LA CROSSE WISCONSIN

Ground Cover, Heat Island and Carbon Sequestration Study

February 2022
Revised 2/11/22

Prepared by:

making change personal
paleBLUEdot LLC

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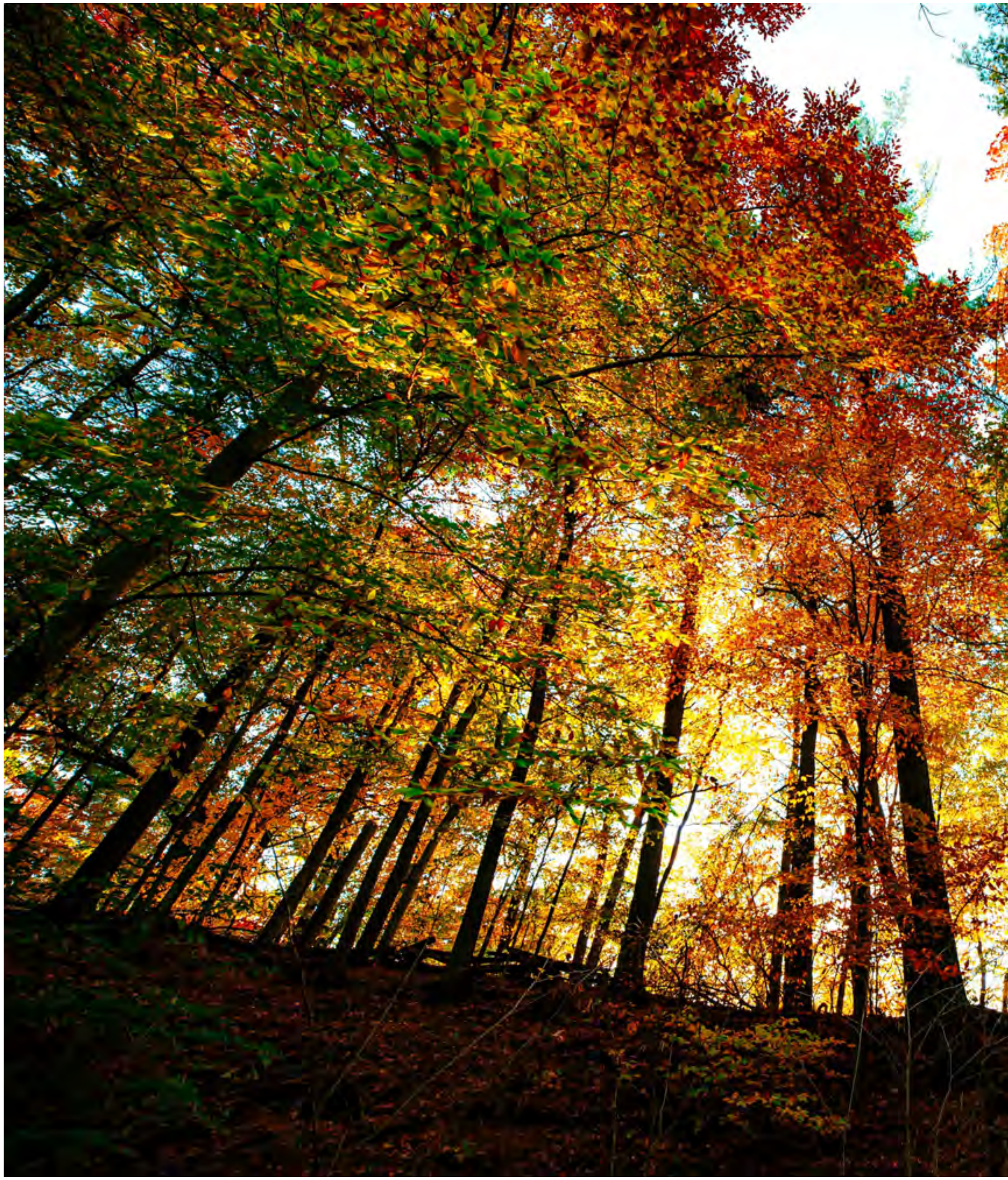
The care of the Earth is our most ancient and most worthy, and after all, our most pleasing responsibility.

Wendell Berry, American Novelist



Introduction

The intent of this study is to support the City of La Crosse in understanding the extent of Citywide 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 City. The findings of this report are to support establishment of goals, strategies, and actions for the City's Climate Action Plan. As a visionary planning document, the goals established for the City should be a "stretch" while also being achievable.

Why Study the City 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.

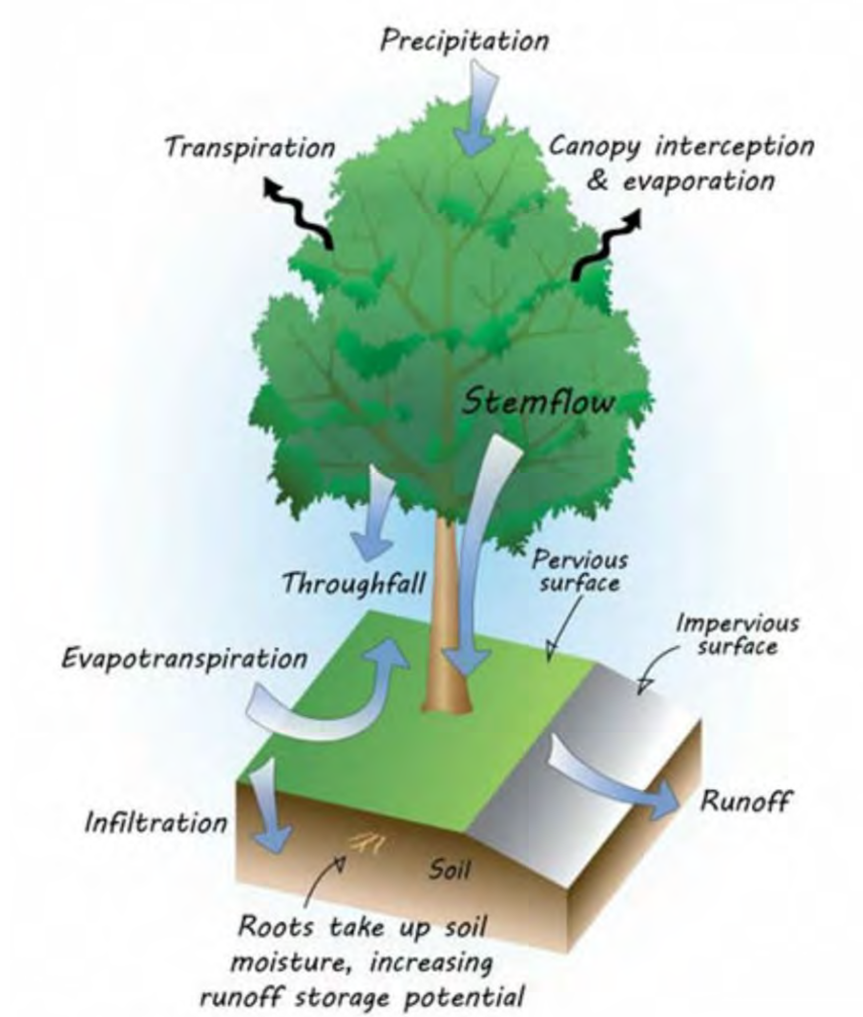
Community Health Benefit of Trees

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

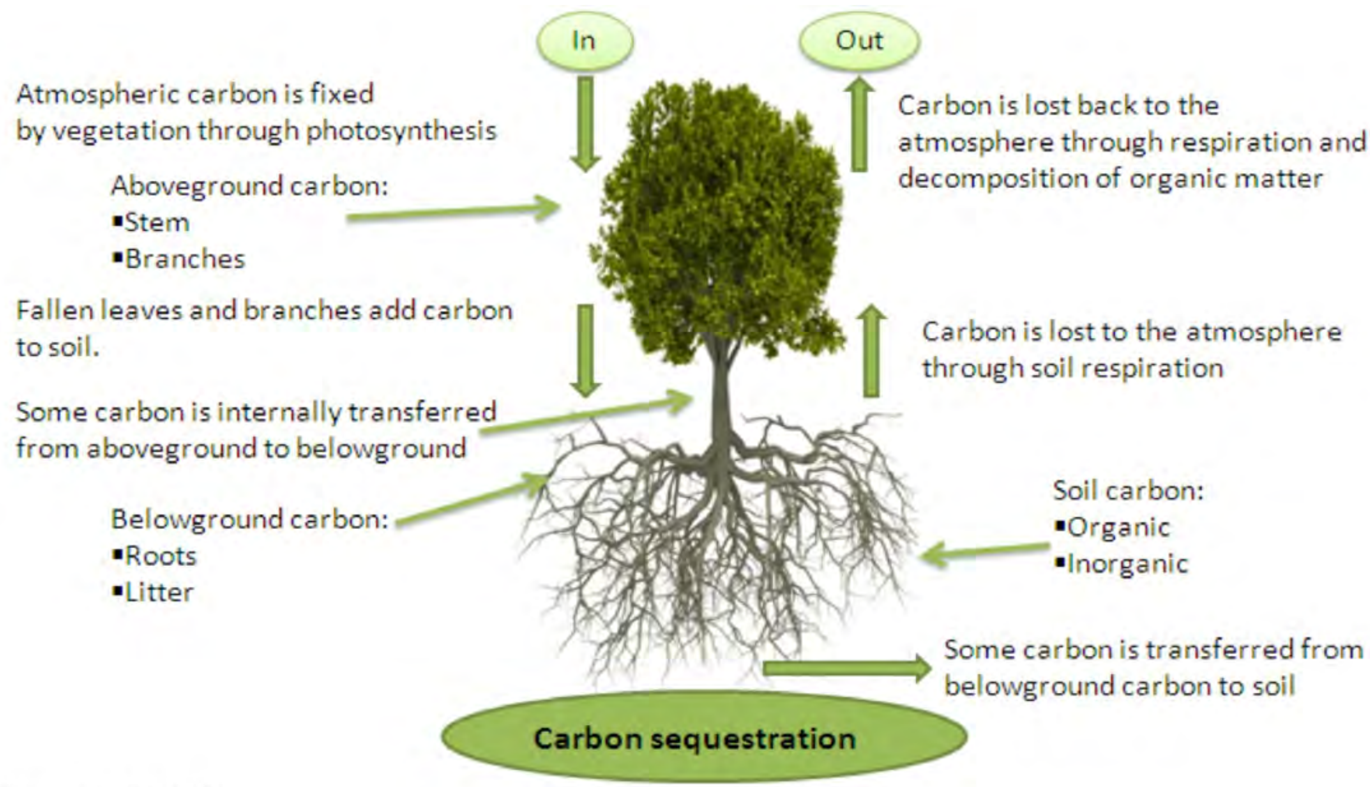
Introduction

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 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)



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

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.

Introduction

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

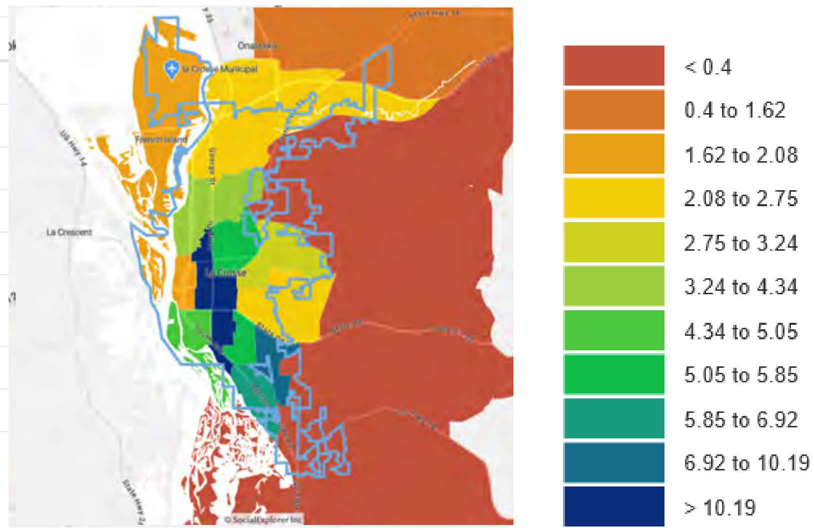
i-Tree Canopy was used to interpret aerial images across the community using 8,149 random points. This overall picture was built up by analyzing the 14 census tracts (see map below) that make up the City of La Crosse. The point samples averaged 580 plots to each neighborhood until a satisfactory standard 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/Gardens, 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 City'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
Dark Impervious Buildings	Dark building roof surfaces
Dark Impervious Pavement	Dark road, parking, sidewalk, trail, and pavement surfaces
Lawn	Maintained lawns
Light Impervious Buildings	Light building roof surfaces
Light Impervious Pavement	Light road, parking, sidewalk, trail, and pavement surfaces
Prairie Grass/Wildflower/Gardens	Non-manicured grasses and wildflowers, flower and vegetable gardens, green/"living" roofs
Tree/Shrub	Trees and shrubs
Water	Open water

Population Density of La Crosse Per Acre by Census Tract



Section 02

Land Coverage Characteristics

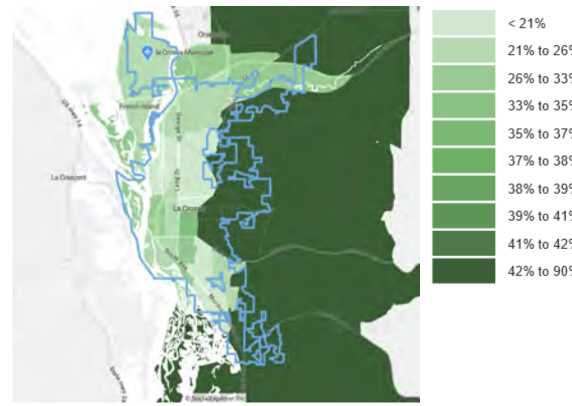
Classification of coverage categories included Tree Canopy, Grass/Shrub/Crop, Water, Impervious Surface Light, and Impervious Surface Dark.

Tree Canopy Coverage

City Average: **30.0%**
(excluding tracts 104.1, 105, 106, 107)

Census Tract High: **68.7%**
Tract: 6

Census Tract Low: **12.2%**
Tract: 11.01

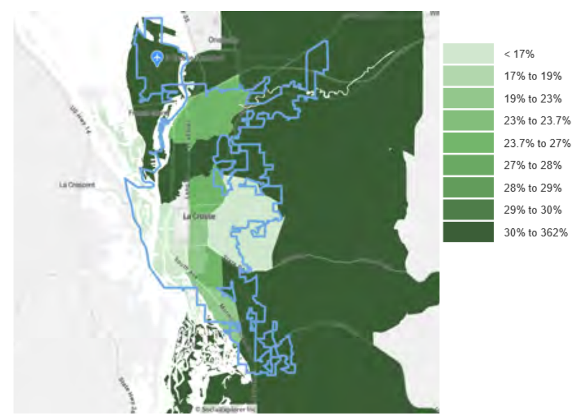


Lawns and Grass Coverage

City Average: **27.2%**
(excluding tracts 104.1, 105, 106, 107)

Census Tract High: **45.0%**
Tract: 103

Census Tract Low: **10.6%**
Tract: 3



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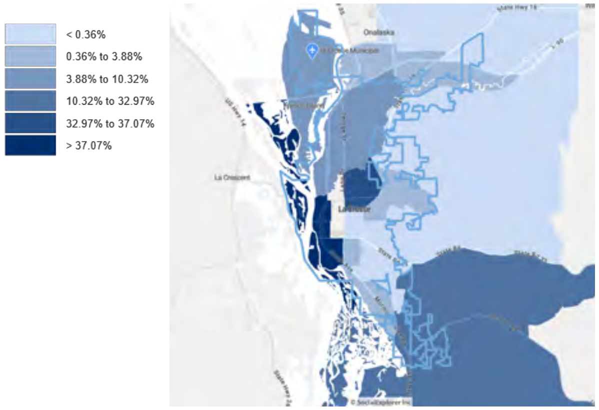
Land Coverage Characteristics

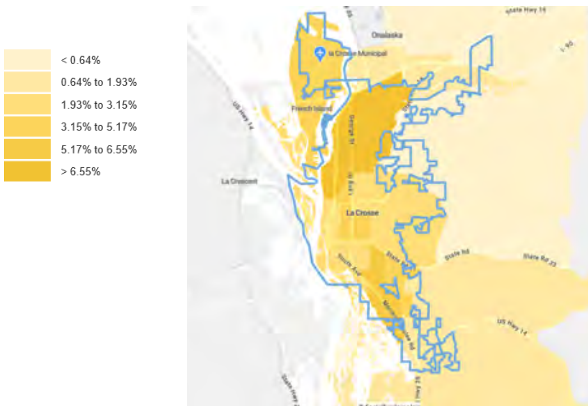


Open Water Coverage

City Average: **11.2%**
(excluding tracts 104.1, 105, 106, 107)

Census Tract High: **47.8%**
Tract: 3

Census Tract Low: **0%**
Tracts: 7,8, 11.01

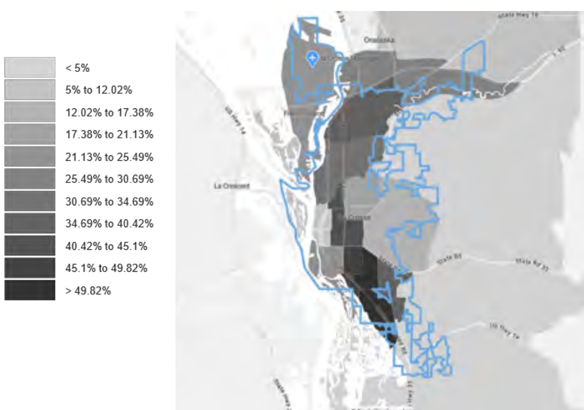


Light Impervious Surface Coverage (buildings+pavement)

City Average: **5.0%**
(excluding tracts 104.1, 105, 106, 107)

Census Tract High: **12.7%**
Tract: 1

Census Tract Low: **1.9%**
Tract: 7



Dark Impervious Surface Coverage (buildings+pavement)

City Average: **26.6%**
(excluding tracts 104.1, 105, 106, 107)

Census Tract High: **58.8%**
Tract: 240.04

Census Tract Low: **10%**
Tract: 3

Section 03

Land Cover Impacts and Benefits

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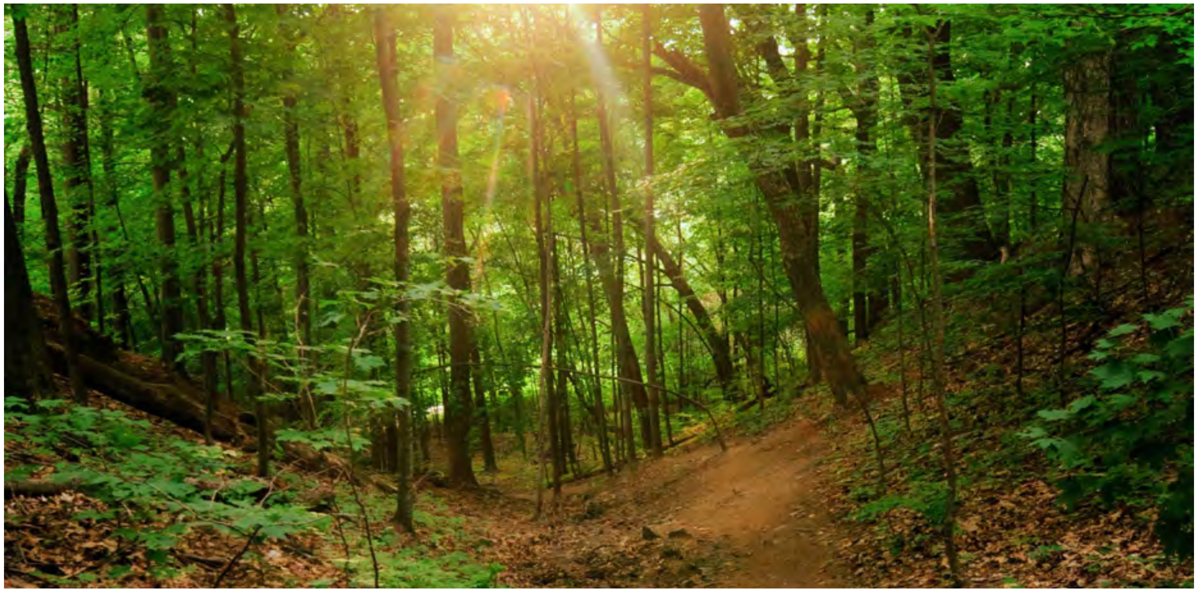
The condition and health of a community's Tree Canopy and green infrastructure and the magnitude and nature of impervious surfaces have meaningful consequences on the area's environment. Estimating the baseline land cover contributions to the community's environment enables the City to project the impact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

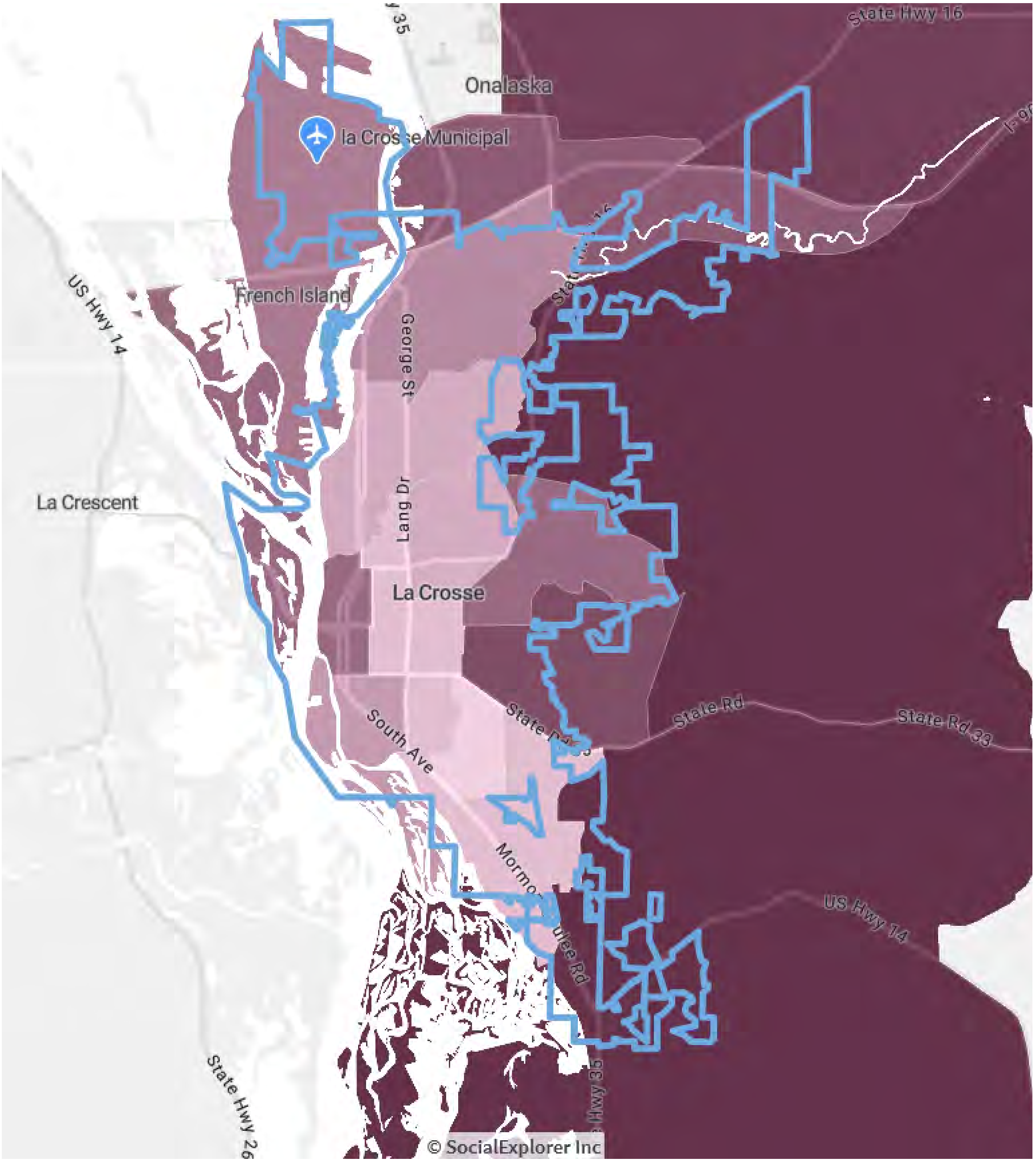
Pollution Absorption by Trees

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 Wisconsin 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 City's Tree Canopy

The values shown in the legends below are mapped by census tract on the following page.

Carbon Monoxide

30,250 lbs

- < 107
- 107 to 181
- 181 to 354
- 354 to 450
- 450 to 747
- 747 to 853
- 853 to 931
- 931 to 1,229
- 1,229 to 7,080
- 7,080 to 7,500
- > 7,500

Nitrogen Dioxide

165,357 lbs

- < 589
- 589 to 1,001
- 1,001 to 1,953
- 1,953 to 2,486
- 2,486 to 4,126
- 4,126 to 4,712
- 4,712 to 5,141
- 5,141 to 6,792
- 6,792 to 38,540
- 38,540 to 40,920
- > 40,920

Ozone

1,578,980 lbs

- < 4,551
- 4,551 to 7,736
- 7,736 to 15,086
- 15,086 to 19,205
- 19,205 to 31,870
- 31,870 to 36,400
- 36,400 to 39,710
- 39,710 to 52,465
- 52,465 to 388,100
- 388,100 to 412,000
- > 412,000

Sulfur Dioxide

99,999 lbs

- < 290
- 290 to 492
- 492 to 960
- 960 to 1,222
- 1,222 to 2,028
- 2,028 to 2,316
- 2,316 to 2,527
- 2,527 to 3,339
- 3,339 to 24,560
- 24,560 to 26,060
- > 26,060

Fine Particulate (PM2.5)

77,317 lbs

- < 232
- 232 to 395
- 395 to 771
- 771 to 981
- 981 to 1,628
- 1,628 to 1,860
- 1,860 to 2,029
- 2,029 to 2,680
- 2,680 to 18,820
- 18,820 to 19,980
- > 19,980

Course Particulate (PM10)

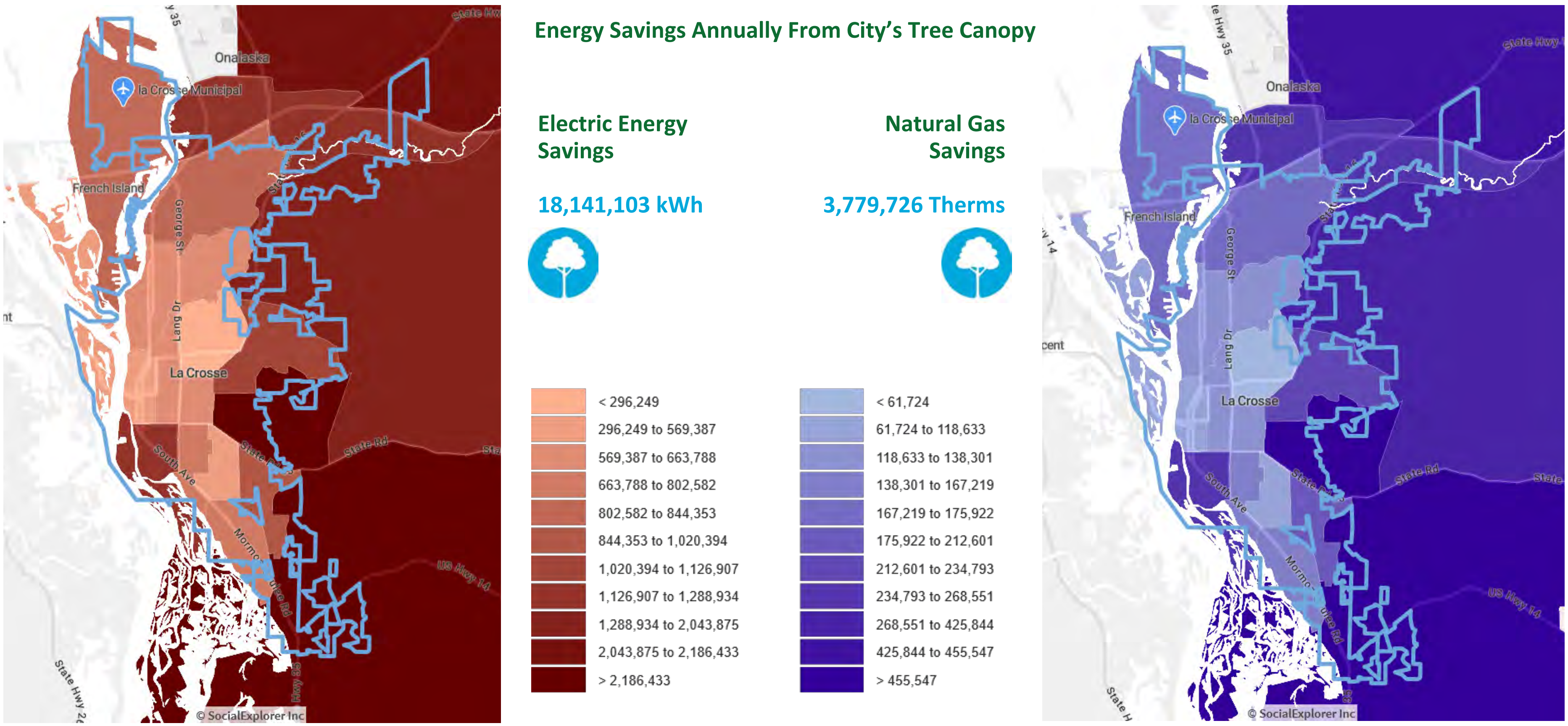
516,902 lbs

- < 1,292
- 1,292 to 2,196
- 2,196 to 4,282
- 4,282 to 5,451
- 5,451 to 9,045
- 9,045 to 11,271
- 11,271 to 14,891
- 14,891 to 130,760
- 130,760 to 138,800
- > 138,800

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 La Crosse's tree canopy. (Note; based on regional averages, it is assumed 25% of electricity consumption is for air conditioning and 80% of natural gas use is for heating buildings.)



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, La Crosse may have an annual average of 50 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 City of La Crosse.

Based on a 2006 study done by Minnesota State University and the University of Minnesota*, the relationship between impervious surface percentage of a City 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 Census Tracts represents the increase in summer temperatures a City would experience if the entire region had impervious land characteristics identical to that Census Tract. 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

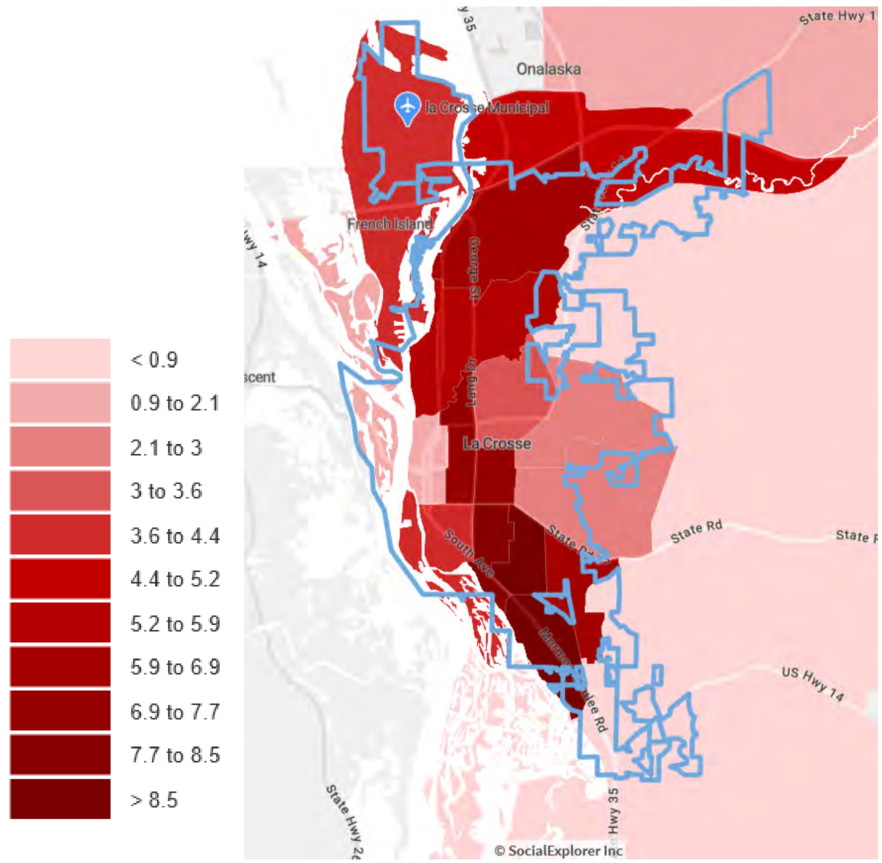
Heat Island Contribution of La Crosse Impervious Surfaces

(summer values)

City Average: **4.5°F**
(excluding tracts 104.1, 105, 106, 107)

Census Tract High: **10.1°F**
Tract: 11.01

Census Tract Low: **1.7°F**
Tract: 3



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.

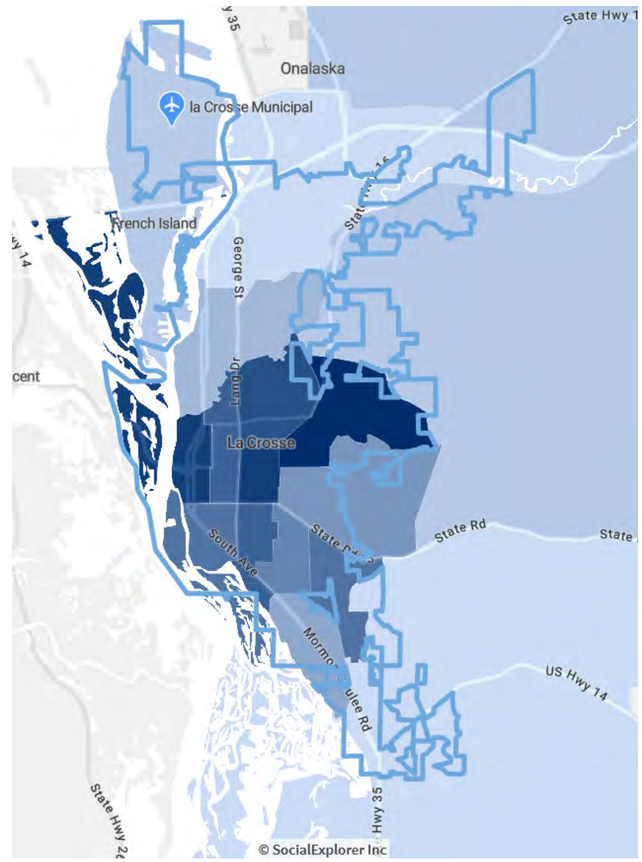
According to data from National Climatic Data Center and NOAA, the city receives 30.6” of precipitation annually. That total precipitation level and the impervious surface coverages can then be used to estimate the total stormwater runoff values by neighborhood as indicated below.

Land Cover Impacts and Benefits

Stormwater Runoff per Acre Generated La Crosse’s Impervious Surfaces Annually

City Average: **329,497** Gallons / Acre
(excluding tracts 104.1, 105, 106, 107)

- > 680,000
- 612,000 To 680,000
- 545,000 to 612,000
- 478,000 to 545,000
- 410,000 to 478,000
- 343,000 to 410,000
- 275,000 to 343,000
- 207,000 to 275,000
- 140,000 to 207,000
- 72,000 to 140,000
- <72,000

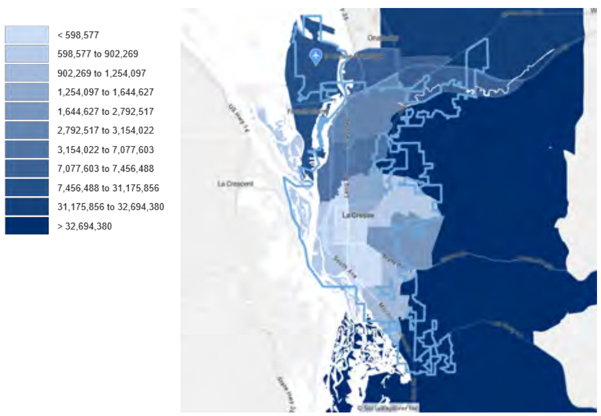


Stormwater Runoff and Management by Green Infrastructure

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.

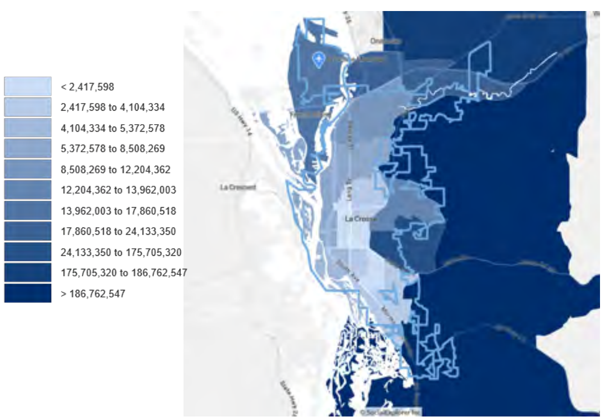
To estimate the total stormwater uptake, in gallons, by neighborhood, we have used calculations developed by stormwater sustainability specialist Aarin Teague and US Forestry Service forester Eric Kuehler. Detailed values can only be calculated using detailed soil hydrology data and accurate runoff curve 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

22.4 Million Gallons
(excluding tracts 104.1, 105, 106, 107)



Total Stormwater Uptake by Trees

93.3 Million Gallons
(excluding tracts 104.1, 105, 106, 107)

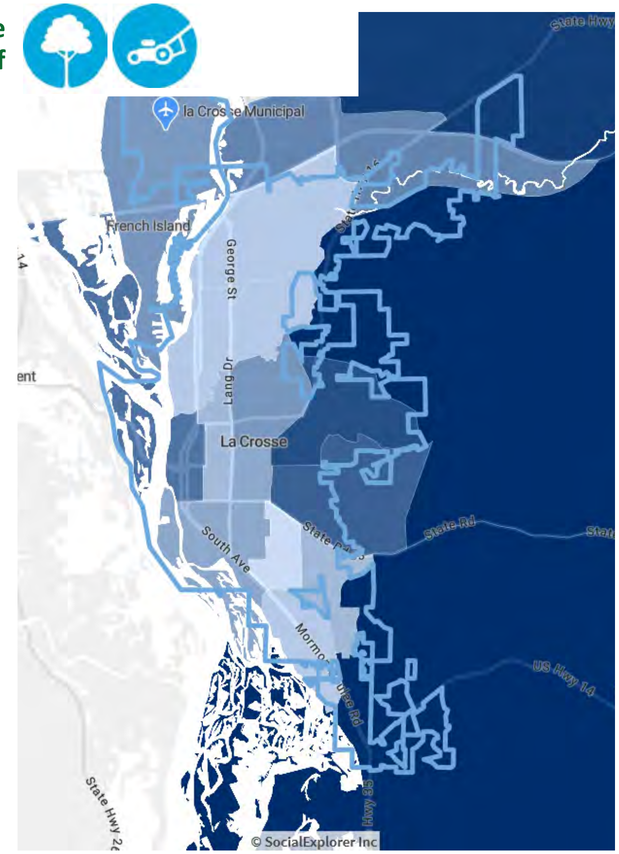
Estimated Percentage of Stormwater Runoff Uptake by Green Infrastructure

City Average:
2.5%
(excluding tracts 104.1, 105, 106, 107)

Census Tract High:
10.7% **Tract: 6**

Census Tract Low:
0.6% **Tract: 11.01**

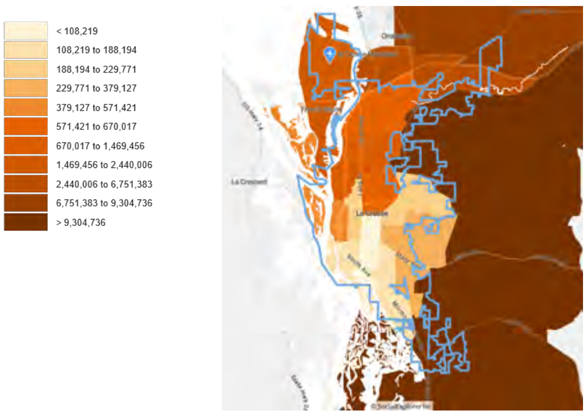
- < 0.9%
- 0.9% - 3.8%
- 3.8% - 6.7%
- 6.7% - 9.6%
- 9.6% - 12.5%
- 12.5% - 15.4%
- 15.4% - 18.3%
- 18.3% - 21.2%
- 21.2% - 24.1%
- 24.1% - 27%
- >27%



Land Cover Impacts and Benefits

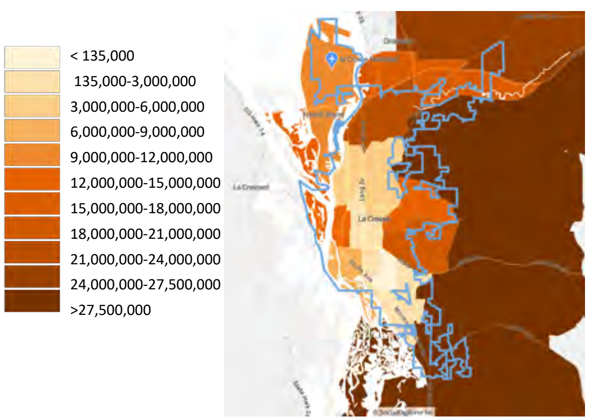
Pollution Absorption - Carbon

By volume, Carbon Dioxide pollution is the largest man-made emission contributing to Global Warming. Throughout the City of La Crosse, 4 billion cubic feet of CO2 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 CO2 sequestered produces 1 pound of carbon stored. The following diagrams are the annual carbon sequestration levels by neighborhood provided by the City's tree canopy and by its lawns and grasses.



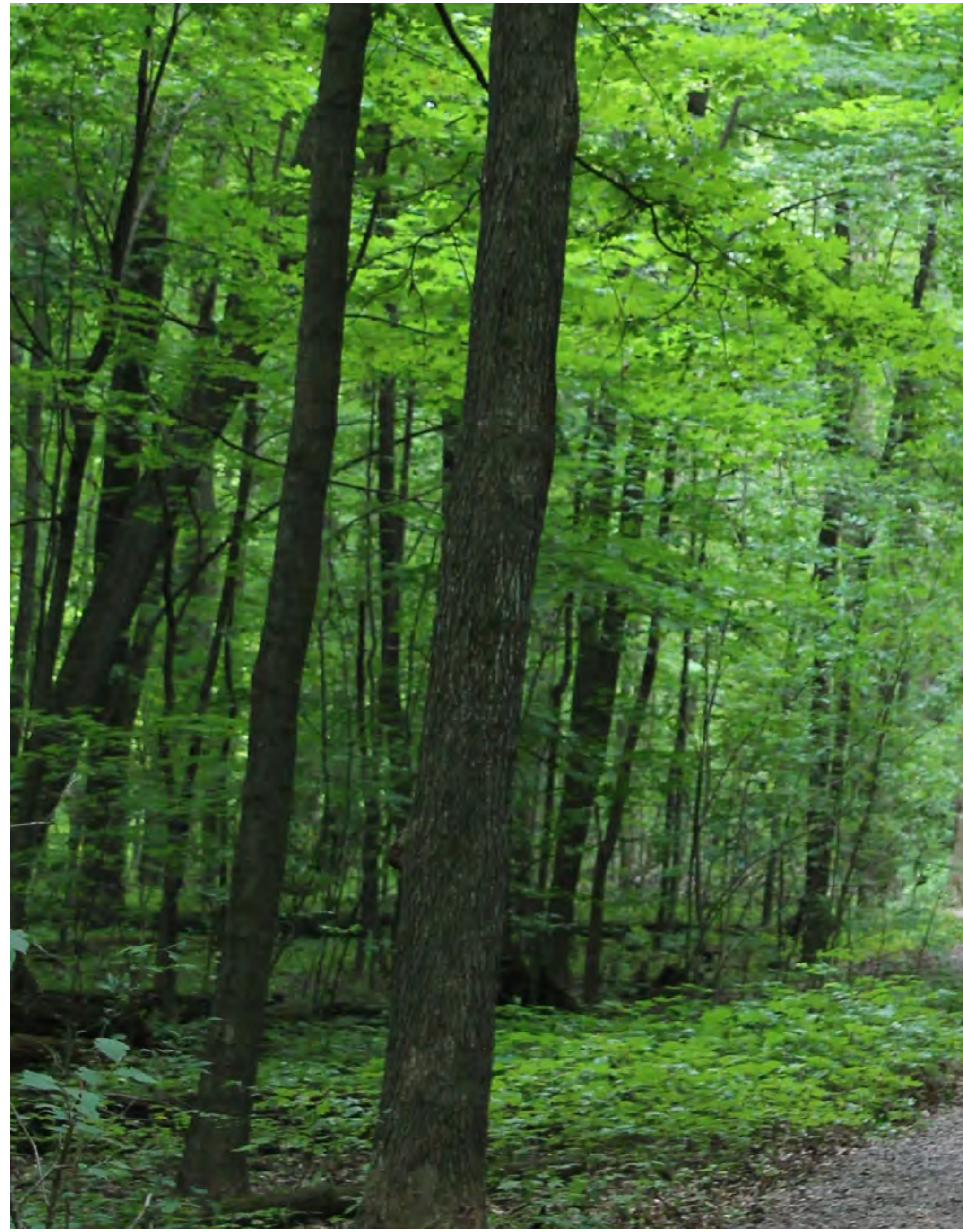
Annual Carbon Sequestration by Grasses

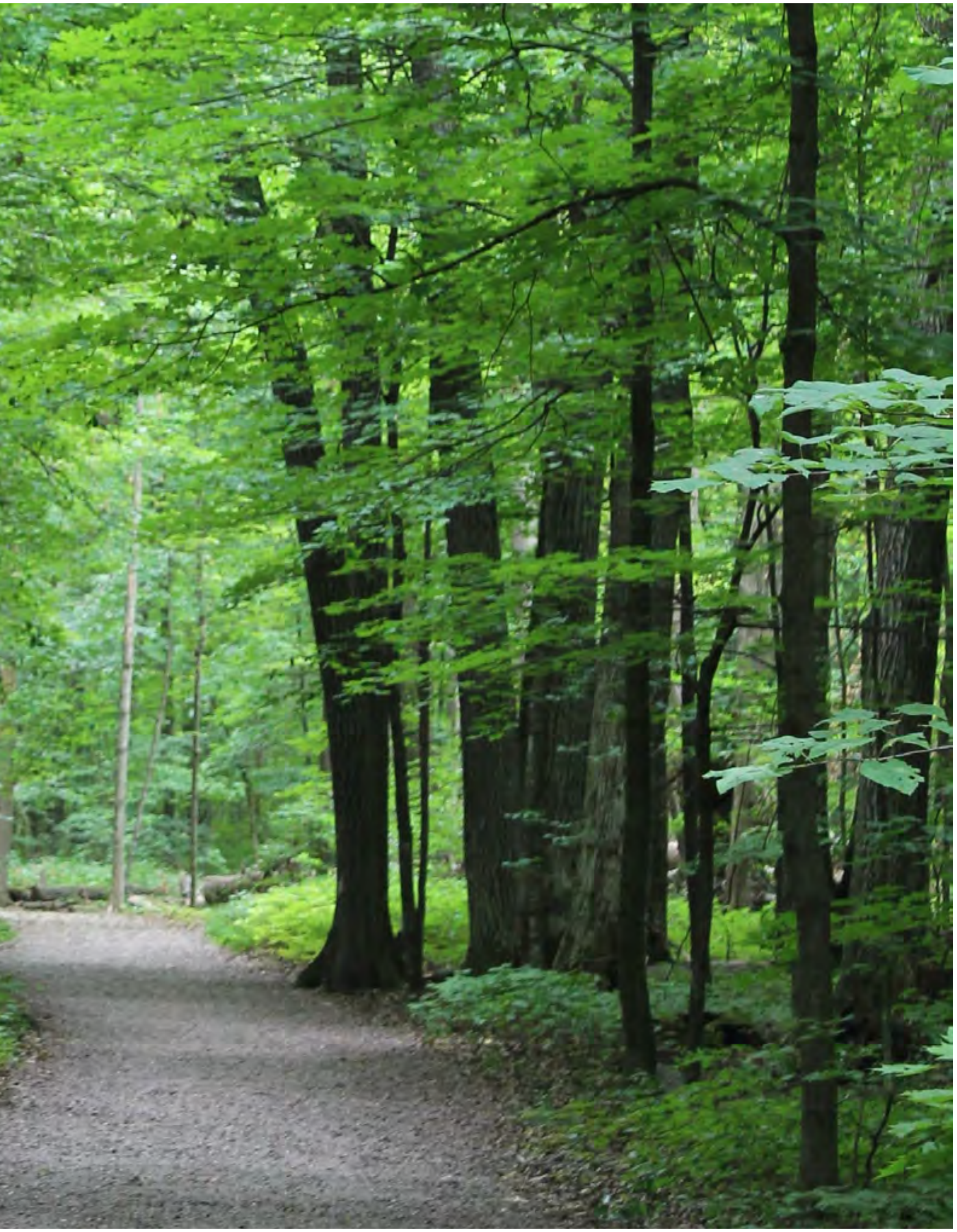
5,292,233 pounds
2,400 Metric Tons —
0.4% of annual GHG emissions
(excluding tracts 104.1, 105, 106, 107)



Annual Carbon Sequestration by Trees

16,727,560 Pounds
7,587 Metric Tons—
1.1% of annual GHG emissions
(excluding tracts 104.1, 105, 106, 107)





Land Cover Impacts and Benefits

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.

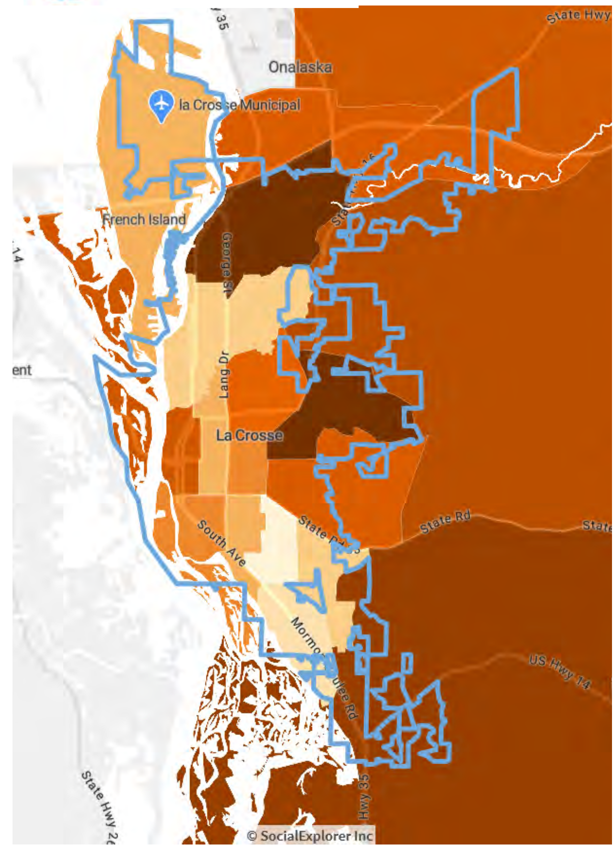
Annual Carbon Sequestration of Green Infrastructure per Acre
(in Pounds)

City Average:
1,576
(excluding tracts 104.1, 105, 106, 107)

Census Tract High:
2,960 Tract: 6

Census Tract Low:
605 Tract: 11.01

- < 821.2
- 821.2 to 944.7
- 944.7 to 1,046.2
- 1,046.2 to 1,182.2
- 1,182.2 to 1,261.8
- 1,261.8 to 1,632.3
- 1,632.3 to 2,030.7
- 2,030.7 to 2,099
- 2,099 to 2,159.3
- 2,159.3 to 2,635.9
- > 2,635.9



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.

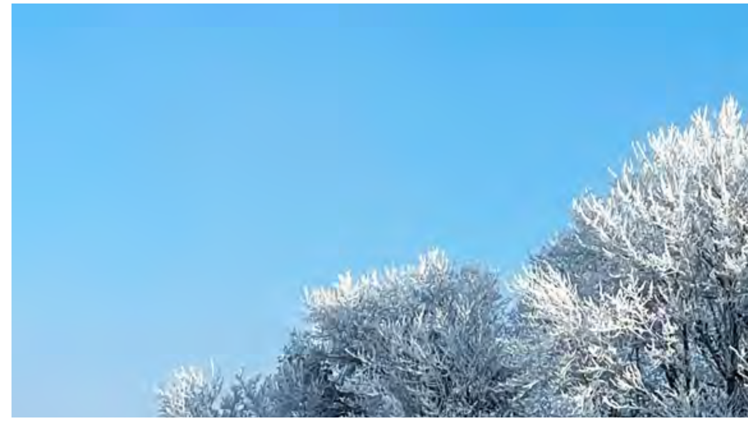
Air Pollution Removal Values

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 (NO_2), ozone (O_3), sulfur dioxide (SO_2), and particulate matter (PM), which includes particulate matter less than 2.5 microns ($PM_{2.5}$) and particulate matter greater than 2.5 and less than 10 microns (PM_{10}).

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; NO_2 at $477.89; O_3 at $2,443.66; $PM_{2.5}$ at $91,955.05; SO_2 at $163.18; PM_{10} at $6,268.44, and CO_2 sequestration at $35.38.

Building Energy Savings Values

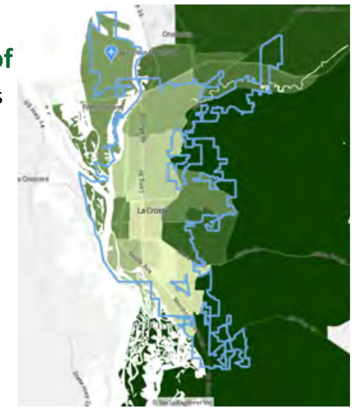
As outlined in Section 3 of this report, building energy savings values can be estimated using average energy affecting tree counts per acre, by community density type, established through the study "Residential building energy conservation and avoided power plant emissions by urban and community trees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



Annual Pollution Absorption Value of Trees (excluding tracts 104.1, 105, 106, 107)

$1.2 Million

- < $22,553
- $22,553 to $38,337
- $38,337 to $74,767
- $74,767 to $95,179
- $95,179 to $157,944
- $157,944 to $180,399
- $180,399 to $196,803
- $196,803 to $260,012
- $260,012 to $1,892,590
- $1,892,590 to $2,009,134
- > $2,009,134



Annual Energy Savings Value of Trees (excluding tracts 104.1, 105, 106, 107)

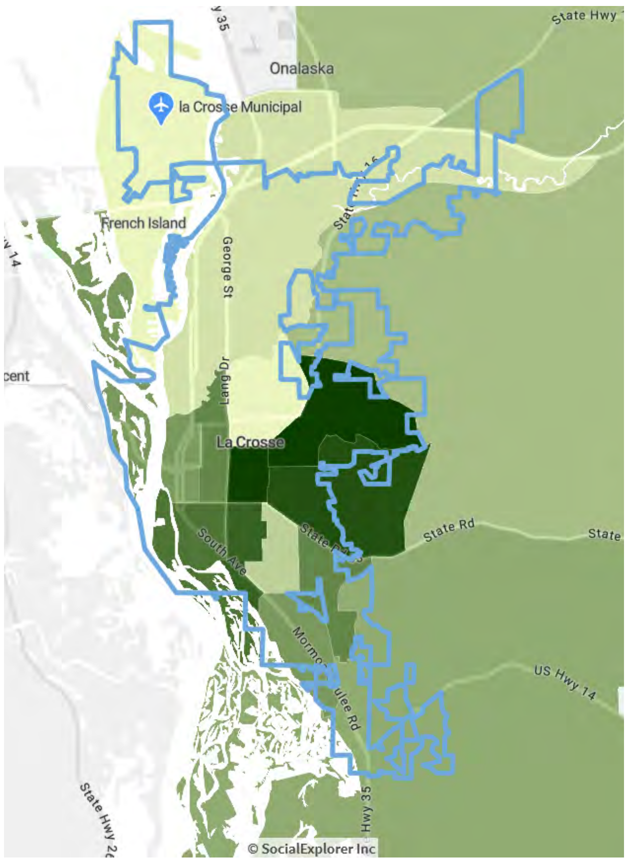
$2.5 Million

- < $66,735
- $66,735 to $128,264
- $128,264 to $149,530
- $149,530 to $180,796
- $180,796 to $190,205
- $190,205 to $229,862
- $229,862 to $253,856
- $253,856 to $290,355
- $290,355 to $460,419
- $460,419 to $492,532
- > $492,532

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 City.



Tree Benefit per Acre

(excluding tracts 104.1, 105, 106, 107)

City Average:

$359

Census Tract High:

$907 Tract: 8

Census Tract Low:

$168 Tract: 5

- < $185.46
- $185.46 to $235.08
- $235.08 to $274.41
- $274.41 to $309.71
- $309.71 to $357.48
- $357.48 to $434.34
- $434.34 to $505.89
- $505.89 to $573.39
- $573.39 to $609.19
- $609.19 to $758.47
- > $758.47

Tree Benefit per Household

(excluding tracts 104.1, 105, 106, 107)

City Average:

$221

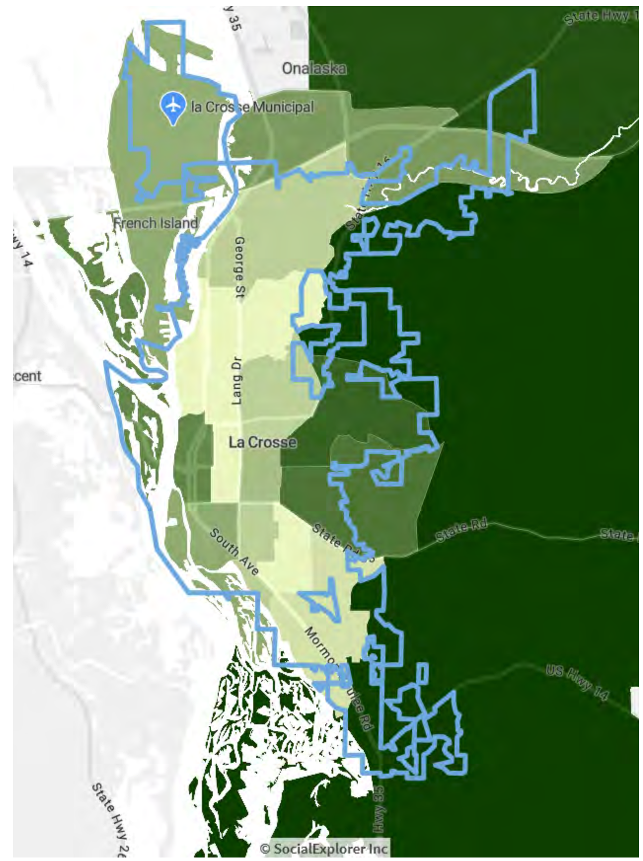
Census Tract High:

$711 Tract: 6

Census Tract Low:

$85 Tract: 4

- < $119.58
- $119.58 to $139.33
- $139.33 to $198.76
- $198.76 to $233.19
- $233.19 to $261.51
- $261.51 to $439.4
- $439.4 to $526.64
- $526.64 to $710.51
- $710.51 to $2,022.69
- $2,022.69 to $2,074.61
- > $2,074.61



Section 05

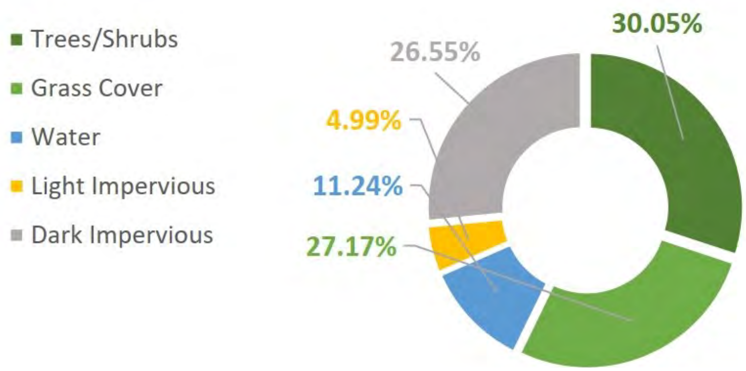
Findings

Click here to return to TOC

The health of the City's green infrastructure and the impacts of impervious land cover affect everyone in the community and City 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 city - 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 City resources.

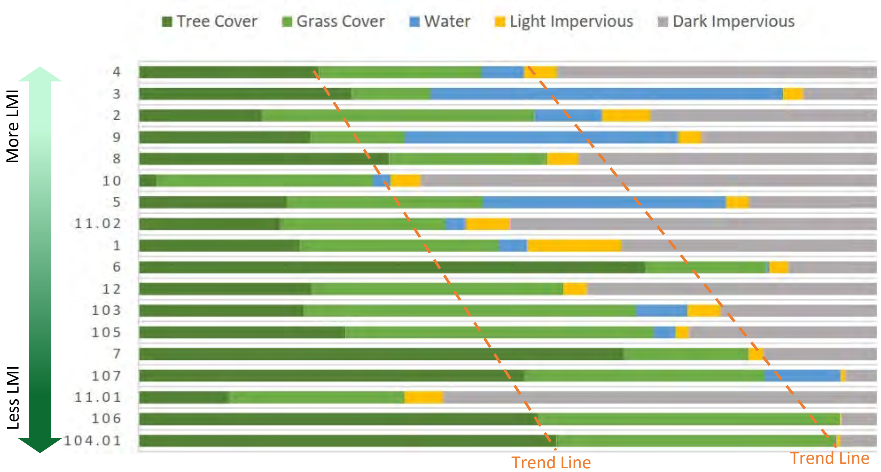
To assist in prioritization, in the following pages, this report reviews the community Green Infrastructure and Impervious Surface data through "filters" in order to arrive at a recommended prioritization of neighborhoods for policy action. These "filters" are based on the land coverage information detailed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

Ground Cover Breakdown by Type
(excluding tracts 104.1, 105, 106, 107)



Ground Cover Characteristics by Census Tract
Organized by Share of Low Income Population (LMI)

The bar chart below provides a side-by-side comparison of the of land cover data detailed in Section 2, by Census Tract.



Findings

Review Criteria - Green Infrastructure

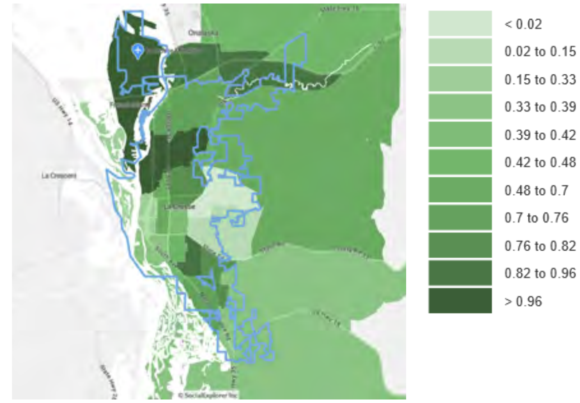
Prioritization of locations for increased green infrastructure included in this report is based on an equity approach. This approach reviews a range of land cover and demographic characteristics of each neighborhood in an "Environmental Equity Index". This process is based on procedures developed by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

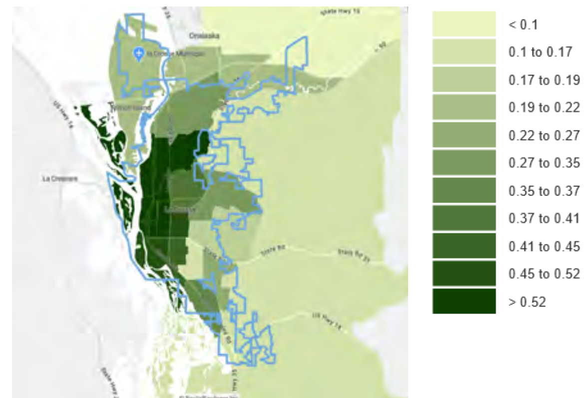
Priority Tree Canopy Increase Based on Tree Stock Potential Levels:

Tree stock potential level refers to the ratio of additional tree canopy potential to the total area of potential tree canopy and existing tree canopy coverage. Higher tree stock potential levels represent higher potential and priority for tree planting. Higher numbers represent higher prioritization based on this category.



Priority Tree Canopy Increase Based on Economic Stress Density:

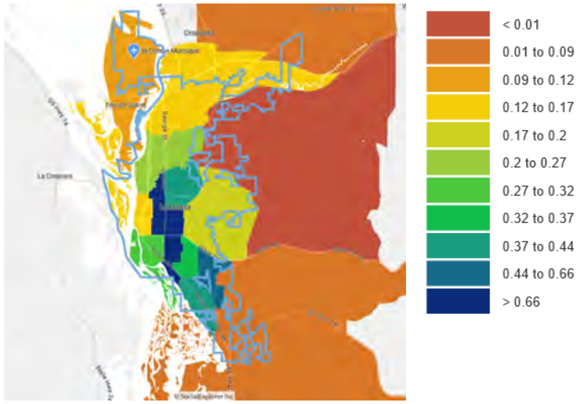
The social, economic, and environmental benefits of a robust tree canopy are a benefit to all community residents, however, those living under economic stress are both more likely to live in areas with lower tree canopy coverage as well as those for whom the benefits have the largest positive impacts. Higher economic stress density values represent higher potential for increasing environmental equity of tree canopy cover. Higher numbers represent higher prioritization based on this category.



Findings

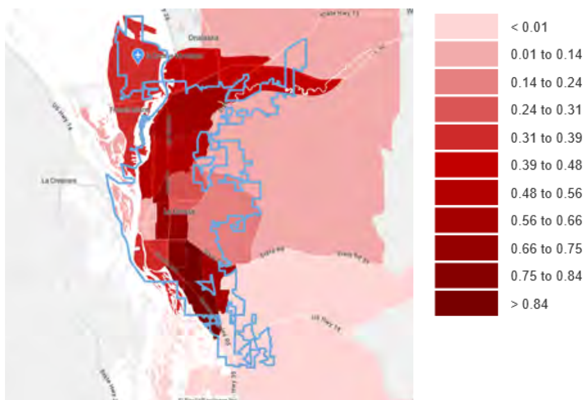
Priority Tree Canopy Increase Based on Population Density:

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.



Priority Tree Canopy Increase Based on Heat Island Mitigation Potential:

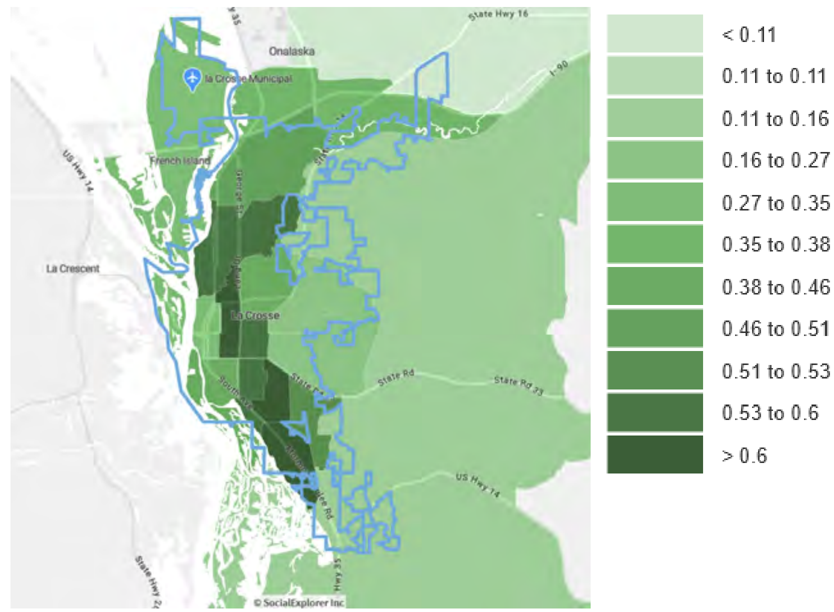
As outlined in Section 3, heat island or micro-heat island impacts are not equally felt throughout the city. This prioritization review organizes the census tracts based on opportunity to mitigate current and future heat island impacts through tree planting. Higher numbers represent higher prioritization based on this category.



Weighted Priority Tree Canopy Increase

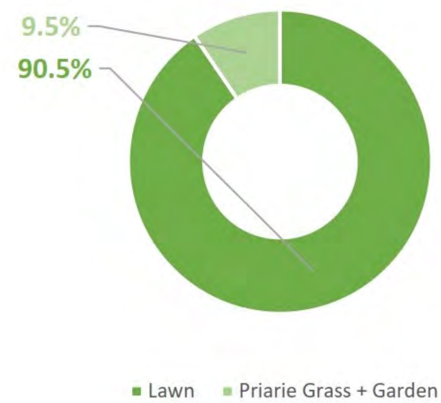
The weighted prioritization for tree canopy increase looks to balance the potential for increased tree canopy with the opportunity to improve tree canopy benefit equity, potential to positively impact as many households as possible, and the need for mitigation of heat island impacts. Higher numbers represent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

Potential for new trees: 20%
Population density: 20%
Low Income Population (equity adjustment): 30%
Heat Island mitigation need: 30%



Findings

In addition to opportunities to expand and improve the city'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.

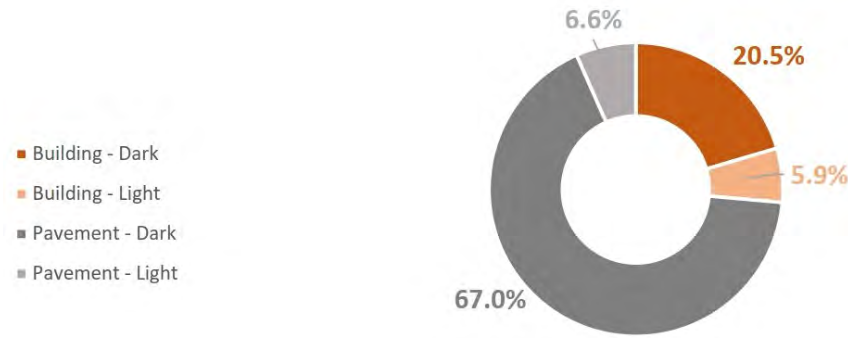


Turf Reduction Potential (excluding tracts 104.1, 105, 106, 107)

As illustrated in the chart to the right, 90.5% of grass lands in La Crosse are manicured lawns—representing a great opportunity for turf reduction. Turf reduction can increase stormwater uptake, reduce potable water use, and increase soil carbon.

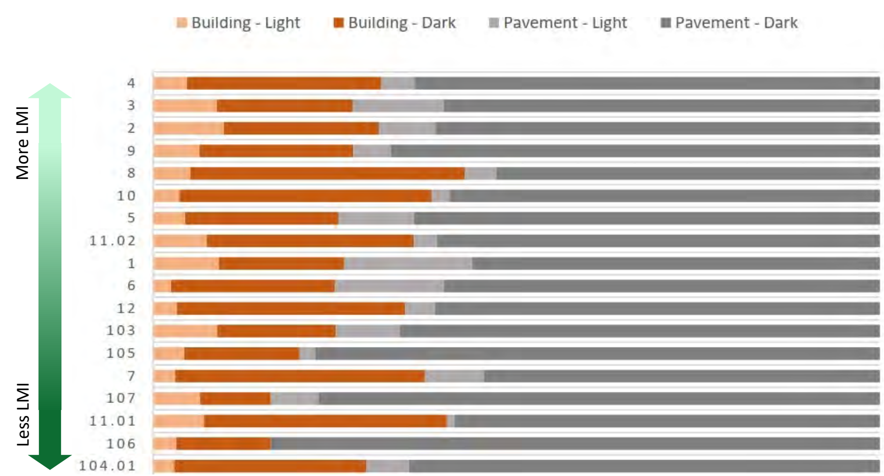
Impervious Surface Characteristic

As outlined in Section 3, the city'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 67% of all impervious surfaces, followed by dark roof surfaces at 20.5%. These represent significant opportunities for decreasing heat island impacts in the community.



Impervious Surface Characteristics by Census Tract

The bar chart to the right shows the impervious surface characteristics by census tract. The portions of the community with the highest shares of dark building and dark pavement surfaces may benefit the most from heat island mitigation strategies like cool pavement systems or green roofs.



Section 06
Calculating Potential Goals

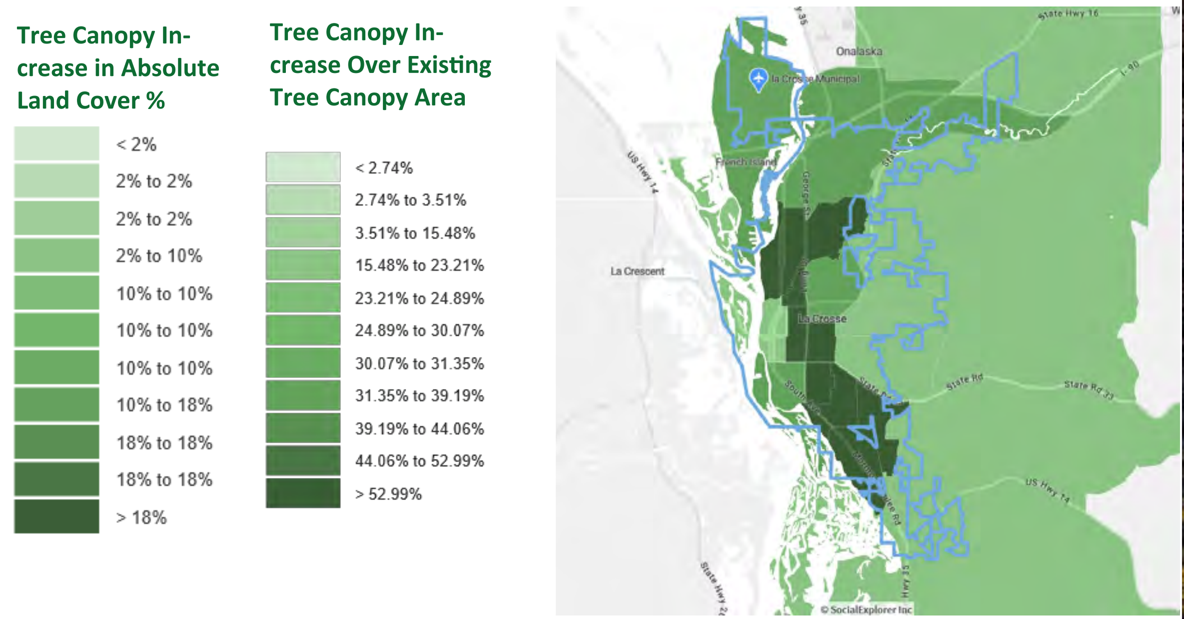
Calculating Tree Canopy Coverage Goal for 2040

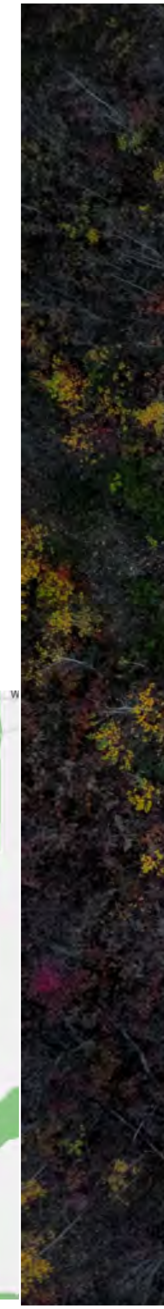
Total tree canopy coverage goals are central to long-range land cover goal recommendations for the city. In support of an "Environmental Equity" approach to tree canopy goalsetting, as outlined in the Findings Section of this report, identification of long-term tree canopy coverage goals includes consideration 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: **18%**
For neighborhoods in middle 1/3rd Neighborhood Priority Ranking: **10%**
For neighborhoods in bottom 1/3rd Neighborhood Priority Ranking: **2%**





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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

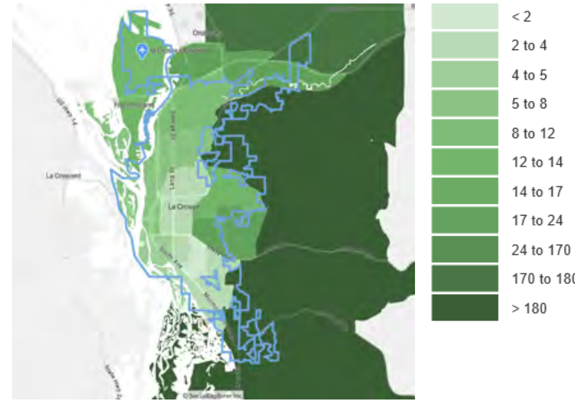
Where:
CB= the existing Tree Canopy;
CG= the growth of existing Tree Canopy (protection and maintenance);
CM= Tree Canopy mortality or loss due to natural and man -induced causes.
CN= Tree Canopy increase from new trees (planting); and
CT= total Tree Canopy Result (or goal)

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

Calculating Potential Goals

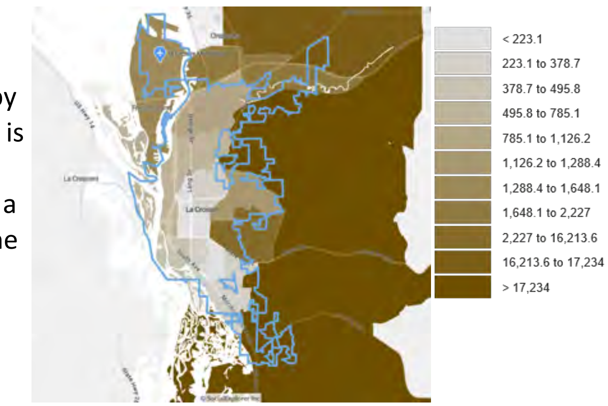
Translating Tree Canopy Coverage Goal To New Tree Planting - Growth Rates (CG)

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 city 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%.



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

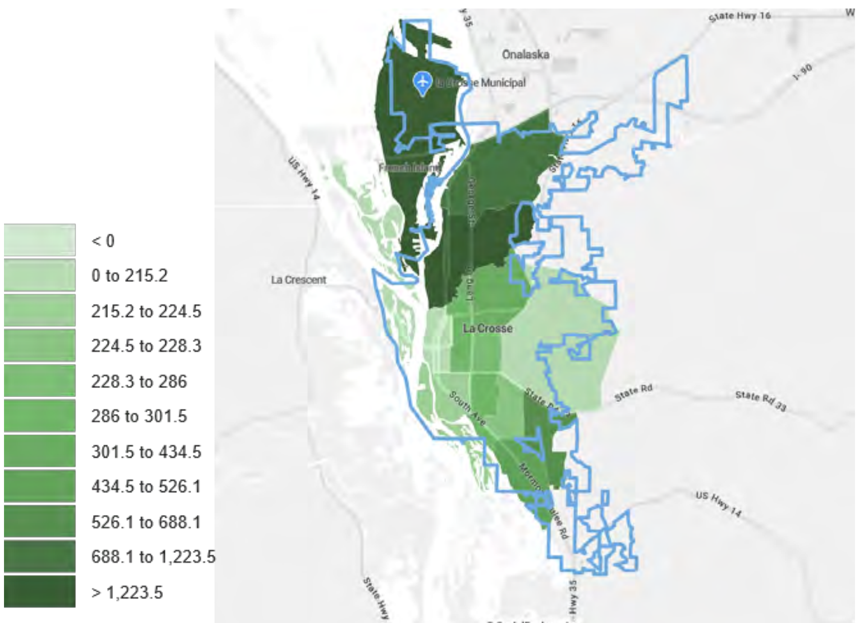
Translating Tree Canopy Coverage Goal To New Tree Planting - New Tree Planting Annual Target (CN)

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 (excluding tracts 104.1, 105, 106, 107):
Note, Acreage represents the canopy coverage at year of planting, with an assumed new tree crown radius of 5':

6,004 New Trees **34** 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 %)
2023	4198	+	92	-	-86	+	34	=	4239	30.3%
2024	4239	+	93	-	-87	+	34	=	4279	30.6%
2025	4279	+	94	-	-88	+	34	=	4319	30.9%
2026	4319	+	95	-	-89	+	34	=	4359	31.2%
2027	4359	+	96	-	-89	+	34	=	4400	31.5%
2028	4400	+	97	-	-90	+	34	=	4440	31.8%
2029	4440	+	98	-	-91	+	34	=	4480	32.1%
2030	4480	+	99	-	-92	+	34	=	4520	32.4%
2031	4520	+	99	-	-93	+	33	=	4561	32.6%
2032	4561	+	100	-	-93	+	33	=	4601	32.9%
2033	4601	+	101	-	-94	+	33	=	4641	33.2%
2034	4641	+	102	-	-95	+	33	=	4681	33.5%
2035	4681	+	103	-	-96	+	33	=	4722	33.8%
2036	4722	+	104	-	-97	+	33	=	4762	34.1%
2037	4762	+	105	-	-98	+	33	=	4802	34.4%
2038	4802	+	106	-	-98	+	33	=	4842	34.7%
2039	4842	+	107	-	-99	+	33	=	4883	34.9%
2040	4883	+	107	-	-100	+	33	=	4923	35.2%

Section 07 Recommendations

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Conclusions

Even with a strong existing green infrastructure, the City has the potential for more. Using research from the University of Minnesota, this study indicates that the City of La Crosse has a heat island impact of at least 3-4 degrees in daytime and 4-6 degrees in nighttime temperature increase. Meanwhile, even with the significant pollution absorption services the City's green infrastructure provides, only a fraction of the man-made air quality impacts occurring in the City are mitigated. Consequently, increases in green infrastructure offer significant reward potential for the City.

Primary Strategic Goal Recommendations

Section 6 of this report provided a range of recommended goals for the City of La Crosse. The overarching goals recommended in this report are:

1) To increase the tree canopy coverage throughout the City, particularly in the Priority Neighborhoods identified in Section 6, to an average of at least 35% City-wide by 2040 (calculation excludes tracts 104.1, 105, 106, 107).
2) Decrease the quantity of "dark" impervious surfaces throughout the City, particularly in neighborhoods identified with higher heat island contributions in Section 3, by an average of at least 5% of total citywide coverage by 2040.
3) Increase pollinator supportiveness of lawns and grasslands in City of La Crosse 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)

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CLIMATE CHANGE PROJECTIONS FOR INDIVIDUAL TREE SPECIES
DRIFTLESS AREA (ECOLOGICAL SECTION 222L)

Midwestern forests will be affected by climate change during this century. Several reports describe the climate change risks to the region's forests and natural communities (WICCI 2017, Handler 2012). Foresters and researchers can use experience and information from past events to develop expectations about how future change might affect forests, but there are limits to what we can learn from the past. For example, future climate change may be beyond what has been experienced in recent centuries. Tools like computer models can help provide answers by testing scenarios that haven't been experienced before.

Remember that models are just tools, and they're not perfect. Models don't account for some factors that could be modified by climate change, like droughts, wildfire activity, and invasive species. If a species is rare or confined to a small area, Tree Atlas results may also be less reliable. These factors, and others, could cause a particular species to perform better or worse than a model projects. Human choices will also continue to influence forest distribution, especially for tree species that are projected to increase. Planting programs may assist the movement of future-adapted species, but this will depend on management decisions.

TREE SPECIES INFORMATION:

The "Tree Atlas" tool uses climate scenarios and current distribution information to project future habitat suitability for individual tree species (Landscape Change Research Group 2014). This page shows the most common tree species in this local area, organized into general categories of future expectations. Full results for all species for two climate scenarios can be compared side-by-side on page 2 to get a sense for the range of possible outcomes.

Despite these limits, models provide useful information about future expectations. It's perhaps best to think of these projections as indicators of possibility and potential change. The model results presented here can be combined with information from published reports and local management expertise to draw conclusions about potential risk and change in the Driftless Area.

SPECIES	ADDITIONAL CONSIDERATIONS
LIKELY TO DECREASE	
Bigtooth aspen	Early-sucessional colonizer, but susceptible to drought
Eastern white pine	Good disperser, but susceptible to drought and insects
Northern pin oak	Tolerates drought and fire
Northern red oak	Susceptible to some insect pests and oak wilt
Paper birch	Early-sucessional colonizer, but susceptible to insects and drought
Quaking aspen	Early-sucessional colonizer, but susceptible to heat and drought
Red maple	Competitive colonizer tolerant of disturbance and diverse sites
Red pine	Susceptible to insect pests and diseases, and limited dispersal.
MAY DECREASE	
American basswood	Tolerates shade but susceptible to fire
Sugar maple	Grows across a variety of sites and tolerates shade
White oak	Fire-adapted and grows on a variety of sites
MIXED MODEL RESULTS	
Black cherry	Susceptible to insects and fire, tolerates some drought
Ironwood	Grows across a variety of sites and tolerates shade

SPECIES	ADDITIONAL CONSIDERATIONS
NO CHANGE	
Black oak	Tolerates drought, but susceptible to pests and diseases
Bur oak	Tolerates drought and fire
Slippery elm	Affected by Dutch elm disease, but tolerates shade
MAY INCREASE	
American elm	Affected by Dutch elm disease, grows across a variety of sites
Bitternut hickory	Tolerates some drought, but not shade
Black walnut	Doesn't tolerate drought or shade
Black willow	Susceptible to drought and fire
Boxelder	Tolerates drought, also disperses and establishes well
Eastern redcedar	Tolerates drought, but susceptible to fire and insect pests
Green ash	Emerald ash borer causes mortality
Hackberry	Tolerates drought, but susceptible to fire
Shagbark hickory	Susceptible to insects and fire
Silver maple	Good disperser and tolerates wet soils, but vulnerable to drought
White ash	Emerald ash borer causes mortality

NIACS
Northern Institute of Applied Climate Science

www.forestadaptation.org

Get this handout online at: **www.forestadaptation.org/Northwoods_treehandouts**

FUTURE PROJECTIONS

Data for the end of the century are summarized for the Climate Change Tree Atlas (www.fs.fed.us/nrs/atlas) under two climate change scenarios. Tree Atlas models future suitable habitat.

▲ **INCREASE**
Projected increase of >20% by 2100

● **NO CHANGE**
Little change (<20%) projected by 2100

▼ **DECREASE**
Projected decrease of >20% by 2100

★ **NEW HABITAT**
Tree Atlas projects new habitat for species not currently present

ADAPTABILITY

Factors not included in the model, such as the ability to respond favorably to disturbance, may make a species more or less able to adapt to future stressors.

+ high
Species may perform better than modeled

· medium

– low
Species may perform worse than modeled

SPECIES	LOW CLIMATE CHANGE (PCM B1)	HIGH CLIMATE CHANGE (HAD A1FI)	ADAPT
American basswood	●	▼	·
American beech	▲	●	·
American elm	▲	●	·
American hornbeam	▼	●	·
Balsam poplar	★	★	·
Bigtooth aspen	▼	▼	·
Bitternut hickory	▲	●	+
Black ash	▼	▼	–
Black cherry	▲	▼	–
Black hickory		★	·
Black locust	▲	▲	·
Black maple	▼	▼	·
Black oak	●	●	·
Black walnut	▲	▲	·
Black willow	▲	▲	–
Blackjack oak		★	+
Boxelder	▲	▲	+
Bur oak	●	●	+
Butternut	▼	▼	–
Cedar elm		★	·
Chestnut oak	★	★	+
Chinkapin oak	★	★	·
Chokecherry	▲	●	·
Common persimmon	★	★	+
Eastern cottonwood	▲	▲	·
Eastern redbud	★	★	·
Eastern redcedar	▲	▲	·
Eastern white pine	▼	▼	·
Flowering dogwood	★	★	·
Green ash	●	▲	·
Hackberry	▲	▲	+
Honeylocust	▲	▲	+
Ironwood	▲	▼	+
Jack pine	▼	▼	·
Kentucky coffeetree		★	·

SPECIES	LOW CLIMATE CHANGE (PCM B1)	HIGH CLIMATE CHANGE (HAD A1FI)	ADAPT
Mockernut hickory	★	★	+
Northern catalpa		★	·
Northern pin oak	▼	▼	+
Northern red oak	▼	▼	+
Ohio buckeye	★	★	·
Osage-orange	▲	▲	+
Paper birch	▼	▼	·
Pawpaw	★	★	·
Peachleaf willow		★	·
Pecan		★	–
Pignut hickory	★	★	·
Pin oak	★	★	–
Post oak	★	★	+
Quaking aspen	▼	▼	·
Red maple	▼	▼	+
Red mulberry	▲	▲	·
Red pine	▼	▼	·
River birch	▲	▲	·
Sassafras	★	★	·
Shagbark hickory	▲	●	·
Shellbark hickory	★	★	·
Shingle oak	★	★	·
Silver maple	▲	▲	+
Slippery elm	●	●	·
Sugar maple	●	▼	+
Sugarberry		★	·
Swamp white oak	▲	▲	·
Sycamore	★	★	·
Tamarack	▼	▼	–
Water oak		★	
Waterlocust		★	
White ash	▲	▲	–
White oak	●	▼	+
Wild plum	▲	▲	·
Winged elm		★	·
Yellow-poplar	★	★	+

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Prepared by:

making change personal
paleBLUEdot LLC

2515 White Bear Ave, A8
Suite 177
Maplewood, MN 55109

Contact:
Ted Redmond
tredmond@paleBLUEdot.llc