Mercury Deposition Monitoring in Kansas: Network Report for 2017

Our Vision – Healthier Kansans living in safe and sustainable environments.

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Table of Contents

Introduction 1

Description of Kansas Mercury Wet Deposition Network 1

Figure 1. Kansas Mercury Wet Deposition Network 2

Discussion of Factors Affecting Mercury Deposition 2

Results for 2016 - Mercury Wet Deposition Network Data 3

Figure 2. Kansas Total Mercury Concentration 2011-2017 4

Figure 3. Kansas Total Mercury Wet Deposition 2011-2017 5

Figure 4. Kansas Total Precipitation 2011-2017 6

Discussion of 2017 Results 7

Appendix A KMDN 2011-2017 Data Tables 8

Appendix B 2011 National Mercury Concentration/Wet Deposition Maps 9

2012 National Mercury Concentration/Wet Deposition Maps 10

2013 National Mercury Concentration/Wet Deposition Maps 11

2014 National Mercury Concentration/Wet Deposition Maps 12

2015 National Mercury Concentration/Wet Deposition Maps 13

2016 National Mercury Concentration/Wet Deposition Maps 14

2017 National Mercury Concentration/Wet Deposition Maps 15

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Introduction

Elemental mercury volatilizes and evaporates into the atmosphere where is circulates freely and constitutes the "global pool" of mercury. Human sources of mercury include by-products of coal-fire combustion, municipal and medical incineration, and mining of metals for industry. Natural sources of atmospheric mercury include outgassing from volcanoes and geothermal vents and evaporation from naturally enriched soils, wetlands and oceans. Some elemental mercury is converted to reactive gaseous mercury in the atmosphere and is deposited back on to the surface of the Earth. This deposition of mercury is monitored by the Mercury Deposition Network which is coordinated through the National Atmospheric Deposition Program.

The Kansas Mercury Wet Deposition Network (KMDN) was established in 2009 per K.S.A. 75-5673. The statute required that the Kansas Department of Health and Environment (KDHE) design a statewide mercury deposition network consisting of at least six monitoring sites. Monitoring activities were to take place for a period of time long enough to determine trends (five or more years) was also specified in that statute. In 2014 K.S.A. 75-5673 was amended eliminating the site quantity requirement. This amendment allowed for KDHE to review the appropriateness of the site locations based on five years of data.

The network in Kansas was designed to assure compatibility with the Mercury Deposition Network (MDN)[1]. The MDN, coordinated through the National Atmospheric Deposition Program (NADP)[2], is designed to study and quantify the atmospheric fate and deposition of mercury. The single largest source of mercury pollution in the U.S. is atmospheric emissions and subsequent deposition associated with combustion from coal-fired power plants, waste incinerators, and chlorine production plants. Atmospheric deposition to surface waters and wetlands has been linked to movement of mercury through the food chain. This can result in elevated levels of mercury in fish and in mammals that consume fish. Mercury affects humans through fish consumption, resulting in health risks especially to developing fetuses and young children. Fish consumption advisories commonly define populations sensitive to mercury as women who are pregnant, may become pregnant, or are nursing and children age 17 or younger.

This report contains a description of the KMDN, information on Mercury deposition and a discussion of the 2017 data.

Photo 1. N-CON Single Chimney Collector used in the network.

Description of the Kansas Mercury Wet Deposition Network

The complete Kansas Mercury Wet Deposition Monitoring Network (KMDN) consists of four sites distributed across the state. The locations of sites in the states of Nebraska and Oklahoma were also taken into consideration to optimize regional mercury network coverage. A map of the network appears below in Figure 1. Each site was chosen to meet

[1] https://nadp.slh.wisc.edu/mdn/

[2] https://nadp.slh.wisc.edu/

specific criteria[3]. Specific regional and local siting criteria must be met before any site is accepted into the national MDN. Sampling at all sites is automated. Precipitation episodes activate the sensor on the collector allowing the lid to open for sample capture. Sample bottles are retrieved every Tuesday. Clean sample glassware is installed for collection of the next week's sample at the time of the operator's site visit. All samples are sent to a national laboratory used by the MDN. Sample analysis and coordination through this national cooperative research program are performed under contract.

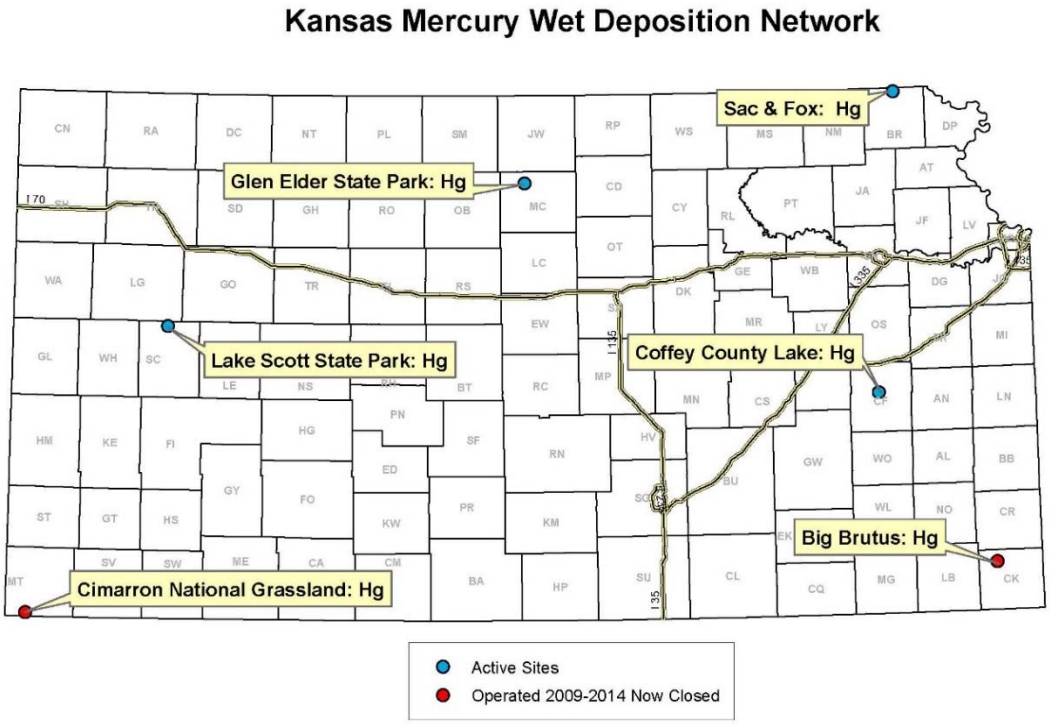


Figure 1. Map of the Kansas Mercury Wet Deposition Network 2009-2017

Discussion of Factors Affecting Mercury Deposition

Most mercury in the atmosphere is present as elemental mercury (Hg^0). Some of this mercury is converted to reactive gaseous mercury (Hg^{2+}), which is the predominant form flushed from the atmosphere by precipitation. It is generally believed that most atmospheric Hg^{2+} is in the form of mercuric chloride ($HgCl_2$). In general, concentration levels and deposition amounts show seasonal variation, both are anticipated to be higher during the warmer months.

Seasonal variation occurs for several reasons:

1) Higher temperatures and faster reaction rates cause more rapid chemical conversion.

2) More oxidants, such as ozone (O_3) and hydroxyl ions (OH^-), which can convert Hg^0 to Hg^{2+} are present.

3) Higher concentrations of Hg^0 are present in the atmosphere due to higher emissions from increased power generation, etc.

[3] https://nadp.slh.wisc.edu/lib/manuals/MDN_Operations_Manual_v2-3.pdf

4) Seasonal increases in precipitation flush more mercury out of the air more efficiently.

There are three factors which affect deposition of atmospheric mercury at any given location. These are:

1) **Concentration,** which is affected by local, regional and global sources.

   The total amount of mercury from non-local sources circulating freely in the Earth's atmosphere at any given time constitutes the "global pool" of mercury. It is estimated that 95 percent of the global pool is Hg^0; this mercury circulates for a period of time estimated to be between 6 months to 2 years. Local contributions to mercury concentrations vary considerably across the planet and within the United States, depending on the distance from the point of measurement to local and regional sources. Local mercury contribution can impact local and/or regional deposition, especially if it is emitted in a reactive form (e.g., Hg^{2+}).

2) **Precipitation,** which removes mercury from the atmosphere.

   Precipitation essentially "flushes" mercury from the atmosphere. It is this mercury that is measured to determine the deposition data values. In general, mercury concentrations appear to be higher when it begins to rain or snow, and measure lower at the end of a precipitation event. This is most evident during periods of prolonged precipitation (i.e., over a period of several hours to several days).

3) **Location** with regard to proximity of local sources.

   As stated above (Factor 1), local mercury concentrations vary considerably across the planet and within the United States, depending upon the distance from the point of measurement to local and regional sources. This factor also varies with wind direction, i.e., whether the sampling point is upwind or downwind of such sources at the time of sampling. In general, the closer a monitor is to a source, provided that it is downwind of that source, the higher the mercury concentration.

   Across Kansas, there can be dramatic shifts in sources of the air coming into the state. For example, southeast Kansas is much more likely to receive tropical air from the south. Out west, this region is dominated by atmospheric flows from farther west (i.e., Pacific air, continental air, etc.). This can exert a significant influence on what the atmosphere contains and what is flushed out. Kansas sources include power plants, cement kilns and mining operations.

Results for 2017 - Mercury Wet Deposition Network Data

The purpose of the MDN is to collect mercury wet deposition data over a long period of time to monitor trends in the levels of mercury deposited over the earth's surface. Short term data analysis is difficult because of seasonal and year to year variability in precipitation amounts and mercury concentrations.

Quality assurance of MDN data occurs at two levels. All data are first reviewed by the national contract laboratory for completeness and accuracy, and assigned codes for samples that were mishandled, contaminated, or affected by equipment malfunction. The final laboratory data set is then forwarded to the MDN Program Office for final quality assurance before generation of annual average concentration and wet deposition maps and posting to the website. Data generated by the Kansas Mercury Deposition Network will be posted to the KDHE website and to the national database annually.

The Kansas trend charts on pages 4, 5, and 6 show mercury concentration, mercury wet deposition, and total precipitation respectively from 2011-2017 for each site. Please note that the 2014 and 2015 reports do not include the site designated KS05, Coffey County Lake. This is due to a large number of invalid samples. Samples were invalidated by the contract laboratory in large part because of equipment malfunctions. The sensor was reportedly opening the lid to the collector during non-precipitation events such as the presence of large concentrations of soils and plant material affecting the sensor. KS05 is included in the 2016 and 2017 reports. Figures 2 and 3 show a spatial variability in the precipitation-weighted mean concentration and wet deposition of total mercury in the three remaining Kansas sites. All data collected and tabulated from 2011 to 2017 is also listed on the table in Appendix A.

1. Concentration, expressed in nanograms of mercury per liter (ng/L) of precipitation collected.

This is the amount of mercury present in the precipitation collected by the sampler. Concentration measurements provide a long-term record of mercury levels in precipitation across the United States.

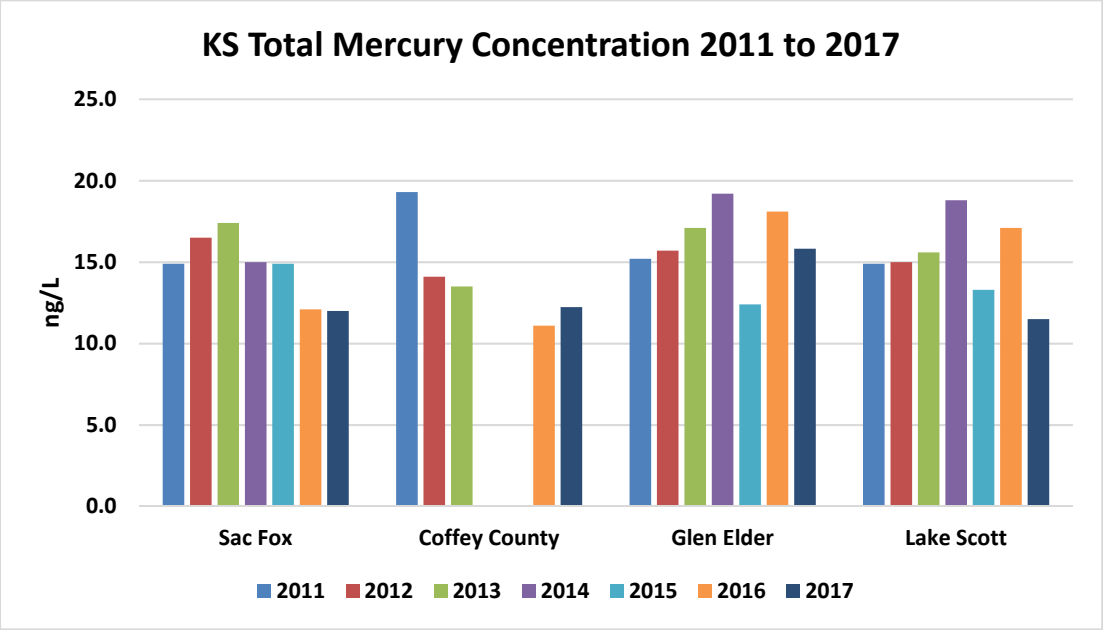


Figure 2. Total mercury concentrations for the Kansas sites 2011-2017, Coffey County Lake 2010-2013 and 2016-2017

2. Deposition, expressed in micrograms of mercury per square meter (µg/m^2).

This is the amount of mercury deposited by precipitation on each square meter of ground at the sampling site. Deposition values, expressed in micrograms of Hg per square meter per unit of time **(µg/m^2/year)**, provide annual estimates of the amount of mercury loaded onto the surface of the Earth in the vicinity of each sampling site. It is a portion of this mercury which enters bodies of water and ultimately enters the food chain through aquatic systems.

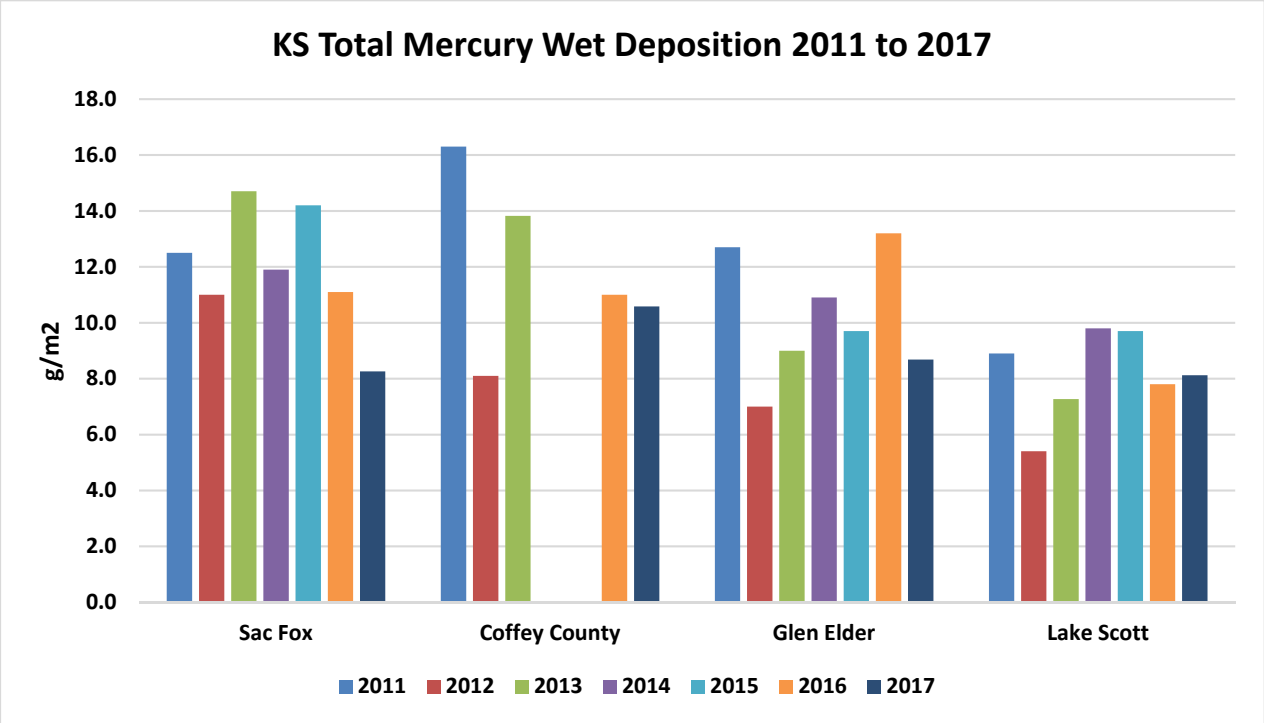


Figure 3. Total mercury wet deposition for Kansas sites 2010-2016, Coffey County Lake 2011-2017 and 2016-2017

3. Total precipitation depth collected, expressed in centimeters (cm).

This is the depth of precipitation, snow and rain, collected which when multiplied by the concentration, gives total wet deposition of mercury on the surface.

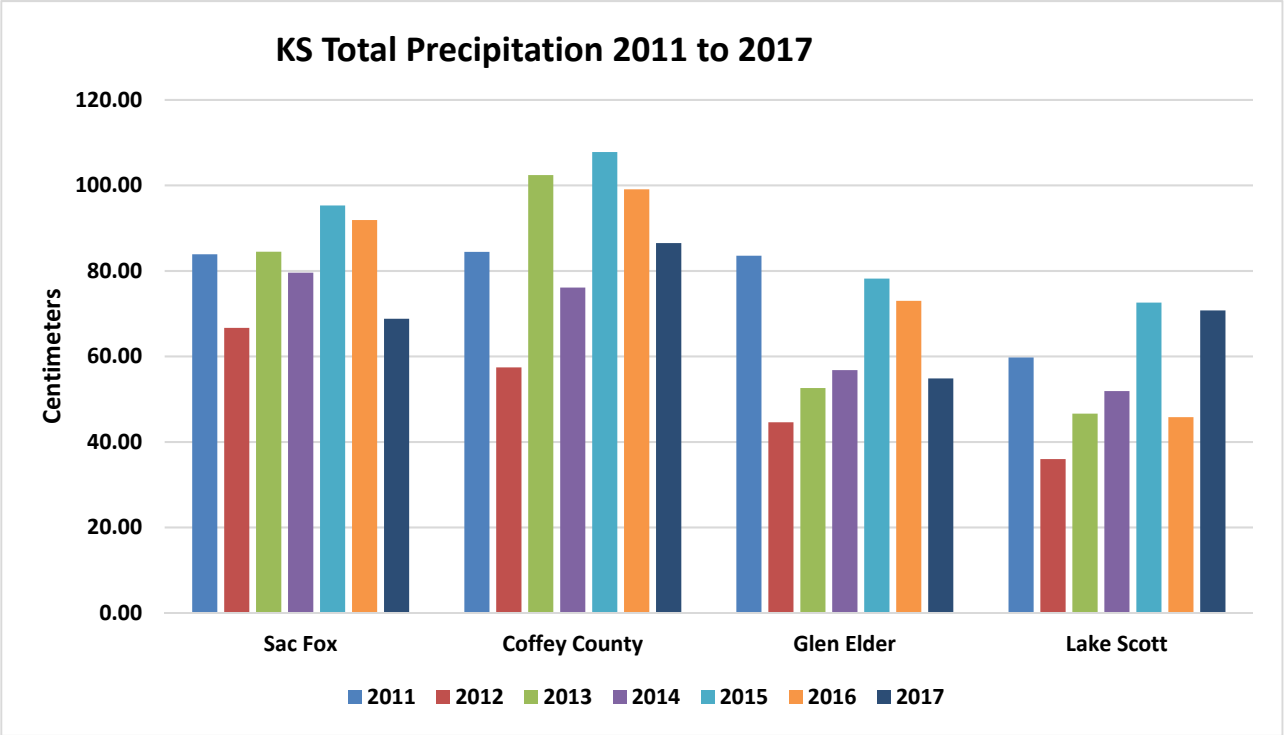


Figure 4. Total Precipitation for Kansas sites 2011 to 2017.

Discussion of 2017 Results

Each of the four sites in Kansas is discussed in this section.

Site ID KS03 is located on the Sac and Fox Reservation in Reserve, KS. In 2017, KS03 received 68.8 cm of precipitation. This was a decrease from 91.9 cm observed in 2016. Mercury deposition also decreased from 11.1 µg/m^2 in 2016 to 8.26 µg/m^2. Concentration decreased slightly from 12.1 ng/L in 2016 to 12.0 ng/L in 2017. With decreases in precipitation, deposition decreases are also typically observed. Likewise, a corresponding increase in the concentration of mercury is observed. The concentration of mercury at this site decreased slightly from the amount measured in 2016. This could indicate lower amounts of mercury in the atmosphere and or precipitation events increased in duration.

Site ID KS05 is located on private property near Coffey County Lake in Burlington, KS. In 2017, KS05 received 86.5 cm of precipitation. This is a decrease from 99.1 cm in 2016. Mercury deposition and concentration of mercury could not be determined in years 2015 and 2014. This was due to a large number of invalid samples as reported in the Results for 2015 and 2014 sections. Site operators started mowing a larger area around the collector in an effort to minimize soils and plant material that were likely activating the sensor to open the lid to the collector during non-precipitation events. It was determined that there were enough valid precipitation samples collected in 2016 and again in 2017 to calculate deposition amounts and determine average mercury concentrations. The concentration of mercury increased between 2016 and 2017 from 11.1 ng/L to 12.2 ng/L. This increase in concentration is what one would expect to see when fewer centimeters of precipitation are observed. Deposition of mercury also decreased between 2016 and 2017 from 11.0 µg/m^{2}to 10.6 µg/m^2. Decreases in deposition are also typical when fewer centimeters of precipitation are observed.

Site ID KS24 is located at Glen Eder State Park in Mitchell County. In 2017, KS24 received 54.9 cm of precipitation. This was a decrease from 73.0 cm observed in 2016. Mercury deposition decreased from 13.2 µg/m^2 in 2016 to 8.7 µg/m^2. Typically, deposition levels decrease with decreases in precipitation. Concentration decreased from 18.1 ng/L in 2016 to 15.8 ng/L in 2017. This decrease in concentration is not typically observed when precipitation decreases. These observations could indicate that precipitation events increased in duration. The decrease in concentration could also indicate lower levels of mercury in the atmosphere.

Site ID KS32 is located at Lake Scott State Park in Scott County. In 2017, KS32 received 70.8 cm of precipitation. This is an increase from 45.8 cm in 2016. Mercury deposition increased slightly between 2016 and 2017 from 7.8 µg/m^2 to 8.1 µg/m^2. Concentration decreased from 17.1 ng/L in 2016 to 11.5 ng/L in 2017. This is typical of what is observed with increased precipitation and deposition. KS32 is located in Western Kansas and typically receives fewer centimeters of precipitation than sites farther north and to the east.

Appendix A

Annual Data 2011-2017**
January through December

Concentration ng/L	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Sac Fox	14.9	16.5	17.4	15.0	14.9	12.1	12.0
Coffey County Lake	19.3	14.1	13.5	N/A*	N/A*	11.1	12.2
Glen Elder	15.2	15.7	17.1	19.2	12.4	18.1	15.8
Lake Scott	14.9	15	15.6	18.8	13.3	17.1	11.5
Deposition (µg/m^2)	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Sac Fox	12.5	11.0	14.7	11.9	14.2	11.1	8.3
Coffey County Lake	16.3	8.1	13.8	N/A*	N/A*	11.0	10.6
Glen Elder	12.7	7.0	9.0	10.9	9.7	13.2	8.7
Lake Scott	8.9	5.4	7.3	9.8	9.7	7.8	8.1
Precipitation (cm)	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Sac Fox	83.8	66.6	84.5	79.6	95.3	91.9	68.8
Coffey County Lake	84.4	57.4	102.4	76.1	107.8	99.1	86.5
Glen Elder	83.5	44.5	52.6	56.8	78.2	73.0	54.9
Lake Scott	59.7	36.0	46.6	51.9	72.6	45.8	70.8

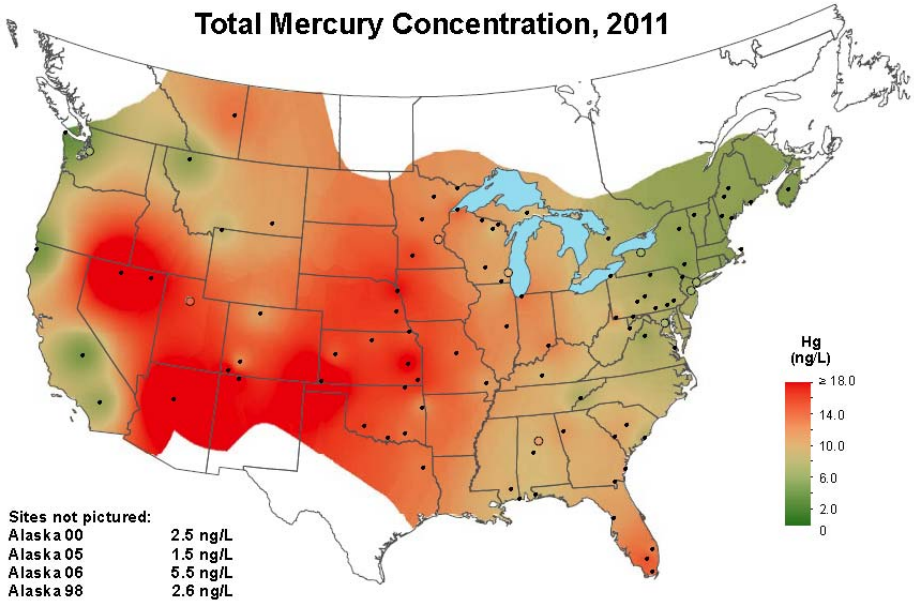
*Coffey County Lake (KS05) was not analyzed in 2014 and 2015 due to large number of invalid samples, please see results section of this report for more information.

**2009 and 2010 data tables are available on the KDHE website.

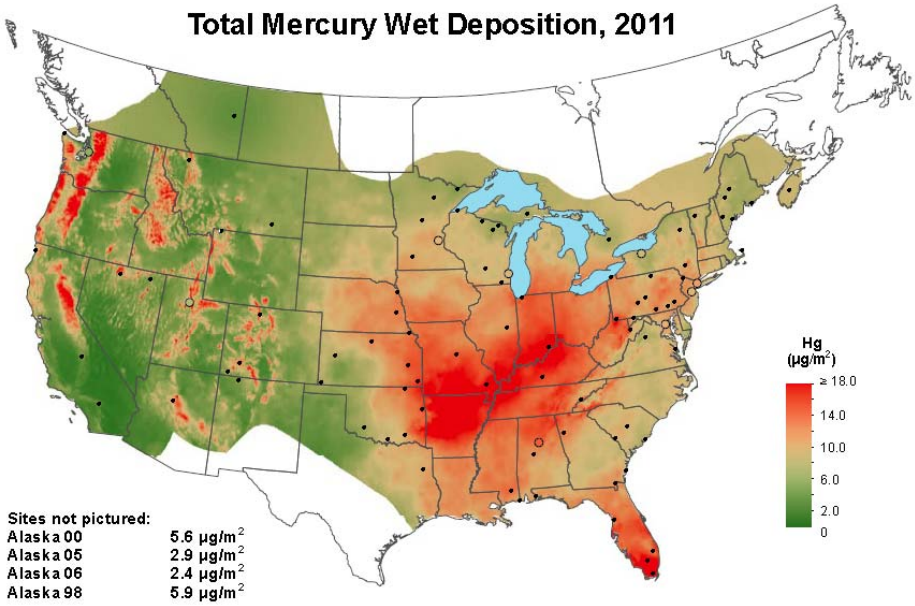
Appendix B

National Mercury Concentration/Wet Deposition Maps 2011-2017

National mercury data are summarized for each year by calculating the annual average values from each site and plotting the information on a national map. The most recent national average concentration and total deposition maps for calendar year 2017 appear in on page 15. MDN maps dating back to 1998 can be found https://nadp.slh.wisc.edu/MDN/annualmdnmaps.aspx.



National Atmospheric Deposition Program/Mercury Deposition Network
http://nadp.isws.illinois.edu



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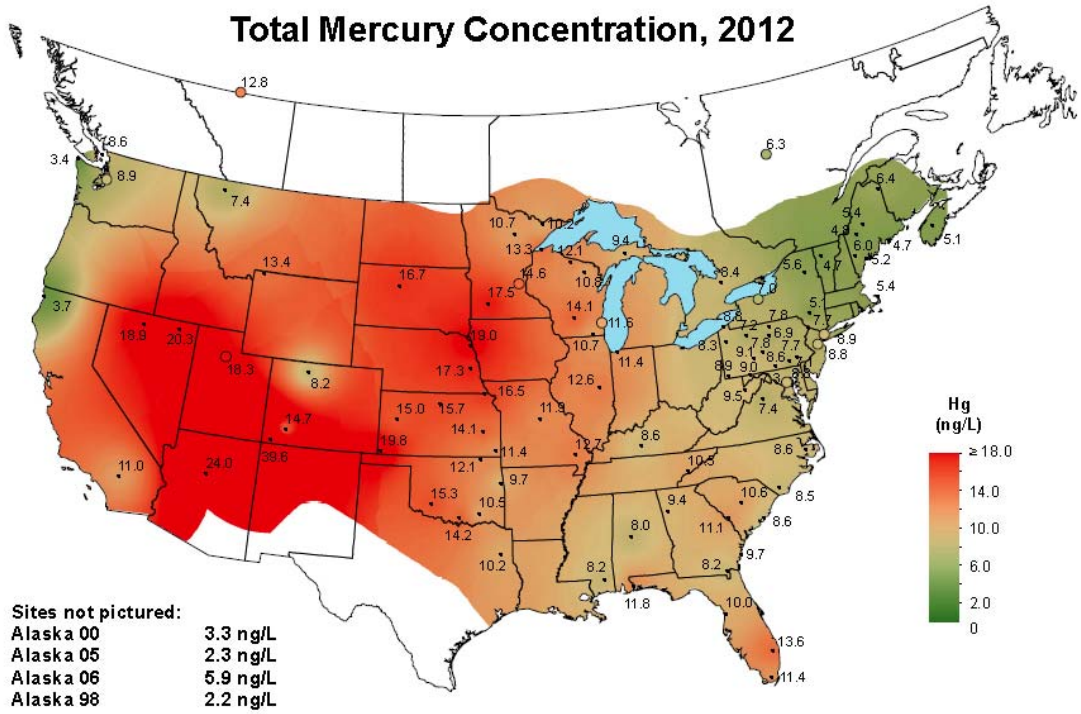

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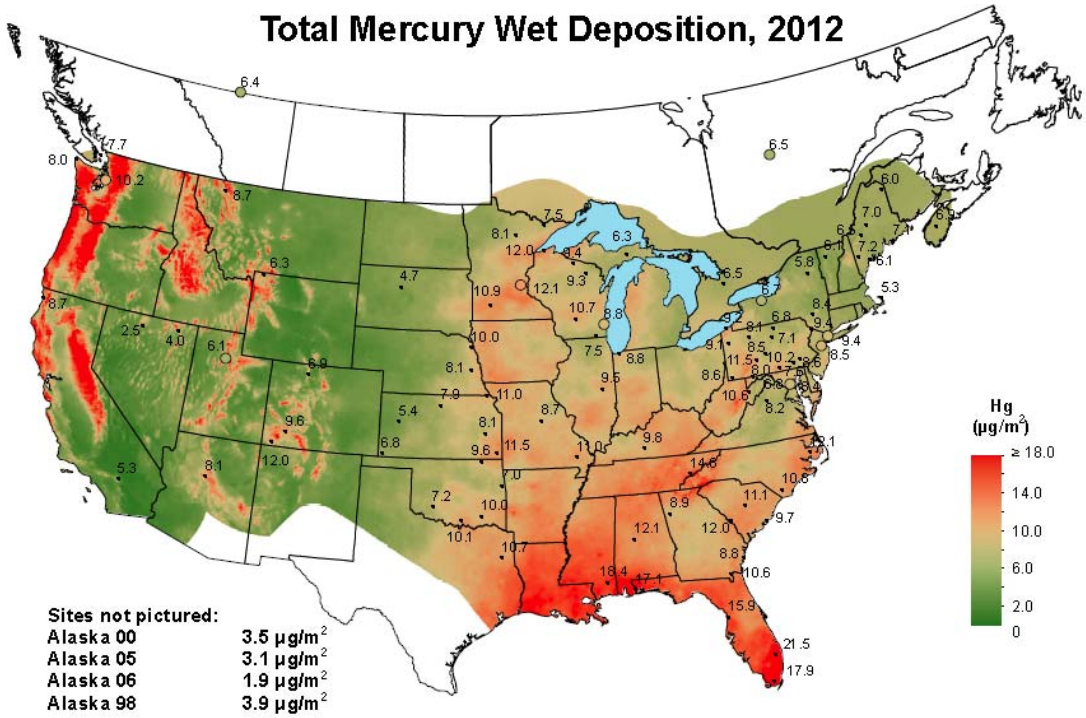

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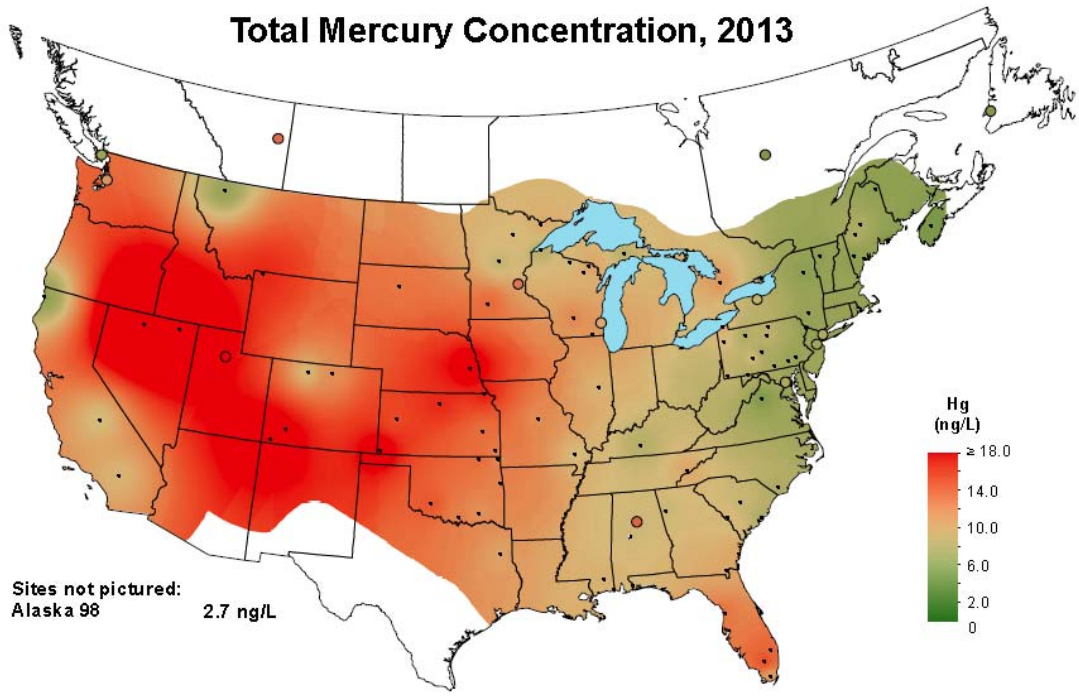

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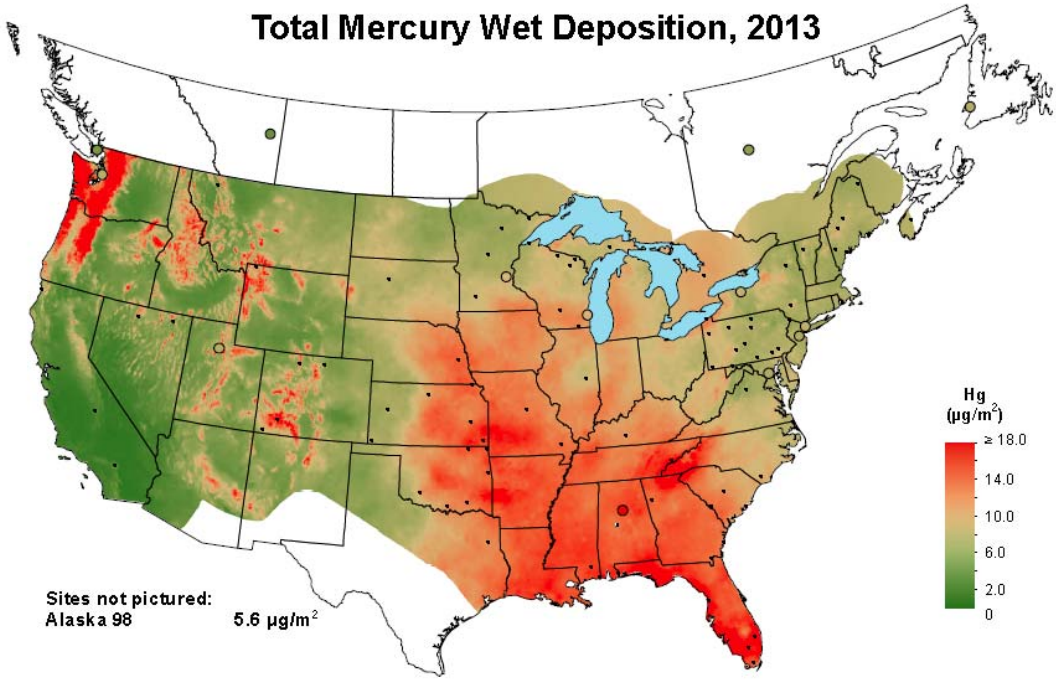

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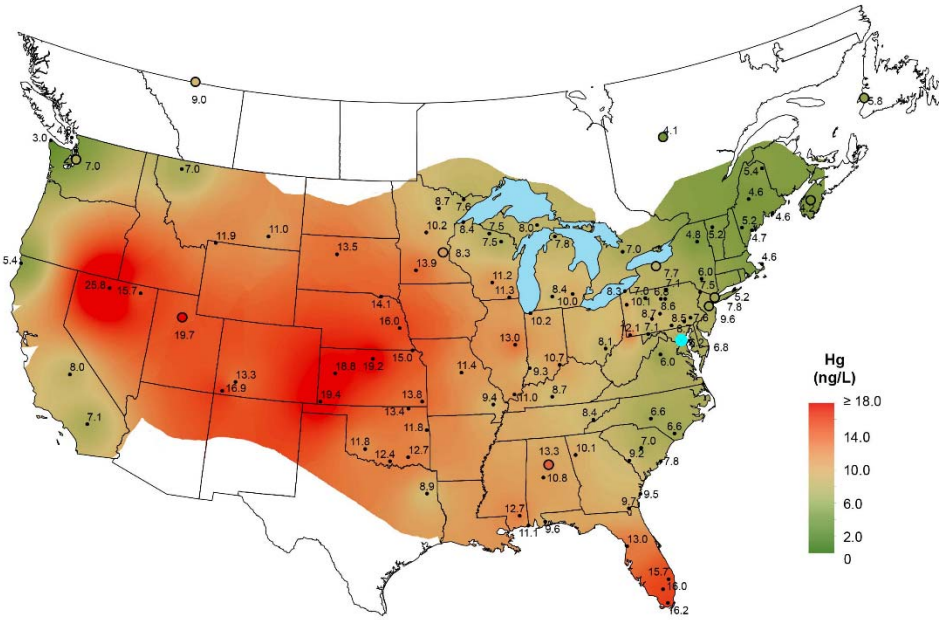
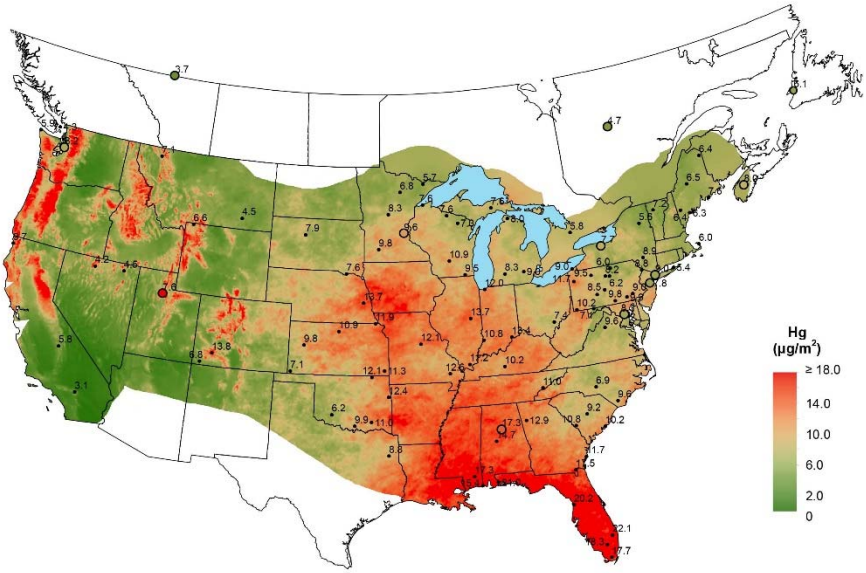
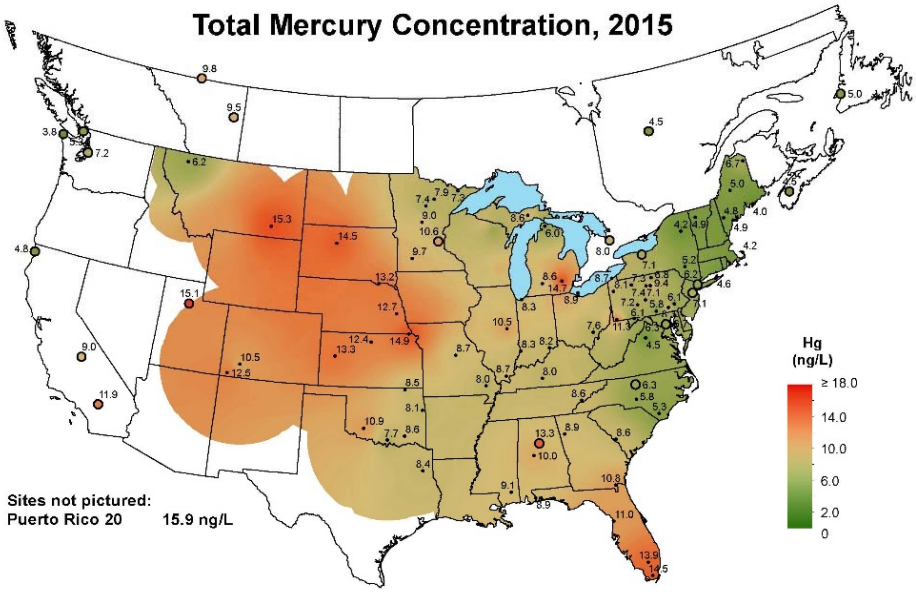
Total Mercury Concentration, 2014



Total Mercury Wet Deposition, 2014





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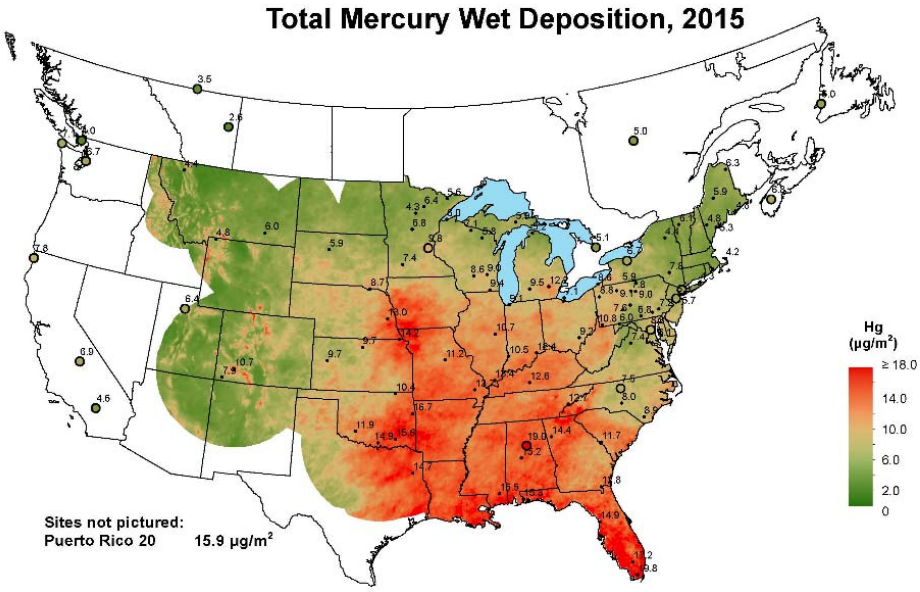

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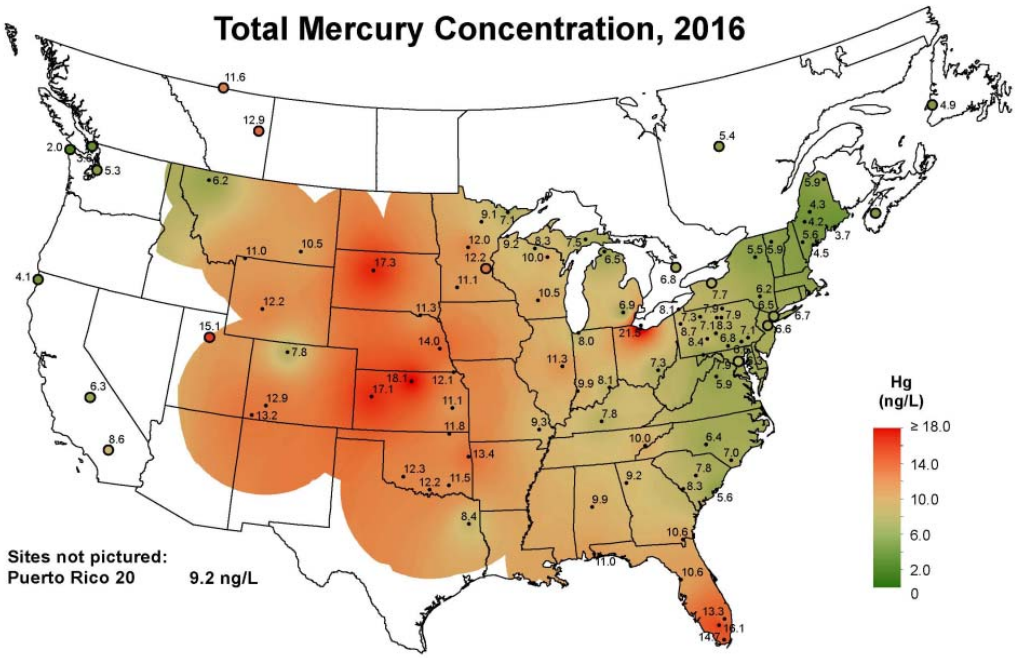

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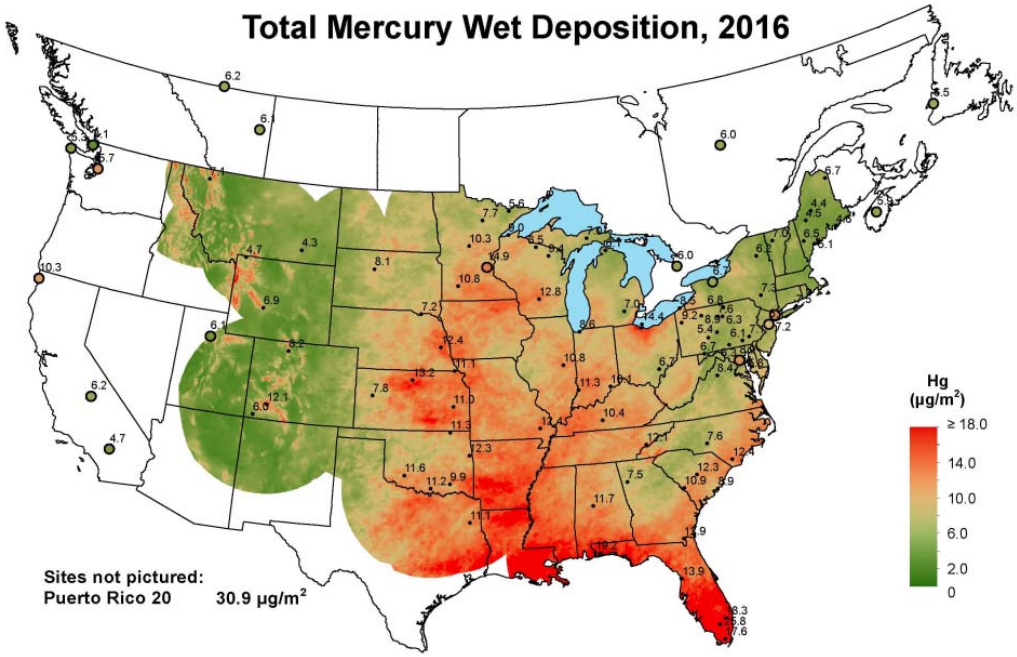

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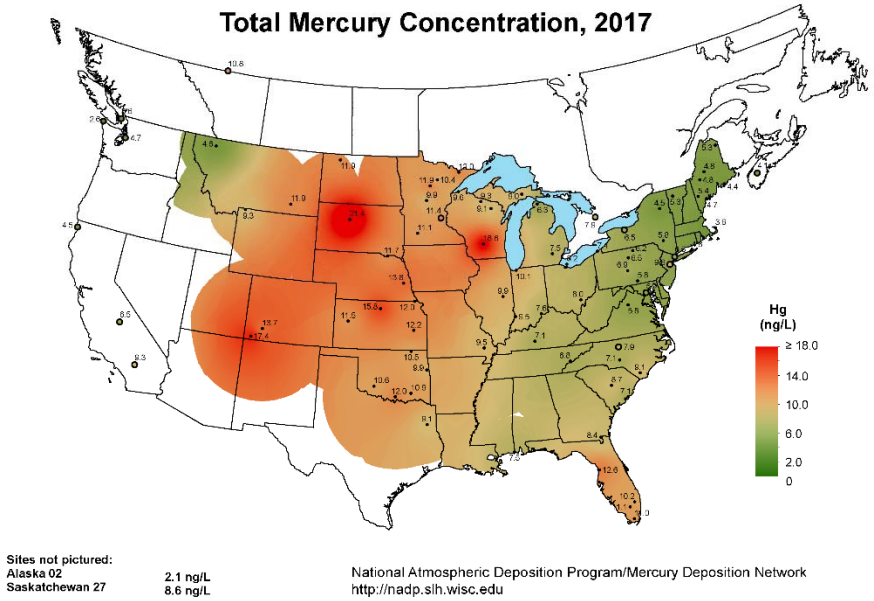
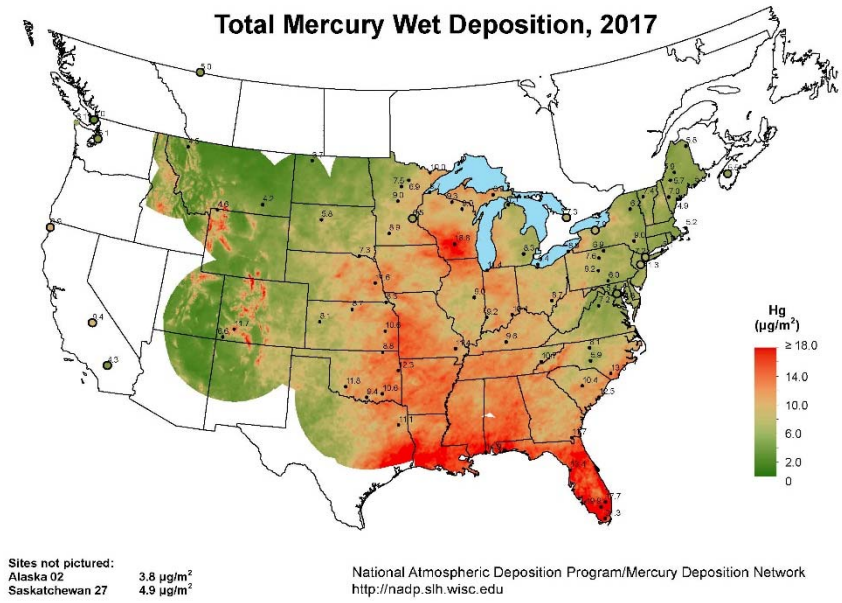

Total Mercury Concentration, 2017
Hg
(ng/L)
≥ 18.0
14.0
10.0
6.0
2.0
0
Sites not pictured:
Alaska 02 2.1 ng/L
Saskatchewan 27 8.6 ng/L
National Atmospheric Deposition Program/Mercury Deposition Network
http://nadp.slh.wisc.edu


Total Mercury Wet Deposition, 2017
Hg
(µg/m²)
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