

MERCURY IN WET-ONLY PRECIPITATION IN THE CATSKILL MOUNTAINS, NEW YORK, 2004-07

PREPARED FOR:

**THE NEW YORK STATE
ENERGY RESEARCH AND DEVELOPMENT AUTHORITY**
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Data Report

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Abstract

In March 2004, a Mercury Deposition Network (MDN) collector was co-located with the existing National Atmospheric Deposition Program precipitation chemistry collector just outside the Biscuit Brook watershed (as defined by the USGS gaging station 01434025) on land owned by the Frost Valley YMCA in Ulster County, NY. Weekly wet-only precipitation samples were collected at the site through the 2007 calendar year. Although surface-water mercury concentrations are low in this

region compared to other areas of New York, such as the Adirondack Mountains, high concentrations of methylmercury have been measured in fish and other aquatic biota in the Neversink Reservoir. Total mercury concentrations in wet-only precipitation were generally low (median of 6.6 ng/L for the study period) at Biscuit Brook compared to other areas of the country. In contrast, total annual mercury deposition was high (median of 137.3 ng/m² for the study period) relative to the rest of the northeastern US and comparable to deposition in Pennsylvania. This difference between concentrations

and deposition resulted from higher annual precipitation at the Biscuit Brook site than at other sites throughout the northeast. Biscuit Brook receives higher annual precipitation because of the orographic effect caused by the Catskill Mountains and moisture that moves northwest from the Atlantic Ocean. The New York State Energy Research and Development Authority has committed funding for the Biscuit Brook MDN collector for an additional three years through 2010.

Introduction

The Mercury Deposition Network (MDN) is administered by the National Atmospheric Deposition Program (NADP); the purpose of MDN is to provide measurements of mercury concentration in wet-only precipitation throughout the nation. Much attention has focused on mercury (Hg) pollution in the United States and elsewhere in recent years (Maltby, 2002; Kidd and others, 2004; Limbong and others, 2004; Seigneur and others, 2004; Storelli and Marcotrigiano, 2004; Wang and others, 2004). Most of this concern centers on methylmercury (MeHg), which is a strong neurotoxin (Clarkson, 1992). Only a small amount (typically less than 1 percent) of Hg derived from the atmosphere is deposited as MeHg, however Hg can be converted to MeHg within the landscape through the process of methylation (Gilmour and Henry, 1991; Rudd, 1995; Gilmour and others, 1998). In addition to methylation within the landscape, Hg biomagnifies, a process whereby the concentration of MeHg increases in organisms as it moves up the food chain and MeHg bioaccumulates, or is stored in animal tissue faster than it is released, causing the concentration of MeHg to increase in animal tissue through time. Methylation, biomagnification, and bioaccumulation cause small amounts of Hg in atmospheric deposition to become large environmental concerns (Rudd, 1995). In 2006, 23 states had issued statewide fish consumption advisories, 13 had issued coastal waters advisories, and a total of 48 states had issued either statewide or waterbody-specific advisories because of Hg contamination (U.S. EPA, 2007). In 2008, the New York State Department of Environmental Conservation (NYS DEC) issued a statewide fish consumption advisory because of high levels of mercury in fish (NYS DOH, 2008).

The MDN has been in operation since 1996 and has grown from 26 sites to currently more than 100 sites in 38 states and six Canadian provinces [<http://nadp.sws.uiuc.edu/>]. There are five active MDN sites in New York State. The New York State Energy Research and Development Authority (NYSERDA) began funding an MDN collector co-located at the Biscuit Brook NADP precipitation chemistry station in March 2004 to support Hg research being conducted by the U.S. Geological Survey and the NYS DEC within the larger Neversink Reservoir watershed (fig. 1). This report describes the results of mercury deposition collection from March 2004 to December 2007 at the Biscuit Brook MDN collector. Interpretation is limited since the purpose of this study is only to provide atmospheric mercury deposition data.

Site Description

The Biscuit Brook MDN collector (NY68) is located in the Neversink Reservoir watershed on property owned by the Frost Valley YMCA. The site operator is employed by the Frost Valley YMCA and the U.S. Geological Survey provides site supervision. The Neversink Reservoir watershed is located in southeastern New York in Ulster County about eight km northeast of Liberty, NY, and drains an area of 238 km² (fig. 1). The Reservoir was formed by damming the Neversink River, which is part of the Delaware River basin. The Neversink watershed was chosen for this study because it is 98 percent forested and is the least developed watershed in the New York City water supply system. The Neversink River is also a popular location for trout fishing. Although surface water mercury concentrations are low in the Neversink watershed (1-2 ng/L), mercury concentrations in reservoir fish are high enough to warrant a fish consumption advisory by New York State (Loukmas and others, 2006). The watershed receives some of the most acidic deposition in the northeastern United States (NADP, 2008) and has been a site of environmental research for many years (Murdoch and Stoddard, 1992; Wolock and others, 1997; Murdoch and others, 1998; Lawrence and others, 2000). The climate is humid continental; mean annual precipitation was 1,616 mm and mean annual temperature was 5.2 °C from 1978-2007 at Slide Mountain weather station operated by the National Oceanic and Atmospheric Administration located about seven km from NY68. There was also a significant increase in total annual precipitation of 0.37 mm per year from 1952-2005 at Slide Mountain (Burns and others, 2007). Precipitation is generally evenly distributed throughout the year, and 20-25 percent occurs as snow. Runoff within the Neversink River Basin averaged 980 mm from 1938-2001, about one-third of which occurred as snowmelt during March and April (Butch and others, 2002).

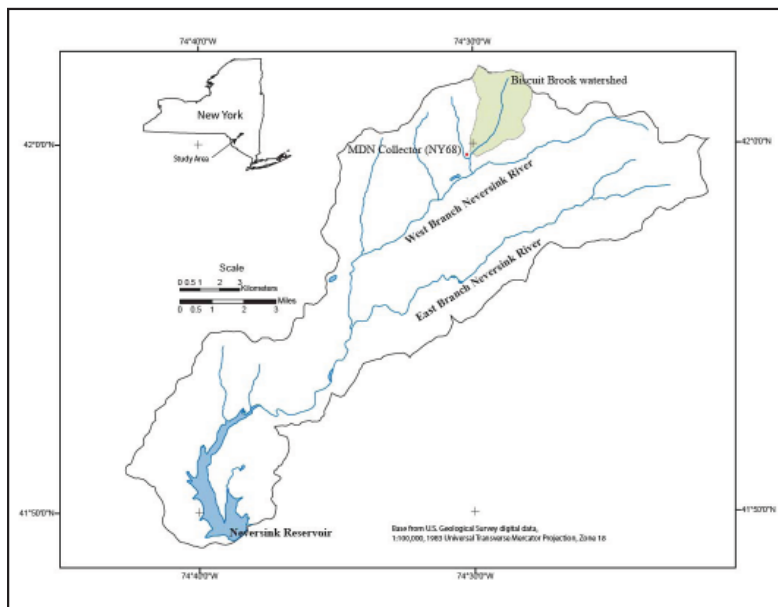


Figure 1.
The Neversink
Reservoir watershed
showing the Biscuit
Brook watershed and
the Biscuit Brook
MDN collector, Catskill
Mountains, NY.

Methods

The MDN consists of more than 100 automated wet deposition collectors and rain gages that quantify wet-only mercury deposition concentration and precipitation amount. The network provides mercury concentration and flux estimates throughout much of the United States and southern Canada. The deposition collector is a modified Aerochem wet-only precipitation collector that uses a wetness sensor to determine when rain is falling and opens the top to a precipitation collector (fig. 2). The Biscuit Brook MDN collector is located in a small clearing just outside the Biscuit Brook watershed (as defined by the U.S. Geological Survey stream gaging station). Samples are collected every Tuesday per MDN protocols and the sample is sent to Frontier Geosciences for total mercury analysis. It takes about six months from the time the sample is collected to when data are available on the MDN Web site [<http://nadp.sws.uiuc.edu/mdn/>, accessed 12/1/2008]. Weekly sample concentrations as well as monthly and annual data summaries are available on the MDN Web site.



Figure 2. The mercury deposition collector (NY68) at Biscuit Brook watershed, Catskill Mountains, NY.

¹Use of trade names does not imply endorsement by the U.S. Geological Survey

Results

There were 198 samples collected during the study period (March 2004 to December 2007); 11 were flagged as questionable and removed from the dataset (typically because of an under catch of precipitation when compared to the rain gage or because debris was present in the sample) and there was no precipitation measured for an additional nine sample weeks. Mercury concentrations in weekly wet-only precipitation ranged from 1.0 to 28.7 ng/L from March 9, 2004, to December 26, 2007, with a median concentration of 6.6 ng/L (fig. 3). The median deposition for NY68 was 137.3 ng/m² during the same period. Mercury deposition was calculated by the NADP Program Office; multiplying weekly concentration by total weekly precipitation. The two highest deposition values were measured during August and September 2004 when high concentrations coincided with a high volume of rainfall (fig. 3). There was no apparent trend in either mercury concentrations or mercury deposition during the study period although the time period was too short to allow a statistical trend analysis. Deposition was highest during the summer each year, but this seasonal pattern was less pronounced for concentration, with peak concentrations occurring anytime from late spring to fall each year (fig. 3).

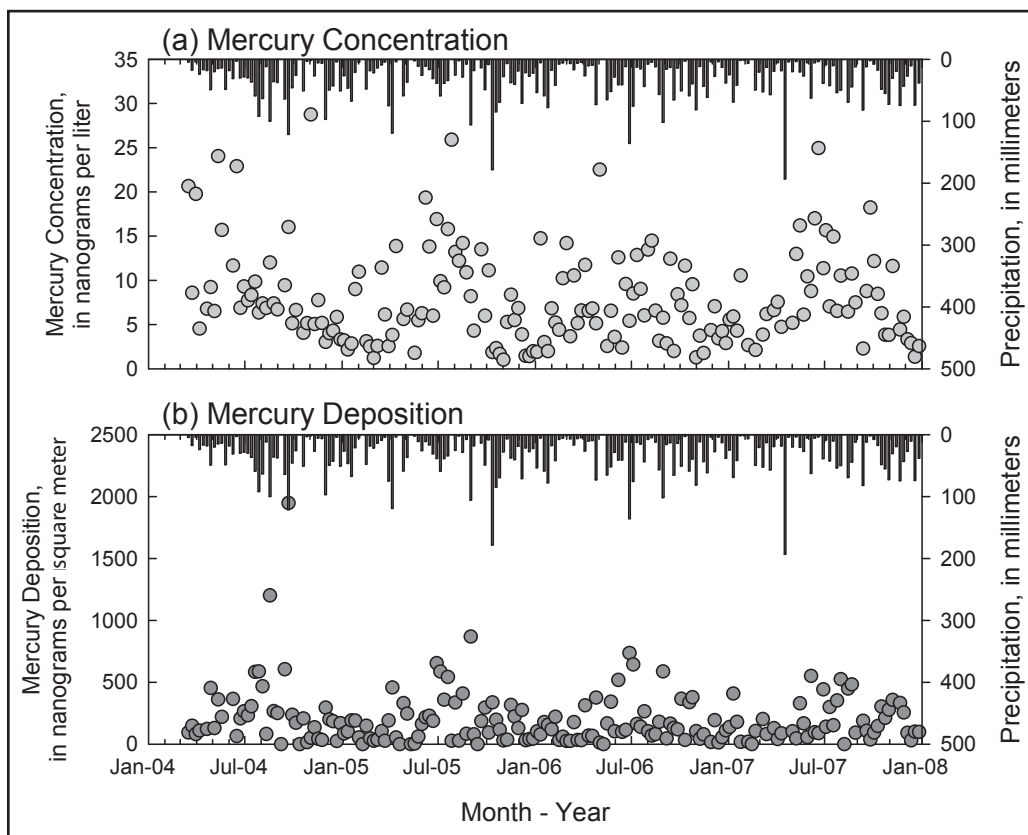


Figure 3. (a) Mercury concentration and (b) mercury deposition measured from March 2004 to December 2007 at the Biscuit Brook MDN site (NY68), Catskill Mountains, NY. Total weekly precipitation is included on each plot for comparison.

Precipitation amount has been measured at NY68 since 1985, and during that period total annual precipitation ranged from a minimum of 1,000 mm (in 2001) to a maximum of 2,010 mm (in 1996). The mean annual precipitation for the 24-year record was 1,420 mm. The period of record for this study (2004-2007) was wetter than average with a minimum of 1,600 mm in 2004 and a maximum of 1,770 mm in 2005. The mean annual precipitation from 2004-2007 was 1,680 mm. During the study period total annual precipitation at NY68 was among the highest recorded across the nation and was consistently the highest measured in the northeastern US. This was especially true during 2007 when NY68 had the fourth highest total precipitation of the more than 250 NADP precipitation gages (fig. 4). The large amount of precipitation at NY68 is attributable to the orographic effect as moisture from the Great Lakes and Atlantic Ocean meet the Catskill Mountains as well as precipitation moving north from the Gulf of Mexico.

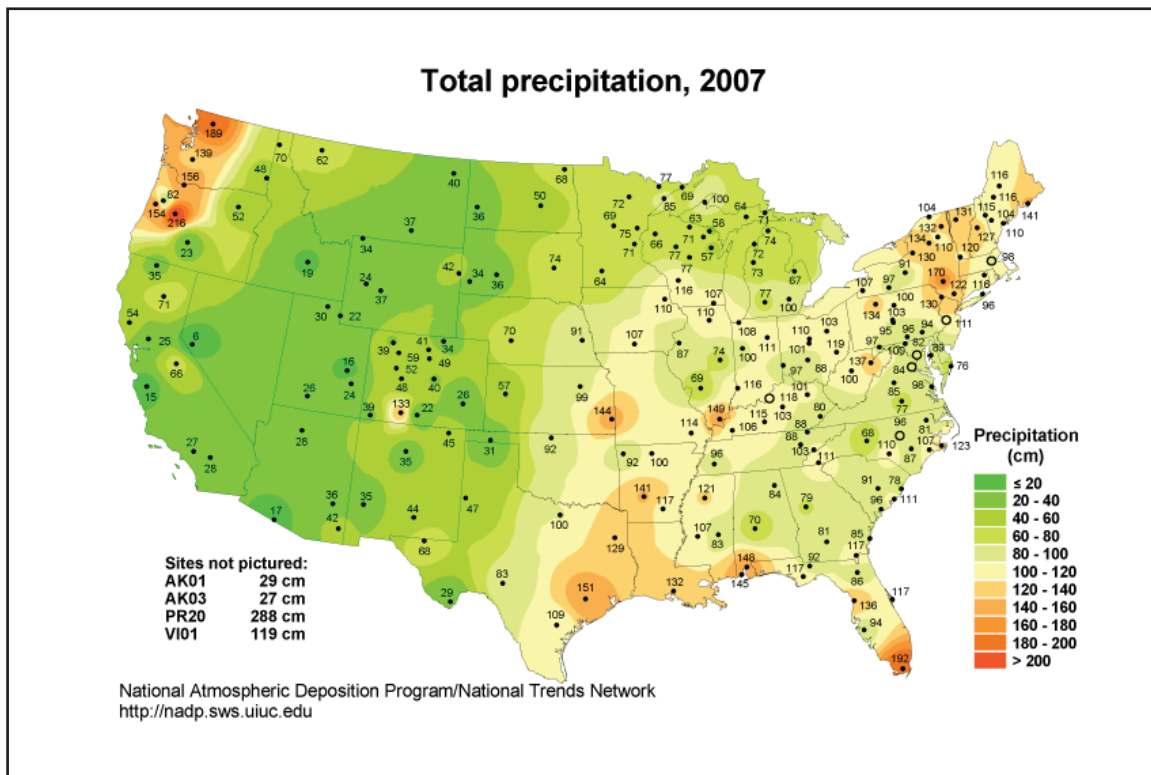


Figure 4. Total annual precipitation for the 2007 calendar year at all National Atmospheric Deposition Program stations (NADP, 2008).

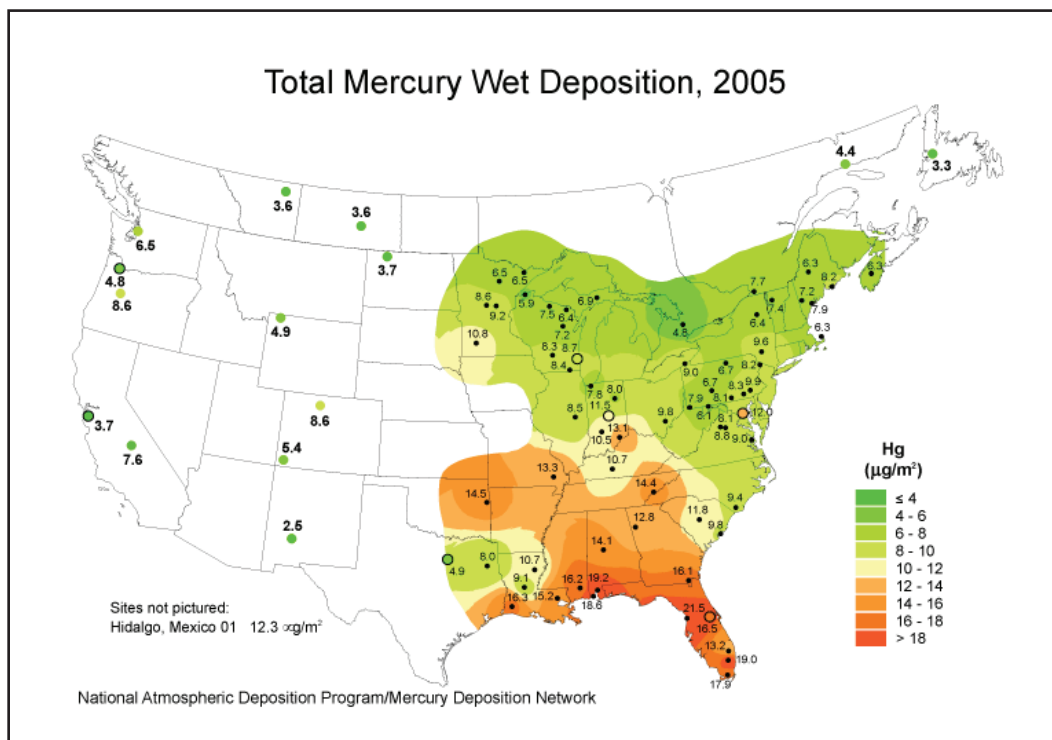
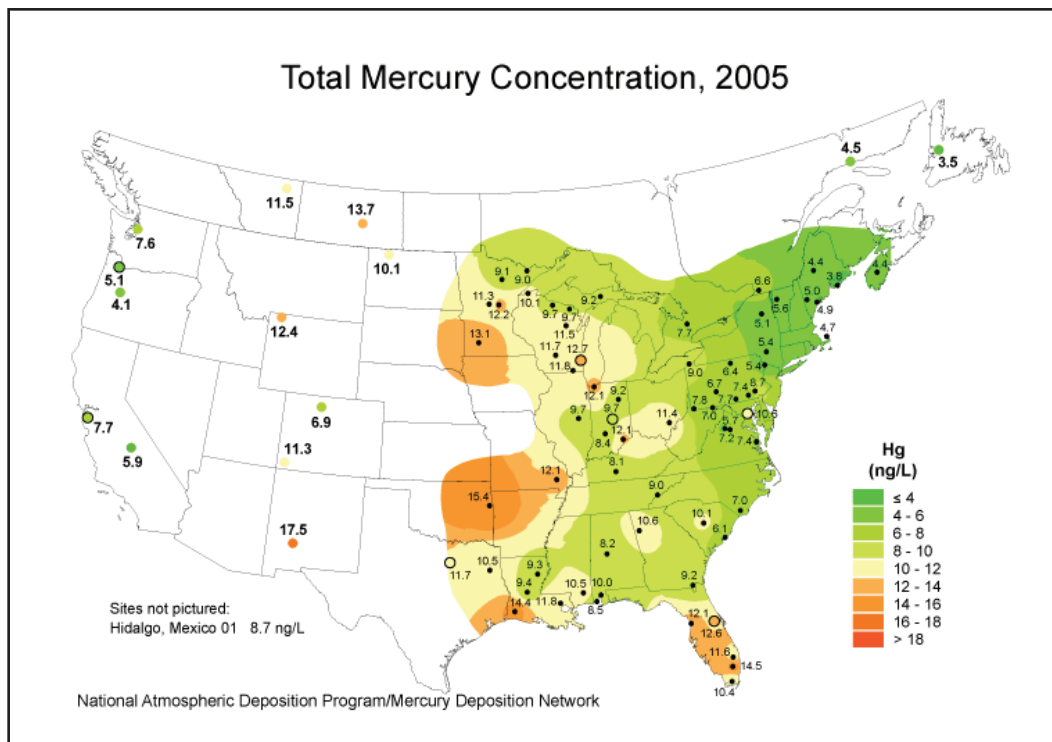


Figure 5. Total mercury concentration and total mercury deposition for the 2005 calendar year at all Mercury Deposition Network stations (NADP, 2008).

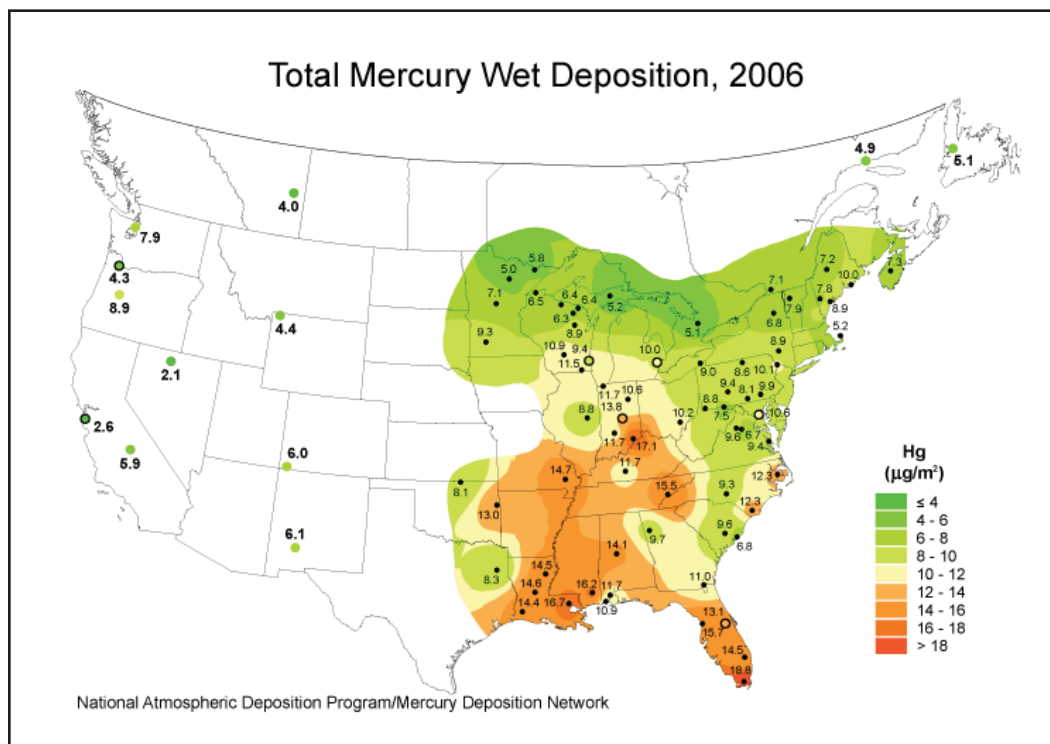
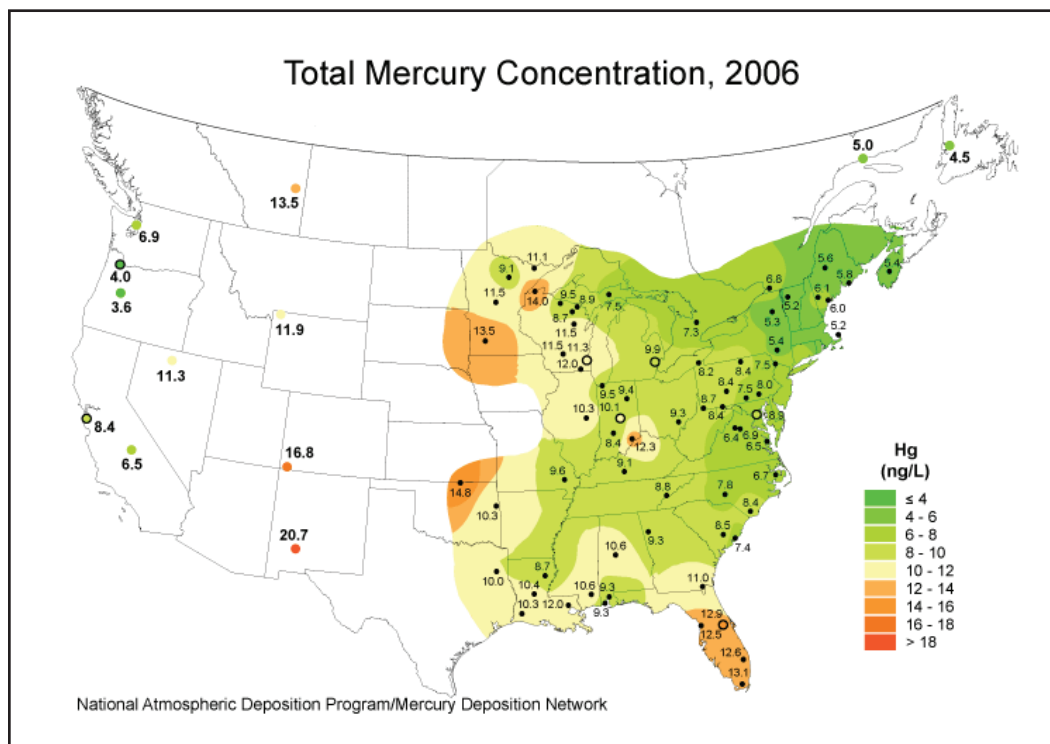


Figure 6. Total mercury concentration and total mercury deposition for the 2006 calendar year at all Mercury Deposition Network stations (NADP, 2008).

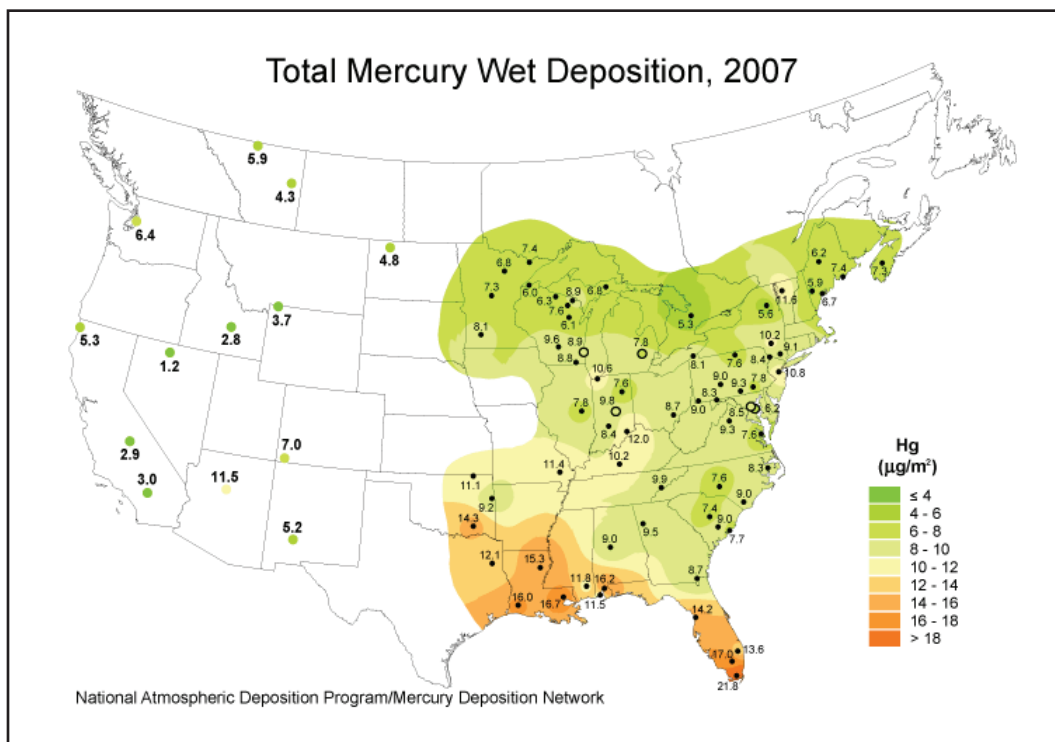
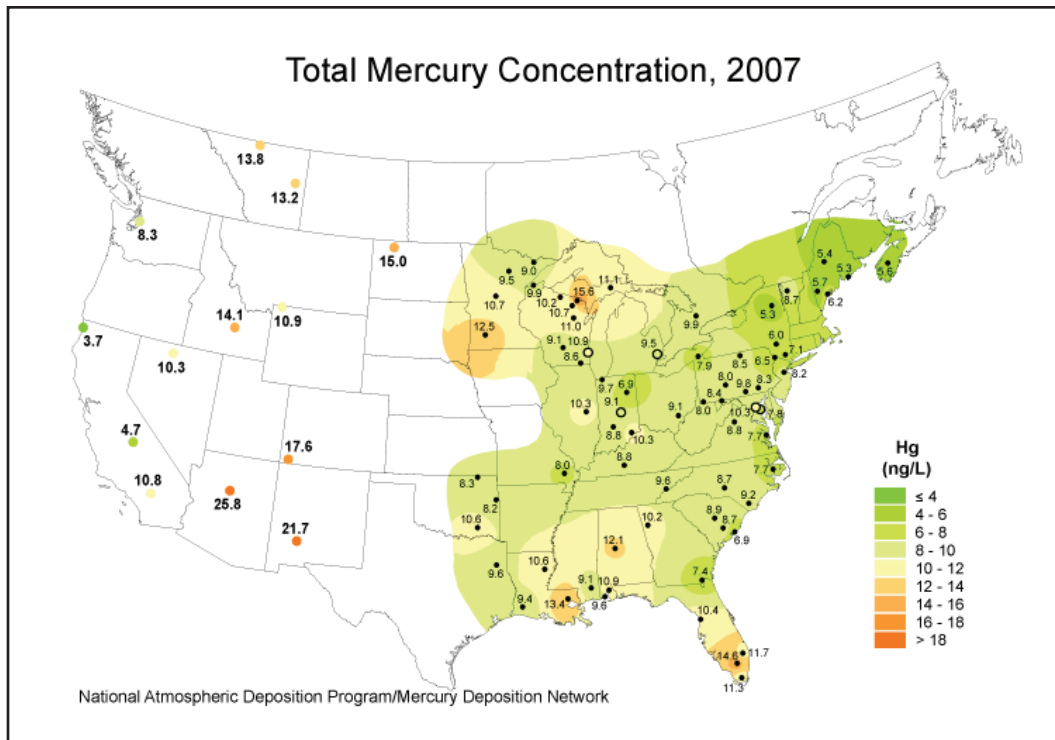


Figure 7. Total mercury concentration and total mercury deposition for the 2007 calendar year at all Mercury Deposition Network stations (NADP, 2008).

Key Findings and Policy Implications

Mercury deposition has been identified as a primary source of mercury to forested watersheds and surface water bodies that are not in proximity to areas of high mercury emissions (Scherbatskoy and others, 1998; Kamman and Engstrom, 2002). Even in areas where mercury deposition is low, biomagnification up the food chain and bioaccumulation in top-level predator fish have prompted fish consumption advisories throughout New York and across the northeastern US (NYS-DOH, 2008). In the Catskill Mountains, particularly in the Neversink Reservoir watershed where NY68 is located, high mercury concentrations have been measured in macroinvertebrates and fish and have resulted in fish consumption advisories for the last several years (Loukmas and others, 2006; NYS-DOH, 2008).

Mean annual mercury concentrations at NY68 were comparable to other sites in the northeast during the study period March 2004 to December 2007, but lower than most of the sites in Pennsylvania. Total mercury deposition was higher at NY68 than at other sites in the northeast because of high precipitation amounts, though deposition was comparable to or higher than deposition in Pennsylvania. The median total mercury concentration at NY68 for the study period March 2004 to December 2007 was 6.6 ng/L. The median total mercury deposition during the same period was 137.3 ng/m². Total mercury deposition in New York was much lower than the highest deposition totals in the nation that were measured in Florida and along the Gulf Coast. All MDN data are available through the NADP Web site at <http://nadp.sws.uiuc.edu/>.

Data from MDN sites in New York have been used to validate deposition estimates based on atmospheric mercury models (Seigneur and others, 2003; Voudouri and others, 2005). MDN data has been used to calibrate estimates of mercury deposition across the northeastern US (Miller and others, 2005) and to evaluate spatial and temporal trends in mercury deposition (Vanarsdale and others, 2005). These studies and many others have informed policy makers at the regional (i.e., the Mercury Action Plan of the New England Governors and Eastern Canadian Premiers) and national levels (i.e., the U.S. EPA has used this network to evaluate progress under the Clean Air Act). Data from the MDN will be a valuable measurement of the success of legislation to limit mercury emissions and deposition in New York State, the mid-Atlantic and Northeast regions, and across the nation.

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