



## Annual Oxidized Nitrogen Wet Deposition

This EnviroAtlas national map portrays annual wet deposition of oxidized nitrogen (kilograms per hectare) within each 12-digit hydrologic unit ([HUC](#)) for 2011. It is based on data from the Community Multiscale Air Quality modeling system ([CMAQ](#)).

### Why is oxidized nitrogen wet deposition important?

Oxidized nitrogen includes nitric acid ( $\text{HNO}_3$ ), nitric oxide ( $\text{NO}$ ), nitrogen dioxide ( $\text{NO}_2$ ), ammonia ( $\text{NH}_3$ ), and particulate nitrate ( $\text{NO}_3$ ), among other compounds; it is produced from the burning of fossil fuels as well as from natural sources such as lightning, forest fires, and bacterial decay. Nitrogen [deposition](#) occurs when nitrogen in the atmosphere is transferred to the earth's surface through [wet deposition](#) 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 western U.S. in particular, microbial communities, such as lichen, are altered and diminished with increased nitrogen deposition.<sup>7,8</sup> In the Rocky Mountains, it causes shifts in biodiversity and replacement of native plants.<sup>8</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?

The map, Oxidized Nitrogen Wet Deposition, 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



Photo: Nara Souza/Florida Fish and Wildlife Commission

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.

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 was created using output from the [CMAQ Modeling System v 5.0.2](#). Meteorology data was processed for 2011 using the [Weather Research Forecast model v3.4](#) with the Pleim-Xu land surface model. Emissions are based on the National Emissions Inventory ([NEI](#)) 2011 platform. The output was corrected for errors in the wet deposition using [PRISM data](#) and for bias in the rainwater concentrations of  $\text{TNO}_3$  and  $\text{NH}_x$  using National Atmospheric Deposition Program ([NADP](#)) data. Finally, the gridded data were summarized by 12-digit HUC. 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.

### What are the limitations of these data?

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. due to differences in climate and land surface. The National Trends Network (NTN), a part of the NADP, provides wet deposition data at numerous sites across the U.S. 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 and 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 data sets 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 resources 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 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](#).

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