**The Role of Trees in**

**Protecting Water Quality on Old Mission Peninsula**

Over the last several years, natural resource researchers and managers are using new computer modeling tools to understand 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](http://www.chesapeakebay.net/wetlands.aspx?menuitem=14641), forests act as giant sponges that absorb and slowly release pollutants such as [nutrients](http://www.chesapeakebay.net/nutrients.aspx?menuitem=14690) and [sediment](http://www.chesapeakebay.net/sediments.aspx?menuitem=14691) from [stormwater runoff](http://www.chesapeakebay.net/stormwater.aspx?menuitem=19515). Forests store, clean and slowly release about two-thirds of the water that maintains [stream flow](http://www.chesapeakebay.net/riverflow.aspx?menuitem=14714) and replenishes [groundwater](http://www.chesapeakebay.net/groundwater.aspx?menuitem=14716).

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 evaporated. 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.

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

**Tree Canopy Cover Study in 2010**

Through a grant from the Michigan Department of Natural Resources' Urban and Community Forestry Program and the USFS State and Private Forestry Program, the Watershed Center Grand Traverse Bay developed a data set of tree canopy cover in the watershed 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. 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**

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| **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-of-Lakes | 162,152  50.4% | 950,028,510 | 161,070  50.1% | 941,101,189 | 1082  0.7% | 8,927,321 |
| 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 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.

**Tree Canopy Cover Study in 2013**

The fact that the 2010 tree canopy study showed that Old Mission Peninsula had increased its capacity to manage stormwater was very interesting, prompting discussions with the township about follow up, more detailed analysis. The CITYgreen analysis placed orchards in a general cropland category, so we were not able to quantify the value of cherry and apple orchards in terms of stormwater management.

At about the time that the 2010 tree canopy cover study was completed, the Watershed Center secured a grant from the Michigan Department of Environmental Quality that allowed, among other things, additional work with Peninsula Township on water quality issues specific to the township. Discussions between township representatives and Watershed Center staff led to a decision to embark on a more detailed analysis of the township's tree canopy cover.

Unfortunately, at about the same time, American Forests decided not to continue support of the CITYgreen software, making additional analysis using that software unwise. The Watershed Center determined that additional analysis should be done using iTree software, which is being supported by the US Forest Service. Because the Watershed Center staff was not experienced in using the iTree software, we worked with URS Corporation and the Grand Traverse Regional Land Conservancy to design a more detailed analysis of the Old Mission Peninsula using iTree. Funding from the MDEQ grant supported this work.

The study involved 30 locations on Old Mission Peninsula selected to represent a variety of land uses - existing agriculture, existing rural agriculture, existing residential, existing commercial, and existing public/semi-public lands. Sample plot size was .1 acre. The data collected from available online sources was then ground truthed with the help of Grand Traverse Regional Land Conservancy staff.

One of the outcomes of the iTree analysis is avoided runoff. When it rains and snows, some portion of the precipitation is intercepted by vegetation, such as trees and shrubs, while the other portion reaches the ground. The portion of the precipitation that reaches the ground and does not infiltrate into the soil because of compacted soiled or impervious surfaces becomes runoff. Trees intercept precipitation, while their root systems promote infiltration and storage in soil. As common sense dictates, larger trees with larger canopies intercept more rain than smaller trees. The more avoided runoff, the less likely it is that pollutants are going to reach a lake, river or stream through stormwater runoff.

This outcome is different from the outcome of the CITYgreen analysis, which measured stormwater storage. The model is run using the average rainfall for a 2 year, 24-hour storm event, which is 2.25 inches in our area. The CITYgreen outcome represents the difference between the existing land use cover, cropland for example, and replacement of the tree canopy of the existing land use cover with a different land cover, such as residential. The outcome results in the amount of additional stormwater management needs as a result of a change in land use with more impervious surface.

Because the iTree software is focused on the role of trees, the outcomes are related specifically to the role of different kinds of trees. We were able to gather direct information about the role of cherry and apple orchards, as well as the role of trees in general throughout the township. The general results of the analysis are outlined below:

Estimated number of trees: 1,130,000

Estimated tree canopy cover: 51.2%

Estimated pollution removal: 118 tons/year at a value of $1.05 million/year

Estimated carbon storage: 108,000 tons ($7.69 million)

Estimated carbon sequestration: 4,390 tons/year ($313,000/ year)

Estimated avoided runoff: 7,451,000 cubic feet/year ($496,000/year)

The data collected from the 30 plots found that sweet cherries, tart cherries, and apples were the most common trees. Extrapolating that data to the entire township and its existing land uses, these orchard trees were the most common trees in terms of number and the fourth most important in terms of avoided runoff.

Specifically, the iTree analysis found that the estimated number of sweet cherries, tart cherries, and apple trees is 318,920 trees across the township and the estimated amount of runoff avoided by these trees is 615,679 cubic feet/year. Conversion of these existing orchards to residential development would result in a substantial increase in the amount of stormwater runoff.

While we anticipated results that helped demonstrate the benefits of the township's farmland protection program in terms of helping manage stormwater runoff, what was surprising were the results about other tree species. Eastern hemlock, sugar maple, and Western white pine were the top three species in terms of avoided runoff in the township. Many of these trees are larger than the orchard trees. For example, all of the apple trees were 3 inches in diameter or less, while the majority of Eastern hemlocks were 9 inches or larger.

However, it is also the nature of the individual trees that impacts its ability to help with managing stormwater. According to the National Tree Benefit Calculator (which uses the iTree software for its calculations), a 3-inch apple tree intercepts 38 gallons of stormwater runoff a year, while a 3-inch Eastern hemlock intercepts 131 gallons of stormwater runoff a year. The largest hemlocks found on the 30 sample plots in Peninsula Township were 18 to 21 inches in diameter. An 18-inch hemlock intercepts 2,254 gallons of stormwater runoff per year.

In total, the existing hemlocks, sugar maples and white pines in the township are responsible for 67 percent of the avoided runoff. The existing mature trees throughout the township on all kinds of land uses play an incredibly valuable role in avoiding runoff and protecting water quality. Preservation and protection of large trees during site redevelopment on all land uses is important to the continued avoidance of runoff and protection of water quality in the township. Any policies or programs that protect large existing trees and encourage the replanting of larger trees on redeveloped sites will help protect the township's water quality.

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| **Tree Species** | **Estimated Number of Trees** | **Estimated Avoided Runoff**  (cubic feet per year) |
| Eastern hemlock | 103,180 | 2,409,143 |
| Sugar maple | 85,760 | 1,403,311 |
| Western white pine | 151,420 | 1,185,764 |
| Orchard trees (sweet cherries, tart cherries, apples) | 318,920 | 615,679 |
| Northern red oak | 31,490 | 602,326 |
| Red pine | 241,870 | 562,432 |
| Red maple | 44,890 | 248,486 |

**Conclusions**

The CITYgreen analysis demonstrated a correlation between an increase in the amount of land in vegetated cover and an increase in the capacity of the land in the township to manage stormwater between 2001 and 2009.

This time period coincides with the implementation of the purchase of development rights program in the township. The program has prevented the conversion of significant amounts of potential impervious surface and contributed to the preservation of orchards and vineyards as well as the retention of wooded areas – land covers which are all preferable to residential development with respect to managing stormwater runoff from impervious cover.

The iTree analysis demonstrated orchard trees play an important role in managing stormwater runoff in the township, as they are the most common trees. The study also showed that allowing existing trees to further mature is the best thing that can be done to better manage stormwater runoff. In other words, retention of existing trees is important to managing stormwater runoff. In terms of how that finding could translate into township policy, encouraging the protection of an existing forested area in a planned unit development as open space provides a greater water quality benefit than protection of an open field. In general, policies that encourage retention of existing trees and planting of new trees will help manage stormwater runoff and improve water quality in the township.