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Muskegon Futures:
Managing the Land

Muskegon Watershed Research Partnership **Volume 2**

Introduction

It is hard to imagine that the Muskegon River Watershed could experience a more dramatic transformation than the massive harvesting of its forests between 1850's and the turn of the 20th Century. Yet, the Muskegon Watershed Research Partnership's (MWRP) Mega Model projections suggest that the next fifty years might bring more ecological change to the region than the last fifty, or even one hundred and fifty years. How are land management decisions we make today affecting the future of the river and Lake Michigan?

Scenario Modeling

In 2002, 37 representatives from 13 watershed organizations and government agencies met with MRWP scientists to decide what management issues should be explored with the developing MWRP Muskegon River Ecological Modeling System (MREMS or Mega Model). Together the group decided to evaluate a number of future land management options ranging from reduced rates of urbanization to forest expansion. Climate conditions for each scenario are the same so differences in ecological outcomes are due only to the landscape management option being tested. Ten different future landscape scenarios (for the period 2010-2100) and 10 historical (1830-1970) landscapes were evaluated using Mega Model estimates of hydrology, temperature, main stem hydraulics sediment transport, chemistry, and the condition of fish and aquatic insect populations for each of the landscapes generated.

Business As Usual (BAU) Scenario

In this scenario the Land Transformation Model (LTM2) constructed future landscapes assuming the average rate of urban and forest growth observed from 1978 to 1998 would continue into the future. Expansions of urban areas and forest occur at the expense of agriculture, and so farming in this version of the future will continue to decline across the watershed, as urban and suburban development expands.

The future of the Muskegon River under this scenario is troubling. During most of the 20th century the effects of expanding urbanization has been partially masked by the even faster re-growth of the watershed's forested lands from the timber harvests of the 19th century. It has been only since the 1980's that forest recovery began to substantially slow while urbanization continued to increase (see FIG. 1).

This urbanizing landscape configuration continues with the BAU scenario, with forest cover slowly declining through the year 2100. That, and the continued growth of urban land cover leads to a new hydrologic function and contaminant availabilities as we approach the 22nd century.

While this might seem like a good thing, the practical implications are that for the next hundred years, both storm flows and summer base flows will be getting larger and larger leading to ever increasing rates of sediment erosion and transport, and lateral flooding. MREMS suggests that many river segments

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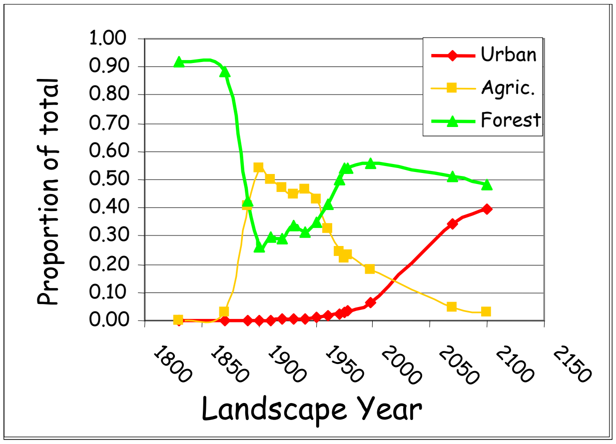
Business As Usual (BAU) Scenario (continued)

FIGURE 1. ***The most important effect of this change in landscape composition, according to the MREMS simulations, will be an increasing efficiency with which the watershed will convert snow and rain into river flow.***



channels will need 10-30% larger conveyance capacities and will move towards that goal by either extensive lateral erosion or by cutting-off existing meanders to increase channel slopes (see FIG. 2). Hand-in-hand with erosion comes downstream channel filling with sand in some areas. The overall result will be a 20-30% increase in the annual rate of sediment delivery to the main stem impoundment system and to Muskegon Lake. Along with sediment, the MWRP models predict increases in rates of carbon, nitrogen, and phosphorus loading to these waters, to Muskegon Lake, and Lake Michigan. Nutrients will in turn contribute to accelerating rates of eutrophication. On a brighter note: water temperatures (assuming no future increase in air temperature or precipitation) will be slightly cooler as a larger fraction of the rainfall is diverted from evapotranspiration to recharge of groundwater aquifers, and surface routing.

The implications of the BAU scenario for river fishes and related organisms are also quite negative. Overall ecological condition of the fish and aquatic insect community declines over time. Based on the MWRP analysis the ecological status of most of the Muskegon River is unimpaired (approximately 10% of river miles ecologically degraded). The Muskegon River today is one of the best examples of an ecologically healthy river system in Michigan's Lower Peninsula. The BAU scenario suggests that by 2070 over 24% of the river system will be ecologically degraded. This implies a drop in fish and insect diversity, and shifts in species composition towards more pollution tolerant organisms and smaller populations of rare and sensitive organisms.

Not all species will be negatively affected, nor all places. Detailed models of main stem Steelhead reproduction suggest that higher flows and marginally lower temperatures with lead to larger populations of smaller steelhead parr each year. The overall effect on adult steelhead production is unclear, but scientists are working on more sophisticated models to evaluate this. Larger, cooler flows may also favor other salmonids in the main stem river, but significant losses of the populations are predicted in many of our important tributary systems.

Reduced Sprawl (RUS) Scenario

In the reduced urban sprawl scenarios we have LTM2 project future landscapes with the constraint that urban land-use in the watershed grows at half the average observed rate. In the real world this could be achieved either by halving the population growth rate (by county), **or** reducing the so-called "sprawl rate" by 50% (***sprawl rate*** *is the ratio of: increase in developed land surface, to increase in human population size*). Alternately, the same effect could be achieved by simultaneously reducing both population growth and sprawl rate (e.g. a 25% reduction in growth and a 25% reduction in sprawl rate yields a 50% reduction in urban land cover). Typically, sprawl rate is reduced by zoning restrictions. Population growth is driven by combinations of economic and aesthetic incentives, disincentives, and the state of the general economy. In this scenario urban expansion is reduced, but forest recovery continues at 1978-1998 rates. The result is a landscape with less urban and much more forest land cover. Because urbanization and reforestation occur at the expense of farmland, agricultural land-use is much reduced (compare in FIG. 2 to BAU scenario).

Since the future is still substantially dominated by urbanization in the southwestern part of the watershed, river flows are still predicted to rise and nutrient levels to increase. But the extent of this change is reduced relative to the BAU scenario. The RUS scenario is a "greener" vision of the future by far, with not only the most forest cover across the watershed, but also with the lowest projected rates of eutrophication in receiving waters, and the least impact on fish and other biological communities inhabiting the river system (see FIG. 2).


Photo Courtesy of AWRI

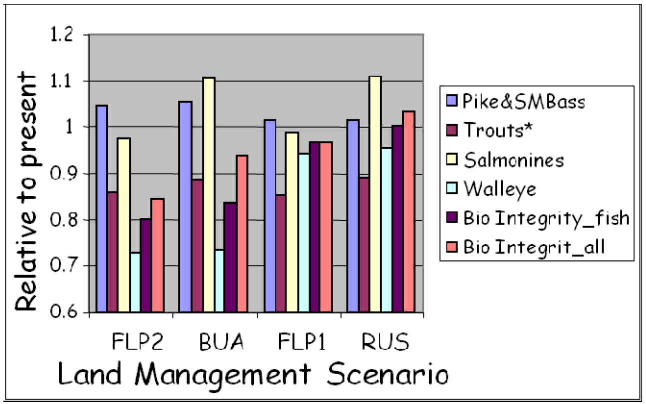


FIGURE 2. Biological responses to MREMS landscape scenarios. Presented as change relative to present day.

Farmland Preservation (FLP) Scenario

Urban sprawl gobbles up farmland, and economically marginal farm land is abandoned to forest. Increasing speculation about the potential for an agricultural rival in Michigan associated with biofuel development requires a vision of the future in which the Muskegon watershed's farmland is more actively preserved in the face of urban sprawl. In the FLP scenarios conversion of existing farmland to shrubs and then forest is not allowed. Urbanization continues at the expense of agricultural lands, either at a reduced rate (FLP1 uses the RUS sprawl rate), or the observed historical rate (FLP2 uses the BAU sprawl rate). FLP1 preserves the most farmland, FLP2 the next most of our major future scenarios . Not surprisingly the results of the MREMS simulations for the farmland preservation scenarios lie roughly in between the results of the highly urbanized BAU and very green RUS scenarios (see FIG. 3). Increases in flow and erosion are still substantial, nitrogen loads and concentrations are quite a bit higher, but phosphorus loadings are lower than in the business as usual scenario. The overall impact on the ecological health of the river lies likewise between the two more extreme land management scenarios.

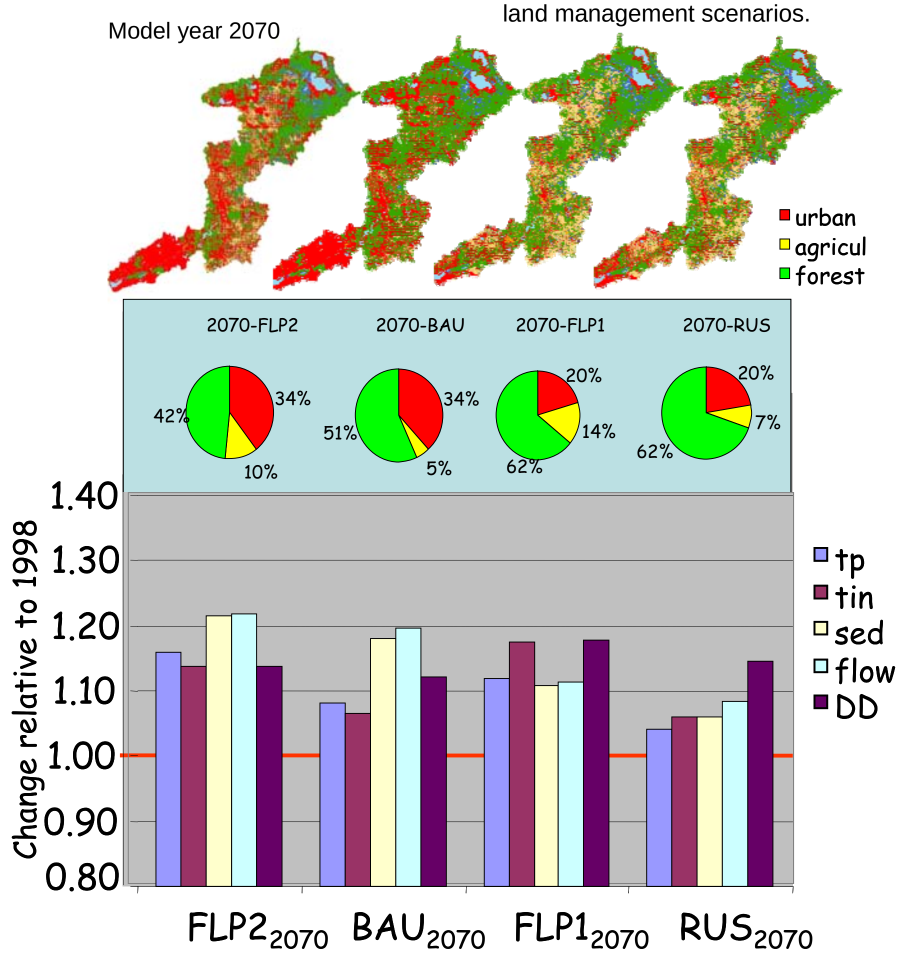


FIGURE 3. Summary comparison of BUA, RUS, and FLP scenario outcomes for model year 2070., and the lower reaches of the Muskegon river. Note that Climate is held constant for all scenarios and that scenarios are ordered by decreasing impact on physical channel variables. TP = average annual total phosphorus load; tin = average annual dissolved inorganic nitrogen load; flow is the average annual discharge rate; DD = channel dominant discharge. Changes in dominant discharge imply a long term trajectory of erosion (DD increasing) or deposition and meander formation (DD decreasing relative to 1998).

Riparian Setback Regulations

"Setback" regulations are a zoning tool often used to protect riparian corridors and watershed ecosystems from the negative impacts of over-development. They involve establishing setback buffers which preclude building and/or other activities within set distances of the water's edge. In some cases these setbacks are also related to floodplain risks and normal high water conditions. The MWRP Mega Model was used to look at the impacts of building restrictions implemented at three different scales. Setback rules were put into effect in model simulation year 1998, so that they only affect future landscapes. Two of the setback scenarios restricted building along the main stem and major tributaries only, at either a setback distance of 100m (~300ft) or 300m (~1000 ft). A third, more extensive setback scenario varied in terms of actual distance to the channel depending on topography and hydrogeology. In that scenario building was excluded from any site that had a ground water travel time of less than one year; a very rigorous setback restriction by normal zoning standards.

The results of the MREMS simulations of the three setback designs were consistent regardless of the underlying landscape scenario to which they applied. Setbacks had little effect on modeled nutrient loads, but altered river hydrology by decreasing annual average flows along the main stem river, and reducing storm flows in many tributaries. Sediment transport and erosion often declined as well. Impacts on the biological community varied with species. The overall affect on fishes was positive, especially for brook trout, rainbow trout, and walleye. However, the scale of the impact of riparian buffer setbacks was, generally, quite small compared to the impact of overall patterns in land-use change described earlier. The smaller setback design of 100m on the main stem and larger tributaries had an almost undetectable impact on MREMS ecological predictions. Large setbacks of 300m provided the most dramatic protection across the board, reducing flow and nutrient levels typically by 1-2%, and increasing habitat for trout and walleye by similar amounts. Compare this to the 20-30% changes driven by land use transitions at the whole watershed level. Sensitivity to the setback designs was about an order of magnitude less than to urbanization and forest change scenarios. This clearly means that setback regulations may help mitigate but not reverse the effects of larger scale land management patterns.

Photo Courtesy of AWRI

A Climate Caveat

In the MWRP modeling studies, rain and temperature patterns are held constant at 1985-2005 levels to allow us to evaluate the effects of landuse change alone. However, precipitation rates on the Muskegon watershed have in fact been slowly climbing since the 1890's; and today's best climate projections call for both increasing rain and temperatures into the next century. Since MREMS predicts a future of higher river loads, increased erosion and sediment transport, and greater pollutant loading with constant weather. Increased precipitation will only exacerbate these problems, and lead to higher rates of change. The configuration of the watershed's landscape will largely determine how much higher.

Photo Courtesy of Gale Nobes

The Bottom Line…

How we decide to use our landscape will largely determine the future of the Muskegon River. MWRP Mega Modeling studies suggest that: (1) Controlling the rate of urban sprawl is the single most potent tool available to protect the future of the river, its fishery, and its receiving waters including Lake Michigan. (2) Maximizing forest cover in the future, will (as it has in the past) provide substantial mitigation of the effects of urban and suburban development. (3) Riparian setback rules provide real ecological value, but cannot compensate for extensive watershed development. (4) The prospect of climate change makes rational land-use planning all the more imperative.

Photo Courtesy of Gale Nobes