Protected Areas and Extensive Productions Systems: A Phosphorus Challenge beyond Human Food

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Childers and colleagues (2011) point out the vitality of phosphorus (P) to life, the large amounts trapped in biomass, the widespread limitation of growth and production in marine, freshwater, and terrestrial ecosystems due to its cycling characteristics, and the current anthropogenic dependence on nonrenewable sources of concentrated P. The article aimed to provide sustainable solutions for humanity by suggesting ways to improve cycling rather than losing P and provided a good overview of the problem focusing on food production. We would like to expand the discussion and also address points of difference. We view the anthropocentric concepts of sustainability and sustainable solutions as extending beyond food production. Considered in isolation, a perfect (i.e., sustainable) P recycling scheme would not prevent further human population increases (Green Revolution II), with all their sequelae, which for other reasons are considered unsustainable. Assuming that humanity needs to maintain a threshold amount of environment in conditions good enough to provide essential ecosystem functions (hydrology, climate, biodiversity, etc.), then we need to discuss P recycling in landscapes beyond industrialized agriculture, including the role of protected areas (PA) in maintaining natural processes. Childers and colleagues addressed this partially when concluding that P is not an issue with pasture-based animal production because P is already recycled in the fields. However, this occurs only when animals die and recycle in the same area, as happens with wildlife in intact environments. Importantly, pasture or range-fed livestock remove P when exported to centers of human use. Extensive sheep production in Scotland removes 0.23 kilograms (kg) P per hectare (ha) per year and such grasslands receive 16 kg of P per year as fertilizer in compensation, and extensive cattle production on Argentine rangelands removes 0.3 kg P per ha per year which was considered unsustainable, except with fertilizer. But wildlife utilization can also remove substantial amounts of P, especially hunting of cervids, also because of their antlers. Deer annually migrating out of a national park before being harvested, remove an estimated 0.32 kg P per ha per year from the park (Flueck 2009a). However, even use of forests by removing only logs exported 0.08–1.02 kg P per ha per year, whereas whole-tree harvest removed 0.24–1.75 kg P per ha per year. These harvested systems lost P regardless of harvest intensity and were considered unsustainable in the absence of fertilizer. Not surprisingly, forest harvesting has required inputs of 15–30 kg P per ha per year to compensate.

Human utilization of landscapes other than industrialized agriculture includes that of rangelands and forests. In many PA worldwide, extensive livestock production, especially agroforestry, is common and is even spreading, under the banner of sustainable development (Monjeau 2010). In addition, wildlife and wood products are harvested. Most of these PA are not being fertilized, neither for P nor other elements that are being continuously exported and might affect ecosystem function (Flueck 2009b). Unless the replacement of P is included as a cost in the park's budgets, which may be economically unviable given the size of many PA, extractive use within reserves is far from being sustainable, because of the tragedy of the commons (Monjeau 2010). Entire landscapes including PA are being exploited by continuous export of livestock, wildlife (exotics in the cases of PA), and wood products, but without fertilizer replacement. We thus posit that P not only is nonsubstitutable for food production, but maybe even more importantly for maintaining other intact ecosystems and their services. We cannot presume that large portions of the planet can sustain extractive use without concomitant corrective measures.

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Response from Childers: Phosphorous Challenges beyond the Food System

Drs. Flueck, Smith-Flueck, and Monjeau wrote a well-conceived letter in response to the paper I published with colleagues entitled "Sustainability challenges of phosphorus and food: Solutions from closing the human phosphorus cycle" (Childers et al. 2011). They present several important ways in which the extractive activities of human society, beyond the food system, affect global and regional phosphorus (P) cycling. The main premise of their response is that we did not consider the entirety of human effects on P cycling, which I acknowledge. Largely because of space limitations, we chose to focus specifically on the food system (per our title); notably, this is the largest component of human extractive uses of P and it is likely to be most malleable to sustainable solutions. Food production also dominates our use of mineral P resources (via fertilizer application). The removal of P from forests (e.g., via timber harvest), from rangelands (e.g., via feed animal harvesting), and from protected areas (e.g., via hunting) all contribute to the human P cycle. The ultimate result may well be P depletion in many of these nonagricultural ecosystems, resulting in lower yields of the products that humans harvest, but I am not aware of many situations where mineral P as fertilizer is being used to replace this extracted P. As such, these aspects of the greater human P cycle do not fit neatly into the aspects of the P cycle we reviewed, which begins with the mining of mineral P to support human food production.

An underlying tenet of both our review and Flueck and colleagues' response is the effect of human extractive activities on the global P cycle, not just on the human P cycle. The ultimate "common denominator" to the myriad sustainability challenges we face is the nexus of human population and per capita affluence, and the growth in both. We routinely hear that the human population will reach about 9 billion people by 2050, which will require a 70–100 percent increase in food production that will be fueled by P fertilizers. As per capita affluence increases, we will also require large increases in resources (including nonrenewables such as P) to support our increasing demands for "stuff," to quote the late George Carlin. The stresses this will put on finite and dwindling biospheric resources are palpable. Why is the "increasing to 9 billion by 2050" prediction presented so often as though it were a nonnegotiable fact? Isn't this number, in fact, both negotiable and pliable? Fundamentally, we must directly address the population–affluence nexus when we envision and implement sustainable solutions to our problems, including when we consider sustainable solutions to closing the human P cycle.

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