Preserving Our Tree Canopy to Protect Water Quality

Watershed Forestry Initiative White Paper 2010-1

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Over the last several years, natural resource researchers and managers have been looking into the role that protecting tree canopy plays in protecting water quality. What they have found is that trees and the canopy that their leaves create are important to protecting water quality, even if the trees are not next to a lake, river or stream. Trees and forests serve our watershed by preventing erosion, filtering contaminants before they enter a waterway, absorbing rainfall and snow melt, recharging aquifers, and slowing storm water runoff.

Trees are one of the most cost-effective, efficient and pleasant tools we can use to help manage stormwater. Similar to wetlands, forests act as giant sponges that absorb and slowly release pollutants such as nutrients and sediment from stormwater runoff. Forests store, clean and slowly release about two-thirds of the water that maintains stream flow and replenishes groundwater.

In the Grand Traverse Bay watershed, the biggest threats to our water quality are not from industrial sources anymore; they are from the cumulative impacts of stormwater flowing over land and through storm drains to our lakes, rivers, and streams, carrying pollutants with them. On sites with natural vegetation, 10 percent of stormwater flows over the surface while 90 percent is infiltrated into the soils or evaporated; on sites with 75 to 100 percent impervious surface, 55 percent of the stormwater flows over the surface while 55 percent is infiltrated into the available soils or evaproted. As presented in the Grand Traverse Bay Watershed Protection Plan, the top two pollutants of concern throughout the entire watershed are sediments and nutrients. For the bay itself, the top two pollutants are nutrients and invasive species. The most common vector for sediments and nutrients to get into our lakes, rivers and streams is stormwater.

Watershed Forestry Defined

Watershed forestry is the use of forests and forestry practices to protect, restore, and sustain water quality, water flows, and watershed health and condition. Several organizations throughout the country have developed watershed forestry programs. One of the goals of these programs is to generate information about the ecosystem services forests provide for our communities. The US Forest Service supports Community-based Watershed Restoration Partnerships in various regions of the country and it works with the Center for Watershed Protection to provide stakeholder groups with tools and information to protect forests in their watersheds. The Chesapeake Bay Program, a partnership of state and federal agencies focused on restoring the bay, has initiated several programs to protect forests in its watershed.

In 2009, the United States Forest Service conducted a review of urban and community forests in Michigan as part of a regional study. The study, titled *Urban and Community Forests* of the North Central East Region, focused on forested lands not in commercial production forestry. It found that statewide tree canopy covers about 42.9 percent of the state, while tree cover in urban and community areas is about 21 percent of these areas. The study also calculated the benefits of Michigan's urban and community trees, as set out below.

Urban and community trees	107.8 million
Carbon stored	20.6 million metric tons
Carbon removed	678,000 metric tons
Air pollutants removed	14,820 metric tons

The study provides information on municipalities, townships and counties, including priority planting areas based on population density, available green space not covered by trees, and tree canopy per capita. For example, on the 100-point scale (with higher numbers having a higher planting priority), Traverse City received a 53 and the Village of Fife Lake received a 39.3. At the county level, Grand Traverse County received a 48.5 and Kalkaska County received a 37.8. The study was designed to provide information to managers of urban and community forests to help design, value, implement and evaluate their programs.

2010 Tree Canopy Cover Study

Through a grant from the Michigan Department of Natural Resources and Environment Urban and Community Forestry Program and the USFS State and Private Forestry Program, the Watershed Center Grand Traverse Bay had developed a data set of tree canopy cover for the years 2001 and 2009 at 30 meter resolution. We then partnered with the Northwest Michigan Council of Governments to run the data through the CITYgreen modeling software for the watershed as a whole and for the nine subwatersheds. The computer model measures tree canopy and quantifies changes over time; quantifies the ecological benefits of trees; and calculates a dollar value for the ecosystem services those trees are providing based on the costs of built infrastructure. CITYgreen calculates the volume of runoff in a 2-year 24-hour storm event that would need to be contained if all trees were removed. In this region, stormwater managers use 2.25 inches of rain as the amount for a 24-hour storm event that happens on average every two years. Also, for this study, orchards were categorized as a cropland land use.

The computer model associates a curve number with a particular land use. The curve number is an empirical parameter used in hydrology to predict stormwater runoff. The numbers were developed by the United States Department of Agriculture through field testing. The lower the curve number, the more stormwater is absorbed or infiltrated. The curve numbers listed below were used in the CITYgreen analysis for Grand Traverse Bay.

CITYgreen Curve Numbers by Land Use	
Trees/Forest cover	55
Meadow	58
Pasture	61
Open space (grass & trees)	61
Shrub	67
Urban (1 acre lots)	68
Urban (.25 acre lots)	75
Cropland	78
Urban (bare)	86
Urban (commercial)	92
Buildings and structures	98

CITYgreen Results

The results of the CITYgreen analysis indicated a decline in total tree cover in the Grand Traverse Bay Watershed between 2001 and 2009 of 4,126 acres, a 1.3% decrease. This means that the entire watershed lost the capacity of those trees to help manage more than 30 million cubic feet of stormwater during a 2.25 inch storm event. Because county stormwater ordinances administered by the county drain commissioners in the region are designed according to statute to address volume specifically and not water quality, the loss of tree canopy cover means that more stormwater is reaching our surface waters without sufficient nutrient and sediment infiltration or absorption to clean the water. Table 1 below presents a summary of the analysis on a watershed-wide and subwatershed level.

Table 1

CITYgreen Stormwater Results July 2010	2001 Tree Canopy (acres); percentage of all land uses	2001 Stormwater Storage (cubic feet)	2009 Tree Canopy (acres); percentage of all land uses	2009 Stormwater Storage (cubic feet)	Change Tree Canopy Cover (acres); percentage cover lost	Change in Stormwater Storage (cubic feet)
Grand Traverse Bay Watershed	306,071 49.4%	1,679,987,361	301,945 48.7%	1,649,883,686	4126 1.4%	30,103,675
Acme	5672 67.3%	30,385,878	5650 67%	30,224,391	23 0.4%	161,487
Boardman	99,691 54.9%	511,306,357	97,118 53.5%	492,835,875	2573 2.6%	18,470,482
East Shore	8772 44.3%	47,080,777	8606 43.5%	45,813,075	167 1.9%	1,267,702
Elk-River-Chain-	162,152	950,028,510	161,070	941,101,189	1082	8,927,321

of-Lakes	50.4%		50.1%		0.7%	
Mitchell	2859 28.5%	12,814,875	2791 27.9%	12,665,532	67 2.4%	149,343
Old Mission	5567 28.0%	28,151,001	5558 27.9%	28,153,191	9 0.2%	-2190
Ptobego	2187 23.9%	11,237,803	2172 23.7%	11,182,985	15 0.7%	54,818
West Shore	17,528 40.2%	90,582,175	17,449 40.0%	90,306,511	79 0.5%%	275,664
Yuba	1641 30.6%	7,388,413	1531 28.5%	6,796,219	110 7.2%	592,194

The largest gross tree canopy cover decline by subwatershed occurred in the Boardman River sub-watershed, where canopy cover decreased by 2,573 acres, or a 2.6 percent. The loss translates to a decline in stormwater management capacity of more than 19 million cubic feet. Because there is a fair amount of state forest lands in the Boardman River subwatershed, the results could simple document state timber management practices taking place in the area. If so, then the tree canopy cover should increase in the next several years as a result of trees regenerating in timber management areas. However, if the loss is the result of land use conversion, it is not a favorable trend for water quality protection.

The largest percentage tree canopy cover decline occurred in the Yuba Creek subwatershed, which saw a 7.2 percent decline in tree canopy cover. This subwatershed does not include state forest lands, so it is likely that this decline is the result of land use conversion. This trend is not favorable for water quality protection.

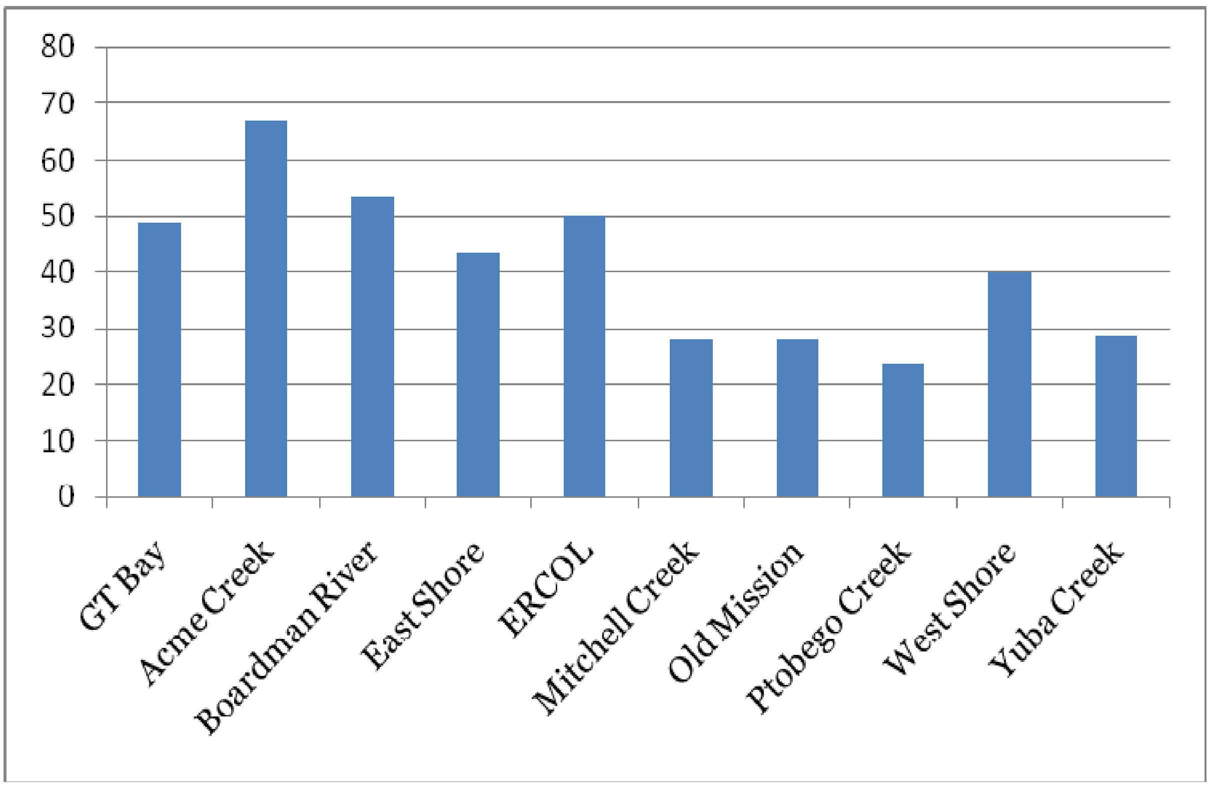
The smallest percentage decline occurred in the Old Mission subwatershed, which saw a 0.2 percent decline in tree canopy cover. This subwatershed experienced an *increase* in the ability of the land cover to manage stormwater, as shown by the negative number in the change of stormwater management capacity in Table 1. While Old Mission lost nine acres of tree canopy cover, it gained 26 acres of cropland cover, resulting in more vegetated land cover in the subwatershed. Between 2001 and 2009, the local government that encompasses the vast majority of the subwatershed, Peninsula Township, continued implementation of its farmland preservation program. While the CITYgreen results cannot be directly linked to the farmland preservation program, it is likely that the program is one of the reasons that vegetated land uses in the subwatershed increased.

The results from the Old Mission subwatershed demonstrate that trees are not the only land cover that provides stormwater management benefits. In general, vegetated land covers slow, filter and absorb stormwater more effectively than land covers where the soils have been compacted or covered with impervious surface.

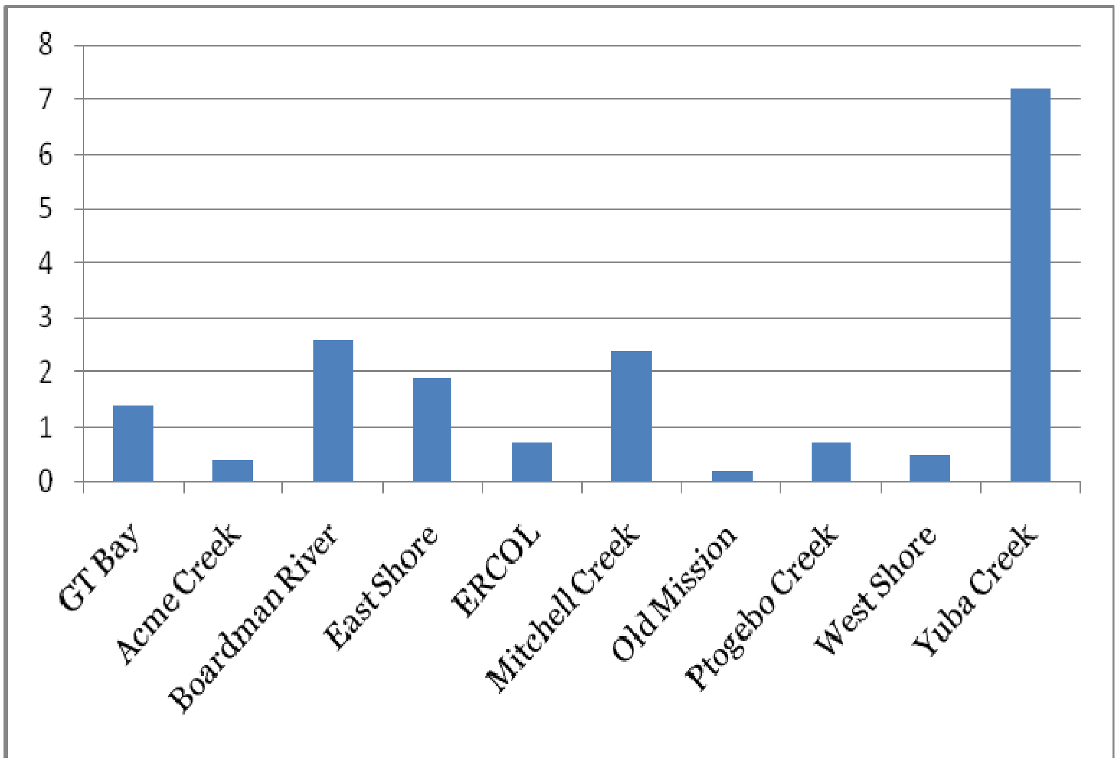
The CITYgreen analysis provides a landscape-scale picture of our tree canopy cover for the entire watershed and the nine subwatersheds. Graph 1 shows the percentage of tree canopy cover as a land use. American Forests recommends that cities east of the Mississippi River set a tree canopy cover goal of 40 percent and suburban areas east of the Mississippi set a goal of 50 percent. While the watershed as a whole is very close to meeting the 50 percent goal, several of the subwatersheds are not. One follow up to this study will be to engage local governments and other stakeholders in a conversation about setting tree canopy cover goals and identifying tools to help reach those goals.

Graph 2 shows the percentage change in tree cover for the watershed as a whole and for the nine subwatersheds. This information helps us identify where change in tree canopy cover is happening the fastest, consider the reasons for that change, and identify appropriate actions to address the rate of change. It also demonstrates that monitoring the changes in tree canopy cover over time will help identify larger trends and areas of concern.

Graph 1: Percentage Tree Canopy Cover 2009



Graph 2: Percentage Tree Canopy Cover Lost Between 2001 and 2009



Water Quality Implications

The CITYgreen modeling also uses a water quality analysis developed from the Natural Resources Conservation Service's Technical Release-55 (TR-55) on urban hydrology for small watersheds and Long Term Hydrologic Impact Analysis (L-Thia) to model water quality changes related to land uses. Generally, the relationship between rainfall, runoff and the curve number is non-linear, meaning that small changes in land use or rainfall can produce large changes in runoff. Because there were changes in several land use categories, the results of this analysis cannot be used to draw conclusions about loss of tree cover on water quality. However, Table 2 outlines some of the default loading values for several land uses. Based on these default values developed from field testing, stormwater runoff from forested areas has lower levels of pollutants than more developed land uses.

Table 2

Land use	CN	N mg/l	P mg/l	SS mg/l	Zn ppm	Lead ppm	Copper ppm	Cd ppm	Cr ppm	BOD Ppm	COD ppm
Paved lot	98	1.807	0.443	212.33	0.08	0.009	0.009	0.0075	0.0021	49.5	25.5
Commercial	85	2.096	0.443	69.00	0.18	0.013	0.009	0.0075	0.0100	116.0	23.0
Urban	83	2.096	0.209	69.00	0.08	0.009	0.009	0.0075	0.0021	49.5	25.5
Forest	73	0.780	0.150	39.00	0.006	0.005	0.010	0.0010	0.0075	0.0	0.5

CN = curve number; N=nitrogrn; P=phosphorus; SS=suspended solids; ZN=zinc; Cd=cadmium; Cr=chromium; BOD=biological oxygen demand; COD=chemical oxygen demand.

A sample of water quality standards helps provide some context to these numbers. The Michigan Department of Natural Resources and Environment uses 1 mg/l as its phosphorus standard for water quality permitting. The United States Environmental Protection Agency's drinking water standards for nitrates and nitrites is 10 mg/l. Municipal wastewater treatment plants in Michigan are usually required to meet a 30mg/l average over a 30-day period as their standard.

Air Quality and Carbon Sequestration

CITYgreen also models the air quality and carbon sequestration benefits from tree canopy cover. In terms of air quality, the model calculates the amount of nitrogen dioxide (NO2), sulfur dioxide (SO2), ozone (O3), carbon monoxide (CO), and particulate matter less than 10 microns (PM10) absorbed and filtered by the tree cover. The values used in the model were developed by the United States Forest Service through data collected from 55 cities across the country. With respect to carbon storage and sequestration, the model again relies on research from the United States Forest Service about the amount of carbon dioxide removed by leaves and carbon stored in the tree's biomass.

Table 3

CITYgreen Air Quality and Carbon Sequest-ration Results July 2010	2001 Tree Canopy (acres)	Pounds of air pollutants removed	Total Tons of Carbon stored/ Sequest-ered annually	2009 Tree Canopy (acres)	Pounds of air pollutants removed	Total Tons of Carbon stored/ Sequest-ered annually	Change in air pollutants removed	Change in Tons of Carbon stored/ Sequest-ered annually
Grand Traverse Bay	306,070.9 (49.4%)	20,189,761	131,707/ 1,025	301,945.0 (48.7%)	19,917,596	129,931/ 1,012	272,165	1,776/ 13

Watershed								
Acme	5672.4 (67.3%)	374,178	2,441/ 19	5649.5 (67.0%)	372,667	2,431/ 19	1,511	10/ 0
Boardman	99,691.2 (54.9%)	6,576,061	42,899/ 334	97,118.4 (53.5%)	6,406,348	41,791/ 325	169,713	1,108/ 23
East Shore	8772.3 (44.3%)	578,657	3,775/ 29	8605.5 (43.5%)	567,655	3,703/ 29	11,002	72/ 0
Elk-River-Chain-of-Lakes	162,152.1 (50.4%)	10,696,253	69,776/ 543	161,070.2 (50.1%)	10,624,886	69,311/ 540	71,367	465/ 3
Mitchell Creek	2858.8 (28.5%)	188,578	1,230/ 10	2791.4 (27.9%)	184,133	1,201/ 9	4,445	29/ 1
Old Mission	5567.2 (28%)	367,239	2,396/ 19	5557.7 (27.9%)	366,608	2,392/ 19	631	4/ 0
Ptobego	2187.4 (23.9%)	144,290	941/ 7	2172.1 (23.7%)	143,278	935/ 7	1,012	6/ 0
West Shore	17,527.9 (40.2%)	1,156,214	7,543/ 59	17,448.7 (40.0%)	1,150,992	7,508/ 58	5,222	35/ 1
Yuba	1641.0 (30.6%)	108,247	706/ 5	1530.9 (28.5%)	100,986	659/ 5	7,261	7/ 0

Conclusion

State forests and commercial timber lands provide an important element to our economic base. All our trees and forests help define our up north sense of place and our rural character. However, we don't often consider the importance of non-commercial forests and trees in our watershed. Our CITYgreen analysis of the Grand Traverse Bay watershed and the nine subwatersheds helps us better understand all the services our forests and trees provide for our communities.

Trees are important to water quality because they help slow rainfall, filter sediments and absorb nutrients during storm events. Trees and natural vegetation are integral elements of effective stormwater management in our watershed. If climate change results in more high peaks of runoff from larger storm events, as some studies have predicted, effective management of stormwater will only become more imperative to protecting our Up North water quality~and quality of life.