Are Tree Species Diversity and Water Quality Related?

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Tree species diversity is crucial to minimize the impact of pests and disease outbreaks. After the introduction of Dutch Elm disease (DED), it became painfully evident how devastating tree pest outbreaks can be. Dutch Elm disease dramatically impacted canopy cover in Minneapolis in the 1970's and 80's. Before the introduction of Dutch Elm disease, Minneapolis was estimated to have between 200,000 and 600,000 Elms. The total cost of tree and stump removal, trimming, insect and disease control, inspection, and replanting as a result of DED in Minneapolis was $8 million in Minneapolis alone, and more than $5 million dollars each of the next 9 years.

As trees provide a wide range of ecological, social, and economic benefits, a sudden large decrease in tree canopy cover has far reaching effects. As trees provide stormwater volume and water quality benefits, it would stand to reason that a drastic decrease in canopy cover would result in decreased stormwater benefits and, as a result, water quality of receiving water bodies would be affected. It is therefore not surprising that the 1970's outbreak of Dutch Elm Disease (DED) in Minneapolis does indeed correlate to declining water quality in Minneapolis' Chain of Lakes. After canopy cover decreased dramatically, over 15 square miles in 20 years, in Minneapolis following the 1970's DED outbreak, water quality also significantly declined in Minneapolis' signature amenity. It took tens of millions of dollars to turn the water quality clock back to 1970, pre-DED.

Aside from the high direct costs associated with water quality problems, many indirect impacts result from water quality problems. For example, several studies found that real estate values go down as lake water quality decreases. Krysel et al (2003) studied the correlation between water clarity and lakeshore properties, using water clarity as a proxy for water quality. They found that water clarity positively affected prices paid for lakeshore properties located on Minnesota Lakes within the Mississippi Headwaters Board jurisdiction. Their results showed that if lakes experienced a one meter change in water clarity, the "expected property price changes for these lakes are in the magnitude of tens of thousands to millions of dollars." The change in lakeshore property prices for a one meter change in water clarity varied from lake to lake. Other researchers also found correlations between water quality in Wisconsin (David 1968 in Krysel et al 2003), southeast Michigan (Brashares 1985 in Krysel et al 2003), and Maine (Boyle et al 1998 in Krysel et al 2003).

If Minneapolis' 1970's urban forest had been more diverse, canopy cover would not have changed as dramatically due to DED. How would the costs that resulted from the water quality decline in Minneapolis' Chain of Lakes and large scale elm removals compare with the costs of maintaining tree species diversity targets?

How will Minneapolis' urban forest be affected by Emerald Ash Borer (EAB)? How can we protect the Chain of Lakes, Minneapolis' crown jewel, from future impacts of massive loss of tree canopy? Minneapolis currently has more than 30,000 ash street trees, approximately 10,000 ash trees located on park properties and an estimated 200,000 ash trees on private property (Minneapolis Park and Recreation Board, 2014), for a total of approximately 240,000 ash trees. In the words of the Minneapolis Park and Recreation Board, "Whether on public or private land, all ash trees are destined for infestation by EAB." The number of ash trees that will be lost in Minneapolis due to EAB could therefore very likely be as great as the number of elms lost in the 1970's and 1980's.

Minneapolis is not the only city prone to drastic negative environmental and economic impacts from tree pests and diseases. Rauch et al (2006) analyzed tree canopies in 12 cities in Eastern North America and found "an overabundance of Acer and Fraxinus", which are susceptible to Asian longhorned beetle and EAB, respectively, both devastating insect pests. They further report that "The most common genus of street tree was Acer. Maples were found in all cities where they comprised from 15% to 57% of the street trees. The next most common genera were Fraxinus and Quercus…In several of the cities surveyed, more than 50% of the street trees could be lost or require protection if these pest become widespread." The ecological and financial impacts of these pests are enormous. Potential costs associated with removals of urban ash trees alone in the US, for example, are estimated at $20 to $60 billion, not including replacement costs (Cappaert et al 2005 in Rauch et al 2006). How far would $20 to $60 billion dollars go to increase diversity to reduce such catastrophic tree pest outbreaks? How about an order of magnitude less: $2 to $6 billion?

Urban foresters recommend setting tree diversity targets to minimize the drastic effects of tree pest and disease outbreaks. For example, the "5-10-20" rule recommends a species, genus, family ratio of no more than 5% of one species, no more than 10% of one genus, and no more than 20% of one family for an urban forest. However, not many species can thrive in typical urban growing conditions, so the level of diversity of healthy urban trees that can realistically be achieved in urban conditions is extremely limited. The most significant problem urban trees face is the inadequate volume of soil useable for root growth. Research has shown that trees need approximately 2 cubic feet of soil volume for every 1 square foot of canopy area (e.g. Lindsey and Bassuk 1991). Most urban trees, confined to a 4' x 4' x 4' tree pit hole, have less than 1/10th the rooting volume they need to grow large. Therefore I propose improving growing conditions in urban areas to make it possible for a more diverse array of species to thrive in urban conditions, for example, by providing rootable soil volume under paved surfaces where adequate above ground rooting volume is not available. Techniques to provide rootable soil volume under paved surfaces make it possible for underground urban space that is currently used only for utility chases, to also be used to grow larger and more diverse trees.

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