Surface Runoff from Agricultural Land

This EnviroAtlas national map provides modeled estimates of surface runoff at the outer edges of all agricultural fields within each 12-digit hydrologic unit (HUC) in millimeters (mm) of water for 2002. Surface runoff is water that has flowed over the soil's surface.

Why is surface runoff from agricultural land important?

Agriculture can affect the quantity and quality of water in streams and waterbodies. Surface runoff from agricultural land can carry sediment and pollutants. It can also contribute to changes in hydrology.

Runoff from the surface of fields can carry soil with it; it can also transport anything that was applied to the field. This includes nutrients from fertilizer, pesticides, pathogens such as bacteria, and other contaminants.[1] Sometimes sediment in runoff carries pollutants with it. Surface runoff tends to carry more sediments and pollutants than subsurface water flow.[2]

Runoff can contain nitrogen (N) and phosphorus (P). N and P are both nutrients that are critical to the existence of life on earth, but excess nutrients in fresh and near-coastal waters can result in algal blooms. Algal blooms can interfere with fishing and recreation and make drinking water difficult to treat; they can produce toxins that can make people sick and cause fish kills. The decay of particularly large blooms can reduce oxygen levels (a condition known as hypoxia) in offshore waters to a point that is too low for many species to survive, which creates "dead zones."

Runoff from the surface of fields can carry soil with it; when these sediments are carried to waterways, they can kill aquatic species, fill up reservoirs, and make drinking water harder to treat.[1] Also, because surface runoff can remove topsoil, it can degrade agricultural fields over time.[3] Soil types and condition can affect runoff. For example, reducing soil organic matter (plant and animal materials decomposing in the soil) can make it harder for water to infiltrate into soils, which increases runoff.[4] Surface runoff from fields can change the timing and flow of runoff.[1] This can change the flow regime (the pattern of flow for a stream) and increase water flows to streams.[1] These changes can affect aquatic species, increase erosion in streams, change the shape of the stream channel, and contribute to flooding.[1] Ditches added to fields can change stream morphology and increase flow.


Photo: EPA, Lexington, KY

These impacts can make streams and water bodies less safe for people to use for recreation and drinking water. They can also harm aquatic organisms. Changes to agricultural practices, such as tilling fields less often and planting trees and grass near streams (riparian buffers) can reduce these impacts.

How can I use this information?

The map, Surface runoff from agricultural land (mm), can be used to identify potential sources of water pollution and to understand hydrologic changes associated with agriculture. They can be viewed with layers describing water demand to suggest where runoff might pose a risk to water supply. While the model output is based on 2001/2002 data that may not represent current conditions, the information about the movement of water at the edge of agricultural fields can be used as a baseline to compare with current and future projections.

How were the data for this map created?

These data were created using the Fertilizer Emissions Scenario Tool for CMAQ (FEST-C). FEST-C combines Meteorology data for 2002 produced by the Weather Research Forecast model v3.4 and wet and dry atmospheric deposition to agricultural soils estimated by bidirectional CMAQ5.2[5] with field-level biogeochemistry and edge-of-field water movement simulated by the Environmental Policy Integrated Climate (EPIC) model. Simulations were performed for more than 100,000 rectangular grid cells (12km on a side) that form a continuous modeling layer across the conterminous U.S. These EPIC simulations are representative of regional, rather than local-scale conditions and assume conservation tillage on

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representative soils for specific crops at the HUC-8 (subbasin) scale. Irrigated and rain fed management simulations were performed for each of 22 major commercial crops. The results were then aggregated across all agricultural land in a simulation grid cell.[6] In order to pair land use with the meteorological and emission scenarios, the agricultural area in each grid cell was estimated using National Land Cover Database (NLCD) 2001 and US Department of Agriculture (USDA) 2002 Census of Agriculture county-level data. The gridded data are summarized by 12-digit HUC. For detailed information on how this data was generated, see the metadata.

What are the limitations of these data?

EnviroAtlas uses the best data available, but there are still limitations associated with these data. These data layers contain substantial uncertainties; they are based on models and large national geospatial databases. This map reflects assumptions about soil, weather, crop variety, and crop-specific management conditions in each 12-digit hydrologic unit. Given that 2001 and 2002 deposition, land use, and management practices data were used in the model, the data layer may not be representative of current conditions. Early simulation design and performance evaluation for 2002 yield, fertilizer use, and predicted plant and harvest dates are reported in Cooter et al.[6] These simulations represent nutrient applications that roughly follow regional nutrient management practices on the most prevalent agricultural soils as identified in the National Resources Inventory at the HUC-8 level. The use of average grid cell slope could result in the over-estimation of horizontal water and nutrient losses by the model for some crop/soil combinations, particularly for tile drainage systems. Regional-scale studies of edge-of-field N and P losses are not generally available. Comparison of some 2002 EPIC nutrient export results for the Upper Mississippi River Basin (UMRB), lying within the larger Mississippi/Atchafalaya River Basin, to other published modeling studies are presented in Cooter et al.[4] Comparisons of model estimates of crop yield, fertilizer application amounts and timing, crop planting and harvest dates, and irrigation water use agree with USDA and US Geological Survey (USGS) estimates that rely heavily on site-specific survey information representing long-term average conditions of overall spatial pattern and magnitude.[7,8]

How can I access these data?

EnviroAtlas data can be viewed in the interactive map, accessed through web services, or downloaded. The NLCD 2001 can be downloaded from the MRLC and the Census of Agriculture can be downloaded from the USDA's website.

Where can I get more information?

A selection of publications related to surface runoff and dissolved nutrients is listed below. To ask specific questions about this data layer, please contact the EnviroAtlas Team.

Acknowledgments

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Selected Publications

1. Blann, K.L., J.L. Anderson, G.R. Sands, and B. Vondracek. 2009. Effects of agricultural drainage on aquatic ecosystems: A review. *Critical Reviews in Environmental Science and Technology* 39:909–1001.

2. Robertson, E.M., and D.A. Saad. 2013. SPARROW Models used to understand nutrient sources in the Mississippi-Atchafalaya River Basin. *Journal of Environmental Quality* 42:1422–1440.

3. Baumhardt, R., B. Stewart, and U. Sainju. 2015. North American soil degradation: Processes, practices, and mitigating strategies. *Sustainability* 7:2936–2960.

4. Cooter, E.J., L. Ran, D. Yuan, and V. Benson. 2017. Exploring a United States maize cellulose biofuel scenario using an integrated energy and agricultural markets solution approach. *Annals of Agricultural & Crop Sciences* 2(2):1031.

5. Appel, K.W., K.M. Foley, J.O. Bash, R.W. Pinder, R.L. Dennis, D.J. Allen, and K. Pickering. 2011. A multi-resolution assessment of the Community Multiscale Air Quality (CMAQ) model v4.7 wet deposition estimates for 2002–2006. *Geoscientific Model Development* 4:357–371.

6. Cooter, E., J. Bash, V. Benson, and L. Ran. 2012. Linking agricultural crop management and air quality models for regional to national-scale nitrogen assessments. *Biogeosciences* 9:4023–4035.

7. Brakebill, J.W. and J.M, Gronberg. 2017. County-level estimates of nitrogen and phosphorus from commercial fertilizer for the conterminous United States, 1987–2012: U.S. Geological Survey data release.

8. Yuan, Y., R. Wang, E. Cooter, L. Ran, P. Daggupati, D. Yang, R. Srinivasan, and A. Jalowska. 2018. Integrating multimedia models to assess nitrogen losses from the Mississippi basin to the Gulf of Mexico. *Biogeosciences* 15:7059–7076.