Legacy Phosphorus Conservation Outcomes Webinar
Answers to Questions from Chat

Question 1:

Do we know how much P are in soils around the world and what fraction of the P are native vs P that accumulated due to human activities?

KLEINMAN RESPONSE. Although attempts have been made to tackle aspects of this question, they are indirect estimates. For instance, McDowell et al. used various databased to estimate P in soils using a variety of soil databases. In addition, as shown in the presentation, a variety of authors have used basic accounting of inputs of fertilizers and outputs of commodities to estimate whether P is accumulating or being systematically depleted (Sabo et al., Kellog et al., Spiegal et al.,). None of these approaches have the resolution to understand the uneven distribution of P in soils, or to effectively differentiate between natural and anthropogenic sources.

Rich McDowell and colleagues took stab at estimates of soil P across the globe.

https://www.nature.com/articles/s41597-023-02022-4

In the southeastern United States, USGS sought to estimate natural sources of phosphorus to watersheds as part in support of its SPARROW modeling.

https://pubs.usgs.gov/sim/3102/pdf/sim3102_book.pdf

Sattari et al. provided continental estimates of what they refer to as "residual P".

https://www.pnas.org/doi/10.1073/pnas.1113675109

Question 2:

Just an observation that there are a handful of non-anthropogenic incidences of P excess. Green Bay Wisconsin is one - but of course those are rate by comparison

Great presentation Pete. You mentioned the concentration of poultry on the Delmarva. Yes, there is a tremendous amount of litter. My question is - If the litter is applied at anticipated crop needs isn't that a better form than commercial fertilizer?

KLEINMAN RESPONSE:
Poultry litter is a terrific soil amendment that contributes a lot more than just P to soil. As a result, there is good demand for poultry litter. In general, litter doesn't move far enough to

avoid legacy P build up, even though, as a dry manure, it has properties that are favorable to long-distance transport. As responsible stewards of our natural resources, P in byproducts such as poultry litter represents an important fertilizer resource that should be recycled. The manureshed initiative, mentioned in the webinar, seeks to expand opportunities for the sustainable use of manure P in crop production by identifying barriers to manure resource redistribution over different scales and offering solutions to improve that redistribution. Ray Bryant and colleagues provide an excellent overview of issues related to poultry manuresheds: https://pubmed.ncbi.nlm.nih.gov/34309029/

Question, continued*:*
Second, with the insensitivity of grain production to service the poultry industry, are there management actions that can effectively reduce P loss?

KLEINMAN RESPONSE. Because US poultry production is dominated by vertically integrated industries, there is an incredible potential to make real strides in improving the circularity of resource flows between grain producers and poultry producers. I mentioned the importance of manureshed management, something that should be at the heart of sustainable poultry production. Very real barriers exist to coordinating between grain and poultry producers, so, approaching this strategically, at scale, offers the best opportunity for change.

Question, continued*:*
Pete you have not mentioned hydrology management. What about potential for conservation drainage to trap and or treat P?

KLEINMAN RESPONSE:
Yes, I kept the webinar focused mostly on conservation relative to sources of P in the environment. Hydrology in general represents the greatest source of uncertainty with regard to P fate in the environment. There is a major need to improve our understanding of the interaction of hydrology with P sources to quantify P fate. I did, however, mention the importance of critical source areas, i.e., the relatively small area of land in many watersheds that accounts for the majority of watershed P export. Critical source areas are those areas where active hydrology that can mobilize and transport phosphorus to a waterway coincides with sources of phosphorus. Because of that hydrologic activity, critical source areas may need to be managed differently than other areas on farms and ranches, perhaps even below the agronomic optimum for crop response.

I think your question may be directed to the management of drainage waters using water control structures such as coffer dams to temporarily store water that would otherwise be discharged in artificial drainage? Controlled drainage has been shown, generally, to reduce

nutrient loads, including P loads, by reducing the overall volume of water discharged by a drain or a ditch. Admittedly, there have been studies that have pointed to trade-offs with dissolved P release (e.g., reductive dissolution of iron-bound P), and timing of export associated with controlled drainage (coffer dams tend to be wide open during springtime when P losses from agricultural fields have their greatest downstream impacts). Note that relationships between drainage water management and phosphorus were dealt with in a previous Conservation Outcomes Webinar: **Addressing Water Quality Outcomes Through Nutrient and Water Management:** Webinar Recording (Captions Available), Presentation with Citations, and Additional Resources One-Pager

Question, continued:
The Bay Model scores 0 for P reduction from cover crops. Reaction?

KLEINMAN RESPONSE. I had to look this up as I was not part of the workgroup that developed the Bay Model efficiencies for cover crops. It appears to me that cover crops are assigned a greater potential for reducing P (and sediment) in systems with substantial tillage, where soil conservation is expected to address the majority of P loss in runoff. However, the credit for sediment-bound P reduction is lower, or eliminated (the 0 you refer to in the "Bay Model"), when it comes to no-till systems where soil erosion is less of a concern to P loss (due to the soil conservation benefits of no-till). Cover crops are a wonderful tool controlling sediment-bound P losses. However, as I mentioned in the webinar, cover crops are not designed to address P loss and they are not an. effective tool for dissolved P management. You can read more about this issue in the following article: https://acsess.onlinelibrary.wiley.com/doi/pdfdirect/10.1002/ael2.20084

Question 3:
An example of practical application of practices to address legacy P - the use of riparian buffers to generate "credits" in water quality trading in Wisconsin requires harvesting of buffer vegetation (e.g. for forage) to drawdown soil nutrients and mitigate against accumulation of legacy P.

KLEINMAN RESPONSE:
Wow! This example sounds like a model for riparian buffer programs that prioritize water quality outcomes. What you describe is one of the practices that our team recommends to address legacy P in the riparian soils.

Question 4:
Will the Assessment give estimates of the approximate size of the amount of P being lost from ongoing ag soil P fertilization programs relative to that amount being released into waterways from all of the legacy sources of P that the Assessment identifies? I am

wondering about how much of the P loss problem can be addressed through in-field P management work relative to the losses from all of the other legacy sources (not to mention from the naturally occurring, non-anthropogenic sources).

KLEINMAN RESPONSE:
The USDA Legacy Phosphorus Assessment Project is using site characterization data to support SWAT modeling so that we may make large watershed estimates of the outcomes of efforts to target legacy P. This simulation modeling will provide a better sense of the ability to mitigate some, but not all, sources of P in the watersheds where we are working. In particular, our scenarios should provide better insight into the outcomes of implementing conservation strategies that prioritize legacy P management. You have identified some factors that will contribute to the variability in effectiveness of legacy P management across different watersheds.

Question, continued*:*
How do we deal with the fact that "trapping practices" will eventually accumulate enough mineral P that they can become sources of loss of mineral P? Does that trapped mineral P need to be regularly recovered from the traps? If so, how do we do that?

KLEINMAN RESPONSE:
Yes. To start, trapping practices need to be monitored for P accumulation in areas where they are expected to provide non-point P mitigation benefits. Options to address accumulated P include soil nutrient drawdown (see Mark Reidel's note in the chat about the Wisconsin program that includes drawdown as part of the installation of riparian buffers), dredging (something that can have real trade-offs so needs local understanding of its potential for effectiveness), and stabilizing the source to minimize P remobilization. As presented in the webinar, soil nutrient drawdown must include (a) monitoring of soil P, including vertical stratification, (b) a cessation of P application to soils that are targeted for drawdown, (c) selection of appropriate crop rotation, (d) a strategy for what to do with the harvested biomass.

Question 5:
Wonderful presentation, Pete. Can you please describe the concerns around legacy P specific to the Snake River basin? Or are there sources you'd recommend to research this further for the Snake?

RESPONSE FROM DAVE BJORNEBERG, LEAD OF THE USDA LEGACY P PROJECT'S SNAKE RIVER SITE:
Historically, sediment transport from furrow irrigated fields was the primary water quality concern in the Snake River. Sediment transport to the Snake River has decreased as

farmers have converted from furrow irrigation to sprinkler irrigation and irrigation districts have installed water quality ponds to trap sediment. Furrow irrigated fields continue to be the primary source of P in the Snake River. Soluble P increases as water flows over soil during furrow irrigation and then flows to the Snake River.

Question 6:
Do no-till systems typically struggle with phosphorus stratification? If so, how would you recommend managing this issue in these areas?

KLEINMAN RESPONSE:
Yes, no-till systems are highly susceptible to vertical stratification of soil phosphorus. The SMART approach to nutrient management includes "assessment", in addition to managing Source, Method, Rate and Timing. Regularly measuring vertical stratification in soils is an important part of the "assessment". As for the "method" of application, subsurface placement of phosphorus will help, to some extent. Rotating management, including consideration of crops and tillage, is foundational.

Question 7:
Did you look at legacy sediment and P removal in floodplains as a soil P drawdown method?

KLEINMAN RESPONSE:
We do consider these practices, to some extent. Notable, there is a sister project, the USDA Legacy Sediment Assessment Project, that is exploring legacy sediment management. The focus of the Legacy Sediment Project is further downstream that the USDA Legacy P Assessment Project, so the two projects are quite complementary. Even so, we consider dredging of sediment in impoundments as part of the suite of practices for legacy P mitigation. We also are recommending the consideration of soil nutrient drawdown as part of riparian buffer management (see my responses above to other questions).

Question 8:

Do these timelines for drawdown speak to the need to reduce application rates of manure to those frequencies if you do your applications based on P plant needs rather than N needs which is how most manures are generally applied?

KLEINMAN RESPONSE:
Soil nutrient drawdown has been identified as a practice to target accumulated P in soils that poses a water quality risk. What you describe (P-based application rate) is already offered as part of the SMART approach to nutrient management. Such an approach can certainly be used to draw down soil P.

BETSY DIERBERGER (NRCS National Agronomist) COMMENT:

Manure nutrients on perennial forage, forage uses nutrients, nutrients harvested in forage, forage fed to livestock, manure applied to field again… slow draw down

KLEINMAN RESPONSE:
Another great point. If you aren't "SMART" about what you do with nutrients in your farming system, you may end up in a never-ending loop. That's why I like the "assessment" portion of the SMART acronym. Soil nutrient drawdown includes: cease nutrient application to soil; identify appropriate crop rotation and harvest crop to extract soil phosphorus; use the SMART system to determine where those extracted nutrients ultimately end up (their fate); monitor your soil phosphorus status, including vertical stratification.

Question 9:

Does NRCS offer financial assistance for transporting manure?

BETSY DIERBERGER RESPONSE:
Currently the conservation practice available as an incentive practice is Waste Recycling (633) The on-farm agricultural use of nonagricultural waste by-products, or the off-farm nonagricultural use of agricultural waste by-products. Not 634 Waste Transfer.

ADDITIONAL RESPONSE:
The definition of CPS 634 is: A system using structures, pipes, or other conduits installed to convey wastes or waste byproducts from an agricultural source to a storage facility, treatment facility, or land application site. It is also noted that "This practice does not apply to hauling waste material with equipment or vehicles."

Question 10:
Have you used composting worms, black soldier fly larvae or other alternatives to transform animal manure on these manure watersheds?

KLEINMAN RESPONSE:
We have worked with vermicompost in the past in the Chesapeake Bay Watershed, but it went through a boom-and-bust cycle and was not scalable. I am a strong proponent of developing systems that better value our byproducts. Adding value to manure is key to moving it longer distances so that legacy P buildup is less of a concern. These technologies all show potential to help, but, there are no silver bullets. For these excellent technologies to work, they need to be part of systems that balance economic-social/logistical-agronomic-environmental concerns.

Question 11:

Considering that some conservation practices might not mitigate P loss on farms already saturated with manure, I wonder if it'd be a more effective policy to put money towards transporting the manure longer distances in the manureshed, rather than paying for CPs on the saturated farm.

KLEINMAN RESPONSE:
I think that manureshed management is essential to solving system-level imbalances (farm-gate, watershed, regional) in nutrients that underpin legacy phosphorus impacts. However, a foundation for mitigating P loss is SMART nutrient management, as described in the webinar. As I mentioned in the webinar, in the case of these complicated conservation topics, it's not a case of one or the other, but about being comprehensive in our approach.

Question 12*:*
What about the P contribution from widespread application of glyphosate. Great presentation.

KLEINMAN RESPONSE:
This is an interesting question that arises from time to time, and, in recent years has been posed as a hypothesis for greater dissolved P loads in places like the Western Lake Erie Basin. From my distant perch in the Rocky Mountains, I would say that the science around this topic is underdeveloped, and, that links to water quality concerns are more hypothetical (not substantiated by empirical data).

Glyphosate P is not considered in nutrient management planning, which focuses on fertilizer and manure P. In the past, it was thought that P contributions to agricultural soils from glyphosate application were so low as to be undetectable from a nutrient budgeting standpoint (agronomic soil testing is largely insensitive to the additions of P provided by glyphosate). I do recall at least one study that observed pulses of dissolved P around the time that glyphosate application occurred. However, the dissolved P pulses in runoff could also be explained by other phenomena, such as the lysing of plant cells due to herbicide action.

I found this interesting review of glyphosate P addition as a result of the evolution of glyphosate resistance by weeds:

https://esajournals.onlinelibrary.wiley.com/doi/full/10.1002/fee.1985#:~:text=In%20addition%20to%20raising%20ecotoxicological,of%20P%20in%20agricultural%20watersheds

Sounds like an interesting area of research!