

Relationship of Tree Species Diversity and Water Quality

2014 ISA Annual International Conference and Trade Show

Milwaukee, WI

Presented by: L. Peter MacDonagh, PLA, FASLA, ISA, LEED AP, RHS



Lake Calhoun, Chain of Lakes, Minneapolis, MN

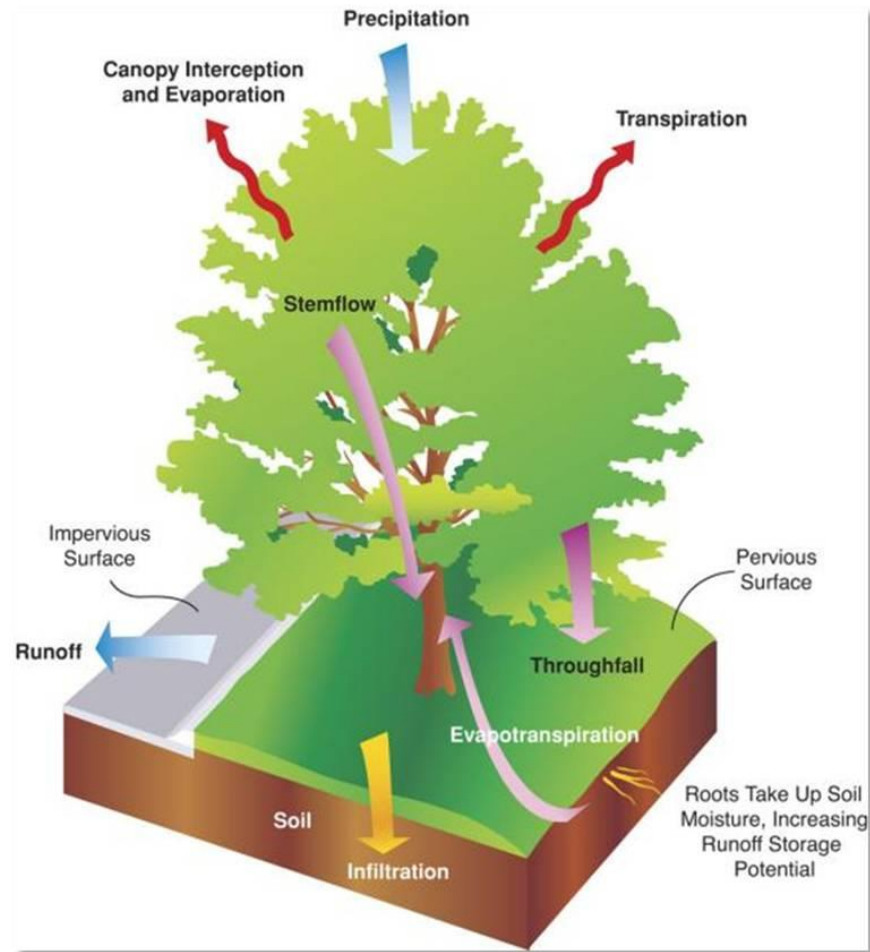
Relationship of Tree Species Diversity and Water Quality



Overview: Correlation of Tree Canopy Loss and Water Quality

- Potential Value of Trees
- Challenges Realizing Potential Value
 - Canopy Loss
 - Lack of Species Diversity
 - Changes in Hydrology
- Building Resiliency in Our Urban Tree Canopy
- Correlation of Canopy Loss and Water Quality
 - Lake Calhoun
- How Resiliency in Urban Tree Canopy can Positively Impact Water Quality

Relationship of Tree Species Diversity and Water Quality

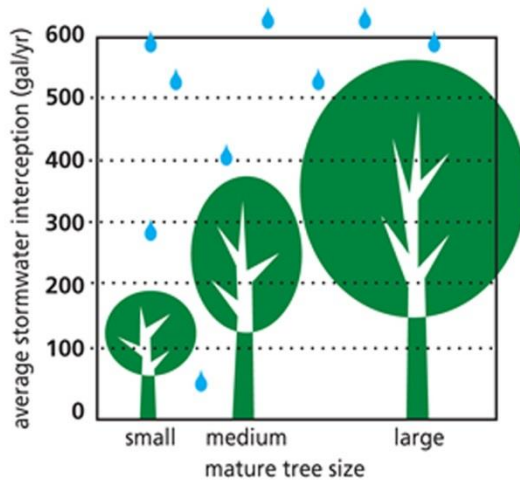


There are many benefits of trees to stormwater management. The big three are:

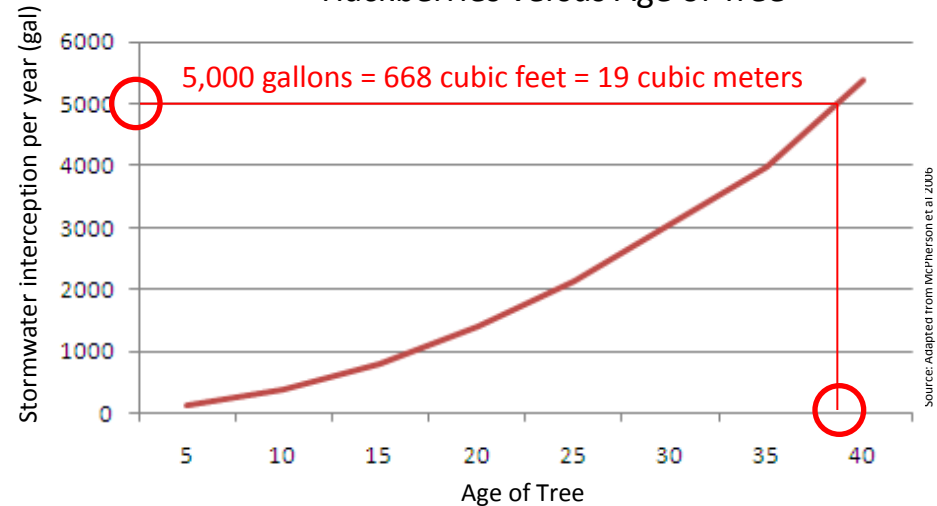
- Interception
- Infiltration
- Evapotranspiration

Relationship of Tree Species Diversity and Water Quality

The larger the tree, the more stormwater it can manage.



Annual Stormwater Interception by Hackberries versus Age of Tree



Source: Adapted from McPherson et al 2006

The benefits of LARGE trees and stormwater are well documented, but **the average lifespan for downtown urban street trees is 13 years**

from Skiera, B.; Moll, G. (1992) The Sad State of City Trees. *Am. Forests*. March/April, 61-64.

The potential of large trees is never realized.



5,000 gallon tank

<http://www.heathwatersystems.com/>

Image from PortlandOregon.gov

<http://www.heathwatersystems.com/>

KestrelDesignGroup

Relationship of Tree Species Diversity and Water Quality

DeepRoot

Investment vs. Returns for Healthy Urban Trees:

Lifecycle Cost Analysis



Prepared by: The Kestrel Design Group, Inc.

i-Tree Inputs

Costs

- Pruning
- Pests and Diseases
- Infrastructure Repair
- Irrigation
- Cleanup
- Liability and Legal
- Administration
- Bioretention Maintenance

Benefits

- Energy Savings
- CO₂ Storage
- Air Quality
- Stormwater
- Aesthetic/Other
- Stormwater Bioretention
- Stormwater Utility Fee Credit

Investment vs. Returns for Healthy Urban Trees. Why planting a tree correctly matters.

- Net cost of 13-year tree: \$3,094
- Net benefit of a 50 year tree: \$25,427

•1,000,000 trees planted incorrectly = \$3,094,000,000 net loss

Relationship of Tree Species Diversity and Water Quality



<http://princetonamericanelm.blogspot.com/>

Since 1977, a total of 63,700 Elm trees have been removed in the boulevards of Minneapolis

In addition, almost 300,000 elm trees have been removed from the entire City, with an average DBH of >30 inches.

In the Late 1800s, American Elm made up 90% of the boulevard trees in Minneapolis

- 1963: First Dutch Elm Disease Detected in Trees
- **1977: 31,000 Elm Trees Removed**
- **1978: 20,000 Elm Trees Removed**
- 2004: 10,000 Elm Trees Removed
- 2005-2015: 2,700 Elm Trees Removed, on average

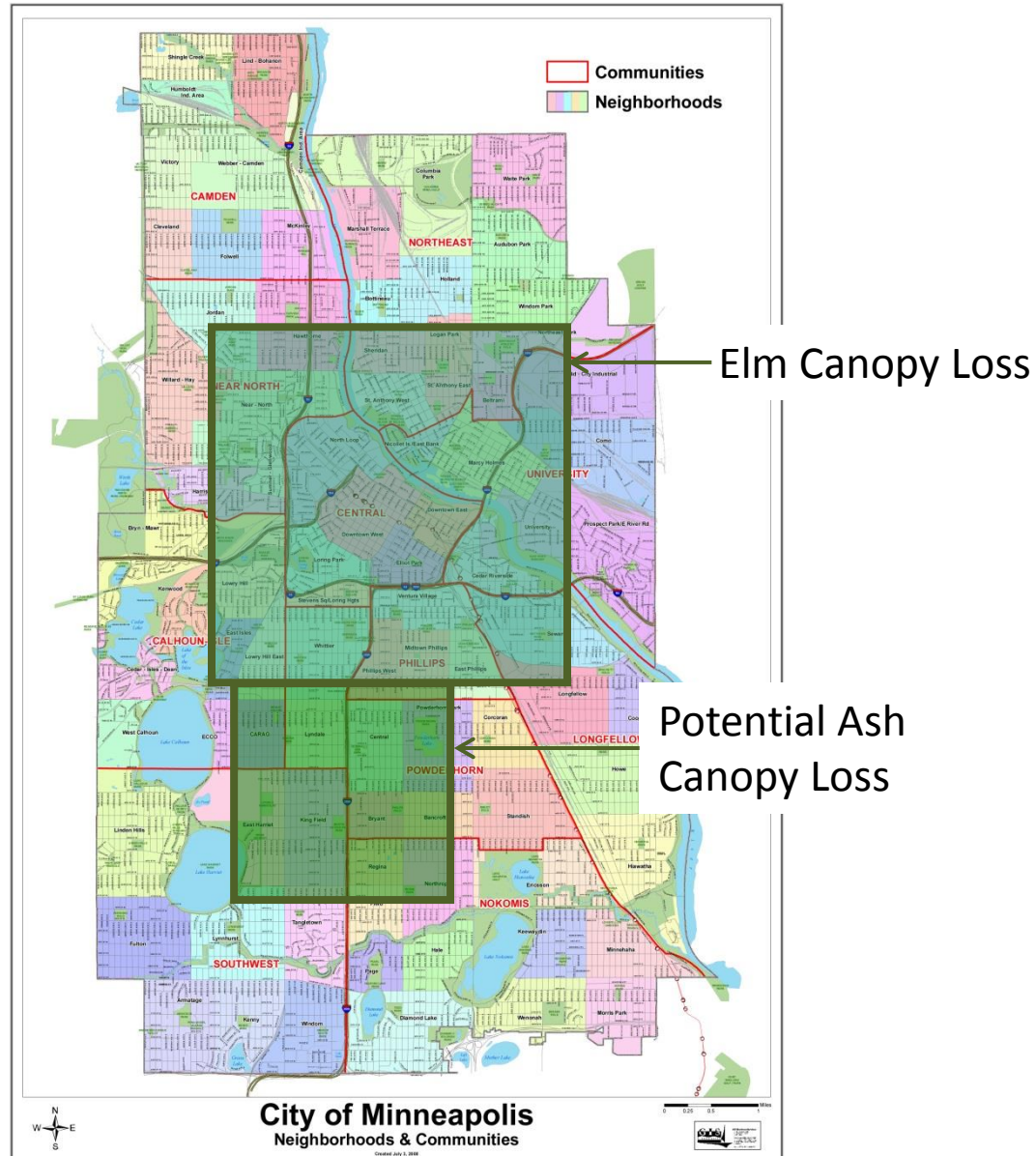
Relationship of Tree Species Diversity and Water Quality



Emerald Ash Borer and anticipated impacts on water quality

- i-Tree report shows that **21% of all Minneapolis canopy is made up of ash trees**
- Over 200,000 public and private ash trees
- 40,000 of which are on public property
- Stopped planting ash in 2006
- 2014 Canopy Removal and Replacement Plan has been developed
- The City of Minneapolis has approved a tax levy for the work required in the anticipated **\$9 million dollar project** (Star Tribune, December 2013)

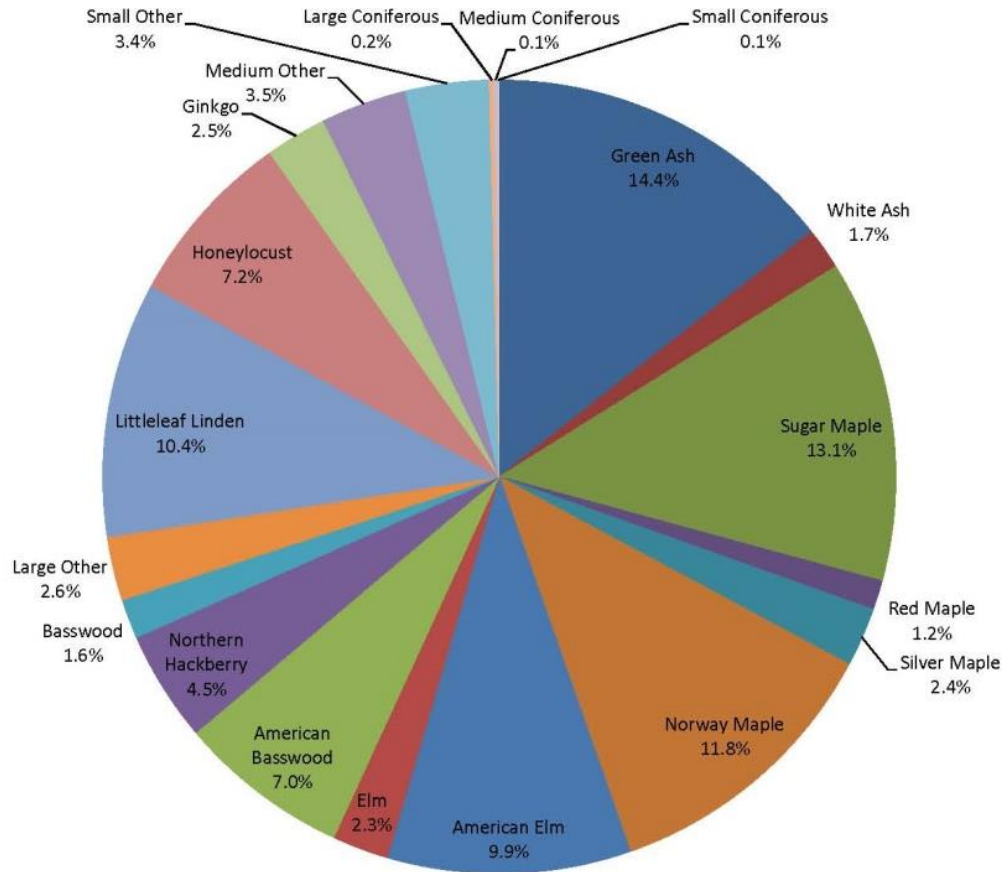
Relationship of Tree Species Diversity and Water Quality



Relationship of Tree Species Diversity and Water Quality

Distribution of Tree Canopy Species in Minneapolis (%)

Minneapolis Municipal Tree Resource, 2005, McPherson et. al.

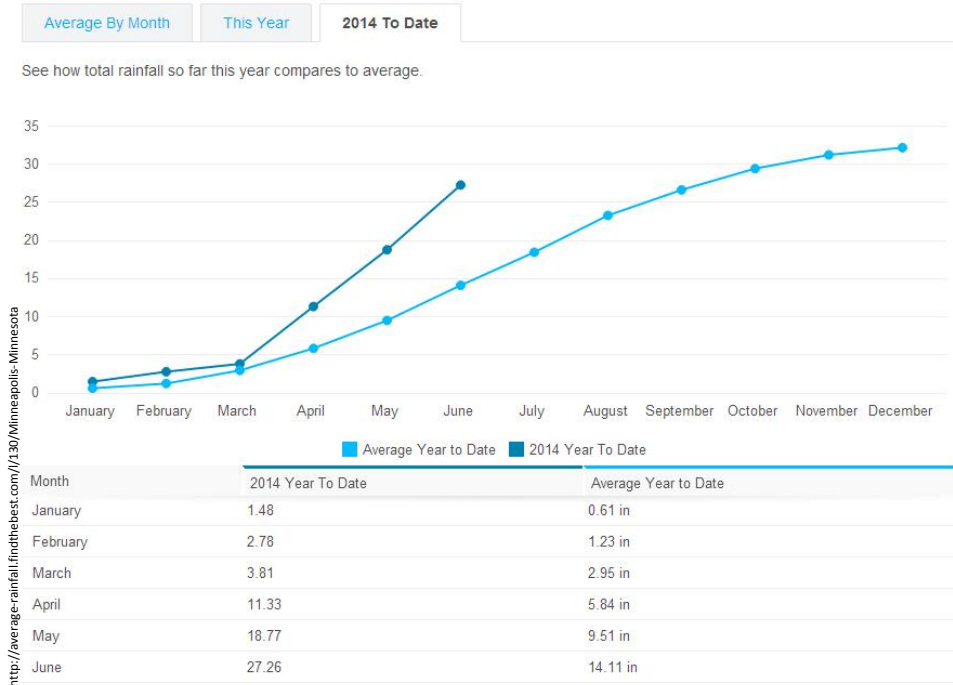


Canopy loss is coupled with the ongoing challenge for urban species diversity

- The current mix of urban tree canopy shows that 54.5% of the City is made up of 3 genera of deciduous trees: **Ulmus**, **Fraxinus**, and **Acer**.

Relationship of Tree Species Diversity and Water Quality

Monthly Rainfall



Percentage Change in Very Heavy Precipitation

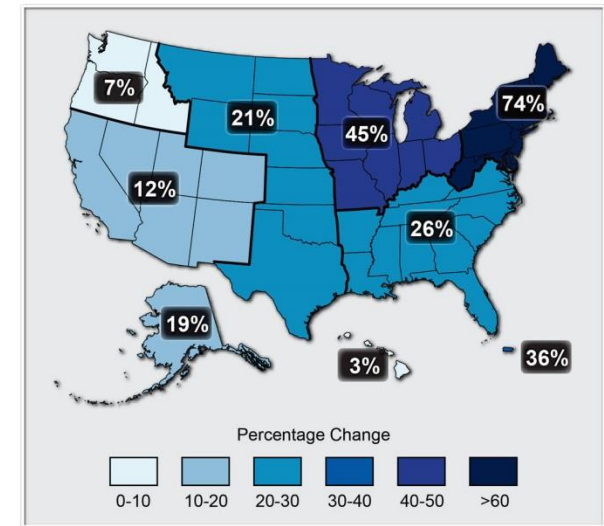


Figure 2.16: Percentage Change in Very Heavy Precipitation
 Caption: The map shows percent increases in the amount of precipitation falling in very heavy events (defined as the heaviest 1% of all daily events) from 1958 to 2011 for each region. There are clear trends toward a greater amount of very heavy precipitation for the nation as a whole, and particularly in the Northeast and Midwest. (Figure source: updated from (Karl et al. 2009) with data from NCDC)

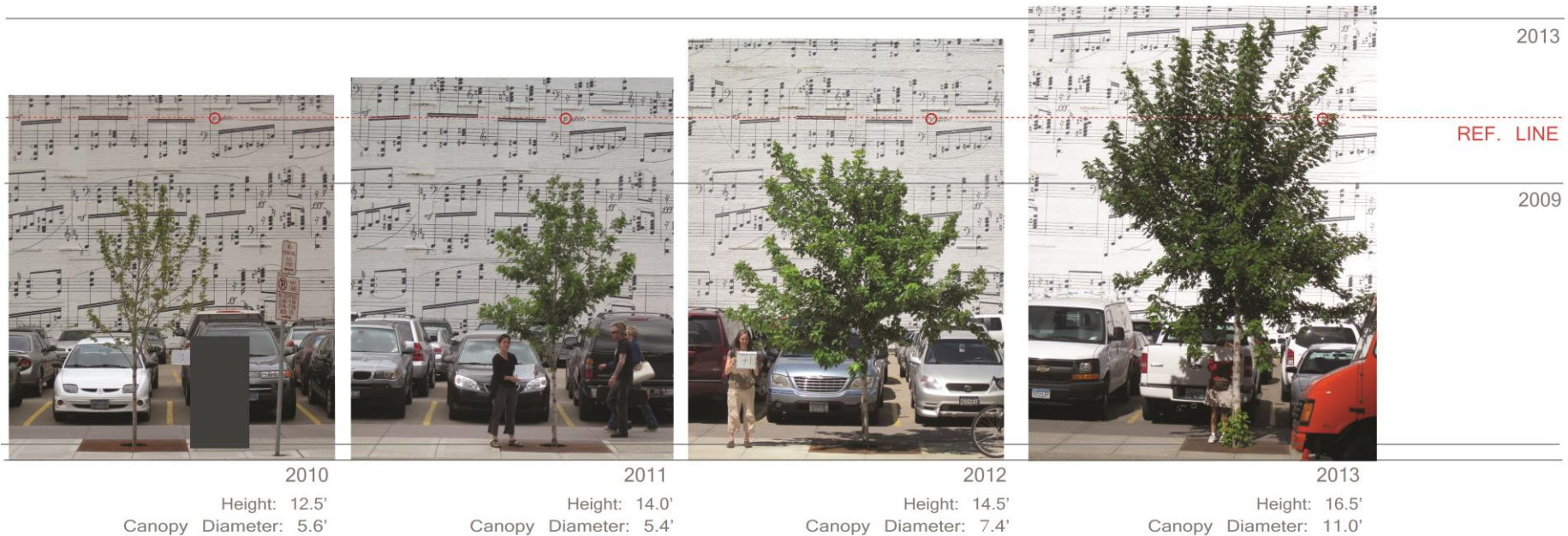
Source: National Climate Assessment Draft January 2013;
<http://ncadac.globalchange.gov/download/NCAJan11-2013-publicreviewdraft-chap2-climate.pdf>

Now we have a loss of canopy and lack of species diversity, coupled with broad, long-term hydrologic changes

- The average annual rainfall for Minneapolis is 32.16 inches.
- In 2014, between January and June, Minneapolis has already received 27.26 inches of rain.

Relationship of Tree Species Diversity and Water Quality

How do we begin to build resiliency into our urban tree canopy so that the potential of trees can be realized?



Overview of Yearly Growth:
2010-2013: 4' taller, 5.4' wider

Relationship of Tree Species Diversity and Water Quality



Typical Urban Soil Profile

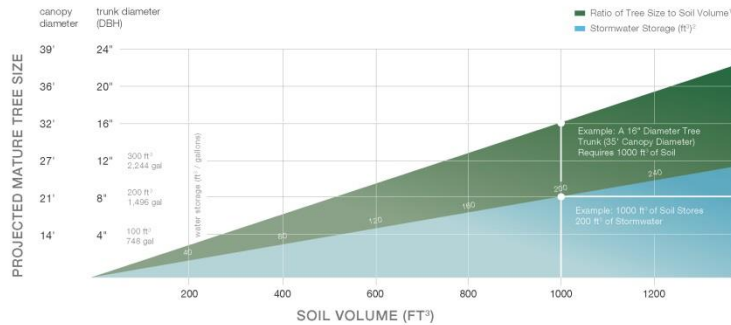


Typical Loam Soil Profile

Build resiliency by rebuilding the soil so that the potential for trees and soils to work together for comprehensive stormwater treatment is possible.

Relationship of Tree Species Diversity and Water Quality

HOW MUCH SOIL TO GROW A BIG TREE?



RATIO OF TREE SIZE TO SOIL VOLUME

Soil volumes depicted in this chart is based on the amount of roots loam soil can support with optimum compaction for root growth.

Several studies^{3,4,5} have calculated a relationship between tree growth and soil volume. Below is an example from one such study, and its soil volume methodology.⁶

Crown projection (drip line area)

- × Leaf area index
- × Evaporation rate
- × Evaporation ratio
- × Volume of water used by tree daily (water loss)

Water loss

- × Percent water holding capacity of soil
- × Volume of soil (to hold water used by the tree)

Volume of Soil

- × Rainfall frequency (estimated number of days between rain events)
- × Volume of soil (to meet demands of the tree for a certain period of time)

This soil volume methodology indicates that every 1 ft³ to 3 ft³ of soil results in 1 ft² of projected tree canopy diameter. Field observations indicate that trees that share soil may need less soil volume per tree. For example, 25-year old street trees sharing soil in Charlotte, North Carolina, with 700 ft³ of soil per tree have grown an average of 16" DBH (diameter at breast height) and have a 98% survival rate. 25-year old trees sharing soil in Bethesda, Maryland with 600 ft³ soil per tree have grown 14"-20" DBH and continue to flourish.

STORMWATER STORAGE

The line on the graph is based on 20% soil water holding capacity in a bioretention soil mix. This is a conservative estimate based on bioretention research⁷ and soil water properties.⁸

Total soil porosity

- × Field capacity of soil
- × Available water storage within soil

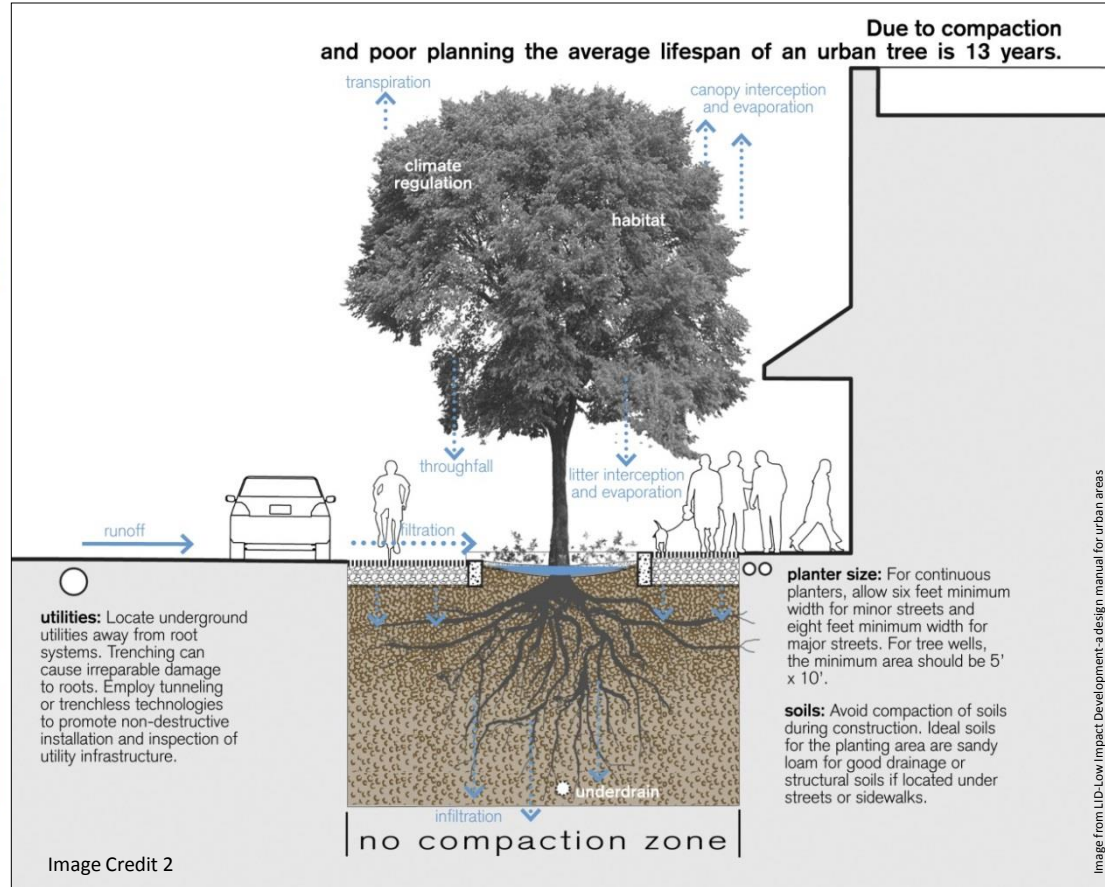


Image from LID-Low Impact Development-a design manual for urban areas

Build resiliency by providing rootable soil volume to build resilience in the landscape.

- 1 square unit of projected canopy needs 2 cubic units of rootable soil
- The big 3 of stormwater management by trees: interception, infiltration, evapotranspiration

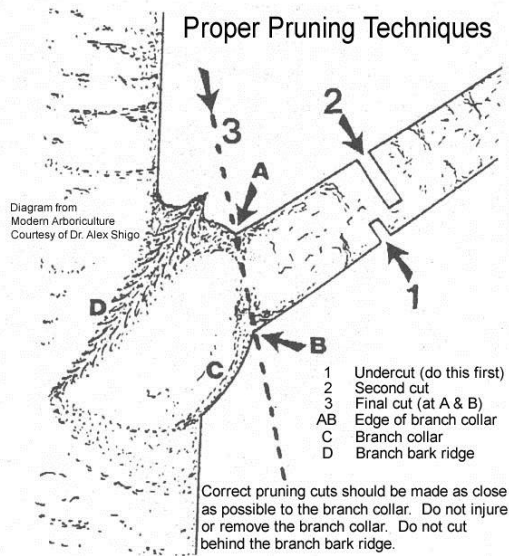
Relationship of Tree Species Diversity and Water Quality



<http://www.kidcyber.com.au/topics/soil.htm>



<http://www.gorfflandscapedesign.com/wp-content/uploads/2013/02/Nursery-1-10004527.jpg>



<http://www.texasvictorygarden.com/wp-content/uploads/2012/11/pruning-tg-limb.jpg>



Build resiliency by increasing species diversity in an urban setting and prevent re-repeating the past. This can be achieved by:

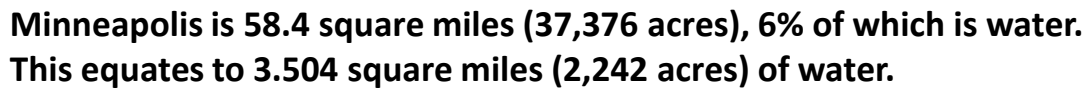
- providing rootable soil volume
- choosing the right species for the right site and soil conditions
- provide proper planting
- directing stormwater to these trees
- proper maintenance

Relationship of Tree Species Diversity and Water Quality

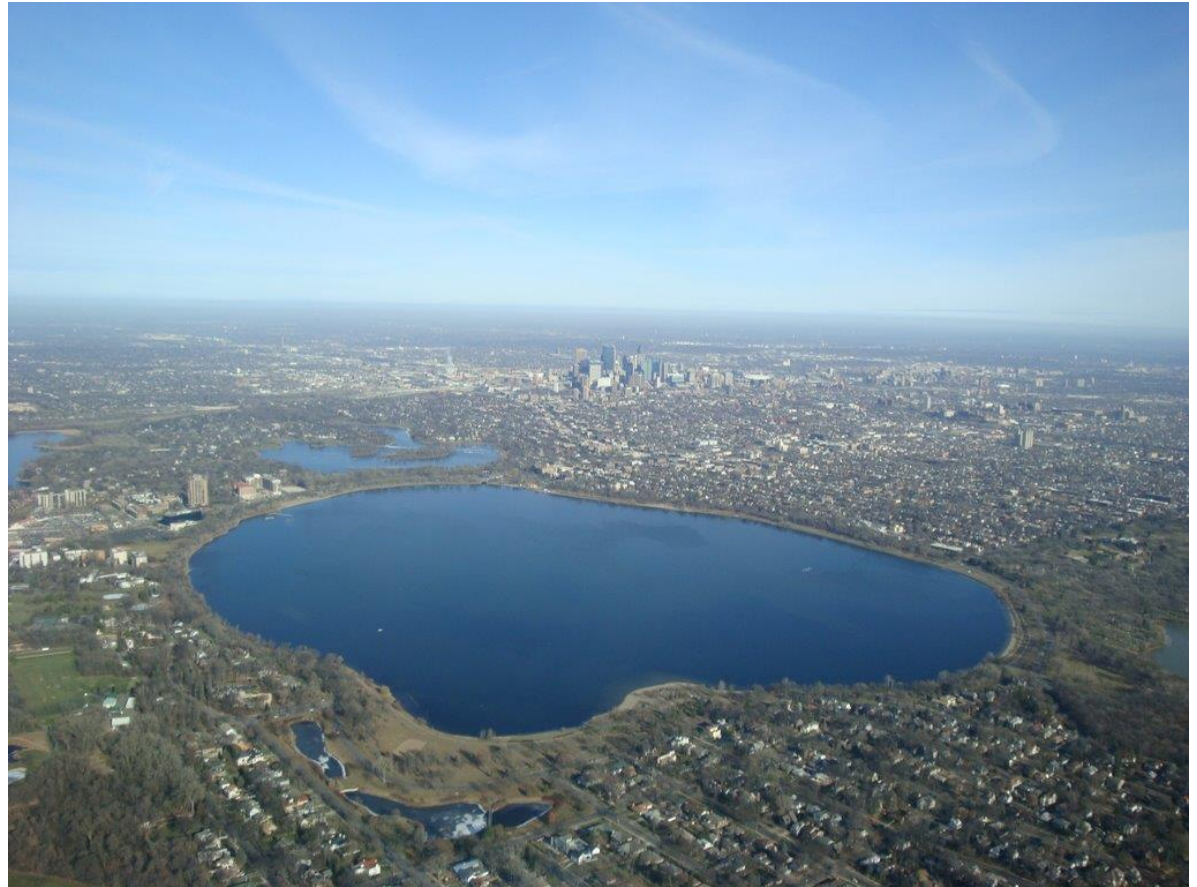


Exploring the Correlation of Tree Canopy Loss with Decrease in Water Clarity

Minneapolis Urban Tree Canopy (UTC)

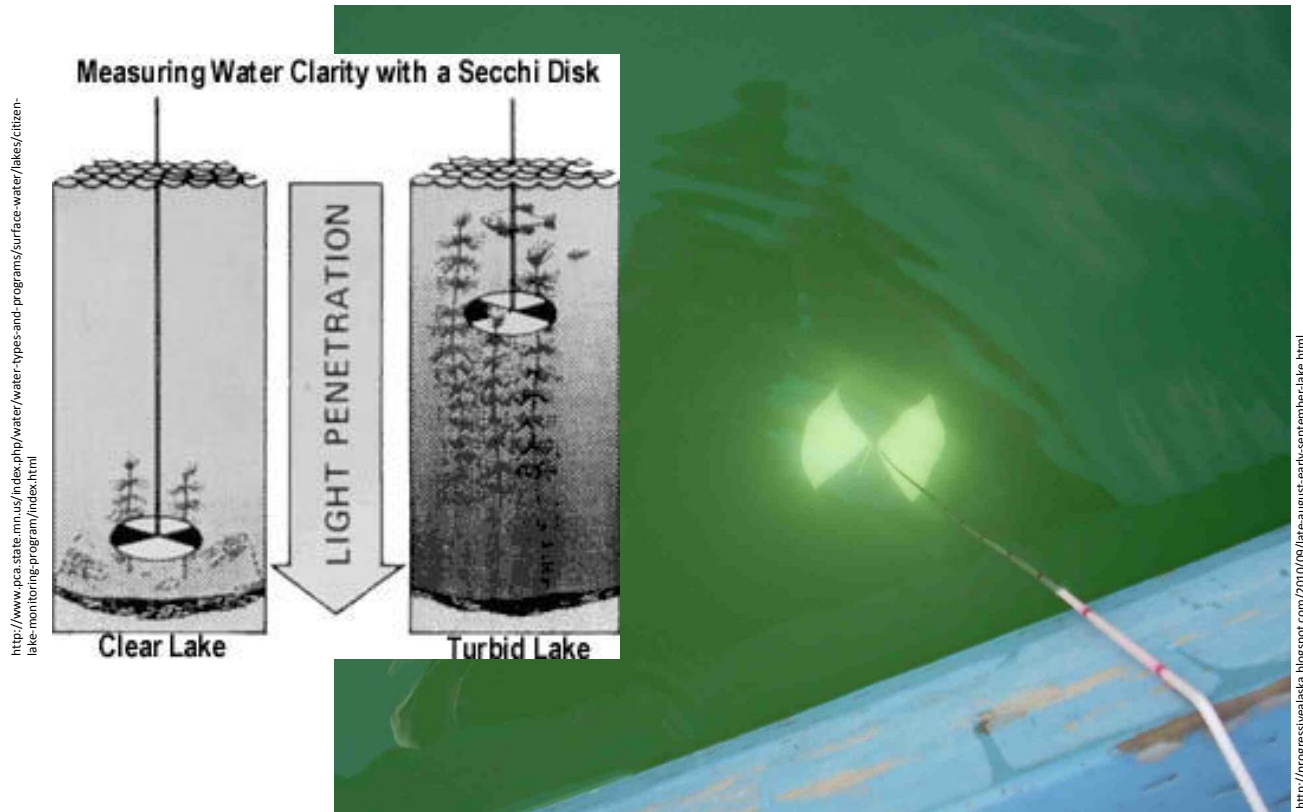


Relationship of Tree Species Diversity and Water Quality



**Focus on data from Lake Calhoun, the largest, deepest lake in the Chain of Lakes system -
At 87 feet deep, 401 Acres**

Relationship of Tree Species Diversity and Water Quality



Using water clarity as a proxy for water quality

Water transparency is a quick and easy measurement that tells a lot about a lake's water quality

- It indicates the amount of light penetration into a lake.
- It provides an indirect measure of the amount of suspended material in the water, which in many cases is an indication of the amount of algae in the water.

Relationship of Tree Species Diversity and Water Quality

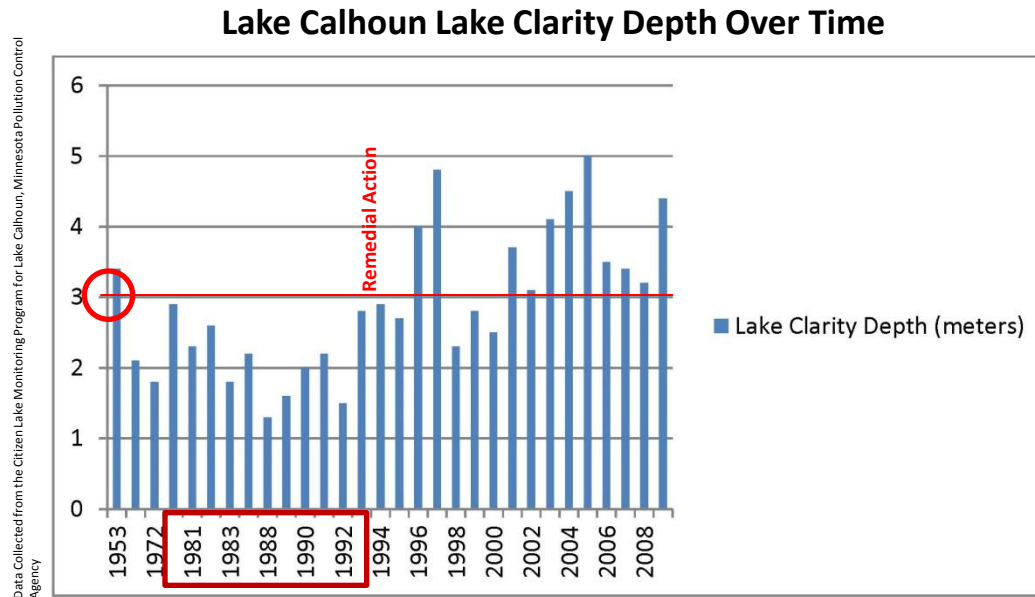


http://extras.mnginteractive.com/live/media/stories/2009/1027/20091027_091028estateLeak.jpg

A study completed by Mississippi Headwaters Board and Bemidji University (Krysel, Charles, et al, 2003) found that:

- In Minnesota, if lakes experienced a one-meter change in water clarity, the expected property price changes for these lakes are in the tens of thousands to millions of dollars.
- Homebuyers are influenced by water clarity when making purchases and are willing to pay more for a better environment

Relationship of Tree Species Diversity and Water Quality



There is a correlation to loss of tree canopy and water clarity

Following the removal of Elm trees (during the late 1980s and early 1990s), there was a **marked decrease in water clarity depth** in the Chain of Lakes, yet building development remained constant throughout the contributing sub-watershed around Lake Calhoun.

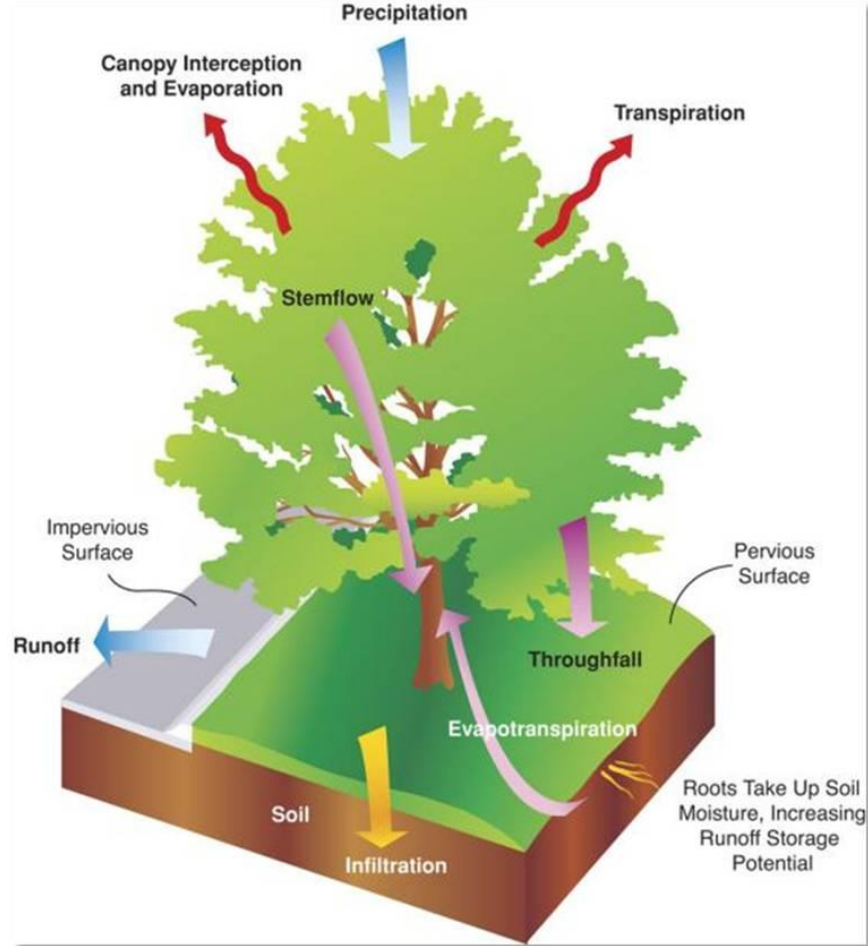
Relationship of Tree Species Diversity and Water Quality



A Remedial Action Plan was created to restore water quality in chain of lakes IN ADDITION to tree removal and replacement cost...

In 1990 citizens and interested groups formed the Minneapolis Chain of Lakes Clean Water Partnership (CWP) and started one of the largest urban lake restoration projects in the United States. CWP established nutrient reduction goals for each of the lakes in the chain, then set out to accomplish these goals through **\$12.4 million of rehabilitation actions.**

Relationship of Tree Species Diversity and Water Quality



Building resiliency in how we plant and manage trees allows for the potential of trees to be realized.

Relationship of Tree Species Diversity and Water Quality



Contact Information:

peter@tkdg.net
www.tkdg.net