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# WHAT'S IN A PHOSPHORUS FOOTPRINT?

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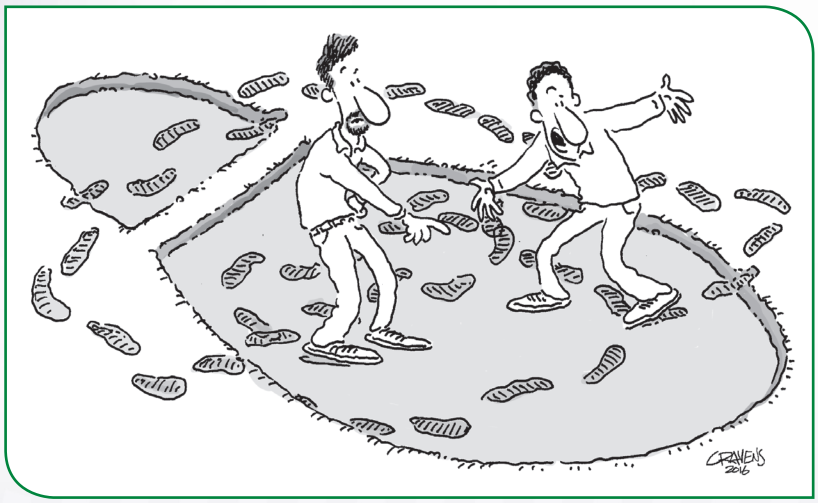
Footprints tell a story. They track where you have been. Carbon and water footprints are increasingly being used to track progress on issues like climate change and water scarcity. The concept of a phosphorus footprint of food has also been introduced. Both footprints and efficiencies are used as performance metrics to tell a story about agricultural sustainability. But they can confuse as well as enlighten! To get the story right, we need to understand these metrics.

A footprint can describe resource consumption or environmental impact. A water footprint, for example, represents the amount of water used to make a product—a resource consumed. A carbon footprint, on the other hand, represents the net effect of the production and use of a product on the earth's greenhouse gas balance—an environmental impact. A phosphorus footprint could represent either. If it's calculated as the amount of mined phosphate used in the production of your food, it's an indicator of resource depletion. If it's calculated as the amount of phosphate released into waterways, it's an indicator of impact on aquatic ecosystems.



Footprints are similar to efficiencies. In fact, they are actually reciprocals to each other. A footprint is input required per unit of output; efficiency is output per unit of input. Both need to be defined clearly, since they represent very different things depending on how they are calculated.

If the footprint is defined as the amount of mined phosphate used in the production of food globally, currently it amounts to about four times the amount of the phosphate contained in food. Stated the other way, the phosphorus use efficiency of the whole food chain is about 25%. There are huge uncertainties in those figures, but there are many parts of the chain, including food wastes, in which phosphorus is lost.

If the footprint is defined as amount lost to waterways, it is a much different number. Total river exports of phosphorus, including soil erosion, amount to about 6 to 13% of the fertilizer P applied in major agricultural watersheds like the Maumee in the USA, the Thames in the UK, and

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the Yangtze in China. That suggests that most of the fertilizer either goes into the harvested crop or remains in the soil.

Which matters more—consumption of the resource, or contamination of waterways? Both are important issues, but one is more urgent. The best estimates of phosphate reserves indicate enough to support a few centuries of current consumption rates. But water quality and algal blooms are occurring right here and right now, and seem to be increasing concerns to many people. It’s both the kind and the size of the footprint that matter.

The use of phosphate fertilizer in crop production is only one part of the full chain of phosphorus use. Its efficiency is often questioned, and at first glance it seems the literature has a very wide range of values. The wide range results from different calculation methods. Calculated as single-year crop recovery—the increase in crop uptake by a single crop as a fraction of applied fertilizer—efficiencies are generally low, rarely exceeding 25% and more often only 10 to 15% of the phosphorus applied. But most of the phosphorus not taken up by the crop remains in the soil for future crops. Calculated as an output-input balance, over the long term, recovery is often in the range of 50 to 70% or even higher. Indeed, globally, harvested crops remove about 70 to 100% as much P as is applied as fertilizer. The difference between recovery and balance is greater for phosphorus than for nitrogen, since phosphorus is better retained in soils.

It’s important to think long term, and in whole systems. Improved efficiencies and smaller footprints are good goals, but need the checks and balances of other important metrics that carry the rest of the story. Footprints don’t cover every fate. Phosphorus retained in the soil plays a positive role in the nutrition of future crops. Phosphorus lost from the soil can impact ecosystems even in amounts smaller than can be detected by changes in footprints. Efficiencies focus on rates, but all 4Rs of Nutrient Stewardship, including source, timing, and placement, influence sustainability of phosphorus nutrition in crop agriculture.

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