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Phosphorus Fate and Transport across Fields and Catchments: Addressing the Paradoxical Dilemma

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Awareness and scrutiny of agriculture's role in contributing phosphorus (P) to surface water impairment has increased due to recent high profile harmful algal bloom outbreaks. In addition, an inability to meet target P-load reductions in large catchments in the USA, such as Chesapeake Bay, Lake Erie, and Mississippi River, has brought into question the effectiveness of current and future conservation strategies designed to mitigate such loads. This has led many to question the efficacy of these measures and to call for stricter land and P-management strategies and the recognition of several paradoxes related to the management of agricultural P.

"The Finite Resource and Environmental Abundance Paradox"

While P is a finite resource, with an expected life of 300 years using modern mining technologies, less than 20% of mined fertilizer P reaches the food products consumed, only 10% of the P in human wastes is recycled back onto agricultural land, yet P deficits occur across 30% of global cropland.

"The Blue – Green Paradox"

An increasingly affluent population is becoming more demanding of cheap, reliable food sources and wanting inexpensive clean, safe water for many essential and recreational uses. We now face many challenges in balancing competing demands for protecting and restoring water quality and aquatic ecology, with sustainable and efficient agricultural production. After the low hanging fruit of remedial measures are adopted, remaining conservation practices become increasingly less cost-beneficial and raises the old conundrum of "who benefits and who pays?"

"The Conservation Legacy P Paradox"

Many conservation practices have been implemented to retain (e.g., no-tillage, cover crops, contour plowing, ridge tillage) and trap P (e.g., buffer strips, riparian zones, wetlands) on the landscape rather than enter waterways. Yet, the capacity of those practices to retain is finite and there are more and more examples of conservation practices transitioning from P sinks to P sources.

In this presentation, we examine the drivers of legacy P at the watershed scale, specifically in relation to the physical cascades and biogeochemical spirals of P along the continuum from soils to rivers and lakes, and via surface and subsurface flow pathways. Close examination of long-term P flux, weather patterns, and land management identified several natural and managed drivers that have inadvertently accelerated the accumulation of P at the soil surface and flux of P via subsurface drainage. This indicates a paradoxical conundrum where well-intended conservation measures may have cumulative impacts, which have converged with changing weather patterns and catchment hydrology to increase P fluxes. In seeking solutions, we must better quantify P sinks and sources as they are transported through catchments, to develop realistic expectations for adoption of conservation strategies and timescales for aquatic ecosystem recovery.