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Fact Sheet
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Synthetic Nitrogen Fertilizer Application

This EnviroAtlas national map displays the mean application rate of synthetic nitrogen (N, kg N/ha/yr) within each 12-digit hydrological unit (HUC) in the conterminous United States (excluding Hawaii and Alaska) for the year 2006. These data are based on county and state surveys of fertilizer sales and use. The mean rate of application describes fertilizer application to agricultural systems and is calculated for the 12-digit HUC, not for agricultural lands within the HUC.

Why is nitrogen fertilizer important?

Nitrogen (N) is a fundamental building block for life. Though N is abundant on earth, much of it is in the form of an atmospheric gas, N_2, which is not usable by most organisms. Reactive N, however, can be used by all organisms, though it is much less abundant than N_2. Reactive N is created naturally through lightning strikes and by specialized bacteria that convert (or fix) N_2 gas into reactive N. Before the 20th century, availability of reactive N limited plant productivity in many ecosystems, thus limiting food production.

In the past century, humans have developed technology that can transform N_2 into reactive N, largely through a process called Haber-Bosch fixation (HBF). HBF is the primary technology used to create synthetic N fertilizers that are used widely around the world. HBF and other practices associated with food production and energy consumption have increased the annual amount of reactive N that is applied to terrestrial ecosystems three-to-fivefold above pre-European levels in United States. Though human-created nitrogen inputs, particularly synthetic N fertilizer, are critical for maintaining food supplies, inefficient nitrogen use in agriculture and society has led to countless human health and environmental problems. These problems include increased health risks from air pollution, contamination of drinking water supplies, increased frequency and severity of harmful algal blooms, hypoxia in freshwater and coastal marine ecosystems, and negative effects on climate.

Synthetic N fertilizer is the largest source of reactive N in U.S. terrestrial ecosystems. It is critical for maintaining food production and supporting international trade. However, a large percentage (~50%) of the fertilizer applied to agricultural fields never actually reaches the crop. Instead, the fertilizer is lost to the surrounding environment and can


Photo: Eric Vance, EPA

pollute air, land, and water resources. This pollution can have negative effects on plants and animals, and degrade the quality of outdoor areas that people use for recreation, particularly lakes, streams, rivers, and coastal areas.

Information on synthetic N fertilizer application can help inform policy decisions designed to combat nitrogen pollution. By identifying hotspots of fertilizer nitrogen inputs at local, regional, and national scales, approaches to reduce nitrogen loading and pollution can be optimized. Spatial information allows for regional assessments of synthetic nitrogen fertilizer application, and it can help assess cost-benefit trade-offs of nitrogen loading.

EnviroAtlas provides a measure of synthetic nitrogen fertilizer application to facilitate comparisons of nitrogen input across hydrologic units of varying size. More information on inputs of reactive N to the U.S. can be found in data fact sheets describing biological nitrogen fixation in natural and semi-natural ecosystems, biological nitrogen fixation in cultivated systems, and nitrogen inputs from manure produced in confined animal feeding operations.

How can I use this information?

The map, Synthetic Nitrogen Fertilizer Application, is one of a group of EnviroAtlas maps that display reactive N inputs to the conterminous US. These data can be used either alone or in conjunction with other data layers to help identify areas where nitrogen is a significant pollutant source. The information can be used in models that examine the transport and cycling of nitrogen across terrestrial and aquatic

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ecosystems. Information on synthetic N fertilizer application 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?

Synthetic N fertilizer inputs in 2006 were estimated using county-level estimates of farm nitrogen fertilizer inputs. We acquired county-level data describing total farm-level inputs (kg N yr^{-1}) of synthetic N fertilizer to individual counties in 2006 from the USGS.[1] The National Land Cover Database (NLCD) for 2006 was acquired from the USGS at the scale of 30 x 30 m. These data were converted to per area rates (kg N ha yr^{-1}) of synthetic N fertilizer application by dividing the total nitrogen input by the land area (ha) of combined cultivated crop and hay/pasture (agricultural) lands within a county as determined from county-level summarization of the 2006 NLCD.[2] We distributed county-specific, per area N inputs rates to agricultural lands (30 x 30 m pixels) within the corresponding county.[2] Following this distribution, we used the spatial analyst tool in ArcMap 10.0 (ESRI, Inc., Redlands, CA) to calculate a mean rate of synthetic N fertilizer application to individual 12-digit HUCs (22 March 2011 version). For a more detailed description, see the layer's metadata or the publications below.

What are the limitations of these data?

All national data layers, such as NLCD and county-level synthetic N fertilizer input, are by their nature, imperfect. Nitrogen inputs generated from processing these data sets cannot be taken as absolute truth but as the best available data. National data layers continue to improve and periodic updates to the Atlas will reflect those improvements. Correcting or improving these data sets is beyond the purview of EnviroAtlas.

Users should understand the limitations associated with these data. The quality of the fertilizer data varies from state to state and can be seen by comparing adjacent areas with similar land use/land cover in two different states. The NLCD estimates land cover based on a classification of satellite imagery; the process of classifying imagery into land cover types is not 100% accurate. The mapped data can be used to inform further investigation. Accuracy information for source data can be found on their respective websites.

How can I access these data?

EnviroAtlas data can be viewed in the interactive map, accessed through web services, or downloaded. Data describing national land cover can be downloaded from the Multi-Resolution Land Characteristics (MRLC) Consortium website. County scale fertilizer data can be accessed from the USGS.

Where can I get more information?

Information on nitrogen cycling, nitrogen fertilizer in the U.S., and health and environmental impacts of nitrogen can be found in the publications listed below. For additional information on how the data were created, access the metadata for the data layer from the drop down menu on the interactive map table of contents and click again on metadata at the bottom of the metadata summary page for more details. To ask specific questions about this data layer, please contact the EnviroAtlas Team.

Acknowledgments

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Selected Publications

1. Gronberg, J.A.M., and N.E. Spahr. 2012. County-level estimates of nitrogen and phosphorus from commercial fertilizer for the conterminous United States, 1987–2006. U.S. Geological Survey Scientific Investigations Report 2012-5207, U.S. Geological Survey, Reston, Virginia.

2. Ruddy, B.C., D.L. Lorenz, and D.K. Mueller. 2006. County-level estimates of nutrient inputs to the land surface of the conterminous United States, 1982–2001. U.S. Geological Survey National Water Quality Assessment Program (NAQWA) Scientific Investigations Report 2006–501, U.S. Geological Survey, Reston, Virginia.

3. Compton, J.E., J.A. Harrison, R.L. Dennis, T.L. Greaver, B.H. Hill, S.J. Jordan, H. Walker, and H.V. Campbell. 2011. Ecosystem services altered by human changes in the nitrogen cycle: A new perspective for U.S. decision making. *Ecology Letters* 14: 804–815.

4. Houlton, B.Z., E.W. Boyer, A. Finzi, J. Galloway, A. Leach, D. Liptzin, J. Melillo, T.S. Rosenstock, D.J. Sobota, and A.R. Townsend. 2012. Intentional vs. unintentional nitrogen use in the United States: Trends, efficiency, and implications. *Biogeochemistry* 114: 11–23.

5. Sobota, D.J., J.E. Compton, and J.A. Harrison. 2013. Reactive nitrogen inputs to US lands and waterways: How certain are we about sources and fluxes? *Frontiers in Ecology and the Environment* 11:82–90.