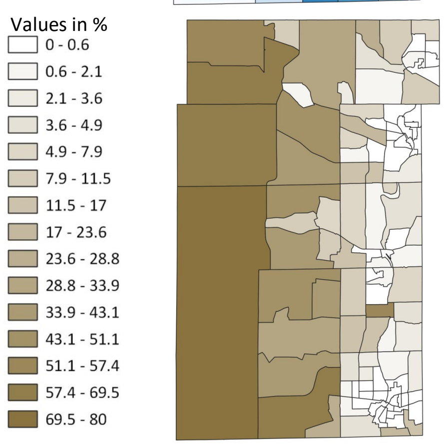
County High: **54.9%**
Tract 8507.1

County Low: **10.8%**
Tract 8524.03



Land Coverage Characteristics





Open Water Coverage

County Average: **1.9%**

County High: **16.6%**
Tract 8546

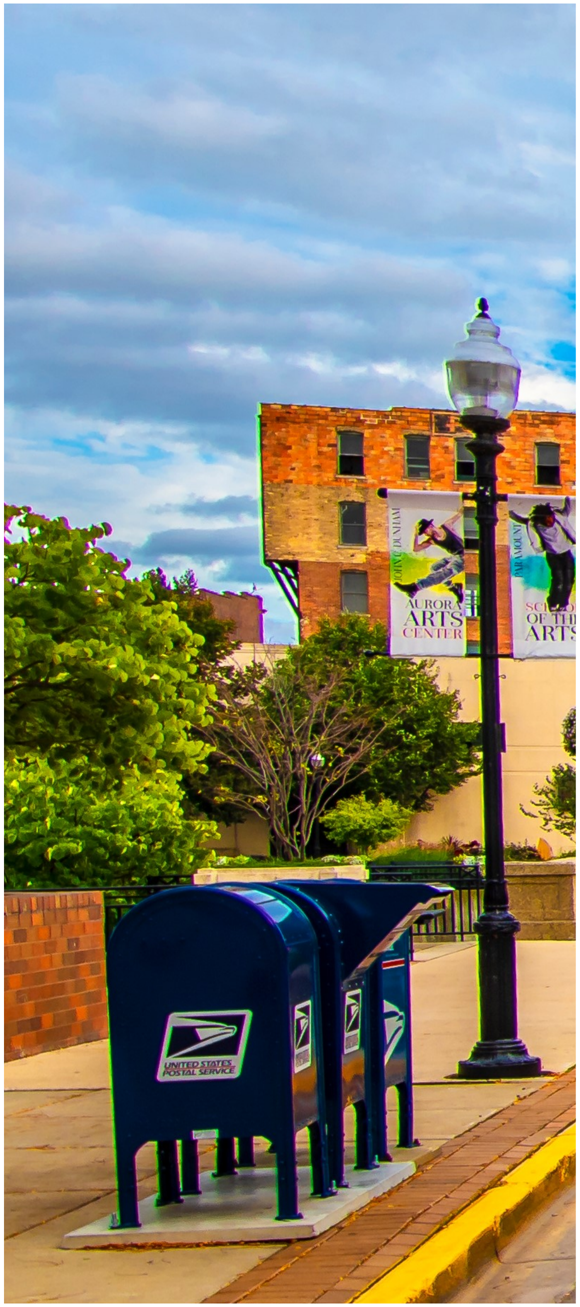
County Low: **0.0%**
Multiple Tracts

Agriculture Land Coverage

County Average: **41.0%**

County High: **80%**
Tract 8524.03

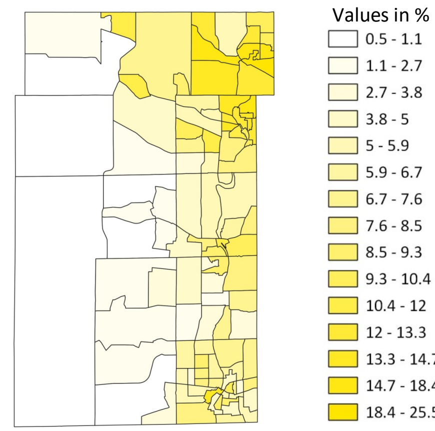
County Low: **0.0%**
Multiple Tract



Land Coverage Characteristics

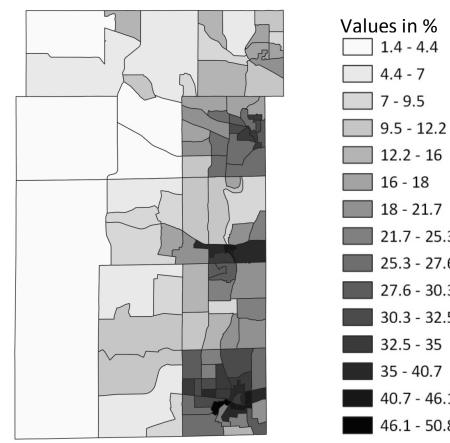
Light Impervious Surface Coverage (buildings+pavement)

County Average:	**4.0%**
County High:	**25.5%** Tract: 8504
County Low:	**0.5%** Tract: 8507.05



Dark Impervious Surface Coverage (buildings+pavement)

County Average:	**9.8%**
County High:	**50.7%** Tract: 8547
County Low:	**1.4%** Tract: 8524.03




NEWSIES: SEPTEMBER 4 - OCTOBER 20
ED BY RUSH COPLEY MEDICAL CENTER
PARAMOUNT
LUTHER VANDROSS TRIBUTE
GEORGE MICHAEL TRIBUTE
OCT 25
OCT 26
EDDIE B
BEAUTY & THE BEAST

Section 03
Land Cover Impacts and Benefits

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The condition and health of a community's Tree Canopy and green infrastructure and the magnitude and nature of impervious surfaces have meaningful consequences on the area's environment. Estimating the baseline land cover contributions to the community's environment enables the County to project the impact of potential strategies and to track improvements over time. The following maps in this section diagram the impacts and benefits of the County's Tree Canopy, grass, and impervious surface coverage.

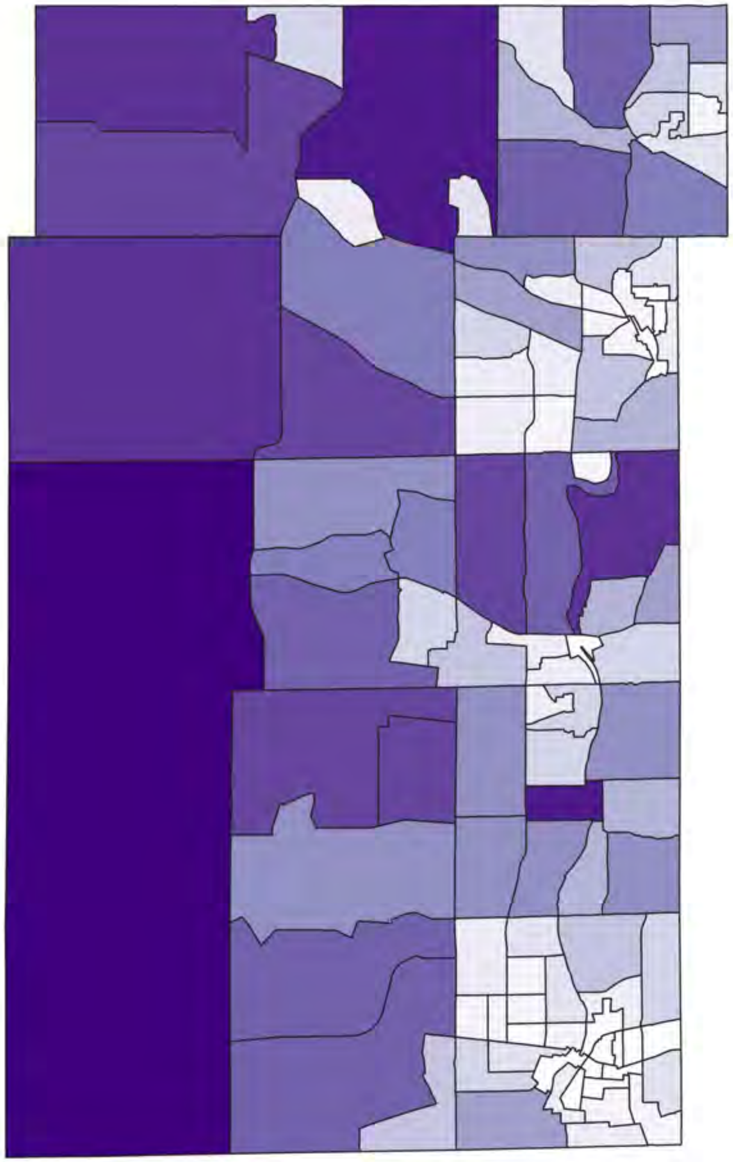
Pollution Absorption by Trees

Air pollution is a major environmental concern in most major metropolitan areas globally. Air pollutants are known to increase incidents of heart disease, asthma, emphysema, and cancer. Meanwhile, global warming projections for Illinois anticipate an increase in the impacts felt by air quality issues. Healthy tree canopies offer the ability to remove significant amounts of air pollutants and consequently improve environmental quality and human health.

Pollution Absorption by Trees - Particulates

Particulate matter pollution is divided into two categories: Fine Particulate (PM2.5) and Course Particulate (PM10). Numerous studies have linked fine particulate pollution with a number of health risks including respiratory disease, asthma, bronchitis, and increased heart disease and heart attacks. Course particulate matter has been shown to aggravate heart and lung diseases and to cause lung damage.

Land Cover Impacts and Benefits



Pollution Absorbed Annually by County's Tree Canopy

Carbon Monoxide
94,905 lbs

- 46 - 125
- 125 - 202
- 202 - 317
- 317 - 451
- 451 - 558
- 558 - 740
- 740 - 840
- 840 - 974
- 974 - 1191
- 1191 - 1669
- 1669 - 2220
- 2220 - 2960
- 2960 - 3380
- 3380 - 5160
- 5160 - 7340

Nitrogen Dioxide
348,969 lbs

- 169 - 545
- 545 - 841
- 841 - 1166
- 1166 - 1658
- 1658 - 2051
- 2051 - 2719
- 2719 - 3085
- 3085 - 3578
- 3578 - 4377
- 4377 - 6134
- 6134 - 8160
- 8160 - 10900
- 10900 - 12400
- 12400 - 18940
- 18940 - 27000

Ozone
2.57M lbs

- 1251 - 3397
- 3397 - 6218
- 6218 - 9376
- 9376 - 12288
- 12288 - 15159
- 15159 - 20094
- 20094 - 22802
- 22802 - 26440
- 26440 - 32347
- 32347 - 45331
- 45331 - 60340
- 60340 - 80480
- 80480 - 91700
- 91700 - 140040
- 140040 - 199540

Sulfur Dioxide
187,027 lbs

- 91 - 247
- 247 - 452
- 452 - 627
- 627 - 891
- 891 - 1103
- 1103 - 1462
- 1462 - 1659
- 1659 - 1924
- 1924 - 2353
- 2353 - 3298
- 3298 - 4380
- 4380 - 5860
- 5860 - 6680
- 6680 - 10180
- 10180 - 14520

Fine Particulate (PM2.5)
133,852 lbs

- 65 - 208
- 208 - 339
- 339 - 485
- 485 - 634
- 634 - 784
- 784 - 1039
- 1039 - 1179
- 1179 - 1367
- 1367 - 1673
- 1673 - 2344
- 2344 - 3120
- 3120 - 4160
- 4160 - 4740
- 4740 - 7240
- 7240 - 10320

Course Particulate (PM10)
718,568 lbs

- 26 - 972
- 972 - 1779
- 1779 - 2621
- 2621 - 3506
- 3506 - 4338
- 4338 - 5750
- 5750 - 6525
- 6525 - 7566
- 7566 - 9257
- 9257 - 12972
- 12972 - 17260
- 17260 - 23040
- 23040 - 26240
- 26240 - 40080
- 40080 - 57100

Land Cover Impacts and Benefits

Energy Savings

Trees are important elements in many urban areas and alter the local climates by producing shade, blocking winds and reducing air temperatures through evaporation of water from leaves. To determine exact energy savings values, tree locations and relationships to buildings need to be assessed in detail. Trees which help buildings reduce their energy consumption based on their location - an example is a tree planted on the South side of a building helping to shade the building from hot summer sunlight - are known as energy-affecting trees. At the community-wide scale, however, reasonable approximations can be calculated using average energy affecting trees per acre based on community density type established through the study "*Residential building energy conservation and avoided power plant emissions by urban and community trees in the United States*." Using these averages, we can estimate the total electrical and natural gas savings contributed by Kane County's tree canopy. (Note; based on Countyal averages, it is assumed 25% of electricity consumption is for air conditioning and 80% of natural gas use is for heating buildings.)

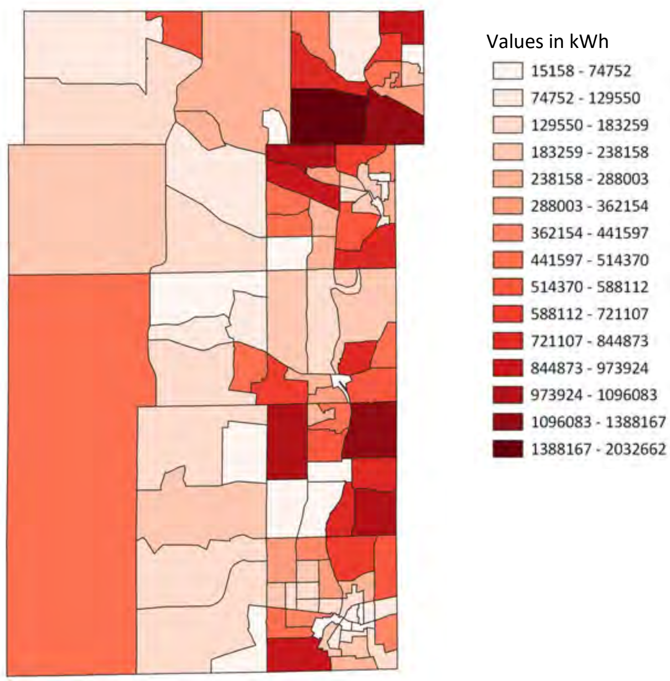
Energy Savings Annually From County's Tree Canopy

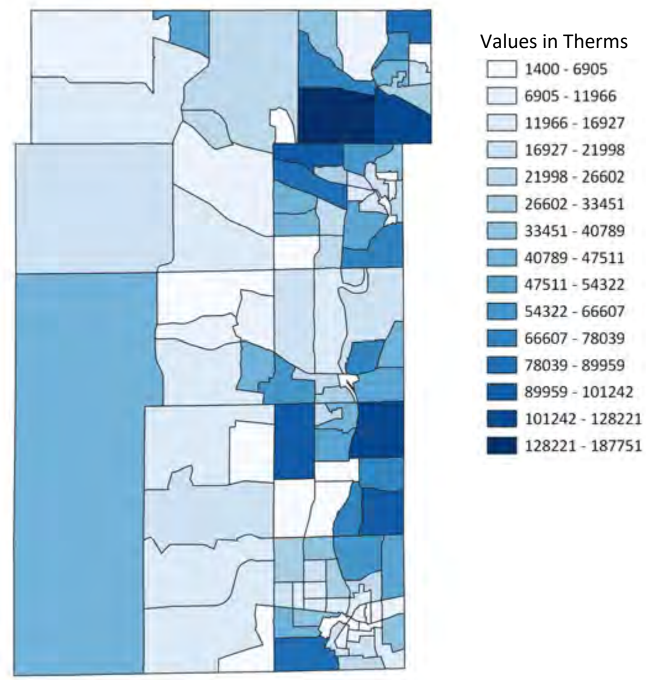
Electric Savings

37,442,230 kWh

Heating Fuel Savings

3.46 M Therms





Heat Island Contribution

Heat island (and "micro-heat island") refers to the phenomenon of higher atmospheric and surface temperatures occurring in developed areas than those experienced in the surrounding rural areas due to human activities and infrastructure. Increased heat indices during summer months due to heat island effects raise human discomfort and health risk levels in developed areas, especially during heat waves.

According to NOAA projections, if global greenhouse gas emissions proceed under a "business as usual" scenario, Kane County may have an annual average of 55 days above 95 degrees compared to the recent 30 year average of 2. Depending upon humidity, wind, access to air-conditioning, humans may feel very uncomfortable or experience heat stress or illness, or even death on days with such high heat indices. Consequently, planning and management efforts to address Heat Island effects will be increasingly important to the Kane County.

Based on a 2006 study done by Minnesota State University and the University of Minnesota*, the relationship between impervious surface percentage of a County and the corresponding degree of heat island temperature increase can be understood as a ratio. The ratios vary slightly for each season. We've selected the ratio for summer heat island contribution as the effects of heat island on heat related risks are and will become increasingly more acute during summer heat waves. The numbers shown below for each of the Countys represents the increase in summer temperatures a County would experience if the entire County had impervious land characteristics identical to that County. These numbers do not necessarily represent the actual summer time temperature difference from tract to tract, but instead are a representation of the comparative level of overall heat island impacts for the overall community.

**Comparison of impervious surface area and normalized difference vegetation index as indicators of surface urban heat island effects in Landsat imagery.* Fi Yuan and Marvin Bauer, February 2007

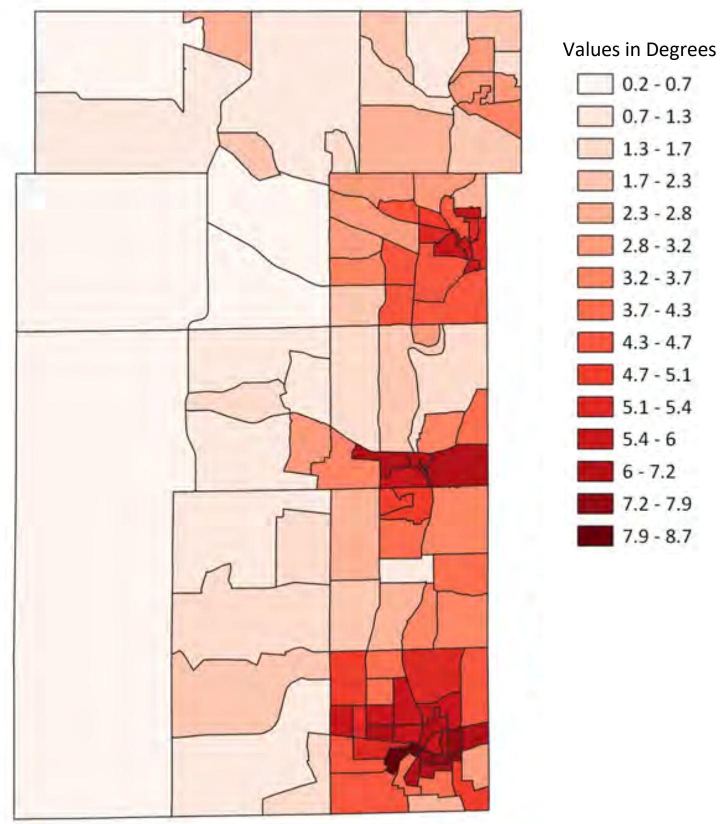
Micro Heat Island Contribution of Kane County Impervious Surfaces
(summer values)

County Average: **1.7°F**

County High: **0.2°F**
Tract 8524.03

County Low: **8.7°F**
Tract 8547

Note: values are county-wide averages. Portions of the county with higher impervious surface coverage will have much higher values



Land Cover Impacts and Benefits

Land Cover Impacts and Benefits

Stormwater Runoff and Management by Green Infrastructure

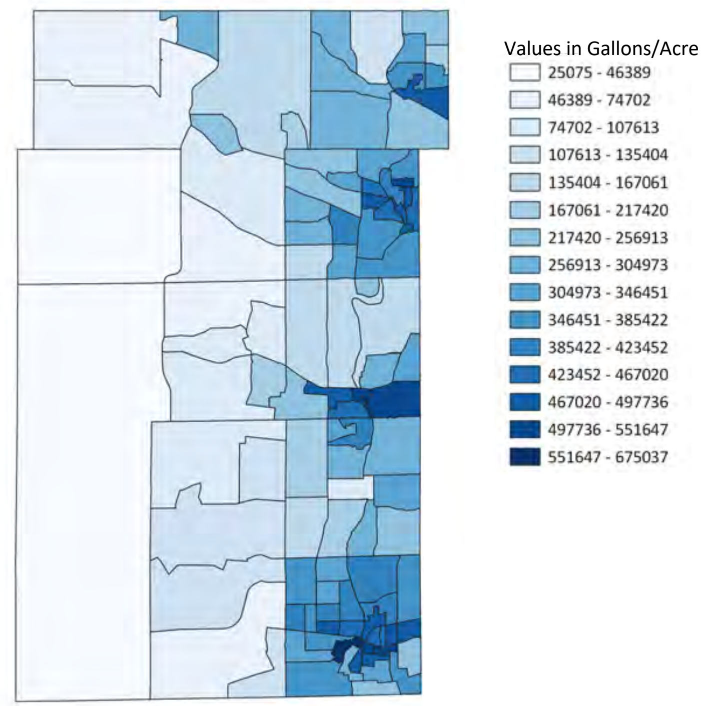
Increases in impervious cover can dramatically increase the impact of so-called 100-year flood events. Typically, floods in areas of high impervious surfaces are short-lived, but extended flooding can stress trees, leading to leaf yellowing, defoliation, and crown dieback. If damage is severe, tree mortality can occur. In addition, flooding can lead to secondary attacks by insect pests and diseases. Some species are more tolerant of flooding than others.

According to data from National Climatic Data Center and NOAA, the County receives 30.6” of precipitation annually. That total precipitation level and the impervious surface coverages can then be used to estimate the total stormwater runoff values by neighborhood as indicated below.

Stormwater Runoff Generated Kane County’s Impervious Surfaces Annually

County Total: **47.99 B** Gallons

County Average: **144,370** Gallons / Acre

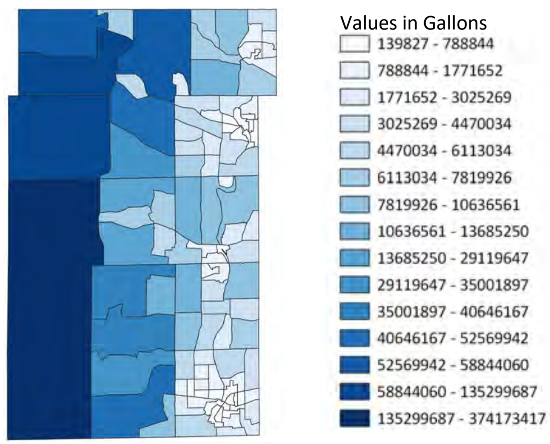


Stormwater Runoff and Management by Green Infrastructure

Green Infrastructure such as native grasses, wetlands, and especially trees are a critical stormwater management tool. Healthy green infrastructure within a community can help protect, restore, and mimic the natural water cycle - which has typically been significantly impacted through community development.

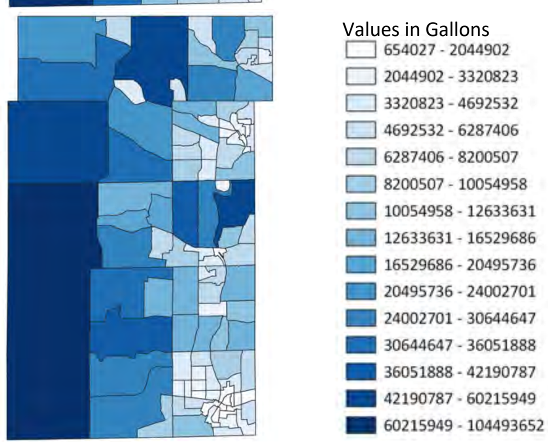
To estimate the total stormwater uptake, in gallons, by neighborhood, we have used calculations developed by stormwater sustainability specialist Aarin Teague and US Forestry Service forester Eric Kuehler. Detailed values can only be calculated using detailed soil hydrology data and accurate runoff curve numbers. As that level of detail is not a part of this study, we've used curve numbers averaged across soil groups A-D for "fair" hydrology and cover conditions. The result should not be considered an accurate indication of total uptake volumes, but rather as an "order of magnitude" analysis tool for comparison between neighborhoods.

These maps indicate the estimated total annual water uptake of trees and of grass/open land as well as the total green infrastructure water uptake as a percentage of the total stormwater runoff of each neighborhood.



Total Stormwater Uptake by Grasses and Agriculture Land

1.25 Billion Gallons



Total Stormwater Uptake by Trees

1.32 Billion Gallons

Estimated Percentage of Stormwater Runoff Uptake by Green Infrastructure

County Average:

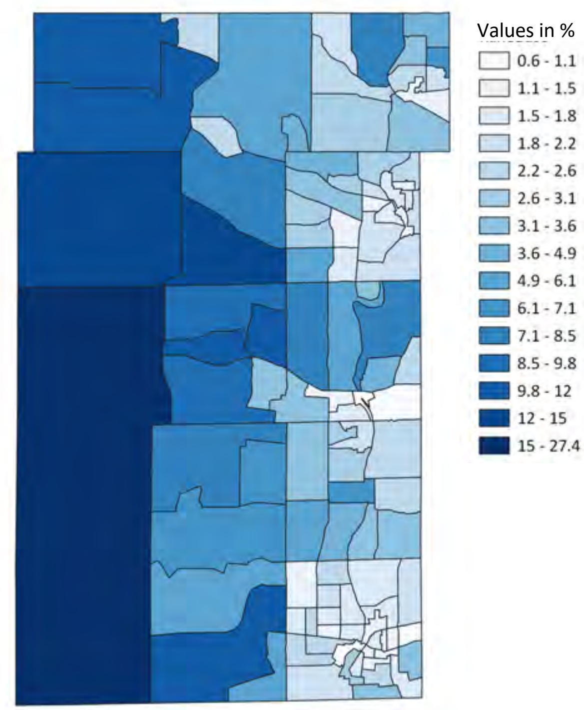
36.2%

County High:

24.4% **Clay County**

County Low:

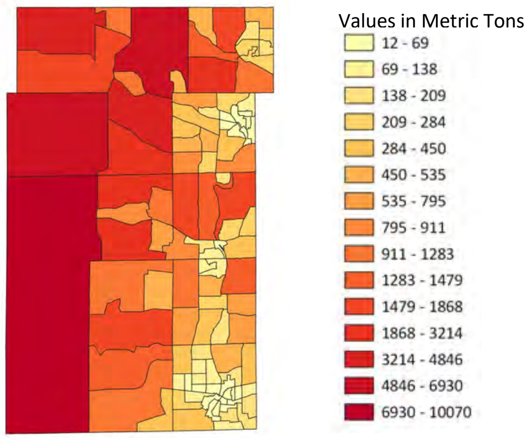
50% **Becker County**



Land Cover Impacts and Benefits

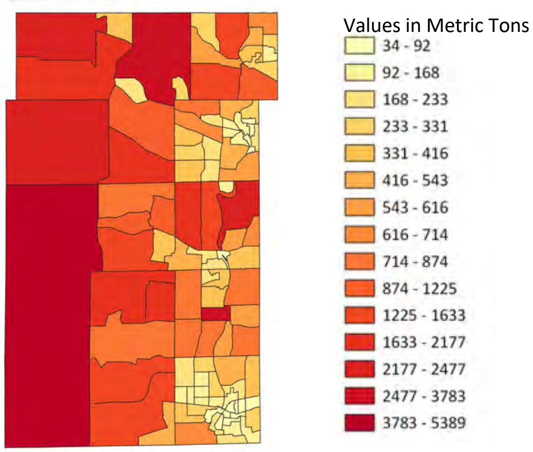
Pollution Absorption - Carbon

By volume, Carbon Dioxide pollution is the largest man-made emission contributing to Global Warming. Throughout the Kane County, 4 billion cubic feet of CO_2 pollution is produced annually by vehicles alone. Carbon Sequestration occurs throughout the growing season of all plants. Long-term carbon storage occurs within the tree/plant structure in the form of the plant material as well as below-grade in the form of soil carbon. 3.663 pounds of CO_2 sequestered produces 1 pound of carbon stored. The following diagrams are the annual carbon sequestration levels by neighborhood provided by the County's tree canopy and by its lawns and grasses.



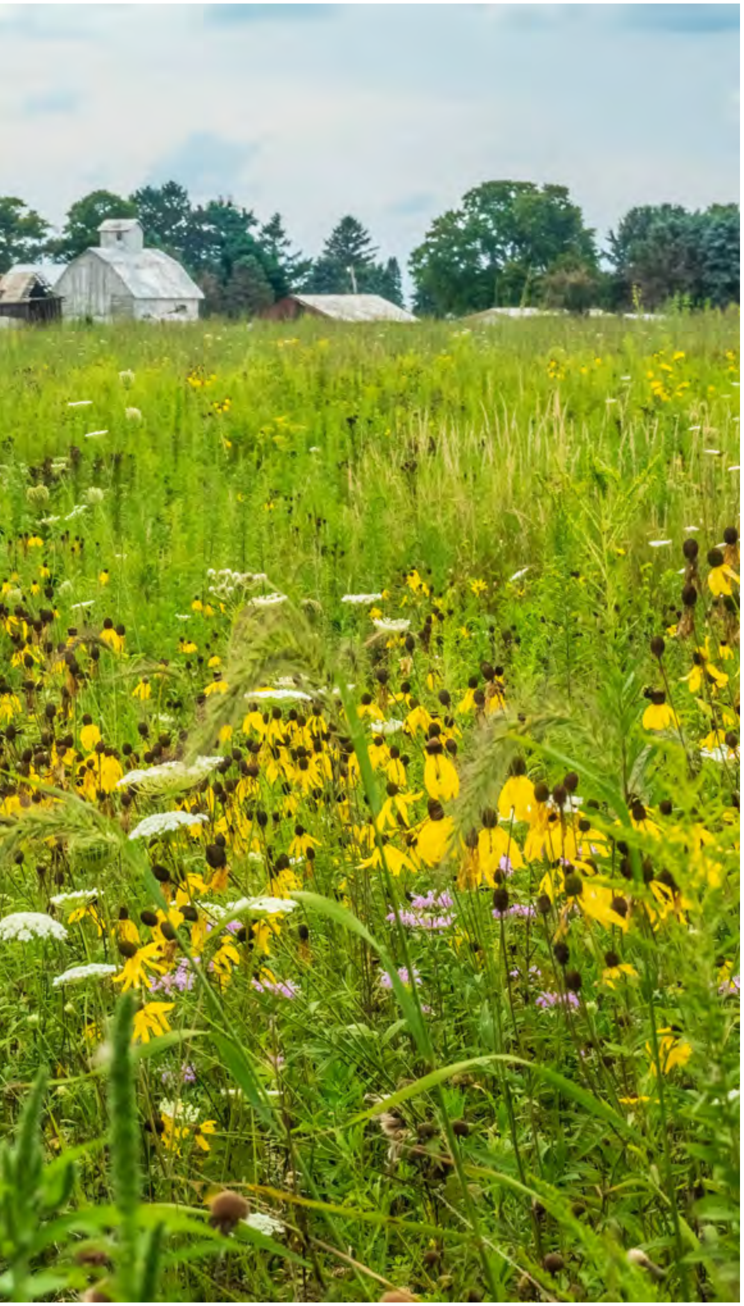
Annual Carbon Sequestration by Lawns and Grasses

86,125 Metric Tons



Annual Carbon Sequestration by Trees

70,086 Metric Tons



Pollution Absorption - Carbon

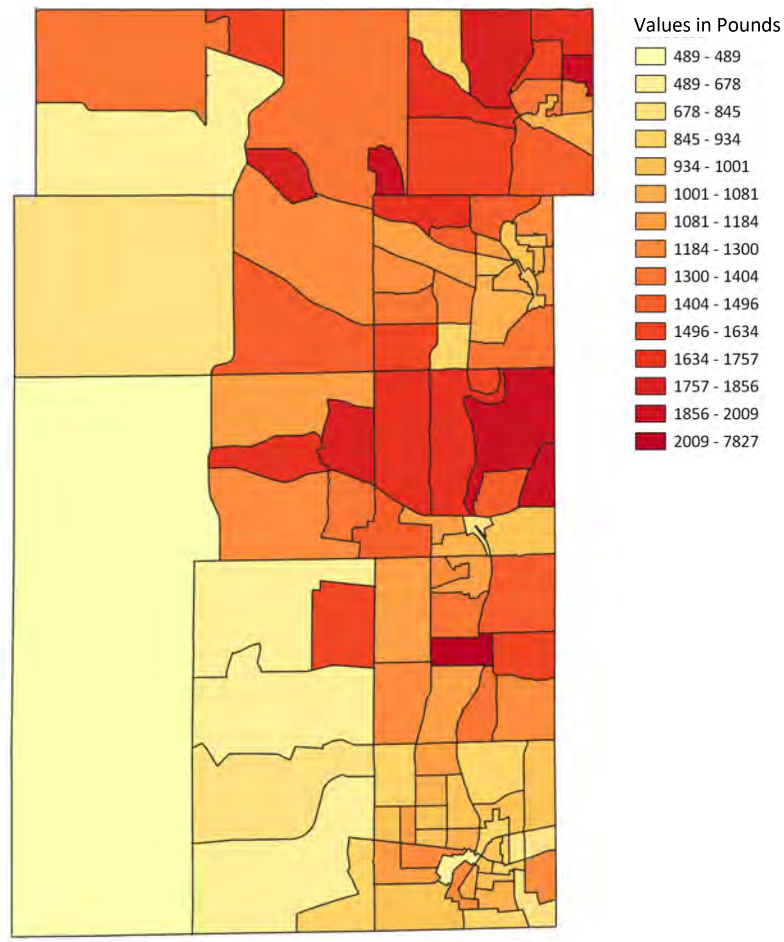
The combined carbon sequestration services of grasses and trees throughout the community can be seen as a measure of equity of green infrastructure when viewed on a per-acre basis. Higher per-acre carbon sequestration rates reflect combined higher rates of per-acre green infrastructure (trees and grasses). In addition, these per-acre values can help guide future tree canopy increase goals by focusing on portions of the community with lower per-acre baselines.

Annual Carbon Sequestration of Green Infrastructure Per Acre
(in pounds)

County Ave:
1,036

County High:
7,827 **Tract 8527**

County Low:
489 **Tract 8524.03**



Section 04

Tree Canopy Economic Value

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In recent years, several computer models have been developed by the USDA Forest Service and collaborators to assist cities in assessing the value and environmental benefits of their tree resources. Each of the benefits outlined in Section 3 of this report have economic benefit as well as environmental benefit.

Air Pollution Removal Values

The air pollutants estimated are the six criteria pollutants included in Section 3 of this report, defined by the U.S. Environmental Protection Agency (EPA); carbon monoxide (CO), nitrogen dioxide (NO2), ozone (O3), sulfur dioxide (SO2), and particulate matter (PM), which includes particulate matter less than 2.5 microns (PM2.5) and particulate matter greater than 2.5 and less than 10 microns (PM10).

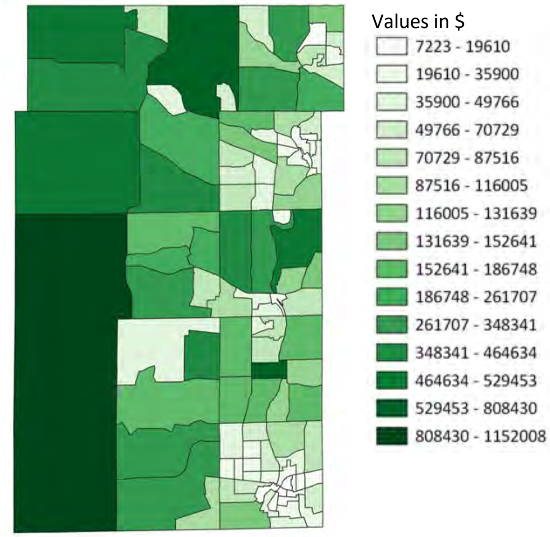
Air pollution removal value estimates are based on procedures detailed in Nowak et al. (2014). This process used local tree cover, leaf area index, percent evergreen, weather, pollution, and population data to estimate pollution removal (g/m2 tree cover) and values ($/m2 tree cover) in urban and rural areas. Current i-Tree Canopy Annual Tree Benefit Estimate values per ton of pollution removed are: CO at $1,333.50; NO2 at $477.89; O3 at $2,443.66; PM2.5 at $91,955.05; SO2 at $163.18; PM10 at $6,268.44, and CO2 sequestration at $35.38.

Building Energy Savings Values

As outlined in Section 3 of this report, building energy savings values can be estimated using average energy affecting tree counts per acre, by community density type, established through the study "Residential building energy conservation and avoided power plant emissions by urban and community trees in the United States." Using these averages, we can estimate the total electrical and natural gas savings contributed by the County's tree canopy using average local electrical and natural gas costs.

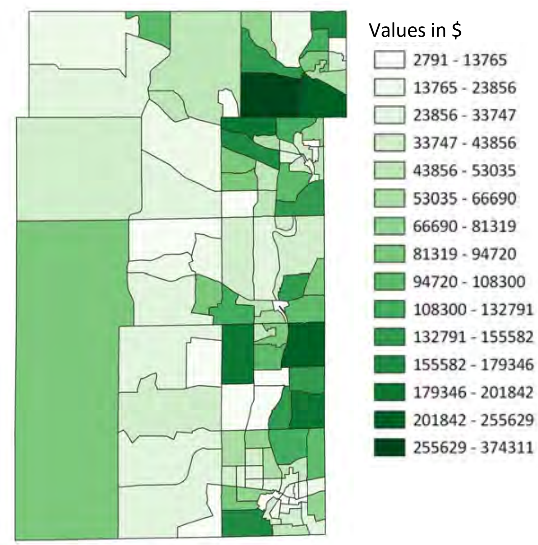
Annual Pollution Absorption Value of Trees

$14,517,113



Annual Energy Savings Value of Trees

$6,894,919



Tree Canopy Economic Value

Equity in Tree Value

The economic benefits outlined on the previous page can be viewed on the basis of value-per-acre and value-per-household to establish an understanding of tree benefit equity throughout the County.

Tree Canopy Benefit Per Acre

County Average:

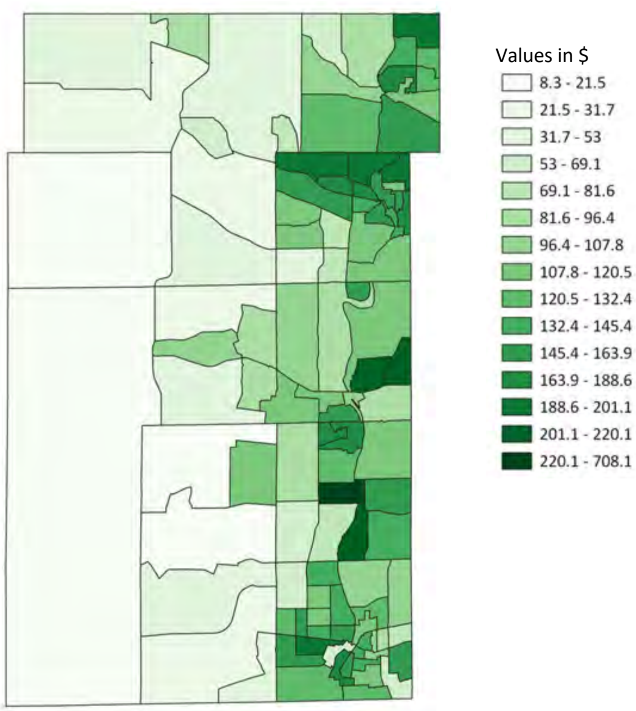
$64.42

County High:

$708.12 **Tract 8527**

County Low:

$8.33 **Tract 8545.07**



Tree Canopy Benefit Per Household

County Average:

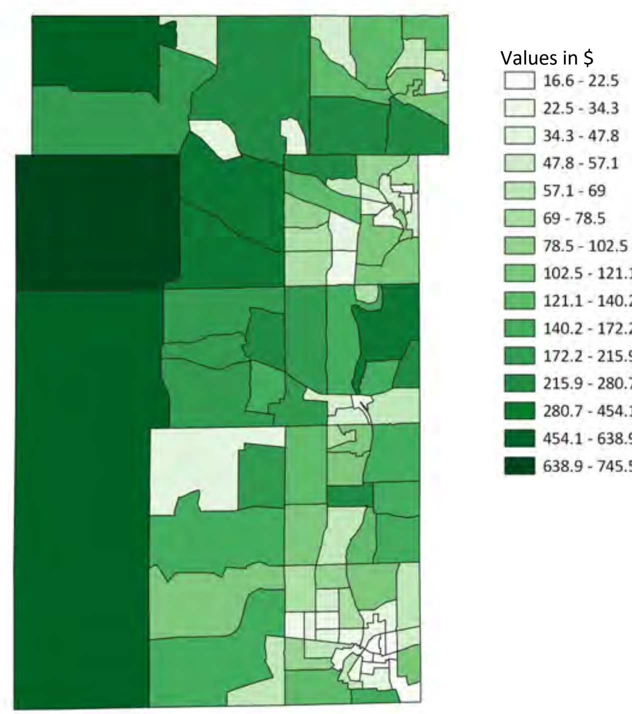
$117.75

County High:

$745.46 **Tract 8507.03**

County Low:

$16.56 **Tract 8536.02**

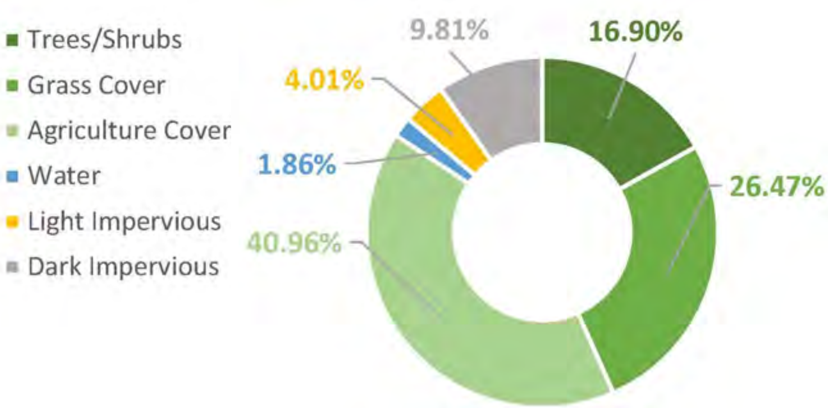


Section 05
Findings

The health of the County's green infrastructure and the impacts of impervious land cover affect everyone in the community and County policies and actions should consider needs of the entire community. As with all planning efforts landcover planning benefits from analysis in order to assist in establishing priorities for efforts. An effort to structure a prioritization should not be seen as an attempt to discard the need to address or improve land cover impacts for any neighborhood of the County - whether or not it is defined as one of the "priority" neighborhoods. Prioritization, however, is necessary to ensure the greatest impact and effectiveness of limited County resources.

To assist in prioritization, in the following pages, this report reviews the community Green Infrastructure and Impervious Surface data through "filters" in order to arrive at a recommended prioritization of neighborhoods for policy action. These "filters" are based on the land coverage information detailed in Section 2 of this report.

Ground Cover Breakdown by Type



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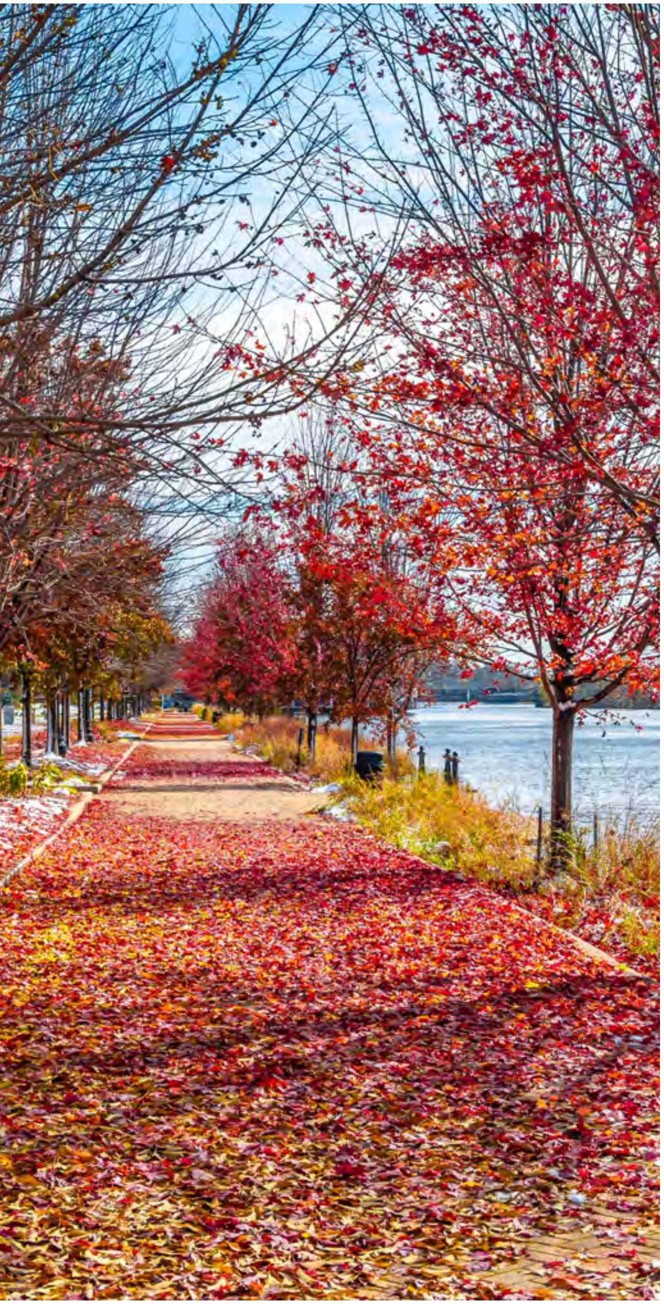


Ground Cover Characteristics by Census Tract

Organized by Share of Low Income Population (LMI)

The bar chart to the right provides a side-by-side comparison of the of land cover data detailed in Section 2, by Census Tract. This comparison organizes the census tracts from those with the highest share of low income households (LMI) at the top and those with the lowest share at the bottom.

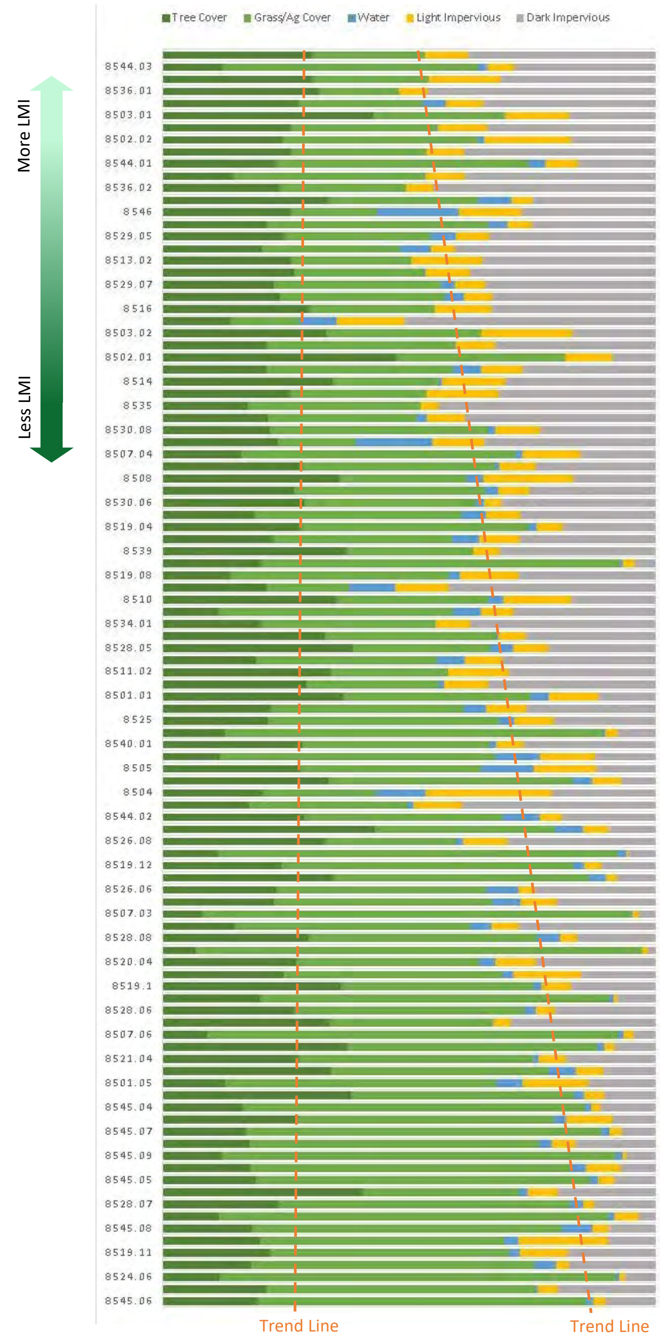
This chart indicates a trend for impervious surface coverage percentages to be higher for those communities with higher LMI populations and lower for those with lower LMI populations.

Meanwhile, there is not a clear county-wide relationship between tree canopy coverage and LMI populations. It should be noted, however, that trends may exist when census tracts within a given municipality are reviewed together.

The Importance of Ground Cover and Heat Island Mitigation

A study by the University of Wisconsin-Madison* found that the warming effect of impervious surfaces within developed areas was effectively countered by the cooling effect of trees, especially when tree canopy coverage was 40% or greater. The same study found that reducing overall coverage of impervious surfaces is critical for the reduction of night-time summer temperatures.

*"Scale-dependent interactions between tree canopy cover and impervious surfaces reduce daytime urban heat during summer," University of Wisconsin-Madison, 2019



Findings

Review Criteria - Green Infrastructure

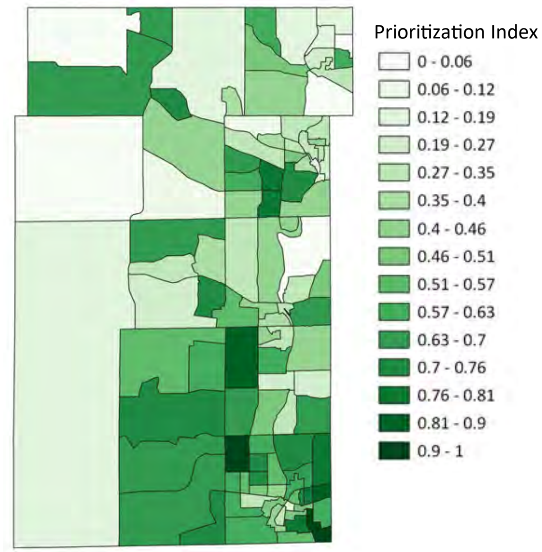
Prioritization of locations for increased green infrastructure included in this report is based on an equity approach. This approach reviews a range of land cover and demographic characteristics of each neighborhood in an "Environmental Equity Index". This process is based on procedures developed by the USDA Forest Service.

To determine the best locations to plant trees, tree canopy and impervious cover maps developed for this report's Section 2 were used in conjunction with U.S. Census data to produce an index of priority planting areas by neighborhood. Index values were produced for each neighborhood with higher index values relating to higher priority of the area for tree planting. This index is a type of "environmental equity" index with areas with higher human population density, higher economic stress, lower existing tree cover, and higher total tree canopy potential receiving the higher index value. The criteria used to make the index were:

- Tree Stock Potential
- Economic Stress Density
- Population Density
- Heat Island Mitigation Potential

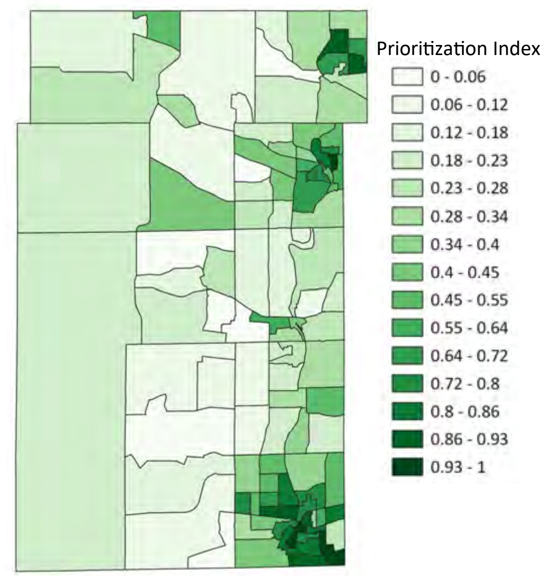
Prioritization based on
Potential for New Trees

Higher values represent increased potential for tree planting based on physical capacity (available open space, open lawn areas, etc)



Prioritization based on
Low Income Density (equity adjustment)

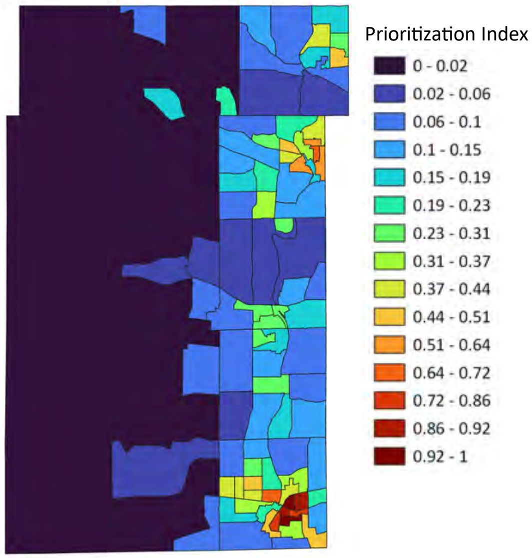
Higher low income density values represent higher potential for increasing environmental equity of tree canopy cover and benefits.



Findings

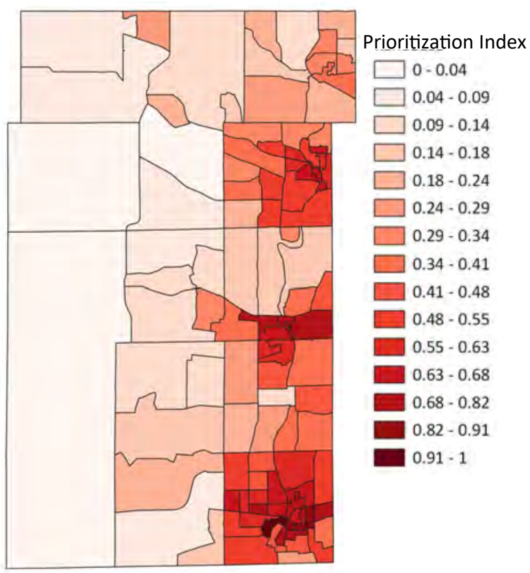
Prioritization based on Total Population Density

The greater the population density, the greater the opportunity for tree planting to impact community members. Population densities shown are estimates based on US Census data by tract. Higher numbers represent higher prioritization based on this category.



Prioritization based on Heat Island Reduction Need

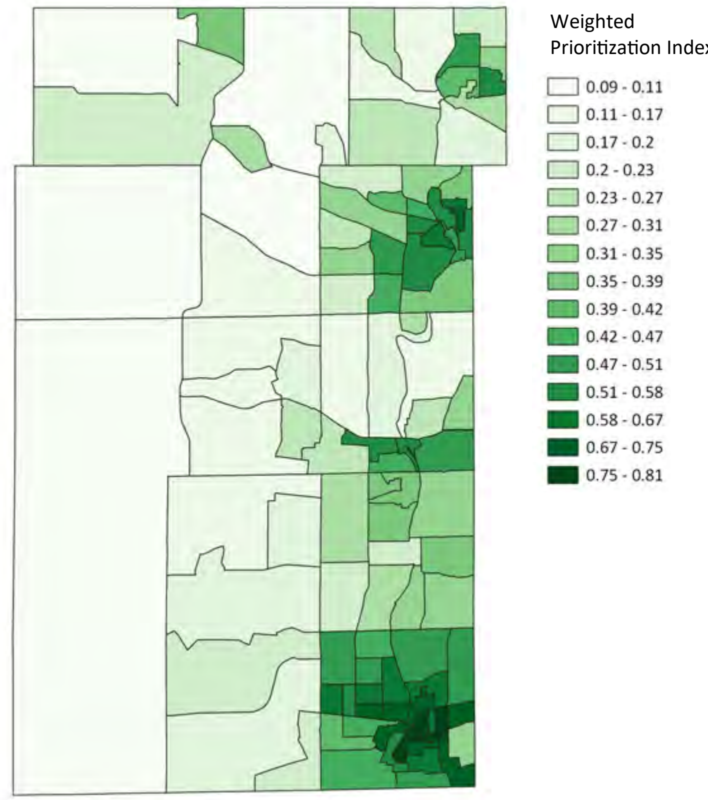
Higher heat island reduction need values represent increased potential for reducing current and future heat island impacts through tree planting.



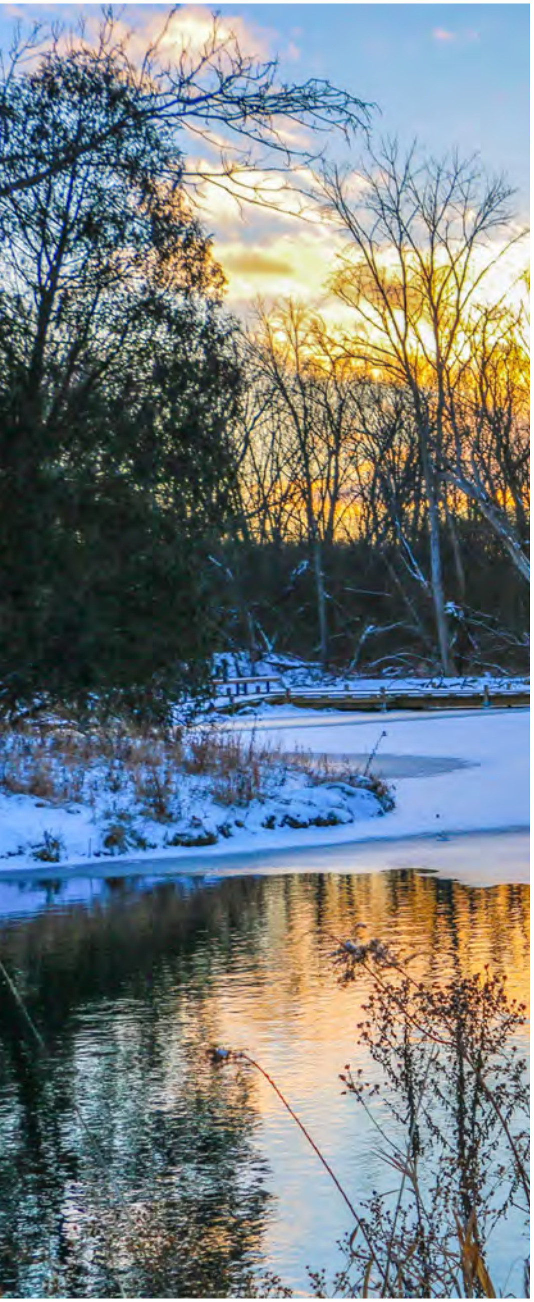
Weighted Priority Tree Canopy Increase

The weighted prioritization for tree canopy increase looks to balance the potential for increased tree canopy with the opportunity to improve tree canopy benefit equity, potential to positively impact as many households as possible, and the need for mitigation of heat island impacts. Higher numbers represent higher prioritization. The priorities above are weighted as follows:

Potential for new trees: 15%
Population density: 15%
Low Income Population (equity adjustment): 30%
Heat Island mitigation need: 40%



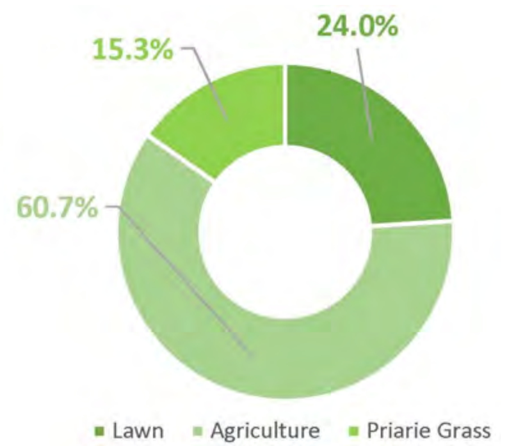
Findings



In addition to opportunities to expand and improve the County's tree canopy, the findings of the ground cover study as outlined in Section 2 may be used to identify additional opportunities for increased heat island mitigation and increased native grass installations.

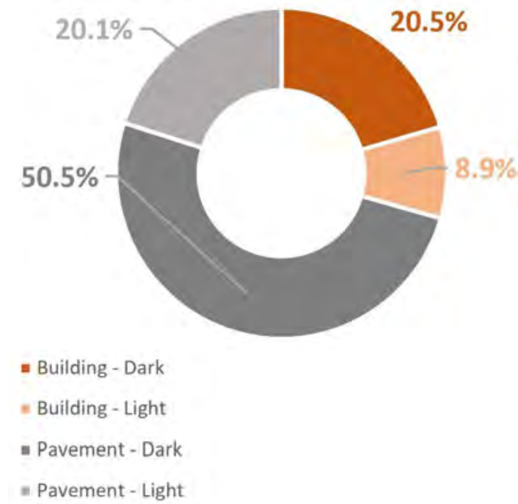
Turf Reduction Potential

As illustrated in the chart to the right, 60.7% of all grasslands in Kane County are agricultural and crop lands. An estimated 15.3% are native prairie and wildflower grasses. The remaining 24% are manicured lawns—representing a great opportunity for turf reduction. Turf reduction can increase stormwater uptake, reduce potable water use, and increase soil carbon.



Impervious Surface Characteristic

As outlined in Section 3, the County's experiences of heat island are directly impacted by the level of impervious surface coverage—particularly dark roofs and pavement. As the diagram to the right illustrates dark pavements make up 50.5% while dark roof structures make up 20.5% for a total of 71% of all impervious surfaces. These represent significant opportunities for decreasing heat island impacts in the community through "cool" and "green" roof and pavement strategies.



Findings

Invasive Tree Species

Invasive species are non-native which can cause environmental or economic harm. Invasive species have the potential to become successfully established, and can often aggressively expand into existing ecosystems. According to the USDA Forest Service, an estimated 5,000 nonnative plant species have been introduced and established and now exist in U.S. ecosystems. Throughout the United States, invasive species pose one of the greatest threats to natural areas and resources.

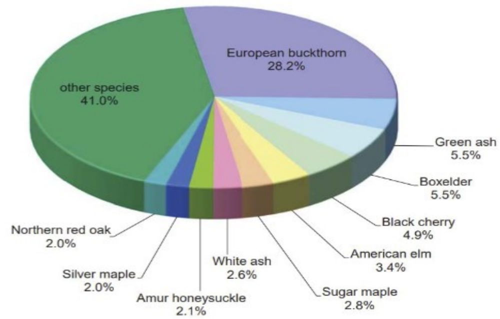
The negative impacts of invasive plants on natural ecosystems may include a reduction in biodiversity, changes in species composition which can disrupt the balance of life supported within an ecosystem, and loss of habitat for native plant, insect, and animal species. Because of these stressors invasive species place on natural ecosystems, they make both the built landscape, and the natural systems less resilient to the effects of climate change. According to the North American Invasive Species Management Association, climate change can accelerate and exacerbate many of the most severe impacts of invasive species.

In Kane County, the Chicago Region Trees Initiative estimates as much as 36% of the tree canopy to be invasive species. Research supported by the USGS Climate Adaptation Science Centers finds that managing and eradicating invasive species at the local scale can more effectively prepare an ecosystem for long-term climate resilience.*

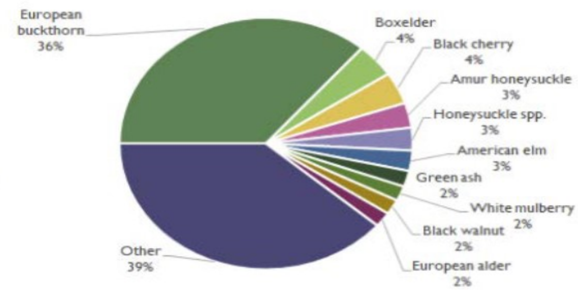
*Source: https://www.pnas.org/doi/10.1073/pnas.2117389119

Change Analysis**

Urban Forestry: Species Diversity



2010



2020

Invasive Species**

30% 2010 42% 2020

2010		2020	
Buckthorn	28	Buckthorn	36
Box Elder	5	Box Elder	4
Black Cherry	5	Black Cherry	4
American Elm	3	Amur Honeysuckle	3
Sugar Maple	3	Honeysuckle	3
White Ash	3	American Elm	3
Amur Honeysuckle	2	Green Ash	2
Silver Maple	2	White Mulberry	2
Northern Red Oak	2	Black Walnut	2
Other	41	Other	39

Key Point:

Eradicate Buckthorn and Honeysuckle

Replace with desirable species

Healthy Hedges
Healthy Homes
Healthy Habitats

**Source: Chicago Regional Tree Initiative presentation to Kane County Energy and Environmental Commission, June 11, 2021

Section 06

Calculating Potential Goals

Click here to return to TOC

Calculating Tree Canopy Coverage Goal for 2040

Total tree canopy coverage goals are central to long-range land cover goal recommendations for the County. In support of an "Environmental Equity" approach to tree canopy goalsetting, as outlined in the Findings Section of this report, identification of long-term tree canopy coverage goals includes consideration of each neighborhood's Tree Stock value (the amount of existing tree canopy compared to available land for tree canopy coverage), population densities, economic stress densities, and heat island mitigation need.

The recommended goals for 2040 Tree Canopy coverage are based on individual neighborhood calculations, corresponding to the neighborhood prioritizations outlined in the Findings Section of this report. 2040 Tree Canopy goals are first calculated as Tree Stock goals, that is, goals calculated against the total potential Tree Stock area (existing tree canopy area + existing lawn/grass/shrub area), with a progressive percentage increase goal based on neighborhood prioritization. As the total Tree Stock area (potential tree canopy) varies by neighborhood, the resulting Tree Canopy percentage varies for each neighborhood.

The recommended Tree Stock increase goals are:

For neighborhoods in the top 1/3rd Neighborhood Priority Ranking: **20%**

For neighborhoods in middle 1/3rd Neighborhood Priority Ranking: **11.5%**

For neighborhoods in bottom 1/3rd Neighborhood Priority Ranking: **3%**

Tree Canopy Increase Over Existing Tree Canopy Area

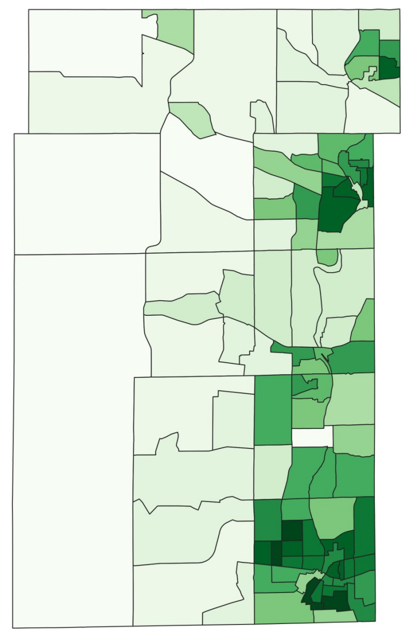
Values in %

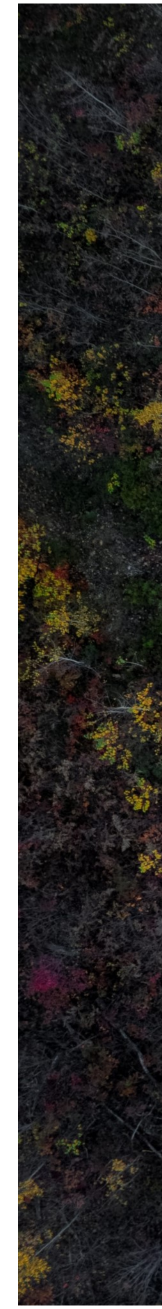
- 3.3 - 4.1
- 4.1 - 5.5
- 5.5 - 7.2
- 7.2 - 11
- 11 - 12.6
- 12.6 - 15.1
- 15.1 - 18
- 18 - 21.2
- 21.2 - 24.1
- 24.1 - 26.6
- 26.6 - 29.6
- 29.6 - 34.4
- 34.4 - 37.2
- 37.2 - 48.2
- 48.2 - 53.9

Tree Canopy Increase in Absolute Land Cover %

Values in %

- 0.3 - 0.5
- 0.5 - 0.9
- 0.9 - 1.3
- 1.3 - 1.8
- 1.8 - 2.6
- 2.6 - 3
- 3 - 3.6
- 3.6 - 4
- 4 - 4.4
- 4.4 - 4.7
- 4.7 - 5.2
- 5.2 - 6.1
- 6.1 - 6.5
- 6.5 - 7.1
- 7.1 - 7.9





Calculating Potential Goals

New Tree Plantings Needed to Achieve Tree Canopy Coverage Goal for 2040

While it is easy to think of the long range Tree Canopy coverage goals for each neighborhood in terms of planting trees, it is critical that tree canopy enhancement goals include a combination of tree protection, tree maintenance, and tree planting in order to be fully realized and efficiently implemented.

A common calculation used to determine the new tree planting requirements in order to meet the long-range tree canopy coverage goals, while recognizing the impacts of tree canopy growth and mortality was established by a 2002 Report to North East State Forester Association by Luley and Bond. That report offers the following conceptual analysis for increasing UTC:

$$CB + CG - CM + CN = CT$$

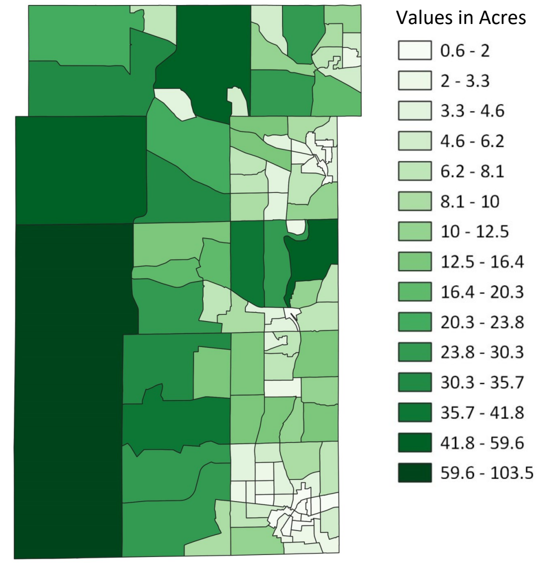
Where:
CB= the existing Tree Canopy;
CG= the growth of existing Tree Canopy (protection and maintenance);
CM= Tree Canopy mortality or loss due to natural and human-induced causes (including removal of invasive species).
CN= Tree Canopy increase from new trees (planting); and
CT= total Tree Canopy Result (or goal)

The maps on the following pages illustrate these calculations for the county.

Calculating Potential Goals

Translating Tree Canopy Coverage Goal To New Tree Planting - Growth Rates (CG)

Consideration of tree canopy growth rate is important in anticipating long-range tree canopy goals and annual new planting needs. According to a 2014 USDA report, the average growth rate for non-managed forests is 2% while the average growth rate for managed forests is 2.5% annually.

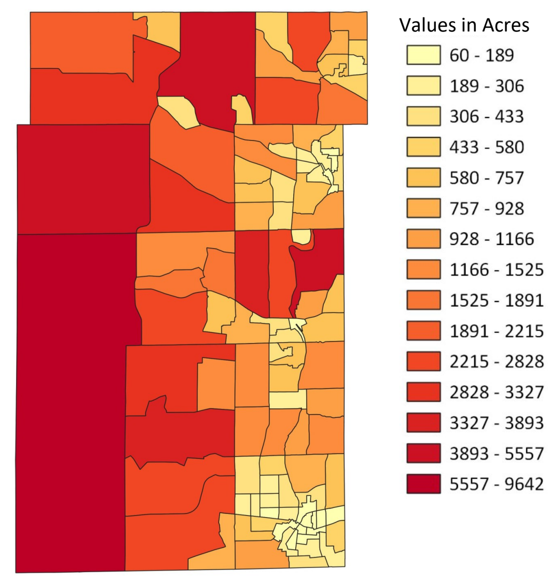


Translating Tree Canopy Coverage Goal To New Tree Planting - Mortality Rates (CM)

As with growth rate, consideration of tree canopy mortality is necessary for long-range Tree Canopy planning. According to the 2014 USDA report, the average mortality rate for non-managed forests is 1.86% while the average mortality rate for managed forests is 1.5% annual. There are few studies exploring mortality rates for trees in urban and suburban settings, those studies that exist indicate a range from 2.7% for general suburban trees and 3.5% to 14% for street trees.* As many trees in the County exist in forest type setting on publicly owned land and much of the balance are general suburban trees observed regularly and likely seen as having value, we recommend using a mortality rate of 1.8%.

Ash Tree Mortality and Invasive Species Removal

Ash trees are projected to be significantly impacted by the infestation of the Emerald Ash Borer insect. Long-term tree canopy planning for the County should anticipate substantial (complete for all non-treated trees) Ash tree mortality within the next 10-15 years. In Kane County, the Chicago Region Trees Initiative estimates 2% of the tree canopy to be Ash trees.



In addition to undesired tree mortality, removal of invasive species may be a required management tactic. Invasive species are non-native which can cause environmental or economic harm. Throughout the United States, invasive species pose one of the greatest threats to natural areas and resources. Invasive species make both the built landscape, and the natural systems we all depend on, less resilient to the effects of climate change. According to the North American Invasive Species Management Association, climate change can accelerate and exacerbate many of the most severe impacts of invasive species. In Kane County, the Chicago Region Trees Initiative estimates as much as 36% of the tree canopy to be invasive species.

With this Ash tree mortality adjustment and an allowance for some invasive species removal, we are using a total tree mortality (TM) of 2.1% annually.

*How Many Trees Are Enough? Tree Death and the Urban Canopy https://scenariojournal.com/article/how-many-trees-are-enough/

Calculating Potential Goals

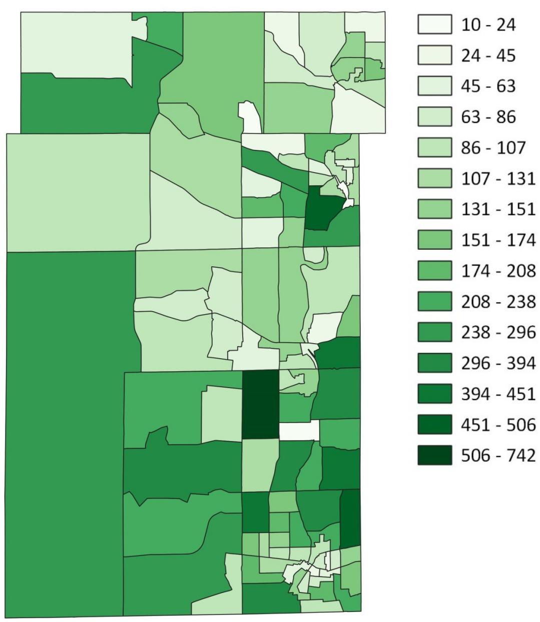
Translating Tree Canopy Coverage Goal To New Tree Planting - New Tree Planting Annual Target (CN)

Using the new planting requirement calculation method (CB + CG - CM + CN = CT) with the previously defined values for existing tree canopy (CB), growth rates (CG), mortality rates (CM), and the 2040 Tree Canopy (CT) goals by neighborhood the required number of new trees to be planted to meet that goal can be identified. The map below shows the annual new tree count required to meet the 2040 tree canopy goals for each neighborhood.

New Tree Planting Annual Target to Meet 2040 Tree Canopy Goal (CN)

Community-Wide Total (Note, Acreage represents the canopy coverage at year of planting, with an assumed new tree crown radius of 5’ planted no more than 22’ apart):

27,100 New Trees **350** Acres



Annual Path to 2040 Tree Canopy Cover Goal

The chart below shows the community wide average values for year beginning canopy cover (CB), annual growth rate (CG), mortality rate (CM), the new tree planting targets (CN) and the year end tree canopy goal (CT) for each year through the 2040 goal.

	CB (existing)		CG (growth)		CM (loss)		CN (new)		CT (year goal)	UTC (year end coverage %)
2024	56171	+	1236	-	-1152	+	374	=	56629	17.0%
2025	56629	+	1246	-	-1161	+	373	=	57087	17.2%
2026	57087	+	1256	-	-1170	+	373	=	57546	17.3%
2027	57546	+	1266	-	-1180	+	372	=	58004	17.5%
2028	58004	+	1276	-	-1189	+	371	=	58462	17.6%
2029	58462	+	1286	-	-1198	+	371	=	58920	17.7%
2030	58920	+	1296	-	-1208	+	370	=	59378	17.9%
2031	59378	+	1306	-	-1217	+	369	=	59837	18.0%
2032	59837	+	1316	-	-1227	+	368	=	60295	18.1%
2033	60295	+	1326	-	-1236	+	368	=	60753	18.3%
2034	60753	+	1337	-	-1245	+	367	=	61211	18.4%
2035	61211	+	1347	-	-1255	+	366	=	61669	18.6%
2036	61669	+	1357	-	-1264	+	366	=	62128	18.7%
2037	62128	+	1367	-	-1274	+	365	=	62586	18.8%
2038	62586	+	1377	-	-1283	+	364	=	63044	19.0%
2039	63044	+	1387	-	-1292	+	364	=	63502	19.1%
2040	63502	+	1397	-	-1302	+	363	=	63960	19.2%

Section

07 Recommendations

Click here to return to TOC

Conclusions

Even with a strong existing green infrastructure, the County has the potential for more. As this report outlines, tree canopy cover in the County provides a number of benefits including pollution absorption, energy consumption savings, carbon sequestration, micro heat island mitigation, and economic benefit. Consequently, increases in green infrastructure offer significant reward potential for the County.

Primary Strategic Goal Recommendations

Section 6 of this report provided a range of recommended goals for the Kane County. The overarching goals recommended in this report are:

1) To increase the tree canopy coverage throughout the County, particularly in neighborhoods with increased vulnerable population shares (see the County's Climate Vulnerability Assessment for more information), an average of at least 1.6% of total County-wide land area by 2040 (equal to an increase of 8.9% over total existing tree canopy coverage).

1) Decrease the quantity of "dark" impervious surfaces throughout the County, particularly in neighborhoods identified with higher heat island contributions in Section 3, by an average of at least 5% of total County-wide coverage by 2040.

1) Increase pollinator supportiveness of lawns and grasslands in Kane County and achieve a 5% turf replacement with native grasses and wildflowers by 2030.

Section A1

i-Tree Technical Notes

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i-Tree Canopy Technical Notes

This tool is designed to allow users to easily and accurately estimate tree and other cover classes (e.g., grass, building, roads, etc.) within their city or any area they like. This tool randomly lays points (number determined by the user) onto Google Earth imagery and the user then classifies what cover class each point falls upon. The user can define any cover classes that they like and the program will show estimation results throughout the interpretation process. Point data and results can be exported for use in other programs if desired.

There are three steps to this analysis:

1) Import a file that delimits the boundary of your area of analysis (e.g., city boundary). Some standard boundary files for the US can be located on the US Census website. Data from these sites will require some minor processing in GIS software to select and export a specific boundary area polygon.
2) Name the cover classes you want to classify (e.g., tree, grass, building). Tree and Non-Tree are the default classes given, but can be easily changed.
3) Start classifying each point: points will be located randomly within your boundary file. For each point, the user selects from a dropdown list the class from step 2 that the point falls upon.

The more points that are interpreted, the more accurate the estimate.

Credits

The concept and prototype of this program were developed by David J. Nowak, Jeffrey T. Walton and Eric J. Greenfield (USDA Forest Service). The current version of this program was developed and adapted to i-Tree by David Ellingsworth, Mike Binkley, and Scott Maco (The Davey Tree Expert Company).

Limitations

The accuracy of the analysis depends upon the ability of the user to correctly classify each point into its correct class. Thus the classes that are chosen for analysis must be able to be interpreted from an aerial image. As the number of points increase, the precision of the estimate will increase as the standard error of the estimate will decrease. If too few points are classified, the standard error will be too high to have any real certainty of the estimate. Information on calculating standard errors can be found below. Another limitation of this process is that the Google imagery may be difficult to interpret in all areas due to relatively poor image resolution (e.g., image pixel size), environmental factors, or poor image quality.

Calculating Standard Error and Confidence Intervals from Photo-Interpreted Estimates of Tree Cover
In photo-interpretation, randomly selected points are laid over aerial imagery and an interpreter classifies each point into a cover class (e.g., tree, building, water).

From this classification of points, a statistical estimate of the amount or percent cover in each cover class can be calculated along with an estimate of uncertainty of the estimate (standard error (SE)). To illustrate how this is done, let us assume 1,000 points have been interpreted and classified within a city as either “tree” or “non-tree” as a means to ascertain the tree cover within that city, and 330 points were classified as “tree”.

To calculate the percent tree cover and SE, let:

N = total number of sampled points (i.e, 1,000)
n = total number of points classified as tree (i.e., 330), and
p = n/N (i.e., 330/1,000 = 0.33)
q = 1 – p (i.e., 1 - 0.33 = 0.67)
SE = √ (pq/N) (i.e., √ (0.33 x 0.67 / 1,000) = 0.0149)

Thus in this example, tree cover in the city is estimated at 33% with a SE of 1.5%. Based on the SE formula, SE is greatest when p=0.5 and least when p is very small or very large (Table 1).

Table 1. Estimate of SE (N = 1000) with varying p.

p	SE
0.01	0.0031
0.1	0.0095
0.3	0.0145
0.5	0.0158
0.7	0.0145
0.9	0.0095
0.99	0.0031

Confidence Interval
In the case above, a 95% confidence interval can be calculated. “Under simple random sampling, a 95% confidence interval procedure has the interpretation that for 95% of the possible samples of size *n*, the interval covers the true value of the population mean” (Thompson 2002). The 95% confidence interval for the above example is between 30.1% and 35.9%. To calculate a 95% confidence interval (if N>=30) the SE x 1.96 (i.e., 0.0149 x 1.96 = 0.029) is added to and subtracted from the estimate (i.e., 0.33) to obtain the confidence interval.

SE if n < 10

If the number of points classified in a category (n) is less than 10, a different SE formula (Poisson) should be used as the normal approximation cannot be relied upon with a small sample size (<10) (Hodges and Lehmann, 1964). In this case:

$SE = (\sqrt{n}) / N$

For example, if n = 5 and N = 1000, p = n/N (i.e., 5/1,000 = 0.005) and SE = $\sqrt{5}$ / 1000 = 0.0022. Thus the tree cover estimate would be 0.5% with a SE of 0.22%.

References

Lindgren, BW and GW McElrath. 1969. Introduction to Probability and Statistics. Macmillan Co. London
Hodges, JL and EL Lehmann. 1964. Basic Concepts of Probability and Statistics. Holden-Day, Inc. San Francisco.
Thompson, S. K. 2002. Sampling, second edition. John Wiley and Sons, Inc., New York, New York.

Section A2

Climate Adaptive Tree Species

(Northern Institute of Applied Climate Science)

Click here to return to TOC

CLIMATE CHANGE VULNERABILITY OF URBAN TREES
CHICAGO, ILLINOIS

This list was developed to aid Chicago, Illinois community forestry practitioners in selecting trees to reduce climate change vulnerability of their urban forests. It is meant to be a complement to other tree selection resources. Other factors may also need to be considered, such as aesthetics, local site conditions, wildlife value, or nursery availability. It is also important to note that some species may have climate benefits but may not be suitable for planting for other reasons, such as having invasive potential or susceptibility to pests or pathogens.

Vulnerability: Trees can be vulnerable to a variety of climate-related stressors such as intense heat, drought, flooding, and changing pest and disease patterns. Climate vulnerability is a function of the impacts of climate change on a species and its adaptive capacity. Species with negative impacts on habitat suitability and low adaptive capacity will have high vulnerability and vice versa. The following factors were used to determine climate vulnerability:

Urban adaptability: Adaptability scores were generated for each species based on literature describing its tolerance to disturbances such as drought, flooding, pests, and disease, as well as its growth requirements such as shade tolerance, soil needs, and ease of nursery propagation. Scores were assigned to species using methods developed in an urban forest vulnerability assessment for Chicago for trees planted in developed sites. A positive score indicates that a species is tolerant to a wide range of disturbances and can be planted on a variety of sites. A negative score indicates a species is highly susceptible to disturbances and/or is limited to specific planting sites.

Hardiness and heat zone suitability: Tree species ranges were recorded from government, university, and arboretum websites. Species tolerance ranges were compared to current and projected heat and hardiness zones for Chicago, Illinois using downscaled climate models under low emissions (RCP 4.5) and high emissions (RCP 8.5) scenarios for changes in greenhouse gases. Trees were considered to have suitable zone suitability if the species' tolerance was within the range of current and projected hardiness and heat zone through the end of the 21st century.

NOTE: This list was primarily created for species planted in developed sites, such as streets, yards, boulevards, and parks. If you are interested in projected changes in habitat suitability for native species in natural areas, see the Climate Change Tree Atlas at www.fs.fed.us/nrs/atlas/.

Current and projected USDA Hardiness Zones and AHS Heat Zones for Chicago, Illinois. Hardiness zone is determined by the average lowest temperature over a 30 year period. Heat zones are determined by the number of days above 86°F.

Time Period	Hardiness Zone Range		Heat Zone Range	
1980–2010	5 to 6		5	
	Low Emissions	High Emissions	Low Emissions	High Emissions
2010–2039	6	6 to 7	6	6
2040–2069	6 to 7	7	7	8
2070–2099	6 to 7	7 to 8	7	9

SOURCE: *Adaptability scores were assigned using methods developed in an urban forest vulnerability assessment for Chicago by Brandt et al. 2017 (https://www.fs.fed.us/nrs/pubs/gtr/gtr_nrs168.pdf). Future heat and hardiness zone information were provided from: https://usfs.maps.arcgis.com/apps/MapSeries/index.html?appid=96088b1c086a4b39b3a75d0fd97a4c40.*

NIACS
Northern Institute of Applied Climate Science

URBAN ADAPTABILITY:

- + ***High:*** *Species may perform better than modeled*
- · ***Medium***
- – ***Low:*** *Species may perform worse than modeled*

ZONE SUITABILITY:

- ✓ ***Suitable***
- ✗ ***Not Suitable***

VULNERABILITY:

- ▼ ***Low:*** *Suitable zone, high adaptability*
- ● ***Low-moderate:*** *Suitable zone, medium adaptability*
- ⊖ ***Moderate:*** *Suitable zone, low adaptability or zone not suitable, high adaptability*
- ○ ***Moderate- high:*** *Zone not suitable, medium adaptability*
- △ ***High:*** *Zone not suitable, low adaptability*

**Invasive species*

COMMON NAME	ADAPT	LOW EMISSIONS ZONE SUIT	LOW EMISSIONS VULN	HIGH EMISSIONS ZONE SUIT	HIGH EMISSIONS VULN
Accolade Elm	+	✓	▼	✗	⊖
Accolade flowering cherry	·	✓	●	✗	○
Allegheny serviceberry	+	✓	▼	✓	▼
American beech	·	✓	●	✓	●
American elm	·	✓	●	✓	●
American linden, Basswood	·	✓	●	✗	○
American plum	·	✓	●	✗	○
American sycamore	·	✓	●	✓	●
Amur corktree*	·	✓	●	✗	○
Amur honeysuckle*	+	✓	▼	✓	▼
Amur maackia	+	✓	▼	✗	⊖
Amur maple*	·	✓	●	✗	○
Apple serviceberry	·	✓	●	✗	○
Austrian pine	·	✓	●	✗	○
Autumn olive*	·	✓	●	✗	○
Bald cypress	+	✓	▼	✓	▼
Balsam fir	·	✓	●	✗	○
Bitternut hickory	·	✓	●	✓	●
Black cherry	–	✓	⊖	✓	⊖
Black hills spruce	·	✓	●	✗	○
Black locust	·	✓	●	✓	●
Black maple	·	✓	●	✗	○
Black oak	–	✓	⊖	✗	△

COMMON NAME	ADAPT	LOW EMISSIONS ZONE SUIT	LOW EMISSIONS VULN	HIGH EMISSIONS ZONE SUIT	HIGH EMISSIONS VULN
Common persimmon	+	✓	▼	✓	▼
Cornelian cherry dogwood	·	✓	●	✗	○
Crabapple	·	✓	●	✗	○
Crimean linden	+	✓	▼	✗	⊖
Cucumber tree	·	✓	●	✗	○
Dawn redwood	·	✓	●	✓	●
Douglas-fir	–	✓	⊖	✗	△
Downy serviceberry	+	✓	▼	✓	▼
Eastern cottonwood	–	✓	⊖	✓	⊖
Eastern hemlock	–	✓	⊖	✗	△
Eastern redbud	·	✓	●	✓	●
Eastern redcedar	+	✓	▼	✓	▼
Eastern white pine	–	✓	⊖	✗	△
European alder*	·	✓	●	✗	○
European beech	·	✓	●	✗	○
European filbert	·	✓	●	✗	○
European hornbeam	+	✓	▼	✗	⊖
European larch	·	✓	●	✗	○
European mountain ash	·	✓	●	✗	○
Flowering dogwood	·	✓	●	✓	●
Freeman maple	+	✓	▼	✗	⊖
Gingko	+	✓	▼	✓	▼
Glossy buckthorn*	+	✓	▼	✗	⊖

Black tupelo, Black gum	+	✓	▼	✓	▼
Black walnut	–	✓	⊖	✓	⊖
Black willow	–	✓	⊖	✓	⊖
Blackhaw	+	✓	▼	✓	▼
Blue spruce	•	✓	●	✗	○
Boxelder	•	✓	●	✗	○
Bur oak	+	✓	▼	✓	▼
Burningbush*	+	✓	▼	✓	▼
Callery pear*	•	✓	●	✗	○
Cherry plum	•	✓	●	✓	●
Chestnut oak	+	✓	▼	✓	▼
Chinese chestnut	•	✓	●	✗	○
Chinese fringetree	+	✓	▼	✓	▼
Chinese juniper	+	✓	▼	✓	▼
Chinkapin oak	+	✓	▼	✗	⊖
Cockspur hawthorn	•	✓	●	✗	○
Common chokecherry	•	✓	●	✗	○
Common elderberry	•	✓	●	✗	○
Common hackberry	+	✓	▼	✓	▼
Common horsechestnut	•	✓	●	✗	○
Common lilac	•	✓	●	✗	○
Common pear	–	✓	⊖	✓	⊖

Gray alder	•	✓	●	✗	○
Gray birch	–	✓	⊖	✗	△
Gray dogwood	•	✓	●	✗	○
Green ash	•	✓	●	✓	●
Hedge maple	•	✓	●	✗	○
Heritage oak	+	✓	▼	✗	⊖
Higan cherry	•	✓	●	✗	○
Honeylocust*	•	✓	●	✓	●
Ironwood	+	✓	▼	✓	▼
Jack pine	–	✓	⊖	✗	△
Japanese maple	•	✓	●	✗	○
Japanese pagoda tree	+	✓	▼	✓	▼
Japanese red pine	–	✓	⊖	✗	△
Japanese tree lilac	+	✓	▼	✗	⊖
Japanese zelkova	+	✓	▼	✓	▼
Katsura tree	–	✓	⊖	✗	△
Kentucky coffeetree	+	✓	▼	✓	▼
Korean mountain ash	•	✓	●	✓	●
Kousa dogwood	+	✓	▼	✗	⊖
Leatherleaf viburnum	+	✓	▼	✗	⊖
Littleleaf linden	+	✓	▼	✗	⊖
London planetree	•	✓	●	✓	●

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**Invasive species*

		LOW EMISSIONS		HIGH EMISSIONS	
COMMON NAME	ADAPT	ZONE SUIT	VULN	ZONE SUIT	VULN
Miyabe maple	+	✓	▼	✗	⊖
Mockernut hickory	·	✓	●	✓	●
Musclewood	+	✓	▼	✓	▼
Nannyberry	+	✓	▼	✗	⊖
Northern catalpa	·	✓	●	✗	○
Northern pin oak	–	✓	⊖	✗	△
Northern red oak	·	✓	●	✓	●
Northern white cedar, Arborvitae	+	✓	▼	✗	⊖
Norway maple*	+	✓	▼	✗	⊖
Norway spruce	·	✓	●	✗	○
Ohio buckeye	·	✓	●	✗	○
Oriental spruce	·	✓	●	✓	●
Osage-orange	·	✓	●	✓	●
Pagoda dogwood	·	✓	●	✗	○
Paper birch	·	✓	●	✗	○
Peach	·	✓	●	✓	●
Pecan	–	✓	⊖	✓	⊖
Peking lilac	+	✓	▼	✗	⊖
Pignut hickory	·	✓	●	✗	○
Pin oak	·	✓	●	✗	○
Prickly ash	–	✓	⊖	✗	△
Privet*	·	✓	●	✗	○
Pussy willow	–	✓	⊖	✗	△
Quaking aspen	·	✓	●	✗	○

		LOW EMISSIONS		HIGH EMISSIONS	
COMMON NAME	ADAPT	ZONE SUIT	VULN	ZONE SUIT	VULN
Slippery elm	·	✓	●	✓	●
Smoketree	+	✓	▼	✓	▼
Smoothleaf elm	–	✓	⊖	✓	⊖
Snow goose cherry	+	✓	▼	✗	⊖
Staghorn sumac	·	✓	●	✗	○
Star magnolia	·	✓	●	✓	●
Sugar maple	·	✓	●	✗	○
Sugarberry	·	✓	●	✓	●
Swamp white oak	+	✓	▼	✗	⊖
Sweetgum	–	✓	⊖	✓	⊖
Sycamore maple*	·	✓	●	✗	○
Tree of heaven*	+	✓	▼	✗	⊖
Tuliptree	–	✓	⊖	✓	⊖
Turkish hazelnut	+	✓	▼	✗	⊖
Washington hawthorn	·	✓	●	✗	○
Weeping willow	·	✓	●	✓	●
White ash	–	✓	⊖	✓	⊖
White fir	·	✓	●	✗	○
White fringetree	+	✓	▼	✓	▼
White mulberry*	·	✓	●	✗	○
White oak	–	✓	⊖	✗	△
White poplar	·	✓	●	✓	●
White spruce	·	✓	●	✗	○
Willow oak	+	✓	▼	✓	▼

Quaking aspen	•	✔	●	✕	○
Red maple	•	✔	●	✔	●
Red mulberry	•	✔	●	✔	●
Red pine	–	✔	⊖	✕	△
River birch	•	✔	●	✔	●
Robusta poplar	•	✕	○	✕	○
Rose of Sharon	+	✔	▼	✔	▼
Russian olive*	+	✔	▼	✕	⊖
Sargent cherry	•	✔	●	✔	●
Sassafras	•	✔	●	✔	●
Saucer magnolia	+	✔	▼	✔	▼
Scarlet oak	•	✔	●	✔	●
Scots pine	•	✔	●	✕	○
Serbian spruce	•	✔	●	✕	○
Shagbark hickory	–	✔	⊖	✕	△
Shantung maple	+	✔	▼	✕	⊖
Shellbark hickory	–	✔	⊖	✕	△
Shingle oak	+	✔	▼	✕	⊖
Shumard oak	•	✔	●	✔	●
Siberian elm*	•	✔	●	✔	●
Silver linden	•	✔	●	✔	●
Silver maple	•	✔	●	✕	○
Willow oak	+	✔	▼	✔	▼
Winter king green hawthorn	•	✔	●	✕	○
Witchhazel	•	✔	●	✕	○
Yellow buckeye	•	✔	●	✕	○
Yellowwood	+	✔	▼	✔	▼

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