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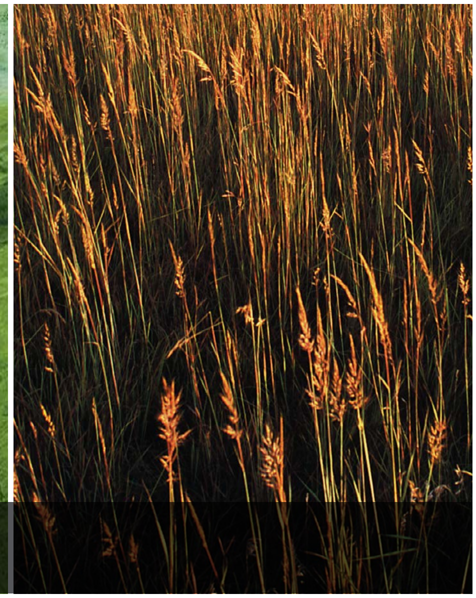

Informing Lake Erie Agriculture Nutrient Management

The US EPA and Environment Canada recently announced new phosphorus (P) loading targets for Lake Erie that are expected to reduce the occurrence and severity of harmful algal blooms (HABs) in the lake's western basin and low oxygen conditions (hypoxia) in the central basin. The Maumee River contributes 48 percent of the phosphorus to the western basin of Lake Erie, and has been identified as the primary driver of HABs. Therefore, the targets limit March-July loadings from the Maumee River to 186 metric tonnes of dissolved reactive phosphorus (DRP), and 860 metric tonnes of total phosphorus (TP) — a 40% reduction from 2008 values.

Six groups of modelers from universities, government, and industry came together to evaluate potential options for agricultural management to reduce phosphorus loads. The project team focused on agricultural nonpoint sources of P, because approximately 85 percent of the P leaving the watershed at the outlet of the Maumee River is from farm fertilizers and manure (Figure 1), even though the total load from the Maumee is only 10% of fertilizer and manure applications in the watershed.

We used multiple models to simulate a range of potential outcomes and raise confidence in model results. Five of the six models used USDA's Soil and Water Assessment Tool (SWAT) - a state-of-the-art watershed model commonly used to test how land management actions influence water quality outcomes. Even though they used the same base model, each group's model was different because of the critical different decisions they make about spatial discretization, input data sources, subroutines to use, land management operations, model parameterization, and calibration approaches. Each of these decisions contributes to real differences between and among SWAT models. The sixth model was a USGS SPAtially Referenced Regressions on Watershed attributes (SPARROW) model.

Phosphorus Delivery (tonne/y, %)

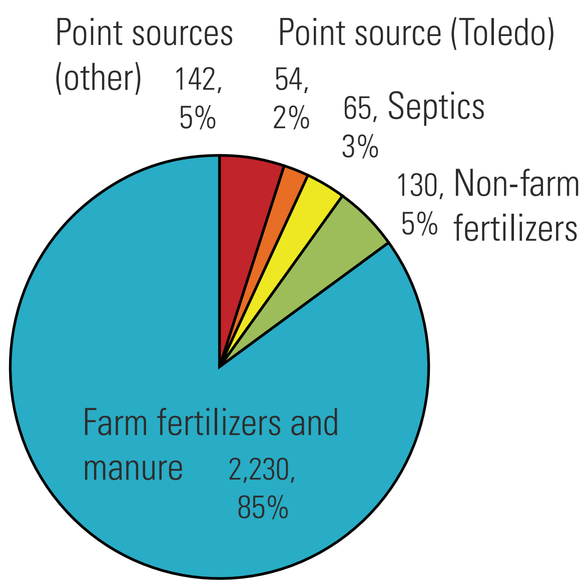

Figure 1: A conservative estimate of the contribution of farm fertilizers and manures to the total Maumee River phosphorus load. The estimated delivery from farm fertilizers and manures (2,230 t/y) is approximately 10% of what we estimate is applied to those farm fields (25,300 t/y). This chart was developed by subtracting the known inputs of point sources, failing septics and non-farm fertilizers (assuming 100 percent delivery to the lake) from the average load from the Maumee River 2005-2014. The delivered load from farm fertilizers and manures also includes legacy sources in soils and streams.

Each group used the same inputs of climate and point sources, and ran their models of the Maumee River watershed for the same time period (2005-2014). Models were validated to observed streamflow and water quality data to increase confidence in their simulation of watershed processes. Agricultural, environmental, and policy stakeholders from the Lake Erie region were consulted to develop agricultural land management scenarios to test in the five SWAT models. Twelve bundles — combinations of one or more agricultural conservation practices — were tested and included a variety of practices — in-field, edge-of-field, and structural.

The bundles were either randomly distributed across the watershed or targeted to P hotspots (vulnerable areas) and, in some cases, marginal lands. They were applied with varying intensity, in terms of the number of practices placed on the same land and/or the geographic extent of practices overall. While not all scenarios may be considered feasible in the current policy and agricultural systems, these scenarios illustrate the extent to which current land management may need to evolve to address the new targets.

MAIN FINDINGS (FIGURE 2, TABLE 1):

- There is a need for widespread adoption of agricultural conservation practices. While meeting the goals is possible with some scenarios, addressing them will be challenging;
- Targeting practices to where they are most beneficial is more effective than random placement;
- Combinations of practices may be needed in order to address the various ways that P is able to move through the landscape; and
- Even bundles that met targets on average may not reach targets every year due to the influence of climate variability.

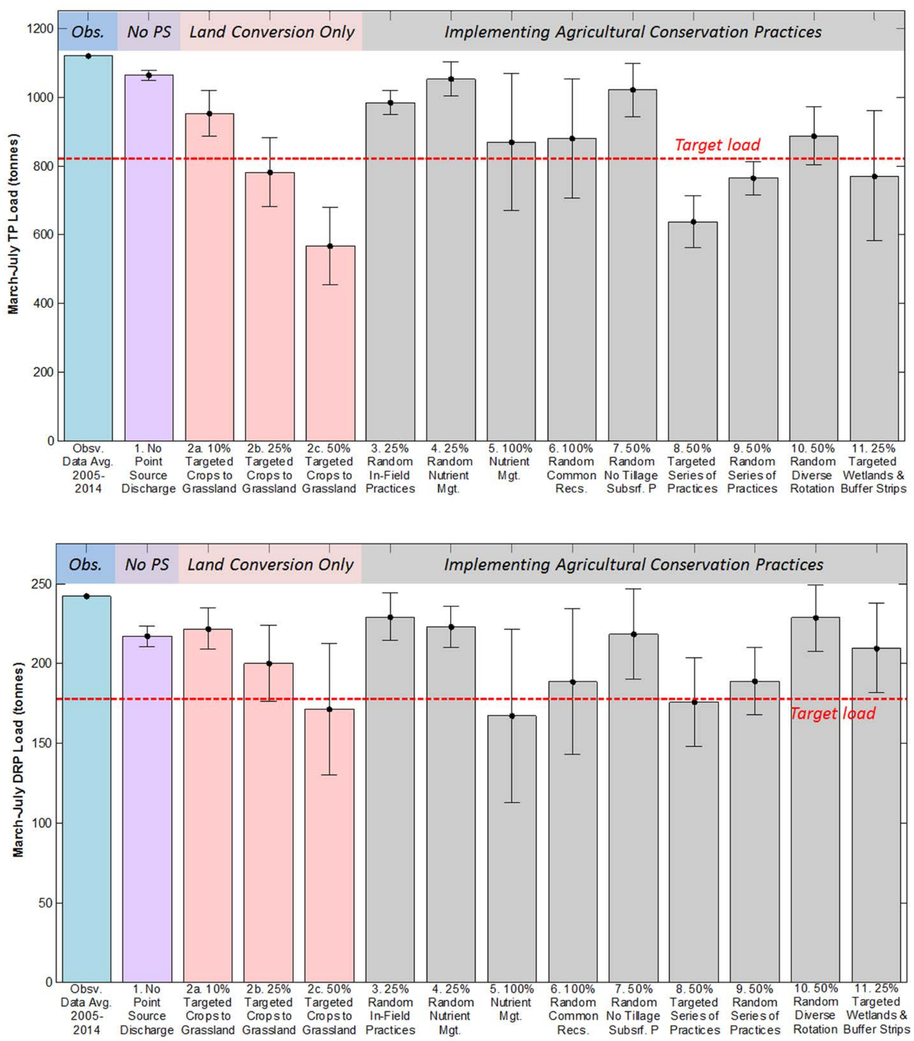

Figure 2: Average and standard deviation of the five SWAT models' March-July TP (top) and DRP (bottom) loads during the 2005-2014 modeling time period. The average observed March-July loads from 2005-2014 are shown in the blue bars, the result for removing all point source discharges in the watershed is shown in the purple bars, and the Annex 4 target loads (area-weighted to Waterville, OH gage station) are shown by the red dashed lines. Pink bars show a dose response as to how much land would need to be converted to grassland in order to meet the targets without going beyond current agricultural conservation measures. Gray bars show the effect of implementing more agricultural conservation.

LEARN MORE

- About the Project: http://bit.ly/WBNutrientsProject
- Read the Full Report: http://bit.ly/WBNutrientsReport
- See the Video: http://bit.ly/LakeErieWatershed

ACKNOWLEDGEMENTS

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SUPPORT

The Water Center addresses critical and emerging water resource challenges to improve the policy and management decisions that affect our waters by integrating decision makers, other end users, and natural and social scientists in collaborative research projects. The Water Center is part of the Graham Sustainability Institute, which integrates faculty and student talent across the University of Michigan, and partners with external stakeholders, to foster collaborative sustainability solutions at all scales.

No.	Name	Policy question	Project findings
1	No Point Source Discharges	Can phosphorus targets be reached by point source management alone?	Removing point sources entirely from the watershed reduced phosphorus loading, but did not achieve targets.
2a-c	Cropland conversion to grassland at 10% (2a), 25% (2b), and 50% (2c) targeted adoption	If agricultural management is unchanged, how much row cropland would need to be converted to grassland to reach the targets?	In this dose-response approach, we found that TP targets could be achieved with nearly 25% conversion of cropland to grassland, and DRP targets were met with closer to 50% conversion. The difficulty reducing DRP loadings may be a result of legacy P stored in soils within the Maumee River watershed.
3	In-field practices at 25% random adoption	What can be achieved at 25% application of in-field practices?	While in-field practices did serve to reduce both TP and DRP losses, random implementation on only 25% of croplands was not enough to achieve either the TP or DRP targets.
4	Nutrient management at 25% random adoption	What level of nutrient management will be sufficient to reach phosphorus targets?	Nutrient management at 25% implementation is not enough to achieve TP or DRP load targets.
5	Nutrient management at 100% adoption	Can nutrient management alone achieve targets?	On average, nutrient management alone has the potential to achieve DRP targets, but not TP targets.
6	Commonly recommended practices at 100% random adoption	What extent of adoption of commonly recommended practices will be needed to achieve the targets?	While 100% adoption of at least one commonly recommended conservation practice helped move average loads closer to target goals, adoption of multiple practices per farm field may be required to achieve the targets.
7	Continuous no-tillage and subsurface placement of P fertilizer at 50% random adoption	Is no-tillage effective provided P is applied below the soil surface?	Implementing subsurface application of P fertilizers in a no-tillage system can help reduce P losses; however, when implemented on 50% of cropland, this combination of practices is not sufficient to achieve load targets.
8	Series of practices at 50% targeted adoption	What extent of targeted in-field and edge-of-field practices reaches the targets?	Results showed that a series of in-field and edge-of-field practices on the same crop fields could achieve the TP load target with random application at 50% adoption and well exceeded the target load with targeted placement of the practices on high P exporting croplands. Targeted implementation was required to achieve the DRP target load. These results indicate the value of targeting conservation practices to lands with the highest P losses.
9	Series of practices at 50% random adoption	What if in-field and edge-of-field practices were applied at random?	
10	Diversified rotation at 50% random adoption	What is the impact of returning to winter wheat and winter cover crops?	The results of the diversified rotations are less conclusive as some of the models had Baseline wheat rotations where the wheat was double-cropped with soybean in the same year. On average, the models showed marked reductions in TP loads and some improvement in DRP loads with the diversified rotation.
11	Wetlands and buffer strips at 25% targeted adoption	How much P reduction can be achieved through structural practices?	Wetlands targeted to 25% of high P loading sub-watersheds and buffer strips targeted to 25% of high P exporting cropland could achieve TP loading targets on average, but not DRP. This is partially due to the fact that much of DRP exits cropland via subsurface drains which are not intercepted by buffer strips.

Table 1: Summary of the project findings according to the policy questions they were intended to address.