

## **Changing regional phosphorus reserves in soils under cropland in relation to food production for different future scenarios**

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Phosphorus (P) plays a vital role in global food production and security. While most studies on future P requirements ignore the role of residual soil P, we use the 0.5 by 0.5 degree spatially explicit Dynamic Phosphorus Pool Simulator (DPPS) to calculate the the dynamics of P in agricultural soils, including its supply, demand, and storage. Any P application that exceeds crop uptake and losses by runoff and erosion accumulates in the soil as "residual P" which can be available for crop uptake for many years depending on the soil characteristics and management. In this study, we investigate the changes in global soil P pool inventories calibrated from historical countrywide crop P uptake up until 2010. We furthermore couple DPPS with the Integrated Model to Assess the Global Environment (IMAGE) in order to assess future soil P reserves until 2050 according to the five socio-economic Pathways (SSP). These scenarios were developed to study the impact of future global change (food and energy production, climate change, land use changes) and are a good starting point for estimating future agricultural nutrient cycling.

Historically, P in agricultural soils has followed very different trends in various parts of the world. Long periods of imbalance between crop production and fertilization leads to either P depletion or accumulation (respectively). These changes in P pool sizes and availability have a very strong spatial variability. In most high-income countries we see increasing soil P reserves in the 1970s and 1980s. In Eastern Europe and the former Soviet Union soil reserves are being depleted since the early 1990s, and in Western Europe soil P pools are nearly constant (inputs equal outputs) in recent years. With the increased availability of soil P, farmers are now able to reduce P inputs from fertilizers while at the same time maintaining or even increasing crop yields. In Africa, farmers have been depleting soil P reserves, and crop yields have only slightly increased in the past century. The scenario target uptake is by far the most important factor determining the projected fertilizer use and the soil P pool sizes.