Phosphorus Application as Manure

This EnviroAtlas national map displays the application rate of phosphorus (P) as manure (kg P/ha/yr) on croplands 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-level data of phosphorus as recoverable manure from concentrated animal feeding operations (CAFOs) and cropland area from the U.S. conterminous wall-to-wall anthropogenic land use trends (NWALT) land cover data for 2012.

Why is phosphorus from manure important?

Manure is often collected from CAFOs and used to fertilize crops. The high nutrient (nitrogen and phosphorus) and organic matter content of manure makes it a good organic fertilizer. If applied properly, manure also recycles some of the nutrients that otherwise would be lost to the air or to aquatic ecosystems. This map presents the estimated application rate of phosphorus in livestock manure that is collected from CAFOs and applied to nearby cropland.

Phosphorus is an essential element for 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 in food production. In response to a presumed or actual phosphorus shortage, farmers may apply additional phosphorus in the form of inorganic fertilizers, food and green waste composts, animal manures, or biosolids from human waste.

Although the application of phosphorus as fertilizers (organic sources like manure and inorganic fertilizer) can increase crop yields, it can also contribute to water quality problems. Phosphorus in runoff and erosion from agricultural fields, pastures, and CAFOs, 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.[1] Even nontoxic algal blooms can 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.


Photo: J Compton

Manure is an important resource for agriculture, but as a pollutant it can negatively affect air quality, surface and groundwater, and human health. Because livestock have a low phosphorus use efficiency—that is, they ingest much more P than they can use to produce meat, bones, and milk, and excrete large amounts of it—CAFOs can be a major source of phosphorus that can be lost to waterways, unless it is safely recycled onto croplands.[2] Understanding the quantity and distribution of phosphorus applied as manure is important to inform management strategies that increase food security and maintain water quality across the U.S. Information on phosphorus application and removal by crops helps researchers and farmers to understand if phosphorus is being over- or under-applied based on crop needs.

How can I use this information?

The map, Phosphorus Application as Manure, is one of four EnviroAtlas maps that display phosphorus inputs and agricultural crop phosphorus demand in the conterminous U.S. Phosphorus Application as Manure and three other maps, Phosphorus Fertilizer Application, 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 from CAFOs is a significant pollutant and where there are opportunities for more efficient management or recycling to meet crop demands. These data can also be used in models to examine the transport and cycling of phosphorus across terrestrial and aquatic ecosystems. Information on manure phosphorus application is, or will be, needed for the development of

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nutrient reduction strategies, nutrient credit exchanges, and payments for ecosystem service.

How were the data for this map created?

Phosphorus manure application inputs to cropland in 2012 were estimated using county-level estimates of recoverable manure from confined feeding operations. Recoverable manure is defined as manure that is collected, stored, and available for land application from concentrated animal feeding operations.[3] County-level data, based on U.S. Census of Agriculture livestock populations and describing total farm inputs (kg P/yr) of P from manure produced by CAFOs 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 manure P 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 NWALT land cover layer. These county-specific per area P input rates were distributed to agricultural lands within the corresponding county. Finally, the ArcGIS Zonal Statistics tool was used to calculate mean kg/km^2/yr of P as manure 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 a county having little agricultural land), manure P application was capped at 10,000 kg P per km^2, which is slightly higher than the maximum reported application rate reported for 2006 by a USDA Farm Financial and Crop Production Practice survey.[4] 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. Finer scale and crop-specific land use data, including CAFO locations and animal type, could improve our understanding of manure P application rates. The data presented here are based on annual livestock populations and available cropland in a county and not on application rates themselves. As such the application rates are neither crop-specific nor field-specific but rather a mean across all cropland. Data reporting accuracy and specificity for livestock may not be the same for all states, contributing to potential error and uncertainty. It is also possible that CAFO manure produced in one county in one year may be applied in another county or during a later year, introducing additional error. This map does not present data on rangeland used to graze animals.

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 data sources, phosphorus pollution risks, and sustainability. To ask specific questions about this data layer, please contact the EnviroAtlas Team.

Acknowledgments

EnviroAtlas is a collaborative effort led by EPA. The data for Phosphorus Application as Manure were compiled by Genevieve Metson of the U.S. National Research Council. The data used to derive the data layer 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. 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.

2. Metson, G.S., G.K. MacDonald, D. Haberman, T. Nesme, and E.M. Bennett. 2016. Feeding the Corn Belt: Opportunities for phosphorus recycling in U.S. agriculture. *Science of the Total Environment* 542 Part B 10.1016/j.scitotenv.2015.08.047.

3. Kellogg, R.L., C.H. Lander, D.C. Moffitt, and N. Gollehon. 2000. Manure nutrients relative to the capacity of cropland and pastureland to assimilate nutrients: Spatial and temporal trends for the United States. U.S. Department of Agriculture, Natural Resources Conservation Service, Washington, D.C.

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

Copeland, C. 2006. Animal waste and water quality: EPA regulation of concentrated animal feeding operations (CAFOs). CRS Report for Congress, Congressional Research Service, Washington, D.C. 26 p.