Refrains in the phosphorus discussion

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When talking about how we regulate phosphorus, I hear the same refrains over and over again.

> **The first one goes something like this**: We have solved the attached P problem, now we just have to find the right tools to solve the soluble P problem. These tools invariably include things like reducing winter manure applications, the 4 Rs, cover crops, trapping nutrients in-stream with two-stage ditches, etc.
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> **The second one is**: Phosphorus inputs have been declining since the 1970s. Isn't this evidence that farmers are doing their share to reduce the pollution problem?

Absolutely, there is truth to each of these, but my take on the policy lessons and the implications for what we should do next are completely different than most others (go figure).

Let's look more closely at the attached P problem we have "solved." One of the vexing problems with phosphorus in watersheds is that it is so persistent. We have added a lot over the years to our crop systems, and our crops have only used about 40% of what we have added in the past 40 years (Figure 1). The rest remains in the ecosystem or is removed by our rivers. The problem of course, is the part that is removed by our rivers and ends up in our lakes, particularly in soluble form.

Is it?

By my calculation, we have accumulated an astonishing 300 lbs of P per acre of farmland in the Maumee river basin (Figure 2). Using a conversion of 2 lbs of P per 1 ppm, this means that about 150 ppm is attached to soils somewhere in the ecosystem, whether it's in farmer's fields, or stream banks, or other parts of the ecosystem in NW. The results probably are not that much different across most other parts of the state or region.

Most of this P is unavailable right now to crops, given that soil tests in Northwest Ohio soils are in the 30-40 ppm P range for available P according to Hermann (2011). Converting to pounds, around 60-80 lbs. P per acre are available for crops, which is actually more than the 25-35 lbs. P (60-80 lbs P2O5) that farmers add to each acre of corn each year. Of these, 15-21 lbs. are removed in crops each year, leaving 10-14 lbs P in stalks and soils, to be further distributed in the ecosystem during the non-growing season.

These numbers are probably an under-estimate of what is left in the ecosystem actually. I have left out inputs due to animal manure. According to Bruuselma et al. (2011), manure P inputs are about 31% of chemical P inputs, so my P input estimate is actually underestimated by quite a lot.

The issue to me is that our effectiveness at trapping P has left a lot of P out there in the ecosystem for us to deal with today. I agree that reducing P inputs will not solve this historical problem right away, but neither will our efforts to continue to trap additional nutrients via our traditional conservation programs. Even supposedly new conservation methods that do nothing more than trap P will not solve the problem, now or in the future.

Now, consider the refrain about declining P input trends. Figure 1 clearly shows that chemical P inputs have declined since their highs of the mid-1970s. In addition, P removal by crops has continued to increase as yields have increased. Removals by the river have fluctuated, but stayed relatively stable in overall terms. River removal is a fairly small part of the total.

So we have added lots of P, but we are adding less and less and our crops are taking up more and more. That's essentially the point Bruuselma et al. (2011) made, although they suggested that we were nearing the point where P inputs needed to start rising again in order to maintain crop yields.

The question really is, why have we been adding less and less? There are lots of reasons, and I'll just mention the two most important. First, the aggregate numbers reported by me and others capture corn, soybeans, and wheat. Since the mid-1970s Northwest Ohio has increased soybean acres and reduced corn and wheat acres. Historically only about 34% of soybean acres receive P treatments, compared to over 90% for wheat and corn. And the rates are about 40% less for soybeans than corn. So, in the last 40 years, we have shifted to a less P intensive crop in NW Ohio and it has slowed our overall P application.

Second, looking at the individual crops, P application rates fell modestly from the 1970s to the early 2000s for corn, but actually rose a bit for soybeans and wheat. Then between 2006 and the present, P application rates fell for all crops, and by quite a lot. You can see this in Figure 1 where P inputs have fallen substantially overall. This could be the effect of growing concerns with the environmental effects of P, but I doubt it. The other "thing" that happened after 2005 was a really large increase in P input prices (Figure 3).

Based on this, I'm inclined to believe that the reduction in P inputs from the 1970s to early 2000s was largely driven by crop switching, while the reduction from 2005 to the present was mostly driven by rising prices. Nothing guarantees that these two trends will last forever. In fact, lower energy prices with hydraulic fracturing, or fracking, may drive down the price of P to "normal" levels. This will lead to increases in P use by farmers.

In summary, my concerns with the refrains I keep hearing and my responses are as follows:

(1) I agree, we have done a great job of trapping P in our soils and our ecosystem. Was this really such a good idea? There are really large levels of P out there somewhere in the ecosystem and they are likely to be contributing to our current problems. Should we continue trying to trap P in the ecosystem or should we just reduce P inputs? In addition to filter strips, riparian zones, and conservation tillage, cover crops and two-stage ditches are another form of trapping. I fail to see how more P trapped in the ecosystem equates with better environmental outcomes in the future.

(2) There is no reason why farmers will not go back to increasing P applications when P prices fall. This is particularly true if P applications enhance yields. I believe they do, after all yields have stagnated since the early 2000s at precisely the time when P applications fell the most.

(3) Philosophically, the more we believe in trapping, the less incentive we have to reduce P inputs or even economize on them (i.e., use the 4R's), especially when prices for P fall.

(4) The 4 R's are an outstanding guidepost. In fact, the reason why farmers have been receptive at all to the 4 R's in recent years is that P prices have been so high. When an input is valuable, people don't waste it. The 4 R's exhort people not to waste their inputs.

(5) Going forward, the best way to enforce a broad-based application of the 4 R's is with a tax on P inputs. Then everyone will have an incentive to use the 4 R's even when P prices fall. Otherwise, as P prices fall, which they probably will, P applications will start to rise again. For completely different reasons, Bruuselma et al. (2011) advocate that P applications should start to increase as farmers use up the chemically available portion in farm fields. With a tax on P, we can ensure that this is done in an environmentally sensitive way.

(6) You will notice here that I fully accept the notion that reducing P will have an impact on crop yields. There is no free lunch. If we want to reduce P in our ecosystems, someone somewhere will have to pay. Right now, the system is set up so that society pays for lots of things that don't solve the problem through conservation programs. My proposal clearly redistributes the costs towards farmers through taxes on inputs.

(7) To avoid having this be a large financial loss to farmers, I propose using some of the money in the conservation programs, and just simply giving that money to farmers in order to make them financially whole from the higher input taxes. This is the most efficient way to handle a pollution problem, and neither farmers nor society will be worse off than they are now. In fact, both will be better off in the future with better water quality.

References:

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Figure 1: Maumee River Basin P added by farmers through chemical fertilizer only, P removed by crops at harvest, and P removed by river. P added and removed by crops is calculated with data from USDA-NASS, and river removals are calculated with data from the National Center for Water Quality at Heidelberg University.

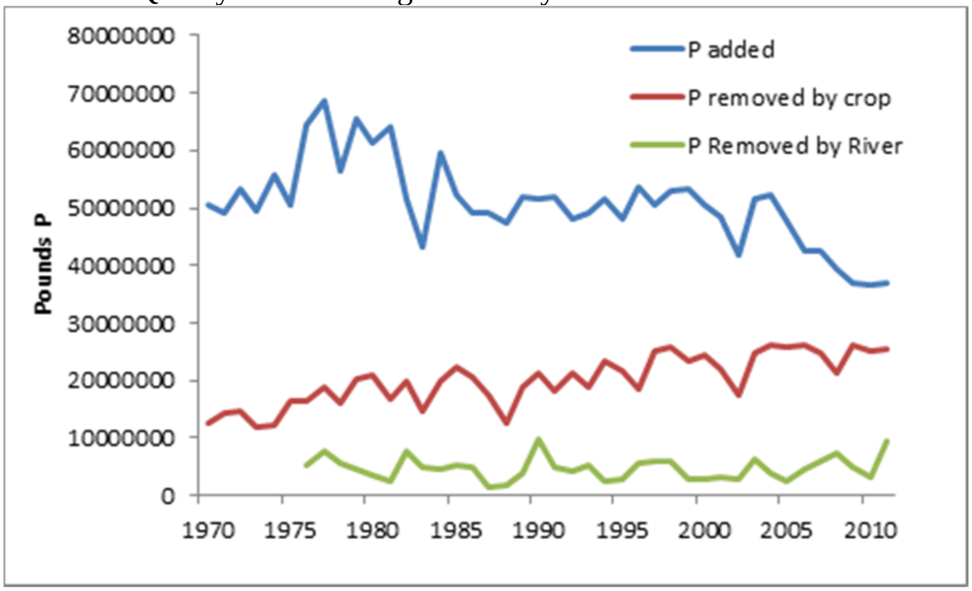

Figure 2: Cumulative excess P buildup per acre in the Maumee river basin. See Figure 1 for information on data used to calculate this.

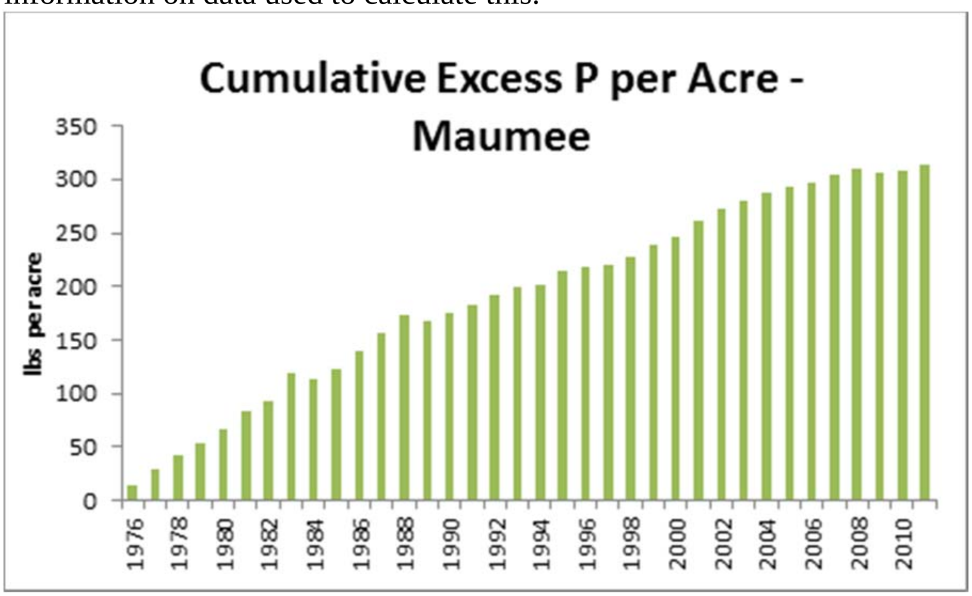

Figure 3: Phosphorus price index (1973 – 2011). These are real prices, indexed to 2011 = 100. Data from World Bank.