



## Annual Reduced Nitrogen Dry Deposition

This EnviroAtlas national map portrays annual dry deposition of reduced nitrogen (kg/ha) within each 12-digit hydrological unit (HUC) for 2017. It is based on data from the Community Multiscale Air Quality modeling system (CMAQ).

### Why is reduced nitrogen dry deposition important?

Reduced nitrogen includes ammonia (NH<sub>3</sub>) and particulate ammonium, NH<sub>4</sub><sup>+</sup>; it is primarily emitted from agricultural systems but also from automobiles. Nitrogen [deposition](#) occurs when nitrogen in the atmosphere is transferred to the earth's surface through [wet](#) or [dry deposition](#). Atmospheric deposition plays an important role in terrestrial, freshwater aquatic, and marine ecosystem functioning and degradation.<sup>1,2</sup> For example, it is the primary source of acidifying chemicals that cause slower plant growth, lower soil fertility, the injury or death of vegetation, and localized extinction of fish and other aquatic species.<sup>3,4,5</sup>

Atmospheric deposition is also an important source of excess nitrogen as a nutrient. Excess nitrogen alters freshwater and terrestrial biodiversity, increases susceptibility of vegetation to insects and diseases, alters surface water quality, and contaminates drinking water supplies.<sup>6,2</sup> Across the US, and in the west in particular, microbial communities, such as those associated with lichen, are altered and diminished with increased nitrogen deposition.<sup>7,8</sup> In the Rocky Mountains, excess nitrogen causes shifts in biodiversity and replacement of native plants.<sup>9</sup> Excess nutrients alter estuarine systems by increasing phytoplankton and algae, leading to [eutrophication](#), loss of habitat, loss of dissolved oxygen, fish kills, and decreased productivity.<sup>10</sup> Nitrogen stressors from the atmosphere have been increasing, posing an increasingly serious problem.<sup>11</sup>

### How can I use this information?

This map provides information from the CMAQ model showing how deposition varies across space due to complex emissions patterns and their transport and transformation. It provides spatially continuous values of concentration and deposition that can be used as input to ecological assessments and ecosystem management strategies. Atmospheric deposition is important to water quality; its contribution to nitrogen loading in a waterbody can be on the order of 15-40%. This data can be used as input to watershed models as part of [Total Maximum Daily Load](#) calculations.



Photo: Nara Souza/Florida Fish and Wildlife Commission

This map also provides important input to critical loads analyses. Critical loads can be defined on the basis of indicators such as species diversity, soil chemistry, and tree growth. Comparison of total nitrogen deposition to critical load values allows users to identify areas where attention is potentially needed to avoid or mitigate damage.

### How were the data for this map created?

This map is based on data from the Community Multiscale Air Quality (CMAQ) modeling system. Because deposition in a HUC can come from a large area, air quality models are an important tool for translating emissions data into information about ecological exposure. Airsheds are very large in comparison to HUCs and they include emissions from multi-state regions. Local deposition is caused by a mix of airshed and distant emissions. This makes it difficult to predict the exposure that results from emissions without the use of a regional air quality model. This map was created using output from the CMAQ Modeling System v 5.3.2. Meteorology data were processed for 2017 using the [Weather Research Forecast model](#) v4.1.1 with the Pleim-Xu land surface model. Anthropogenic emissions are from the EPA's Air Quality Time Series (EQUATES) 2017 modeling platform. The output was corrected for errors in wet deposition using [PRISM data](#) and for bias in the rainwater concentrations of TNO<sub>3</sub>, NH<sub>x</sub>, and sulfate using National Atmospheric Deposition Program (NADP) data. Model predicted values of dry deposition were not adjusted. Model output was summed to create total annual deposition values for each grid cell. Finally, the gridded data were summarized by taking the mean for each 12-digit HUC.

## What are the limitations of these data?

All national data layers are inherently imperfect; they are an estimation of the truth based on the best available science. The mapped data are estimates that should be used to inform further investigation. Periodic updates to EnviroAtlas will reflect improvements to nationally available data.

Atmospheric deposition varies across the U.S. from differences in climate and land surface. Measurements of dry deposition are challenging and expensive, so few observation data are available. While monitoring data are useful, estimates of deposition between monitoring locations can miss changes in value due to the distribution of emissions and variations in the land surface. CMAQ modeling accounts for the complex chemistry of the atmosphere and interactions between chemicals. CMAQ is based on the best available science. Still, the chemistry and physics of the atmosphere are very complicated, and there are uncertainties in the model representations and inputs that result in uncertainties in the predicted concentrations and deposition fluxes. The data have been summarized based on HUCs, but actual atmospheric deposition will vary within the HUC.

## Selected Publications

1. Lovett, G.M., and T.H. Tear. 2008. [Threats from above: Air pollution impacts on ecosystems and biological diversity in the eastern United States](#). The Nature Conservancy and the Cary Institute of Ecosystem Studies, New York. 17 p.
2. Greaver, T.L., T.J. Sullivan, J.D. Herrick, M.C. Barber, J.S. Baron, B.J. Cosby, M.E. Deerhake, R.L. Dennis, J.J. Dubois, C.L. Goodale, A.T. Herlihy, G.B. Lawrence, L. Liu, J.A. Lynch, and K.J. Novak. 2012. [Ecological effects of nitrogen and sulfur air pollution in the US: What do we know?](#) *Frontiers in Ecology and the Environment* 10:365–372.
3. Dennis, R., R. Haeuber, T. Blett, J. Cosby, C. Driscoll, J. Sickles, and J. Johnston. 2007. [Sulfur and nitrogen deposition on ecosystems in the United States](#). EM Feature, Air and Waste Management Association, December 2007:12–17.
4. DeHayes, D.H., P.G. Schaberg, G.J. Hawley, and G.R. Strimbeck. 1999. [Acid rain impacts on calcium nutrition and forest health](#). *BioScience* 49:789–800.
5. Driscoll, C.T., G.B. Lawrence, A.J. Bulger, T.J. Butler, C.S. Cronan, C.Eagar, K.F. Lambert, G.E. Likens, J.L. Stoddard, and K.C. Weathers. 2001. [Acidic deposition in the northeastern United States: Sources and inputs, ecosystem effects, and management strategies](#). *BioScience* 51:180–198.
6. Driscoll, C.T., D. Whitall, J. Aber, E. Boyer, M. Castro, C. Cronan, C.L. Goodale, P. Groffman, C. Hopkinson, K. Lambert, G. Lawrence, and S. Ollinger. 2003. [Nitrogen pollution in the northeastern United States: Sources, effects, and management options](#). *BioScience* 53(4):357–374.
7. Fenn, M.E., J.S. Baron, E.B. Allen, H.M. Rueth, K.R. Nydick, L. Geiser, W.D. Bowman, J.O. Sickman, T. Meixner, D.W. Johnson, and P. Neitlich. 2003. [Ecological effects of nitrogen deposition in the western United States](#). *BioScience* 53:404–420.
8. Pardo, L.H., M.E. Fenn, C.L. Goodale, L.H. Geiser, and C.T. Driscoll. 2011. [Effects of nitrogen deposition and empirical nitrogen critical loads for ecoregions of the United States](#). *Ecological Applications* 21:3049–3082.
9. Baron, J.S., H.M. Rueth, A.M. Wolfe, K.R. Nydick, E.J. Allstott, J.T. Minear, and B. Moraska. 2000. [Ecosystem responses to nitrogen deposition in the Colorado Front Range](#). *Ecosystems* 3:352–368.
10. Paerl, H., R. Dennis, and D. Whitall. 2002. [Atmospheric deposition of nitrogen: Implications for nutrient over-enrichment of coastal waters](#). *Estuaries* 25:677–693.
11. Galloway, J.N. and E.B. Cowling. 2002. [Reactive nitrogen and the world: 200 years of change](#). *Ambio: A Journal of the Human Environment* 31(2):64–71.

## How can I access these data?

EnviroAtlas data can be viewed in the interactive map, accessed through web services, or downloaded. Data and accuracy information for the source datasets can be found on their respective web sites.

## Where can I get more information?

There are numerous resources on nitrogen deposition; a selection of these publications is listed below. Information about the models used can be found at their respective websites. 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 layer list. To ask specific questions about this data layer, please contact the [EnviroAtlas Team](#).

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