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Deposition Trend Guidance

Introduction

For the purpose of Forest Planning, the CL Implementation Strategy recommends using modeled total deposition estimates available on the Portal. Total deposition includes both wet and dry components of deposition, but excludes deposition from clouds and fog. Currently the best national deposition estimates are outputs from the CMAQ v5.1 model using emissions inventory data from 2006. Early in 2013, new total deposition maps (and GIS layers) for nitrogen and sulfur will be available on the Portal. These are being created by Total Deposition Science Committee of the NADP (National Atmospheric Deposition Program) and will cover the 48 continental states of the US. The Total Deposition map products will incorporate the best current knowledge on how to combine measured and modeled deposition into gridded information that can be used in national critical load exceedance calculations. The gridded total deposition is necessary when assessing impacts across the landscape, because measured information alone is considered representative for a relatively short distance (roughly 10 miles) from the wet or dry deposition monitoring sites. Total Deposition map products will be released annually, coincident with posting of the most current CASTNET (Clean Air Status and Trends Network) data. Be advised that the most current year of information posted will usually be about one year behind the current date.

Forests should use the modeled total deposition estimates when calculating CL exceedance, unless regionally refined deposition information is available. If regionally refined deposition estimates are used instead, consult with an air specialist to make sure that the wet and dry components of total deposition are accounted for accurately.

There is one situation where we recommend using measured information: when the CL assessment shows that deposition is close to or slightly over the CL and the deposition information is outdated (as is the CMAQ 2006 deposition information). This is important because the CASTNET 2010 annual report showed the following regional trends:

- CASTNET trend analysis shows sharp declines in sulfur dioxide and particulate sulfate (dry) concentrations in the east and smaller declines in the west; slight declines in total nitrate and particulate ammonium (dry) concentrations in both east and west (pp. 19 – 28).
- CASTNET also reports on total deposition trends, using NADP monitoring data for wet deposition. They show a dramatic decline in sulfur deposition (as well as concentrations in precipitation) since 2006 in the eastern US (Figure 3-8 on page 38), but a slight increase in total sulfur deposition in the west (Figure 3-7 on page 37). Changes in total nitrogen deposition in the east are similar to sulfur deposition trends (with the exception of a slight increase in concentration in 2010); while in the west, total nitrogen flux (change) has been fairly flat with an increase in 2010 (Figure 3-12, page 44).

Given that there have been regional decreases in some pollutants it is possible that an area showing a small exceedance using the 2006 CMAQ deposition data may *not exceed* the CL under current deposition levels. Because of this, Forests showing a small exceedance of the CLs should examine measured temporal trends, from 2006 to the present, to determine the

likelihood that current deposition has decreased to the point where the CL exceedance is eliminated. Alternately, some areas may have experienced recent increases in deposition related to oil and gas development or other new localized sources of emissions. For these areas it is equally important to examine trends because the current exceedance may be greater than shown in the initial analysis.

The best way to examine temporal trends is to use measured concentrations of sulfur and nitrogen in wet deposition available through the NADP/NTN (National Trend Network). Precipitation-weighted concentrations from over 250 monitoring sites have been interpolated across the landscape to develop gridded deposition data that can be used to examine wet deposition trends within the Forest boundary using GIS.

Background

Atmospheric deposition is the process by which airborne particles and gases are deposited to the earth's surface. When these pollutants are deposited in rain or snow they are known as wet deposition. Wet deposition from rain and snow is monitored routinely and extensively across the United States and is a factor of the amount of precipitation multiplied by the concentration of pollutants. Deposition associated with clouds and fog (occult deposition) has been measured only at a few high elevation sites within the US. Although it can account for a significant portion of deposition in these areas (up to two times as much as wet plus dry deposition), it has not been incorporated into modeling efforts and we do not have a good way to incorporate this component of deposition into a forest level trend analysis.

Dry deposition occurs during periods without precipitation but it is not as extensively monitored as wet deposition (dry deposition is measured at 82 sites, wet deposition at over 250 sites). Dry deposition is also more difficult to estimate than wet deposition. The estimation of dry deposition rates requires information on the ambient concentrations of pollutants, meteorological data, and information on land use, vegetation, and surface conditions, all of which are site-specific. Because of this site-specificity, it is difficult to spatially extrapolate dry deposition as is often done for wet deposition.

The trend analysis outlined in this document uses only wet deposition information and therefore is of most value in areas where wet deposition is the major component of total deposition. In the arid Southwest, where dry deposition provides a greater portion of atmospheric deposition, using only wet deposition measurements could produce a gross underestimation of total deposition. Therefore, the trend analysis described in this document is not a recommended refinement of the CL analysis for arid areas.

Wet deposition is a function of the concentration of pollutants in the atmosphere and the amount of precipitation that occurs. However, precipitation varies across the landscape and from year to year, affecting deposition trends. Concentration is the more consistent measure for tracking temporal trends in pollution and interpolating data. The elemental concentration measurements for sulfate (calculated as S) and nitrate and ammonium (calculated and added together as N) should be used to track temporal trends in Forest Plan assessment.

Spatially interpolated data maps use measured pollutant concentrations to estimate concentrations in areas without monitoring. Because not all Forests have a nearby National Atmospheric Deposition Program/National Trends Network (NADP/NTN) monitoring site, the spatially interpolated data maps will be used for this trend analysis effort. This guide will focus on accessing and interpreting data provided in these spatially interpolated maps.

Data Source

Because rain and snow are the primary constituents of wet deposition for many areas, the data from NADP/NTN is generally relied on to evaluate wet deposition of pollutants. NTN samplers collect rain and snow, and NADP has documented deposition for many years in a nationwide network of monitoring sites. The network collects data to evaluate spatial and temporal long-term trends in precipitation chemistry. Precipitation samples are collected weekly and sent to a central analytical laboratory for analysis of hydrogen (acidity as pH), sulfate, nitrate, ammonium, chloride, and base cations, including calcium, magnesium, potassium, and sodium. To ensure accurate and precise data records, precipitation samples are collected and analyzed according to strict clean-handling procedures and a rigorous quality assurance program. Centralized analysis also increases consistency in the data.

Chemical concentration data summaries from each monitoring site are available in multiple forms (including tabular annual and seasonal precipitation weighted means as well as trend plots). Actual site data can be used when the monitor is located within 10 miles of the Forest. However in most cases the Forests will utilize gridded, spatially interpolated concentrations to calculate average annual wet sulfur and/or nitrogen deposition within the Forest boundary.

Deposition Trend Analysis Instructions

NADP/NTN data is stored on the NADP web site. Once downloaded, the data analyzed for this effort should be stored in a tabular format, such as a Microsoft Excel spreadsheet. We recommend storing all information relating to the trend analysis (including GIS projects and data sets) in the project folder. The following steps will take you through downloading the interpolated GIS raster files and conducting the trend analysis.

1. Obtain gridded, spatially interpolated sulfur (S) and nitrogen (N) concentrations from the NADP/NTN web site for the years 2006 – 2012 (or most recent year available). **Make sure that you are downloading files developed for the Critical Loads of Atmospheric Deposition Science Committee (CLAD) because the concentrations in these files have already been converted from sulfate to sulfur (S), and nitrate or ammonium to nitrogen (N). Download files at http://nadp.sws.uiuc.edu/ntn/cladmaps.aspx**
2. For exceedance of CLs of acidification, look at the trend in S and N concentrations. Both sulfur and nitrogen can affect acidification so it is appropriate to examine them simultaneously by adding them together (S+N); examining them separately will allow you to identify the trend of each pollutant, if desired. The unit of measure for S+N concentration is equivalents/liter (eq/L). The unit of measure for S or N alone is milligrams/liter (mg/L).

3. For exceedance of CLs of nutrient nitrogen, look at the trend in N concentrations. It is not appropriate to examine the sulfur trends. Concentrations of N are provided in milligrams/liter.
4. Calculate the annual average deposition within the Forest boundary for each year. This can be done in Spatial Analyst in ArcMap. Within Spatial Analyst, use the "Zonal Statistics as Table" option under the Zonal dropdown menu. In most cases where the forest coverage is broken into multiple polygons, the polygons should be merged before calculating the average concentration value. The forest many want to include estimates for two categories: 1) Forest Service ownership, and 2) private, state, and other ownership. In situations where a geographical explanation for multiple polygons within the coverage exists, work with a GIS specialist to determine the best way to compute a forest-wide annual average.
5. The forest-wide (and/or category–averaged) concentrations for S, N, or S+N (depending on the exceedance you are concerned with) for each year can be exported into a spreadsheet.
6. The final step of the analysis is to develop trend plots for the wet component of S, N, or S+N for the Forest. The trend plot should include the sampling year on the x-axis and the S, N, or S+N concentration on the y-axis. S or N concentration is reported in mg/L. S+N concentration is reported in eq/L. This is a qualitative assessment to examine whether the overall deposition trend is increasing or decreasing. (Statistical analysis software can be used to quantitatively examine deposition trends and uncertainty if desired.)