Phosphorus Fertilizer Application

This EnviroAtlas national map displays the application rate of inorganic phosphorus (P) fertilizer (kg P/ha/yr) on agricultural land in the conterminous U.S. for 2012 summarized by 12-digit hydrologic unit (HUC). These data are based on International Plant Nutrition Institute (IPNI) compilations of county and state fertilizer sales and cropland area from the U.S. national wall-to-wall anthropogenic land use trends (NWALT) land cover data for 2012.

Why is phosphorus fertilizer important?

Phosphorus 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 a result, it is necessary for plant growth along with nitrogen and other nutrients. In many ecosystems, including agricultural systems, phosphorus can be a limiting factor in plant growth and thus food production. In response to such limitations, farmers may apply additional phosphorus in the form of inorganic fertilizers, food and green waste composts, animal manures, or biosolids from human waste. However, when lost from farms, cities, or industry, phosphorus can contribute to water pollution because algal growth is also limited by phosphorus availability in many freshwater and coastal ecosystems.

Since the domestic discovery of phosphorus deposits in the mid-1800s and following agricultural intensification after World War II, inorganic phosphorus fertilizer has become a key agricultural input in the U.S.[1] Phosphorus is mined from concentrated deposits of phosphate rock, primarily located in Morocco, China, and the U.S. (particularly in Florida).[2] As a mined non-renewable resource, inorganic phosphorus fertilizer is subject to potential price fluctuations associated with geopolitical scarcity. Fertilizer use has increased crop yields, but it also creates water quality problems associated with the addition of excess nutrients.[3]

Phosphorus in runoff and erosion from agricultural fields, pastures, and concentrated animal feeding operations, in addition to losses from industry and residences have contributed to algal blooms in lakes and coastal waters. Some algal blooms create harmful toxins affecting drinking water, food production (including shellfish), and recreational safety in waterbodies.[4] Algal blooms cause hypoxia (low oxygen zones) that affect plants and animals in aquatic ecosystems and the industries that depend on them, such as fisheries in the Gulf of Mexico or Chesapeake Bay.

Because of the tension between the essential role of phosphorus in agriculture and its potential for overuse, understanding where and how much is applied to cropland is essential to maintain food security and increase water quality across the U.S. Both current information on phosphorus fertilizer use and historical information on past use is important because phosphorus applied to fields not used by crops in the same year can accumulate in soils.[5] Though the excess fertilizer may be used by plants later, phosphorus losses to waterways will persist after harvest or during a fallow period.

How can I use this information?

The map, Phosphorus Fertilizer Application, is one of four EnviroAtlas maps that display phosphorus inputs and agricultural crop phosphorus demand in the conterminous U.S. Phosphorus Fertilizer Application and three other maps, Phosphorus Application as Manure, Crop Phosphorus Removal, and Net Agricultural Phosphorus Balance, can be used alone or in conjunction with other data layers to help identify 12-digit HUCs where phosphorus is a significant pollutant (through over-application) or where there are opportunities for more efficient management. These data can also be used in models to examine the transport and cycling of phosphorus across terrestrial and aquatic ecosystems. Information on inorganic phosphorus fertilizer application is, or will be, needed for the development of nutrient reduction

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strategies, nutrient credit exchanges, and payments for ecosystem services.

How were the data for this map created?

Inorganic phosphorus (P) fertilizer inputs in 2012 were estimated using county-level estimates of farm P fertilizer inputs. Data describing total agricultural inputs of inorganic P fertilizer (kg P/yr) to individual counties in 2012 were acquired from IPNI. The land cover data used for this map, the 2012 U.S. national wall-to-wall land use trends (NWALT) data, were developed by the U.S. Geological Survey at a scale of 60m X 60m. These data were converted to per area rates (kg P/km^2/yr) of inorganic P fertilizer application by dividing the total P input by the land area (km^2) 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 the county-specific per area P inputs rates from IPNI to agricultural lands from NWALT within the corresponding county. Finally, the ArcGIS Zonal Statistics tool was used to calculate mean kg/km^2/yr of inorganic P fertilizer applied to each 12-digit HUC. This value was divided by 100 to convert to mean kg/ha/yr for each HUC. To correct for some pixels with unrealistically high P application rates (most likely caused by high fertilizer sales in a county with low agricultural acreage), we capped P application at 6000 kg P per km^2, which is double the highest application rate reported for corn in 2010 in a USDA Farm Financial and Crop Production Practice survey.[6] This alteration resulted in less than 1% reduction in total P fertilizer used compared to the reported sales data. For a more detailed description of data creation, 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. To match the latest available fertilizer data, we used 60m resolution land use data that are not crop-specific but reflect total cultivated cropland in the county. Finer scale and crop-specific land use could improve our understanding of phosphorus fertilizer application rates. The data presented here are based on annual farm fertilizer sales as a proxy for farmer application rates and not on application rates directly. As such the application rates are not crop-specific but rather a mean of overall annual cropland within a given county for 2012. In addition, sales data are not reported with the same level of specificity across all states, creating additional uncertainty. It is also possible that fertilizer sold in one county in 2012 may have been applied in another county or during a later year, introducing additional error. IPNI has applied reasonable assumptions to correct for these uncertainties when possible.

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?

A selection of publications related to phosphorus application and ecosystem effects is listed below. Links throughout the fact sheet contain additional information about phosphorus pollution risks and sustainability. To ask specific questions about this data layer, please contact the EnviroAtlas Team.

Acknowledgments

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Selected Publications

1. Roberts, T.L., and D.W. Dibb. 2011. Fertilizer use in North America: Types and amounts in Lal, R. (Ed.), *Encyclopedia of Life Support Systems* (EOLSS), developed under the auspices of UNESCO. EOLSS Publishers, Oxford, U.K. 7 p.

2. Jasinski, S.M. 2013. Phosphate rock: USGS mineral commodity summaries: 2013. U.S. Geological Survey, Washington, D.C.

3. Cordell, D., and S. White. 2014. Life's bottleneck: Sustaining the world's phosphorus for a food secure future. *Annual Review of Environment and Resources* 39:161–188.

4. Anderson, D.M., P.M. Glibert, and J.M. Burkholder. 2002. Harmful algal blooms and eutrophication: Nutrient sources, composition, and consequences. *Estuaries* 25:704–726.

5. Sharpley, A., H.P. Jarvie, A. Buda, L. May, B. Spears, and P. Kleinman. 2013. Phosphorus legacy: Overcoming the effects of past management practices to mitigate future water quality impairment. *Journal of Environmental Quality* 42(5):1308–1326.

6. U.S. Department of Agriculture Economic Research Service (ERS). 2015. Agricultural resource management survey on farm financial and crop production practices. Accessed June 2020.

Falcone, J.A. 2015. U.S. conterminous wall-to-wall anthropogenic land use trends (NWALT), 1974–2012. U.S. Geological Survey Data Series 948, U.S. Geological Survey, Reston, Virginia. 33 p.

Vaccari, D.A. 2009. Phosphorus: A looming crisis. *Scientific American* 300:54–59.