Effects of Conservation Practice Adoption on Cultivated Cropland Acres in Western Lake Erie Basin, 2003-06 and 2012

Executive Summary

The 2012 CEAP survey in the Western Lake Erie Basin (WLEB) enables analyses of agricultural and conservation changes that occurred since the 2003-06 CEAP survey (CEAP-1). This report evaluates those changes and their effects on conservation concerns in WLEB. While the 2012 survey period covered in this CEAP special study reflects conservation actions at the time of the 2011 record algal bloom in Lake Erie, it does not capture producer response to the heightened regional awareness triggered by the bloom. This report also presents outcomes of alternative conservation solutions modeled to assess their potential to address the conservation treatment needs of the variable cropland soils and soil conditions in the region. Particular attention is paid to phosphorus loss dynamics.

The impacts of nutrient and sediment legacy loads must be recognized when assessing agricultural conservation progress in WLEB. Legacy loads and their effects on water quality response to conservation actions are well documented (Meals et al. 2010; McDowell et al. 2002; Kleinman et al. 2011b; Sharpley et al. 2013; Chen et al. 2014), but the magnitude and process dynamics of the legacy loads in WLEB are not well understood. Consequently, analyses presented here represent the impacts of the live load and the in-field legacy load that accumulates during the simulation. Both loads are the result of current agricultural and conservation practices and their effects on potential material losses from farm fields. This report provides information on loss dynamics at the edge of the field and does not include legacy and associated lag-time dynamics due to past land management.

The 2012 conservation condition. This report examines the impacts of conservation practice adoption on five major resource concerns that impact soil health and off-site water quality in WLEB: sediment loss, soil organic carbon change, subsurface nitrogen loss, total phosphorus loss, and soluble phosphorus loss. These analyses indicate that in the 2012 conservation condition:

- Ninety-nine percent of cropland acres are managed with at least one conservation practice, but there is still opportunity to improve conservation management across the basin through the use of complementary practices and comprehensive conservation planning.
- Thirty-five percent of cropland acres have conservation practices in place that adequately address all five resource concerns, and 59 percent of cropland acres have practices that adequately address at least four resource concerns.
- Ninety-six percent of cropland acres are adequately managed to prevent average annual sediment losses of more than 2 tons per acre.
- Seventy percent or more of nitrogen applied is removed by crop harvest on nearly 95 percent of cropland acres.
- Fifty-eight percent of cropland acres are managed with phosphorus application rates at or below crop removal rates.
- Forty-two percent of cropland acres are the source of 78 percent of total annual phosphorus losses and 80 percent of total annual sediment losses.
- Winter application rates were unchanged and remained low, with 13 percent of total phosphorus applied between November and February.
- More than 8.9 million gallons of diesel fuel consumption equivalents were saved from conservation tillage adoption, translating to a reduction of over 99,500 tons of CO_2 emissions.

These highlights demonstrate that most cropland acres in Western Lake Erie Basin have conservation practices in place, while a fraction of the cropland soils are in need of additional conservation treatments to address regional concerns. However, vulnerable soils are not located in large, homogenous tracts, but rather are embedded in fields of other, less vulnerable soil types. Comprehensive conservation planning and application of appropriate conservation systems on nearly all acres will help producers identify and treat vulnerable in-field soils to further reduce sediment, phosphorus, and nitrogen losses.

Assessment of changes in conservation adoption. This CEAP-Cropland special study was designed to assess the 2012 conservation condition and identify changes in agricultural and conservation practices since the CEAP-1 farmer survey (2003-06). Analyses of the two farmer surveys and associated modeling simulations revealed the following, when comparing the 2012 conservation condition with the 2003-06 conservation condition:

- Cropping systems, cropped acres, tillage management practices, and cropping intensity did not change.
- In the 2012 conservation condition, fewer than 6 percent of acres were managed with cover crops.
- Cropland acres managed with one or more structural practice controlling erosion increased from 34 to 54 percent of acres.

- Cropland acres managed with an edge-of-field trapping practice, such as a filter or buffer, increased from 18 to 31 percent of acres.
- Nitrogen and phosphorus application methods improved. Acres on which all nutrient applications were incorporated in some manner (knifed, injected, tilled, or banded) increased. The percent of cropped acres on which nitrogen was incorporated at every application increased from 29 to 43 percent and on which phosphorus was incorporated at every application increased from 45 to 60 percent.
- Management of nitrogen and phosphorus application rate to crop removal ratios did not change.
- Management of nitrogen and phosphorus application timing did not change.
- The percent of acres managed with moderately high or high levels of nutrient application management did not change. In the 2012 conservation condition, 34 and 78 percent of cropland acres were managed at moderately high and high levels for phosphorus and nitrogen, respectively.
- No statistically significant change occurred in the use of soil testing. About 71 percent of acres had a soil test within the last 5 years in the 2012 conservation condition.
- Use of precision agriculture techniques increased. Acres on which GPS was used to map soil properties increased from 8 percent to 36 percent of cropland acres. The use of variable rate technology increased from 4 to 14 percent of cropland acres.

Conservation practice adoption in WLEB was largely maintained between the two surveys, while management that did change moved in a positive direction. Since CEAP-1, there have been no negative changes in agricultural management and conservation practice use by farmers in Western Lake Erie Basin. The significant changes in management and conservation practice adoption that occurred between the two survey periods resulted in the following environmental gains when comparing the 2012 conservation condition with the 2003-06 conservation condition:

- Average sheet and rill erosion decreased from 1.3 to 0.8 tons per acre per year.
- Average sediment lost at the edge of the field decreased from 1.1 to 0.5 tons per acre per year, largely due to the increased adoption of edge-of-field trapping practices.
- Average phosphorus application rates declined, with average annual application rates decreasing by nearly 2.7 pounds per acre, declining from 21.5 to 18.7 pounds per acre per year. Crop removal rates remained constant, at 16.4 and 16.3 pounds of phosphorus per acre per year removed by harvest.
- Average total phosphorus loss declined from 2.3 to 1.9 pounds per acre per year. The decrease was driven by a reduction in surface losses, which correlates with the reduction in sediment losses. Soluble phosphorus losses remained the same, at 1.3 pounds per acre annually delivered past the edge of the field.
- Average nitrogen losses to surface flows decreased from 7.1 to 4.6 pounds per acre per year, although nitrogen inputs and subsurface losses did not change significantly, nor did nitrogen removed by crops at harvest.

The surface runoff control and trapping structural practices adopted between 2003-06 and 2012 provided significant reductions in the long-term average runoff losses of sediment, nitrogen, and phosphorus. However, subsurface losses of the more reactive soluble phosphorus and nitrogen did not decline and represent the primary conservation treatment need in WLEB.

***Conservation Treatment Needs and Solutions*.** Remaining treatment needs for each conservation concern were assessed by comparing simulated average per-acre losses in the 2012 conservation condition with loss thresholds established for these analyses. These thresholds provide a metric for comparison and do not represent current policy or suggest anticipated ecological impacts. Acres on which average annual losses for all five resource concerns (sediment loss, soil organic carbon change, subsurface nitrogen loss, total phosphorus loss, and soluble phosphorus loss) are maintained below the thresholds are considered to have adequate treatment in place. The following are the key points from these analyses:

- Management in place on 35 percent of cropland acres keeps average annual losses below the loss thresholds for all five resource concerns; management on an additional 24 percent of acres achieves loss rates below the thresholds for four resource concerns.
- Soluble phosphorus loss is the greatest treatment need in WLEB, with 42 percent of acres exceeding an average annual loss threshold of 1 pound per acre per year. The majority of soluble phosphorus losses occur through the subsurface pathway.
- Subsurface nitrogen loss is the second greatest treatment need, with 29 percent of acres exceeding the 25-pound-per-acre average annual threshold.
- Management on 20 percent of acres achieves loss rates below the loss thresholds for two or fewer resource concerns. These 20 percent of acres account for 65 percent of total sediment loss, 30 percent of total nitrogen losses, and 45 percent of total phosphorus losses from cropland acres in the 2012 conservation condition.
- Acres on which loss rates are lower than the loss thresholds for all five resource concerns have considerably lower per-acre losses than do acres with management that achieves loss rates below loss thresholds for only two concerns, including 86

percent lower average annual sediment losses, 58 percent lower annual total nitrogen losses, and 77 percent lower total phosphorus losses.

- Acres needing treatment very rarely exist in isolation within single fields. Comprehensive conservation planning considers the soils within the field and develops targeted solutions to meet the needs of each soil. Precision techniques for assessment of needs and variable rate application will likely contribute to the conservation solution in this region.

The alternative conservation management solutions simulated in these analyses were developed with input from local conservationists, researchers, crop consultants, farm groups, and government and non-government organizations in Western Lake Erie Basin. Single-approach strategies included the simulation of the addition of erosion control practices, nutrient management practices, tillage, cover crops, or drainage water management. Simulated multiple-approach strategies applied various combinations of the single-approach strategies to all appropriate acres. Simulated strategies were evaluated for their effects on both yields and edge-of-field losses of sediment, nitrogen, and phosphorus. The findings support the need for individualized, comprehensive conservation planning that addresses the variability within fields. Results demonstrate that there is no "one-size-fits-all" conservation solution, even within an individual field. The conservation strategies demonstrate that careful, comprehensive conservation planning is needed on every cropland acre in WLEB if vulnerable soils are to be appropriately treated. No simulated solution was the optimal solution for every acre and every resource concern. Tradeoffs in terms of nutrient loss reduction and yield sustainability varied by conservation solution.

Exploration of the impacts of conservation solutions, relative to the 2012 conservation condition, demonstrate:

- A simulated solution that incorporates improved nutrient management, erosion control, and cover crop adoption reduces nitrogen losses on 97 percent of acres and phosphorus losses on 95 percent of acres, but decreases corn yields and soybean yields on 45 and 63 percent of acres, respectively. This strategy reduces total phosphorus losses by 43 percent when applied to all acres and soluble phosphorus losses by 27 percent when applied to all acres.
- Simulations including cover crop adoption demonstrate the need for close monitoring of soil phosphorus, because crop yields decline once excess phosphorus is mined from soil. Soil testing can be used to prevent yield losses, and farmers and conservationists must keep in mind that cover crops provide additional soil health and carryover nitrogen-reduction benefits.
- Increased conventional tillage tends to increase sediment losses and reallocate phosphorus from soluble losses to sediment-attached losses. In cases where conventional, more intense tillage is added, total phosphorus losses increase while soluble losses are minimally impacted. If tillage is deemed necessary due to significant phosphorus stratification, it should be accompanied by crop cover adoption, preferably with additional runoff control and trapping measures.