 Agricultural Phosphorus Balance

**This EnviroAtlas national map displays the mean phosphorus (P) balance between inorganic fertilizer and confined manure inputs and P crop removal on croplands in the conterminous United States (excluding Hawaii and Alaska) for the year 2012. These data are based on [International Plant Nutrition Institute](http://www.ipni.net/) compilations of county-level fertilizer sales data, confined manure production, and major crop harvest and P content of these crops, as well as the cropland area from the U.S. conterminous wall-to-wall anthropogenic land use trends 2012 land cover data.

# Why is agricultural phosphorus balance important?

Phosphorus (P) is an essential element of all living organisms, as a component of critical biomolecules for genetic material (DNA, RNA), energy transport (ATP) and membranes (phospholipids) within cells. As such it is necessary for plant growth along with nitrogen and other nutrients. In many ecosystems, including agricultural systems, P can limit plant growth and thus food production. In response to such limitations farmers may apply additional P in the form of inorganic fertilizers, food and green waste composts, animal manures, or biosolids from human waste, which all contain P. When released from farms, cities, or industry, P can contribute to water pollution problems because algal growth is limited by P in many freshwater and coastal ecosystems.

Photo: G. Metson, NRC, Soybean field

Since the domestic discovery of P deposits in the mid 1800’s and following agricultural intensification post World War II, inorganic P fertilizer has become a key agricultural input in the United States1. This inorganic fertilizer comes from mining concentrated deposits of phosphate rock, which are primarily located in Morocco, China, and the USA (particularly in Florida)2. As a mined non-renewable resource, inorganic P fertilizer is subject to potential price fluctuations associated with geopolitical scarcity, in a similar way that oil has been in the past. Increased use of fertilizer has increased crop yields, but also water quality problems associated with the addition of nutrients3. P in runoff and erosion from agricultural fields, in addition to loses from animal manure on pastures or in [concentrated animal feeding operations (CAFOs)](https://enviroatlas.epa.gov/EnviroAtlas/glossary/glossary.html" \l "CAFO), cities and homes (from human excreta and detergents), and industries have contributed to algal blooms in lakes and coastal waters. Some of these algal blooms create harmful toxins affecting drinking water, food production (including shellfish), and recreational safety for humans and pets in the lakes, streams, rivers, and coastal waters4. Even when the algal blooms are not toxic their formation can cause hypoxia (low oxygen zones) which affect plants and animals in aquatic ecosystems and the industries that depend on them, such as fishing in [the Gulf of Mexico](https://www.epa.gov/ms-htf) or Chesapeake Bay..

Because of its essential role in agriculture, but potential as a pollutant, understanding where and how much P fertilizer is applied is important to inform management strategies that increase food security and water quality across the U.S. Information on the balance between P inputs and P uptake/removal from crops (like the 2012 data presented here) is important in order to understand potential areas where surpluses of P on cropland may be a pollution risk while other areas may be in need of additional P to ensure high crop yields.

# How can I use this information?

The map, Agricultural Phosphorus Balance, is one of four EnviroAtlas maps that display P inputs and agricultural crop P demand to the conterminous US. These data could be used either alone or in conjunction with other data layers to help identify areas where P is a significant pollutant source (over application) or where there are opportunities for more efficient management or recycling to meet crop demands. These data could also be used in models that examine the transport and cycling of P across terrestrial and aquatic ecosystems. Information on crop P demand and uptake is, or will be, needed for the development of nutrient reduction strategies, nutrient credit exchanges, and payments for ecosystem services.

How were the data for this map created?

Agricultural Phosphorus Balance in 2012 was estimated by subtracting Crop Phosphorus Removal from Inorganic Phosphorus Fertilizer and Phosphorus Manure Application (P fertilizer+P manure-P crop removal EnviroAtlas layers). We acquired county-level data describing total inorganic P fertilizer, confined manure and total crop P uptake (kg P yr-1) in 2012 from IPNI (see IPNI [detailed methodology](http://nugis.ipni.net/Methods/Removal/) for any of these 2 P inputs and 1 P output)5. We used the U.S. National wall-to-wall land use trends (NWALT6) for 2012, acquired from the USGS, at the scale of 60 m x 60 m. These data were converted to per area rates (kg P km2 yr-1) of crop P removal by dividing the total P input or removal by the land area (km2) of combined cultivated crop and hay/pasture (agricultural) lands within a county as determined from county-level summarization of the 2012 NWALT layer. We distributed county-specific per area P input and P removal rates to agricultural lands (60 m x 60 m pixels) within the corresponding county. We caped P fertilizer application8 at 6,000 kg of P per km2, manure9 at 10,000 kg of P per km2, and crop removal10 at 9,000 kg of P per km2 to correct for some pixels with unrealistically high rates. For a more detailed description, see the layer’s metadata or the publications below.

# What are the limitations of these data?

EnviroAtlas uses the best data available, but there are still limitations associated with these data. In order to match the latest available fertilizer data to create an agricultural balance layer, we used 60m resolution land use data which is not crop specific. Finer scale and crop-specific land use could improve our understanding of P removal rates. The data presented here are based on fertilizer sales data and livestock populations, as a proxy for P input application, and removal considers only a subset of 22 major US crops and are annual in nature. As such the application and removal rates are not crop-specific, site specific or season specific but rather a mean of over all annual crop-land. Data quality reporting may vary between states and counties. Fertilizer sold in one county in one year may be applied in another county or during a later year, introducing additional error. Some crops that may be particularly important to some areas of the country, but not nationally a major crop, were not considered and represents an under estimate of total P removal in these areas of the country (particularly the West).

# How can I access these data?

EnviroAtlas data can be viewed in the interactive map, accessed through web services, or downloaded.

# Where can I get more information?

The references below as well as the links throughout this fact sheet contain additional information about P pollution risks, and sustainability.

# Acknowledgements

EnviroAtlas is a collaborative effort led by EPA. The data for Agricultural Phosphorus Balance were compiled by Genevieve Metson from the US National Research Council. The data used to derive Agricultural Phosphorus Balance came from IPNI and NWALT. The fact sheet was written by Genevieve Metson (NRC), Jana Compton (EPA), and John Harrison (WSU Vancouver).

# Selected Publications

1 Roberts, T.L., Dibb. , D.W., (2011) Fertilizer Use in North America: Types and Amounts, in: Lal, R. (Ed.), Encyclopedia of Life Support Systems (EOLSS). developed under the Auspices of the UNESCO, Eolss Publishers, Oxford, UK.

2 Jasinski, S.M., (2013) Phosphate Rock. USGS Mineral Commodity Summaries 2013.

3 Cordell, D., White, S. (2014) Life’s Bottleneck: Implications of Global Phosphorus Scarcity and Pathways for a Sustainable Food System. Annual review of environment and resources 39, 161-188.

4 Anderson, D.M. et al. (2002) Harmful algal blooms and eutrophication: nutrient sources, composition, and consequences. Estuaries 25, 704-726.

5 Sharpley, A. et al.. (2013) Phosphorus legacy: Overcoming the effects of past management practices to mitigate future water quality impairment. Journal of Environmental Quality 42, 1308-1326.

6 IPNI, (2012) A Nutrient Systen (NuGIS) for the U.S., Norcross, GA. Available at [www.ipni.net/nugis](http://www.ipni.net/nugis)

7 Falcone, J.A. (2015) [U.S. conterminous wall-to-wall anthropogenic land use trends](http://dx.doi.org/10.3133/ds948) (NWALT), 1974–2012: U.S. Geological Survey Data Series 948.

8 USDA ERS, (2015) [Agricultural Resource Management Survey on Farm Financial and Crop Production Practices](http://www.ers.usda.gov/data-products/arms-farm-financial-and-crop-production-practices/tailored-reports-crop-production-practices.aspx). Washington, DC.

9 MacDonald, J.M. et al. (2009) [Manure use for fertilizer and for energy](http://www.ers.usda.gov/media/377385/ap037b_1_.pdf): Report to congress. USDA ERM, Washington, DC.

10 Murrell, T., Childs, F. (2000) [Redefining corn yield potential](https://www.ipni.net/ppiweb/bcrops.nsf/$webindex/7039176BA808FA2C852568EF00560957/$file/00-1p33.pdf). Better Crops 84, 33-37. & Heckman, J. et al. (2001) [Phosphorus and potassium removal in corn](http://www.ipni.net/ppiweb/bcrops.nsf/$webindex/a70dedab36c5da76852569fb001aed9a/$file/01-1p04.pdf). Better Crops 85, 4-5.

Vaccari, D.A. (2009) Phosphorus: a looming crisis. Scientific American 300, 54-59.