Soil Phosphorus Trends in the Lake Erie Region

By Tom Bruulsema

Over the past 15 years, increasing loads of dissolved P into Lake Erie have focused attention on agriculture in its watershed.

During the same time period, soil test P levels have declined. Fewer soils now test at extremely high P levels, and nearly half test at levels where crop yields depend directly on annual P application.

Opportunities to contribute to P load reductions for Lake Erie include better directing P applications to the soils testing below the optimum range, better timing and placement, and improved integration with other conservation practices in a complete 4R Nutrient Stewardship approach.

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Bigger harvests from cropland near Lake Erie have led to lower levels of soil test P. Photo of farmland near Leamington, Ontario.

Recent trends in algal blooms in Lake Erie have focused considerable attention on P losses from agriculture in its watershed. The lake's western basin has been the most affected. Considerable portions of the cropland in Ohio, Indiana, Michigan, and Ontario drain into the western basin. Tributary monitoring has shown increasing trends in the load and concentration of dissolved P from the mid-1990s to the present, particularly for the March through July period. The causes of the increasing trend are not yet fully understood, but since agriculture occupies the majority of the watershed and cycles large amounts of P, it is receiving considerable attention.

Abbreviations and notes: P = phosphorus; CEAP = Conservation Effects Assessment Project; USDA-NRCS = United States Department of Agriculture, Natural Resources Conservation Service.

The 2015 soil test summary by the International Plant Nutrition Institute (IPNI) was the largest ever conducted (IPNI, 2016). Thus data are available and presented here for the distribution of soil test P in these four jurisdictions. **Figures 1a** and **1b** shows the results and trends for relative frequencies of soil test P. These are based on a compilation of all samples submitted to the public and private laboratories that participated in the summary. The number of samples increased over time, largely due to increased frequency and intensity of soil sampling. Representation of the land area is not perfect, however, since some farmers sample more intensively than others. The 2012 CEAP survey of the U.S. portion of the watershed estimated that 71% of the cropland had soil nutrient tests taken in the past five years (USDA-NRCS, 2016).

Several different soil test methods are widely used across the region. Many producers and commercial laboratories use the Mehlich-3 method. To provide comparability over the region, all soil test levels were converted to the Bray and Kurtz P1 soil test, which is the one used as the basis for the region's tri-state soil fertility recommendations. The maintenance range, which can be considered optimum, is 15 to 30 ppm for corn and soybeans, and 20 to 40 ppm for alfalfa and wheat. Soil fertility recommendations in the province of Ontario are based on the Olsen soil test. While Ontario's sufficiency-based recommendations differ from the "build and maintain" approach used in the tri-state region, critical levels are roughly similar.

In each of the four jurisdictions, the frequency of soils testing in the 0 to 15 ppm range increased. Pooled together over the region, the percentage of the soils that were below the lowest critical level increased from 13% in 2001 to 28% in 2015. In addition, yield of some crops could be P limited in the 16 to 25 ppm range as well, which increased from 19 to 22% over the same time period. Thus, currently, P would be expected to limit yields of some crops, if none were applied, on half the cropland in these four jurisdictions.

Concurrent with the increase in soils testing below critical levels, the frequency of soils testing considerably higher than optimum (above 50 ppm) declined from 36 to 26% overall. This represents a reduction of risk to water quality, and is not a threat to crop productivity. The decline was particularly prominent in Michigan and Ontario. It possibly reflects success in nutrient management efforts by livestock operations over the past few decades.

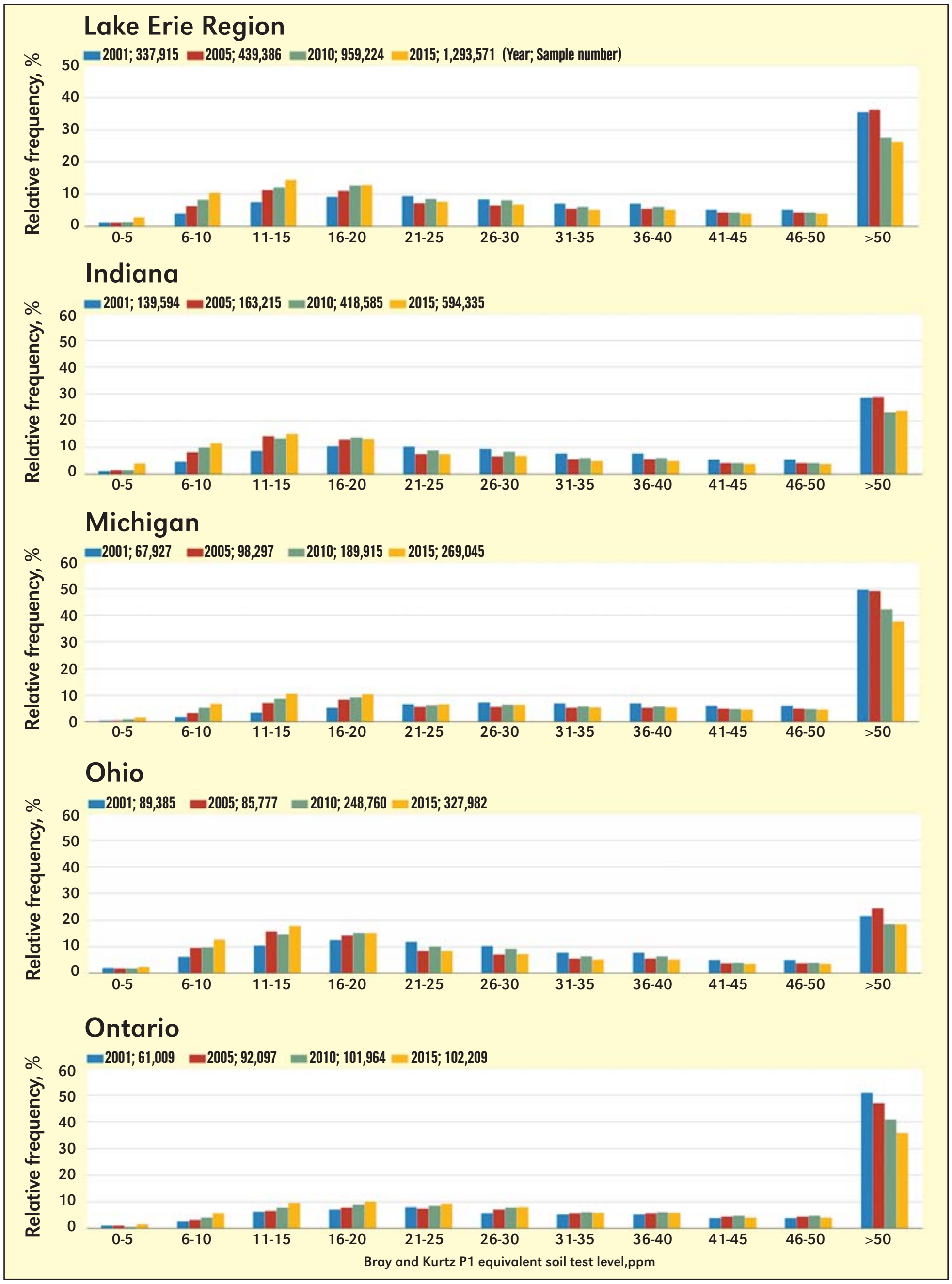

Figure 1a. Relative frequencies of soil test P levels from 2001 to 2015, for the province and three states with substantial drainage into Lake Erie.

The changes in soil test P levels are consistent with changes in the cropland P balance (**Figures 2** and **3**). During the 1970s and 1980s, cropland P balances were in surplus, as indicated for 1987. Over time, with increasing crop yields and removal of P with harvest, surpluses have diminished and deficits have increased. The 2012 CEAP survey found that 58% of cropland acres were managed with P application rates at or below crop removal rates (USDA-NRCS, 2016). Ontario cropland receives a greater proportion of its P inputs as manure than the cropland of the Lake Erie basin in the U.S.; thus, the priorities for reducing risks of P loss to water may differ between these jurisdictions to some extent.

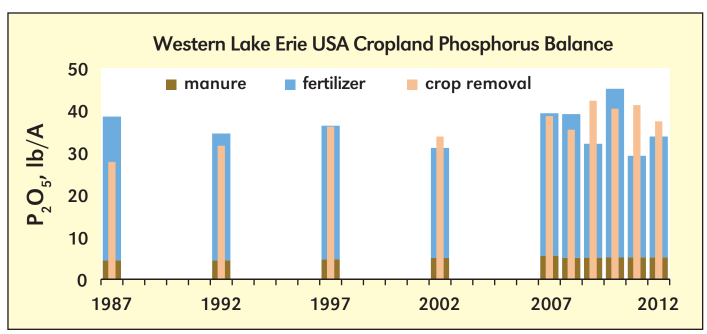

Figure 2. Partial balance for cropland P in the western Lake Erie basin, including the Maumee, Sandusky, Raisin, and Cedar-Portage river watersheds. Inputs include fertilizer and manure applied; output is crop removal estimated from reported yields. NuGIS, 2016.

Given the declining trend in soil test P and cropland P balance, one might assume little opportunity for crop P man-

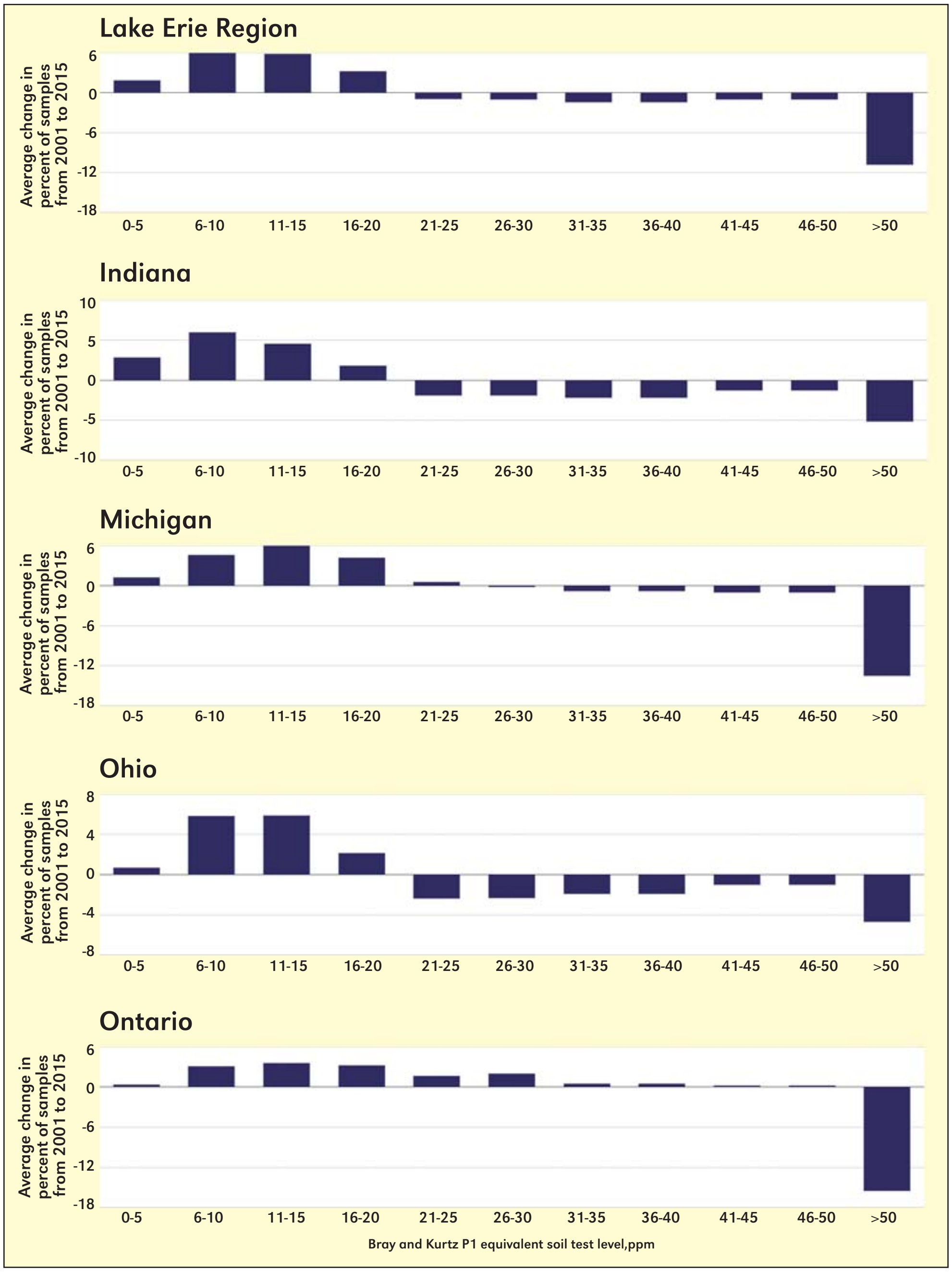

Figure 1b. Average changes in relative frequencies from 2001 to 2015, for the province and three states with substantial drainage into Lake Erie.

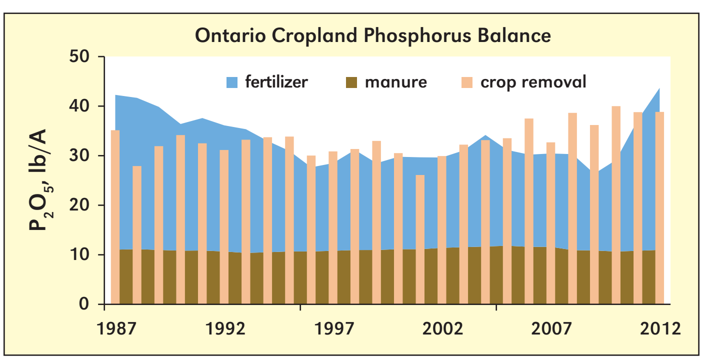

Figure 3. Partial balance for cropland P in Ontario, Canada. Inputs include fertilizer and manure applied; output is crop removal estimated from reported yields, using methods similar to those in NuGIS (2016) and Bruulsema et al., (2011).

agement to contribute to reductions in P losses to water. This is not true. Several important opportunities are only partially revealed in these data.

1. Currently only 38% of soils test in the optimum range of 15 to 40 ppm. There is clear opportunity to better direct more of the current P applications to the 28% of soils that test below the optimum range, and less to the 33% that test above.

2. Placement and timing of P applications could be improved. In 2012, 40% of the cropland received P applications that were neither incorporated, nor subsurface banded, nor injected. Application in winter, between November and February, accounted for 13% of the P applied (USDA-NRCS, 2016).

3. These soil test summary results do not address the issue of P stratification. In conservation-tilled and no-till systems, the top inch of soil can become enriched to as much as three times the level in the recommended sampling depth. Since the P concentration of drainage water is influenced by the concentration of P in the top inch, managing stratification with techniques such as strip tillage offers opportunity to apply P with less loss to water.

4. Additional conservation practices such as drainage water management and cover crops to improve water retention in the soil offer opportunity to maintain or improve crop yields while reducing potential P loss.

The Great Lakes Water Quality Agreement Nutrients Annex has recommended a target to reduce P loadings to Lake Erie by 40% relative to 2008. This very challenging target will not be achieved with P application practices alone. Nevertheless, integration of conservation practices with P application practices in a complete 4R Nutrient Stewardship approach offers opportunity for crop producers, their advisers, and the crop nutrition industry to do their part. BC

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