



# Evaluation of the Sensitivity of Inventory and Monitoring National Parks to Acidification Effects from Atmospheric Sulfur and Nitrogen Deposition

*Northeast Coastal and Barrier Network (NCBN)*

Natural Resource Report NPS/NRPC/ARD/NRR—2011/364



**ON THE COVER**

Some ecosystems and vegetation types, such as remote high-elevation lakes, sugar maple trees, headwater streams, and red spruce trees, are sensitive to the effects of acidification from atmospheric nitrogen and sulfur deposition.

Photograph by: National Park Service

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This report received peer review by subject-matter experts who were not directly involved in the collection, analysis, or reporting of the data. Data in this report were collected and analyzed using methods based on established, peer-reviewed protocols and were analyzed and interpreted within the guidelines of the protocols.

Views, statements, findings, conclusions, recommendations, and data in this report do not necessarily reflect views and policies of the National Park Service, U.S. Department of the Interior. Mention of trade names or commercial products does not constitute endorsement or recommendation for use by the U.S. Government.

This report is available from Air Resources Division of the NPS (<http://www.nature.nps.gov/air/Permits/ARIS/networks/acidification-eval.cfm>) and the Natural Resource Publications Management website (<http://www.nature.nps.gov/publications/nrpm/>).

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## Northeast Coastal and Barrier Network (NCBN)

National maps of atmospheric S and N emissions and deposition are provided in Maps A through D as context for subsequent network data presentations. Maps A and B show county level emissions of total S and total N for the year 2002. Maps C and D show total S and total N deposition, again for the year 2002.

There are eight parks in the Northeast Coastal and Barrier Network. None are larger than 100 square miles. Most are located in or adjacent to the heavily developed coastal corridor between Washington, DC and Boston.

Total annual S and N emissions, by county, are shown in Maps E and F for lands in and surrounding the Northeast Coastal and Barrier Network. Annual county-level S emissions were quite variable, ranging from less than 1 ton per square mile to over 100 tons per square mile. Although a large portion of the network had emissions less than 20 tons per square mile per year, there were substantial areas with higher emissions, including the New York City area, most of Long Island, southeastern Massachusetts and the Cape Cod area, and the area near Washington, DC. County-level N emissions within the network also ranged from less than 1 ton per square mile to greater than 100 tons per square mile. In general, annual county N emissions were between 5 and 20 tons per square mile, but were higher than 20 tons per square mile in many areas, including the New York City area, all of Long Island, and portions of the network near Washington, DC. There were many SO<sub>2</sub> point sources in the network; most of them emitted less than 5,000 tons of S per year, and were located in the vicinity of New York City and south of Boston, which is just outside the network boundary (Map G). There were two near the Washington DC/Baltimore area that emitted larger quantities of S, between 20,000 and 40,000 tons per year. Point source emissions of oxidized (nitrogen oxides, NO<sub>x</sub>) and reduced (ammonia, NH<sub>3</sub>) N are shown in Map H. There were several relatively large (larger than 2,000 tons per square mile) point sources of oxidized N, but no large sources of reduced N, within the network. Most of the largest N point sources were in Maryland.

Urban centers within the network and within a 300-mile buffer around the network are shown in Map I. There is a very high density of large population centers within the network, including New York City and Philadelphia. In addition, Baltimore and Washington, DC are both located on the network boundary.

Total S and N deposition in and around the network are shown in Maps J and K, respectively. Included in this analysis are both wet and dry forms of deposition and both the oxidized and reduced N species. Total S deposition was relatively high, over 10 kg S/ha/yr, with large areas receiving more than 15 kg S/ha/yr. There are scattered areas that receive more than that, up to 30 kg S/ha/yr or more. Total N deposition throughout most of the network ranged from 10 to 20 kg N/ha/yr.

Land cover in and around the network is shown in Map L. There is a wide mix of cover types, including developed land, row crops, pasture/hay, forest, and wetlands.

Map M shows the watershed slope for park lands in the network. Relief is low, with less than 10° average slope in all of the parks.

Map N of park lands requiring special protection against potential adverse impacts associated with acidic deposition is not shown for this network. There are no Class I or wilderness designations in the network.

Network rankings are given in Figures A through C as the average ranking of the Pollutant Exposure, Ecosystem Sensitivity, and Park Protection metrics, respectively. Figure D shows the overall network Summary Risk ranking. In each figure, the rank for this particular network is highlighted to show its relative position compared with the ranks of the other 31 networks.

The Northeast Coastal and Barrier Network ranked at the top of the highest quintile among networks in Pollutant Exposure (Figure A). Emissions and deposition of both S and N within the network are very high. However, the network Ecosystem Sensitivity ranking was low, at the top of the lowest quintile among networks (Figure B). This network also ranked in the lowest quintile in Park Protection, having no wilderness or Class I lands (Figure C).

In combination, the network rankings for Pollutant Exposure, Ecosystem Sensitivity, and Park Protection yielded an overall Network Risk ranking that was relatively low among networks (Figure D). The overall level of concern for acidification effects on I&M parks within this network is considered Low.

Figures E through H are not presented for this network because there are no parks that are larger than 100 square miles. Relative rankings for all parks, including the smaller parks, are given in Table A and Appendix A.

The Pollutant Exposure ranking was Very High for all of the parks in this network except Cape Cod (CACO), which was ranked High. Ecosystem Sensitivity rankings were lower: Low or Very Low for all of the parks except CACO, which was ranked High. For Park Protection, Fire Island (FIIS) was ranked in the second highest quintile; the rest of the parks in this network were ranked Moderate (middle quintile) for this theme. The Summary Risk ranking was High for CACO and Moderate for all of the other parks in this network.

**Table A.** Relative rankings of individual I&M parks within the network for Pollutant Exposure, Ecosystem Sensitivity, Park Protection, and overall Summary Risk from acidic deposition.

<b>I&amp;M Parks<sup>2</sup> in Network</b>	<b>Relative Ranking of Individual Parks<sup>1</sup></b>			
	<b>Pollutant Exposure</b>	<b>Ecosystem Sensitivity</b>	<b>Park Protection</b>	<b>Summary Risk</b>
Assateague Island	Very High	Very Low	Moderate	Moderate
Cape Cod	High	High	Moderate	High
Colonial	Very High	Low	Moderate	Moderate
Fire Island	Very High	Very Low	High	Moderate
Gateway	Very High	Low	Moderate	Moderate
George Washington Birthplace	Very High	Very Low	Moderate	Moderate
Sagamore Hill	Very High	Low	Moderate	Moderate
Thomas Stone	Very High	Low	Moderate	Moderate

<sup>1</sup> Relative park rankings are designated according to quintile ranking, among all I&M Parks, from the lowest quintile (very low risk) to the highest quintile (very high risk).  
<sup>2</sup> Park name is printed in bold italic for parks larger than 100 square miles.

- Map A. National map of total S emissions by county for the year 2002, in units of tons of S per square mile per year. (Source of data: EPA National Emissions Inventory, <http://www.epa.gov/ttn/chief/net/2002inventory.html>)
- Map B. National map of total N emissions by county for the year 2002. Both oxidized (nitrogen oxides, NO<sub>x</sub>) and reduced (ammonia, NH<sub>3</sub>) forms of N are included. The total is expressed in tons per square mile per year. (Source of data: EPA National Emissions Inventory, <http://www.epa.gov/ttn/chief/net/2002inventory.html>)
- Map C. Total S deposition for the conterminous United States for the year 2002, expressed in units of kilograms of S deposited from the atmosphere to the Earth surface per hectare per year. For the eastern half of the country, wet deposition values were derived from interpolated measured values from NADP (three-year average centered on 2002) and dry deposition values were derived from 12-km CMAQ model projections for 2002. For the western half of the country, both wet and dry deposition values were derived from 36-km CMAQ model projections for 2002. NADP interpolations were performed using the approach of Grimm and Lynch (1997). CMAQ model projections were provided by Robin Dennis, U.S. EPA.
- Map D. Total N deposition for the conterminous United States for the year 2002, expressed in units of kilograms of N deposited from the atmosphere to the Earth surface per hectare per year. Wet and dry forms of both oxidized (nitrogen oxides, NO<sub>x</sub>) and reduced (ammonia, NH<sub>3</sub>) N are included. For the eastern half of the country, wet deposition values were derived from interpolated measured values from NADP (three-year average centered on 2002) and dry deposition values were derived from 12-km CMAQ model projections for 2002. For the western half of the country, both wet and dry deposition values were derived from 36-km CMAQ model projections

for 2002. NADP interpolations were performed using the approach of Grimm and Lynch (1997). CMAQ model projections were provided by Robin Dennis, U.S. EPA.

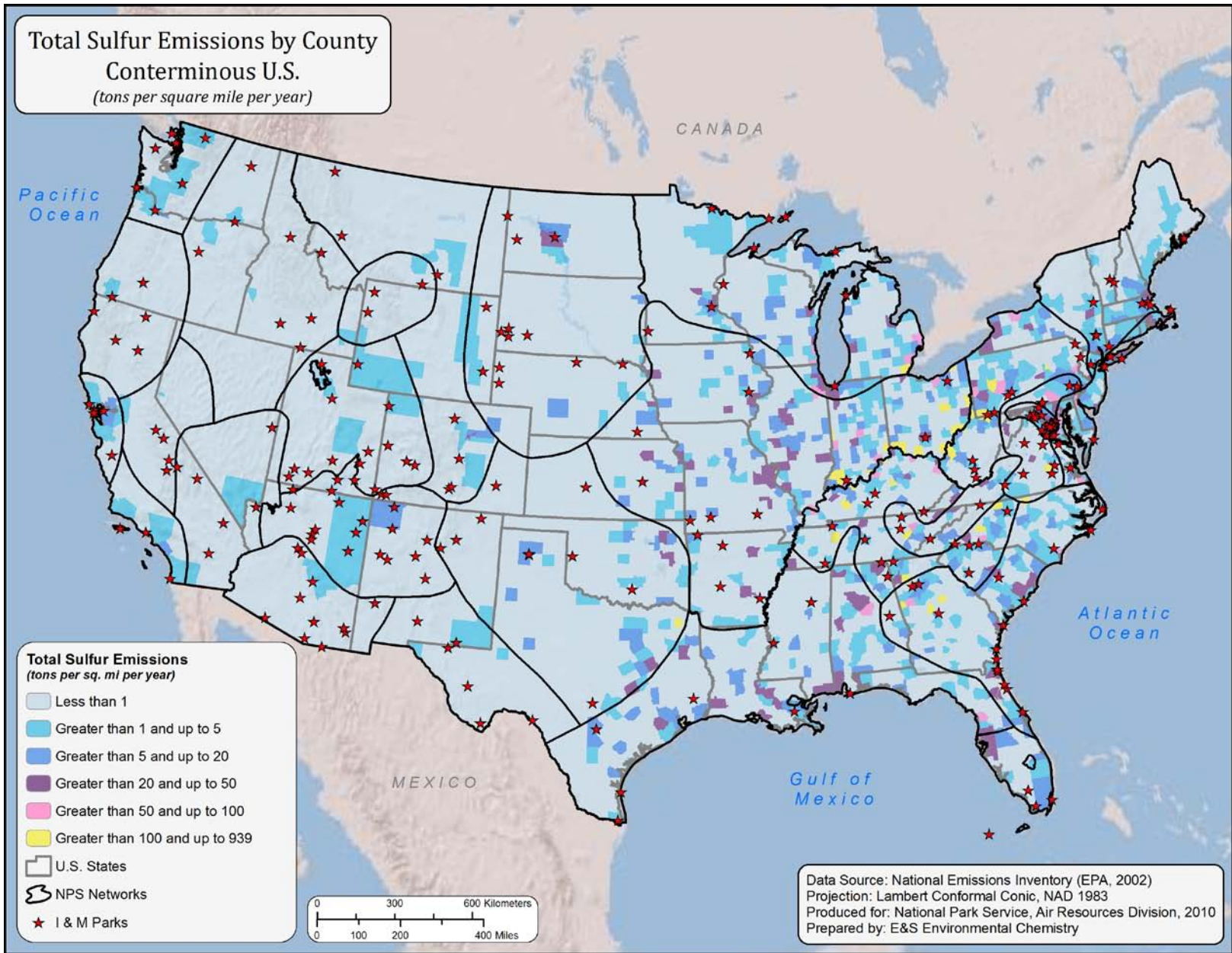
- Map E. Total S emissions by county for lands surrounding the network, expressed as tons of S emitted into the atmosphere per square mile per year. (Source of data: EPA National Emissions Inventory, <http://www.epa.gov/ttn/chief/net/2002inventory.html>)
- Map F. Total N emissions by county for lands surrounding the network, expressed as tons of N emitted into the atmosphere per square mile per year. The total includes both oxidized (nitrogen oxides, NO<sub>x</sub>) and reduced (ammonia, NH<sub>3</sub>) N. (Source of data: EPA National Emissions Inventory, <http://www.epa.gov/ttn/chief/net/2002inventory.html>)
- Map G. Major point source emissions of SO<sub>2</sub> for lands surrounding the network. (Source of data: EPA National Emissions Inventory, <http://www.epa.gov/ttn/chief/net/2002inventory.html>)
- Map H. Major point source emissions of oxidized (nitrogen oxides, NO<sub>x</sub>) and reduced (ammonia, NH<sub>3</sub>) N in and around the network. The base of each vertical bar is positioned in the map at the approximate location of the source. The height of the bar is proportional to the magnitude of the source. (Source of data: EPA National Emissions Inventory, <http://www.epa.gov/ttn/chief/net/2002inventory.html>)
- Map I. Urban centers having more than 10,000 people within the network and within a 300-mile buffer around the perimeter of the network. (Source of data: U.S. Census 2000)
- Map J. Total S deposition in and around the network. Values are expressed as kilograms of S deposited per hectare per year. (Source of data: Interpolated NADP wet and CMAQ Model dry deposition data for 2002; see information for Map C above for details)
- Map K. Total N deposition in and around the network. Included in the total are wet plus dry forms of both oxidized (nitrogen oxides, NO<sub>x</sub>) and reduced (ammonia, NH<sub>3</sub>) N. Values are expressed as kilograms of N deposited per hectare per year. (Source of data: Interpolated NADP wet and CMAQ Model dry deposition data for 2002; see information for Map D above for details)
- Map L. Land cover types in and around the network, based on the National Land Cover dataset. (Source of data: National Land Cover Dataset, [http://www.mrlc.gov/nlcd\\_multizone\\_map.php](http://www.mrlc.gov/nlcd_multizone_map.php))
- Map M. Average land slope within park units that occur within the network, by 10-digit HUC. (Source of data: U.S. EPA National Elevation Dataset [<http://ned.usgs.gov/>])
- Figure A. Network rankings for Pollutant Exposure, calculated as the average of scores for all Pollutant Exposure variables.



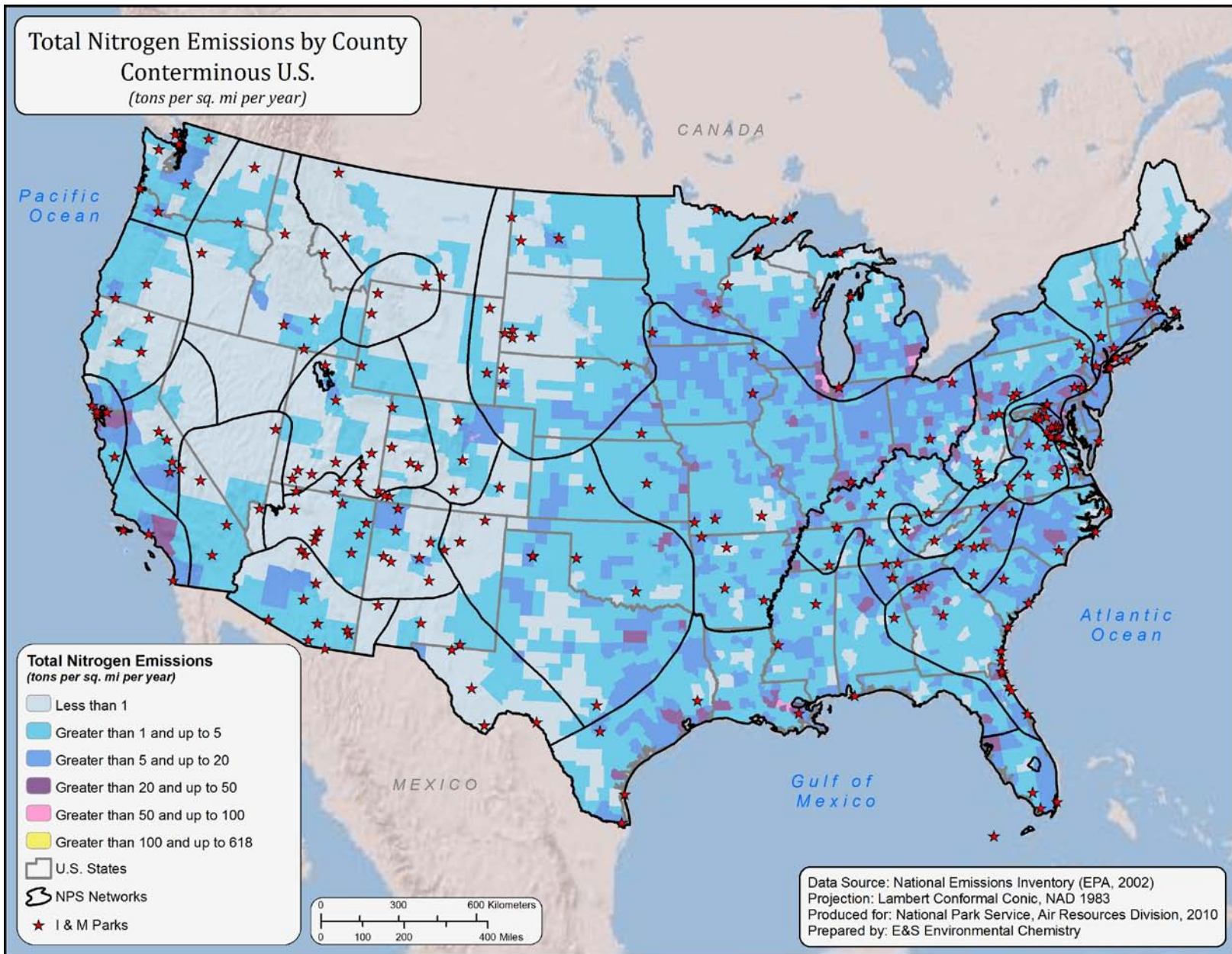
Figure B. Network rankings for Ecosystem Sensitivity, calculated as the average of scores for all Ecosystem Sensitivity variables.

Figure C. Network rankings for Park Protection, calculated as the average of scores for all Park Protection variables.

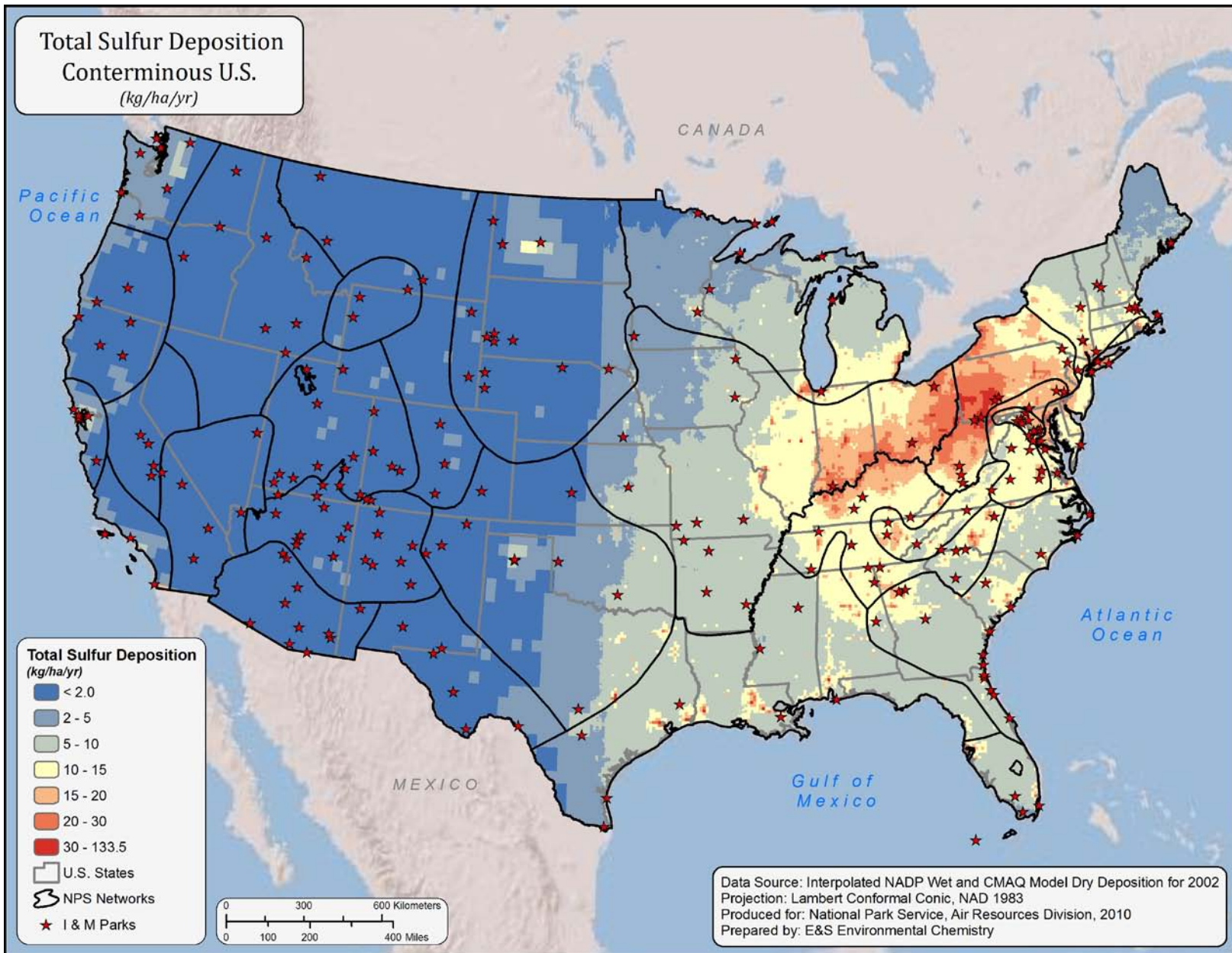
Figure D. Network Summary Risk rankings, calculated as the average of the quintile ranks for the Pollutant Exposure, Ecosystem Sensitivity, and Park Protection themes.



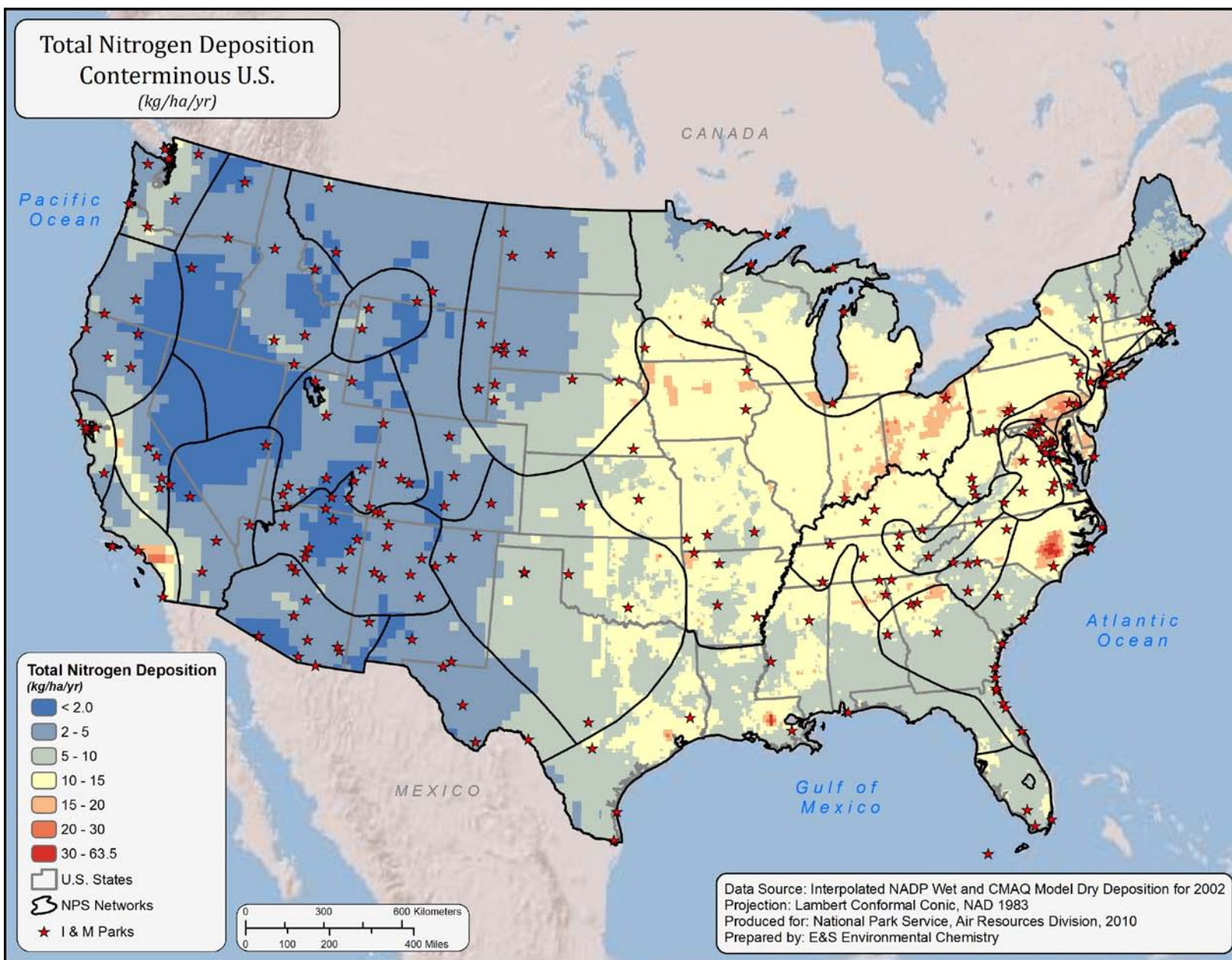
Map A



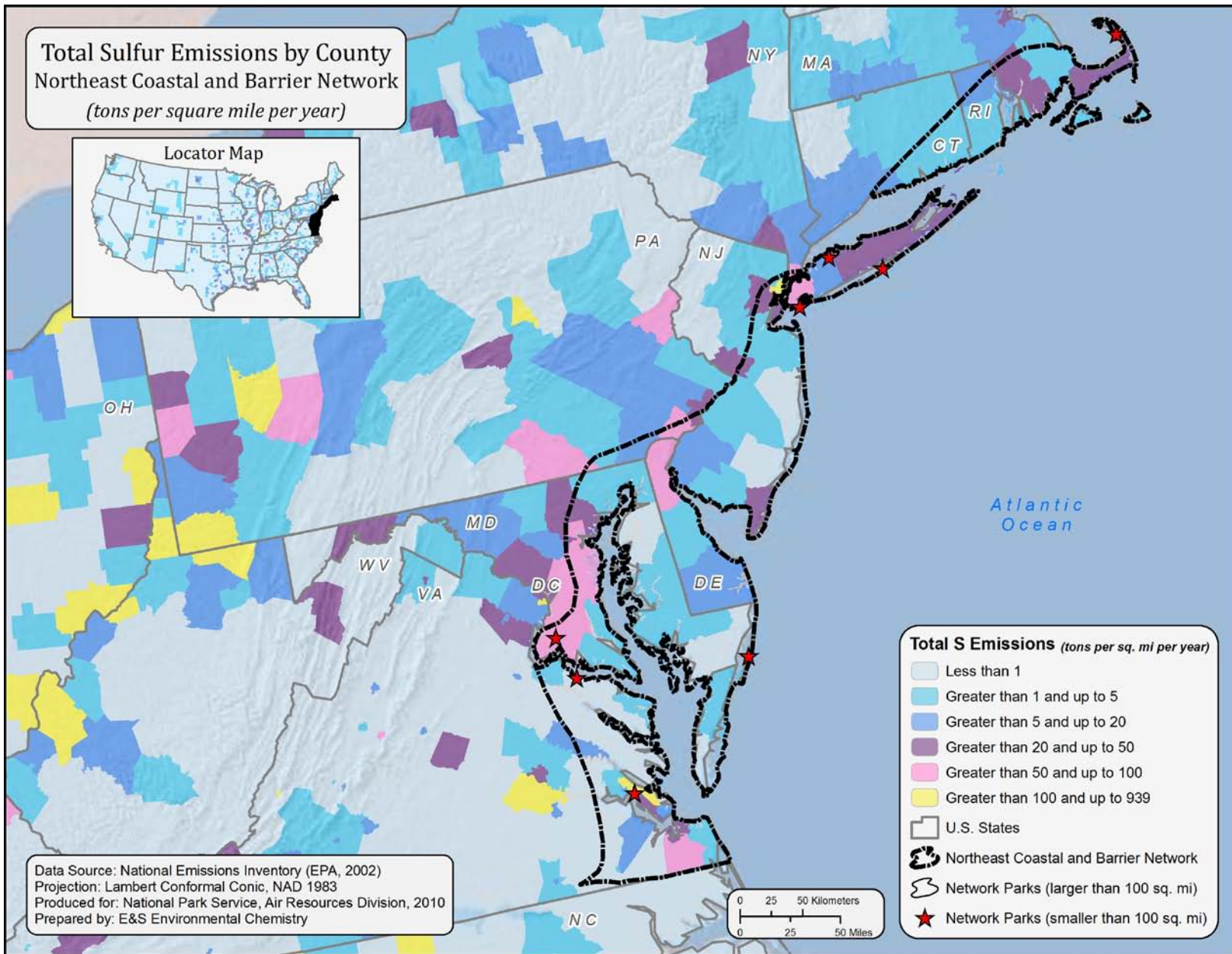
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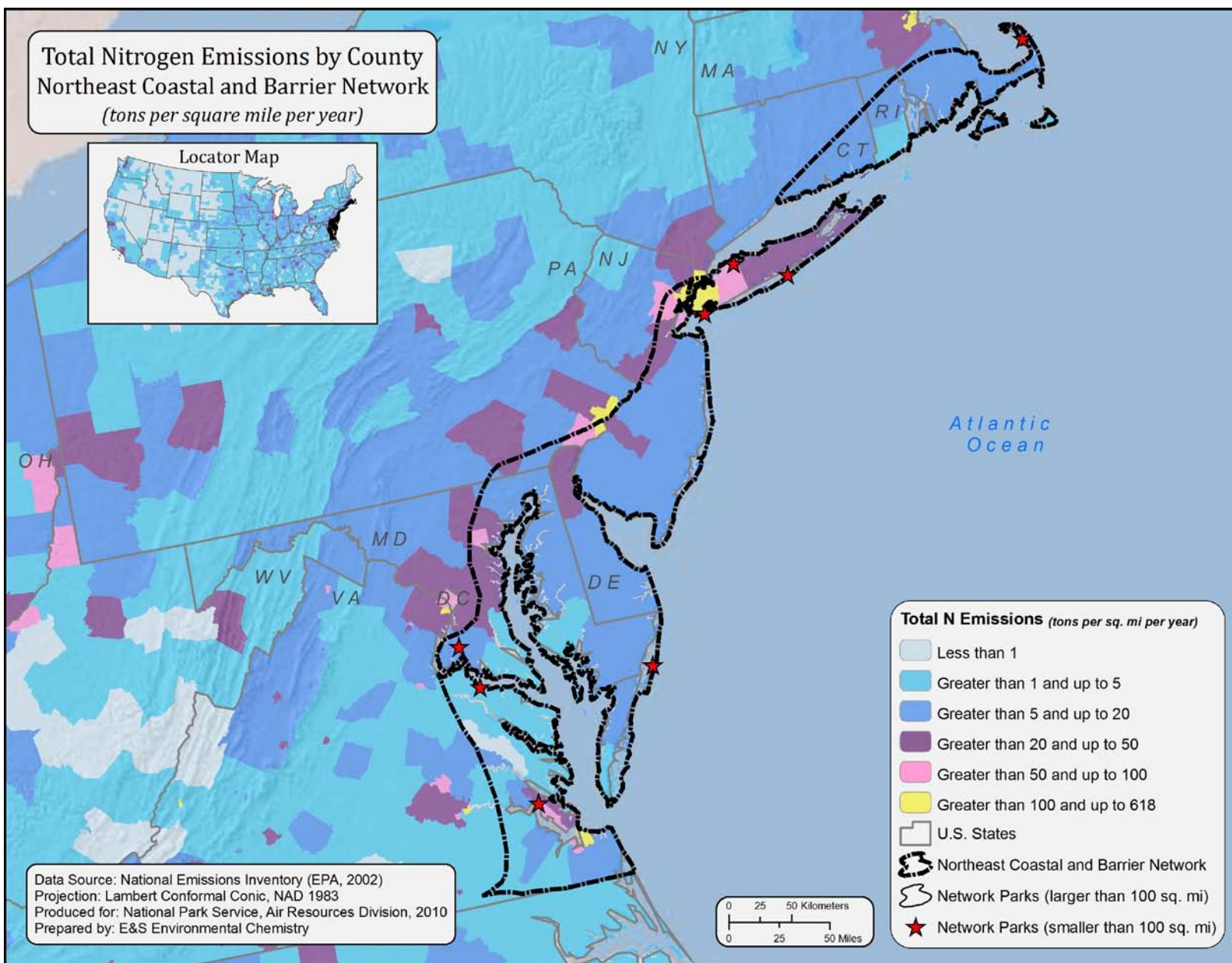
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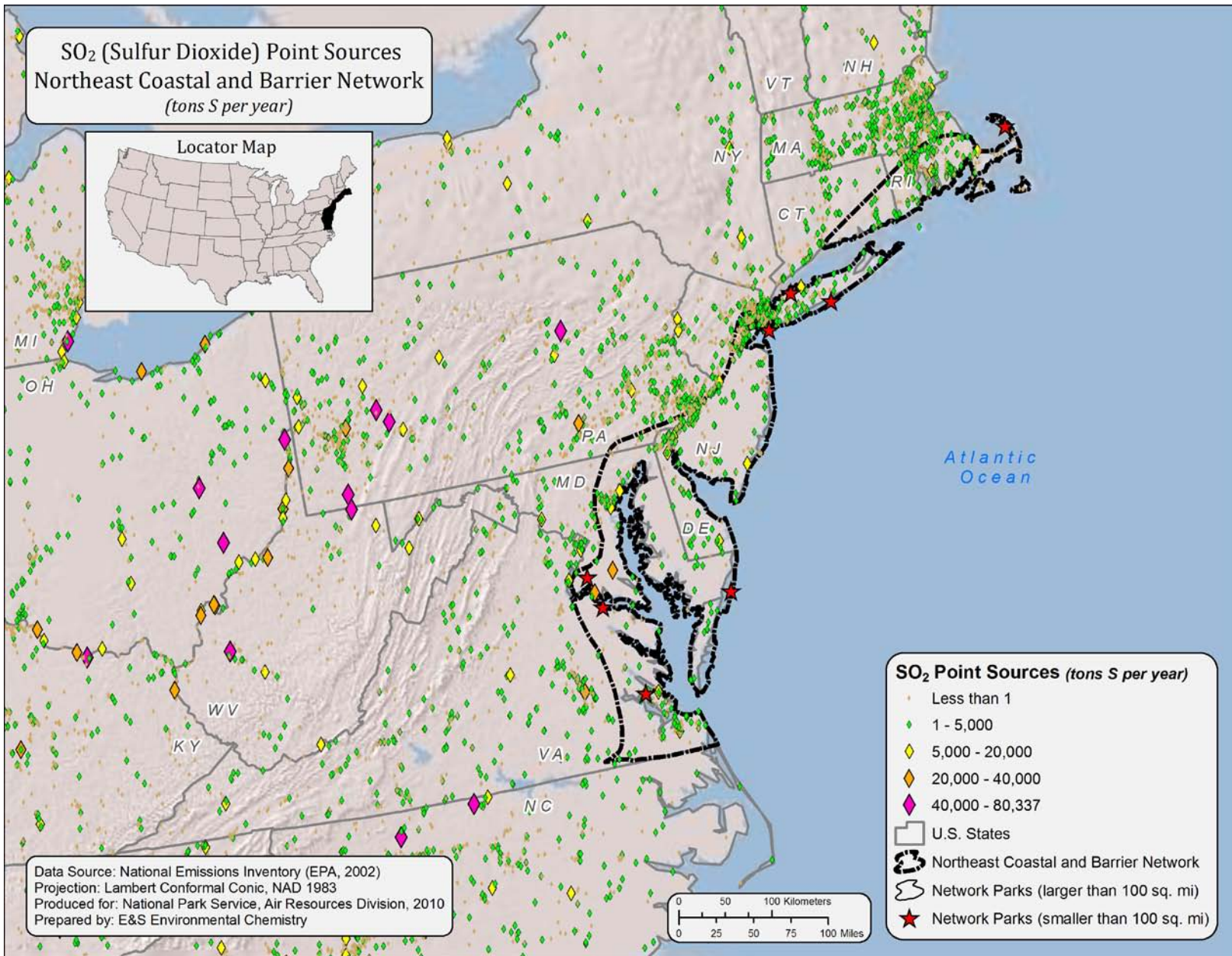
Map D



Map E

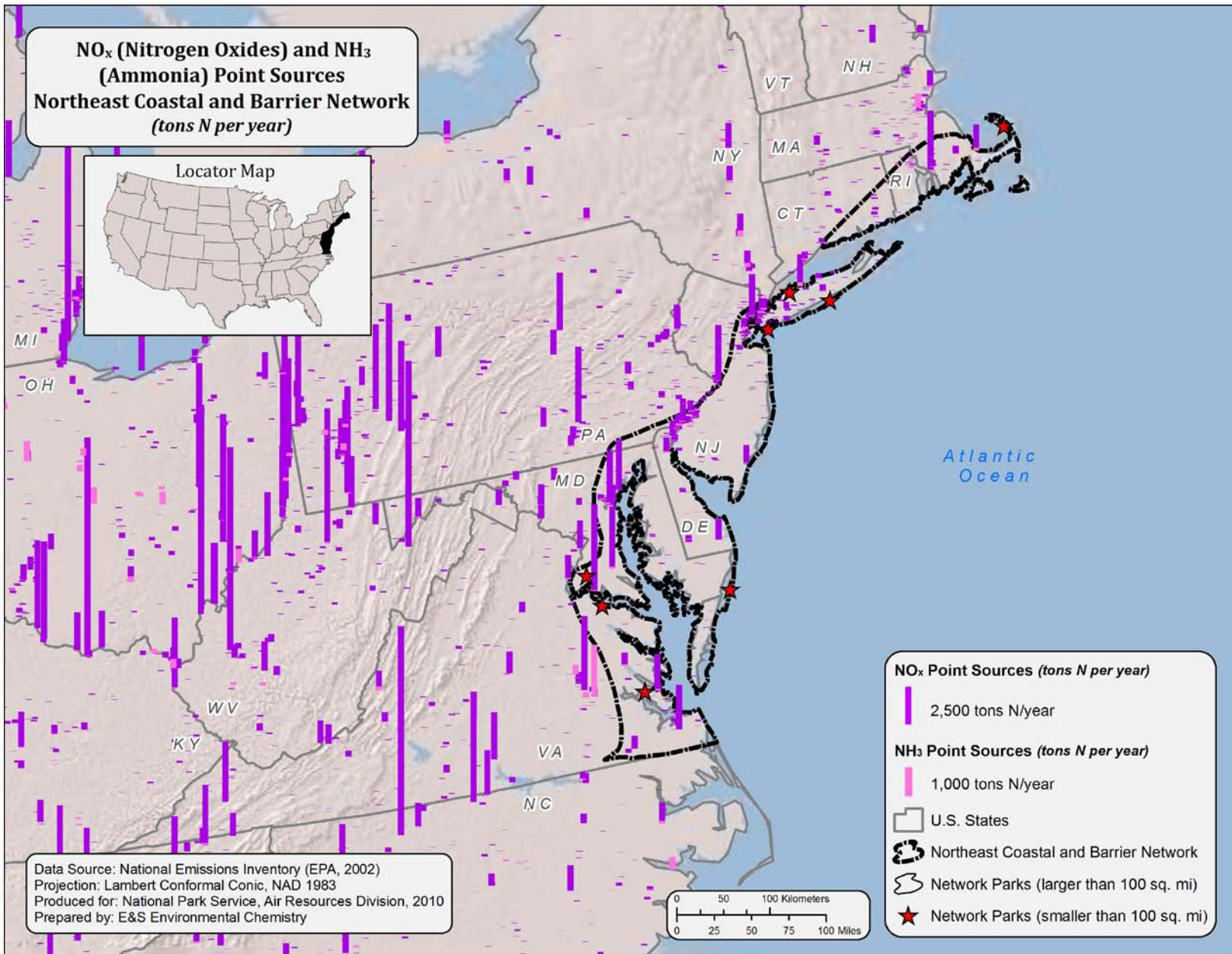


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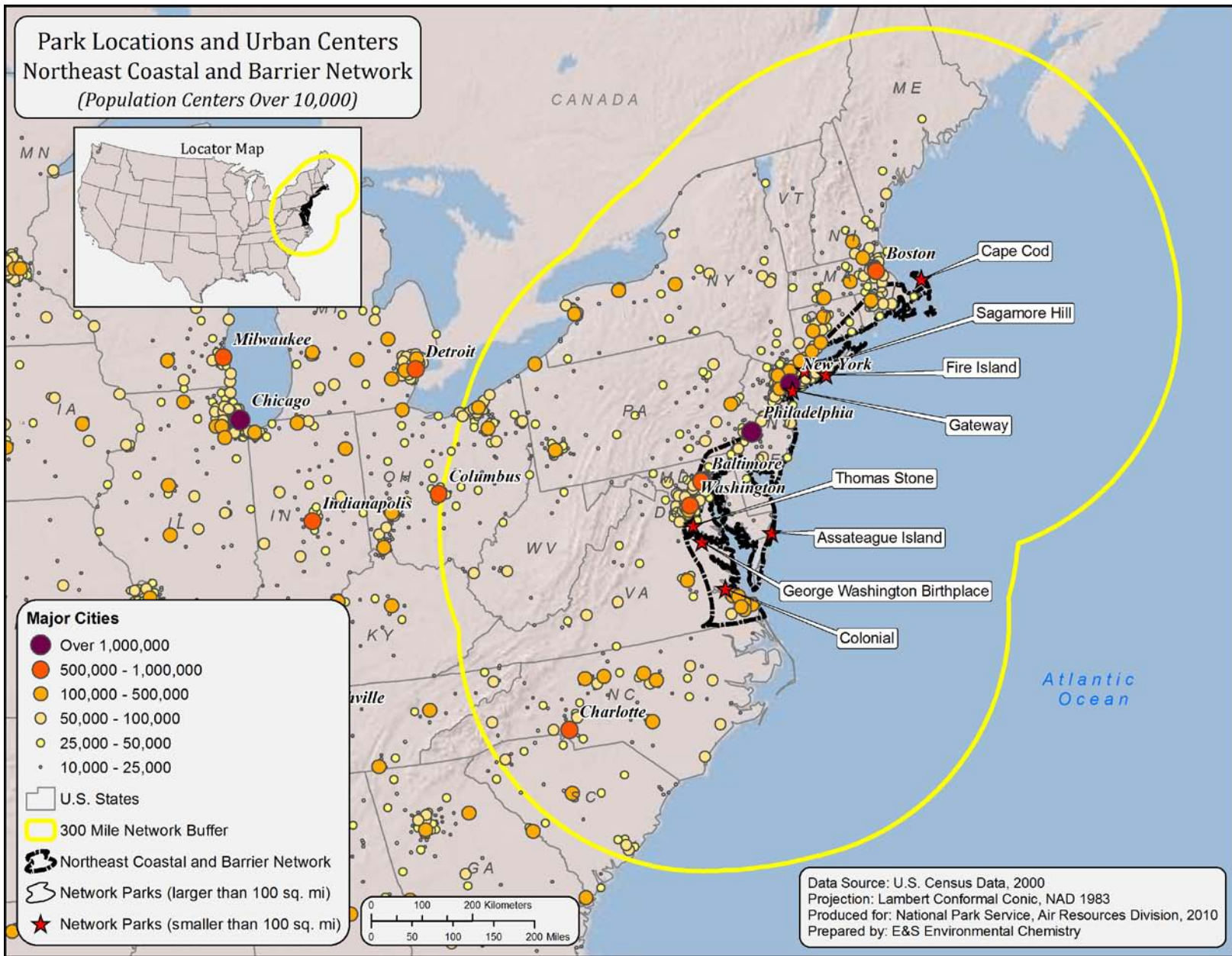


Map G

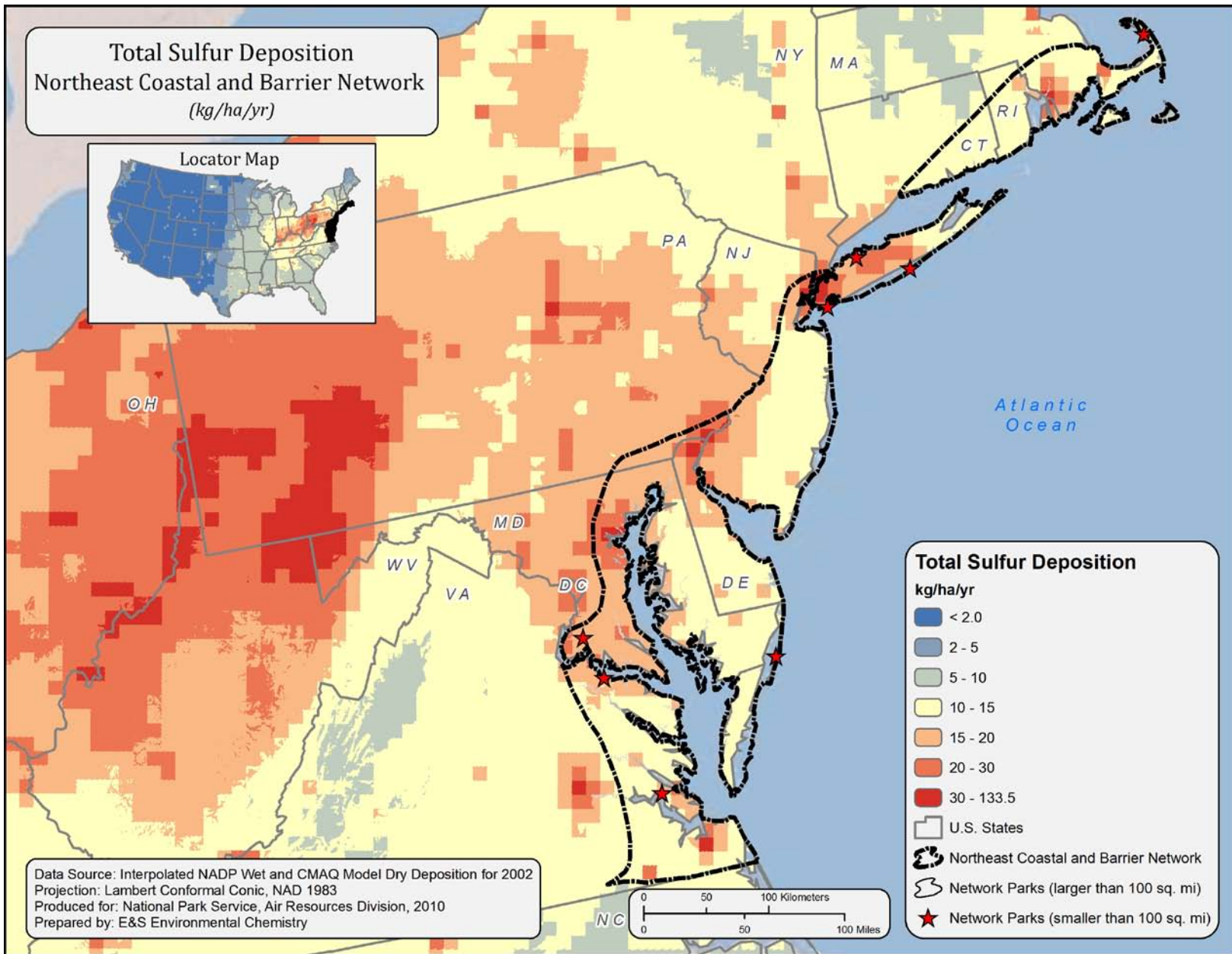




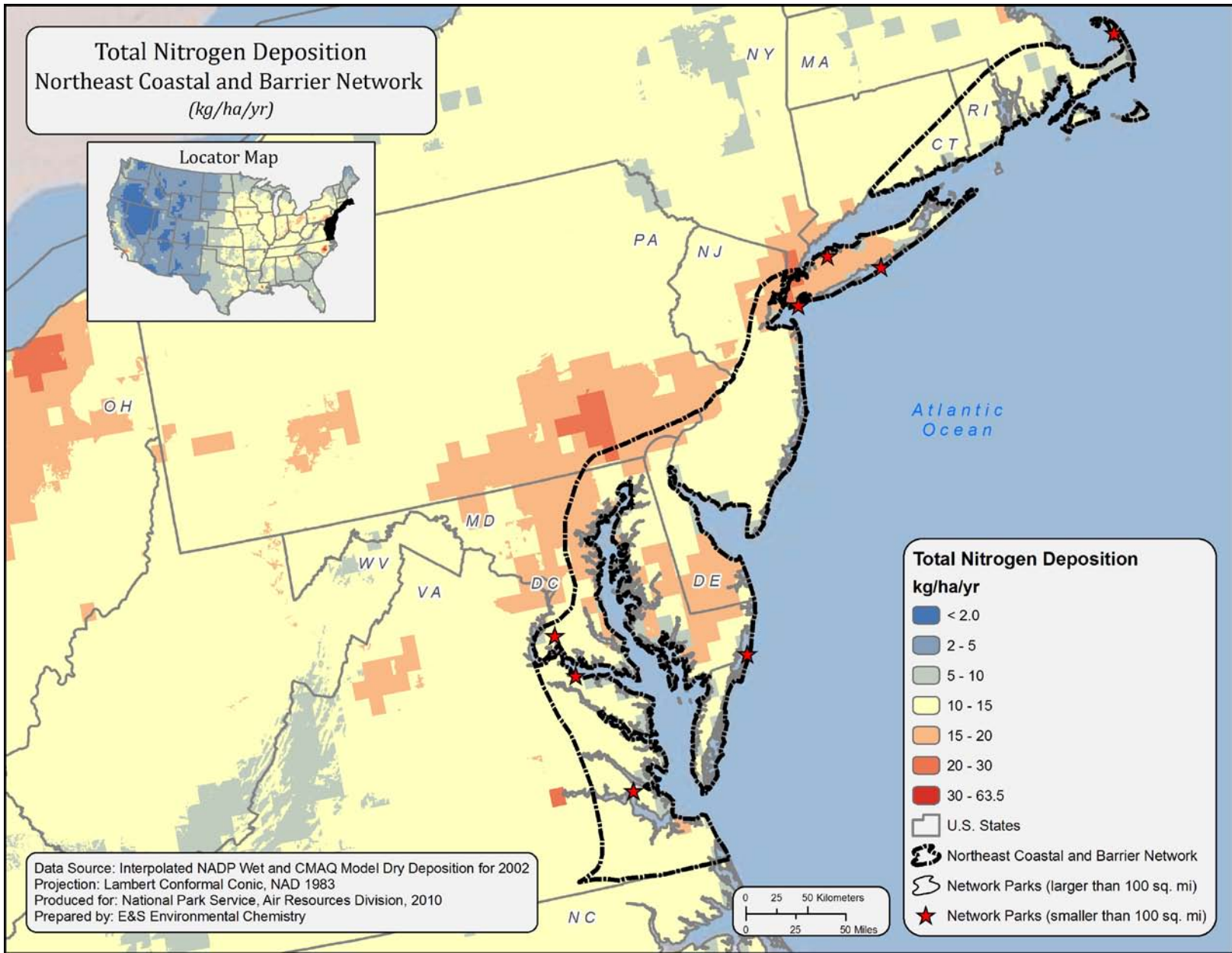
Map H



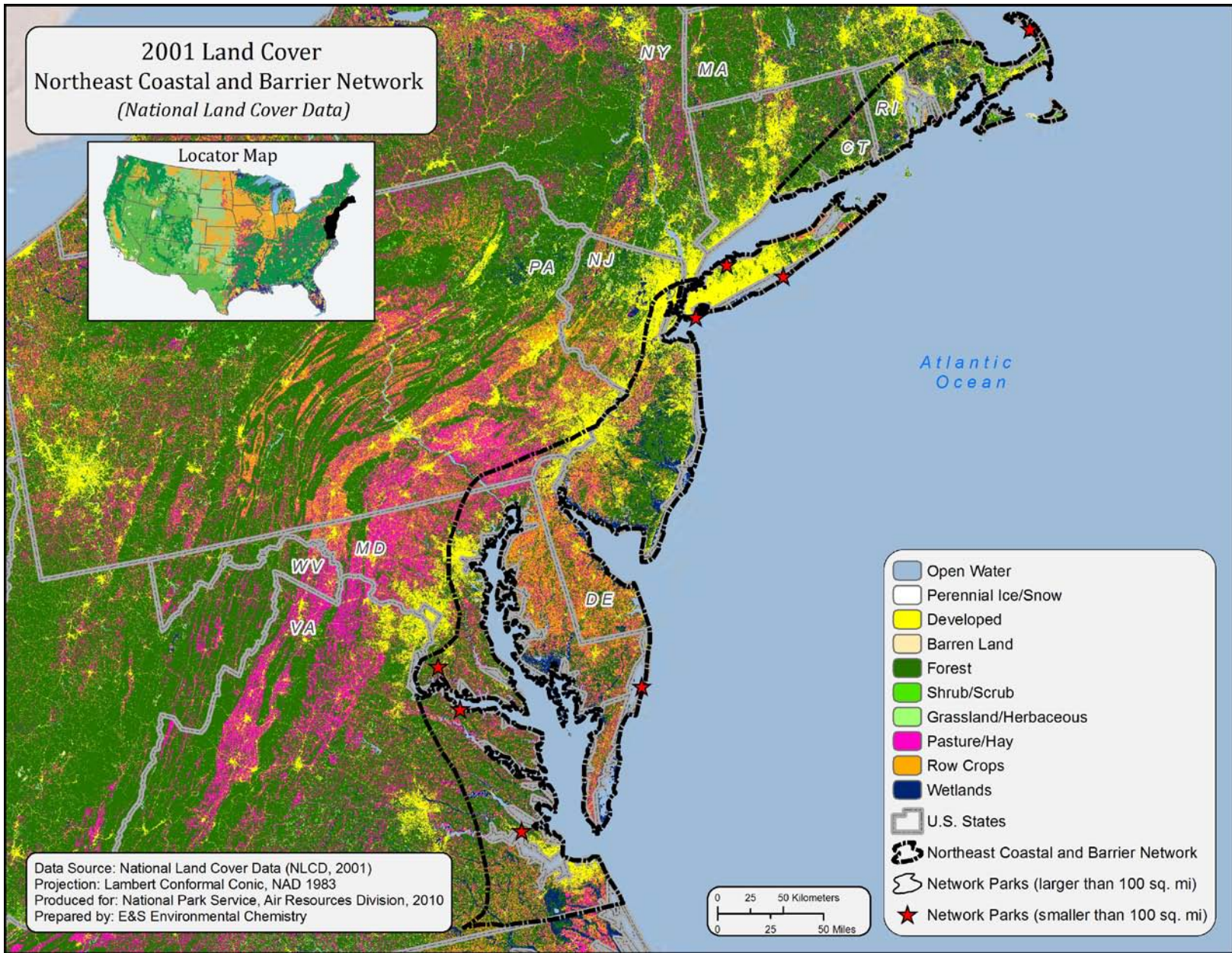
Map I



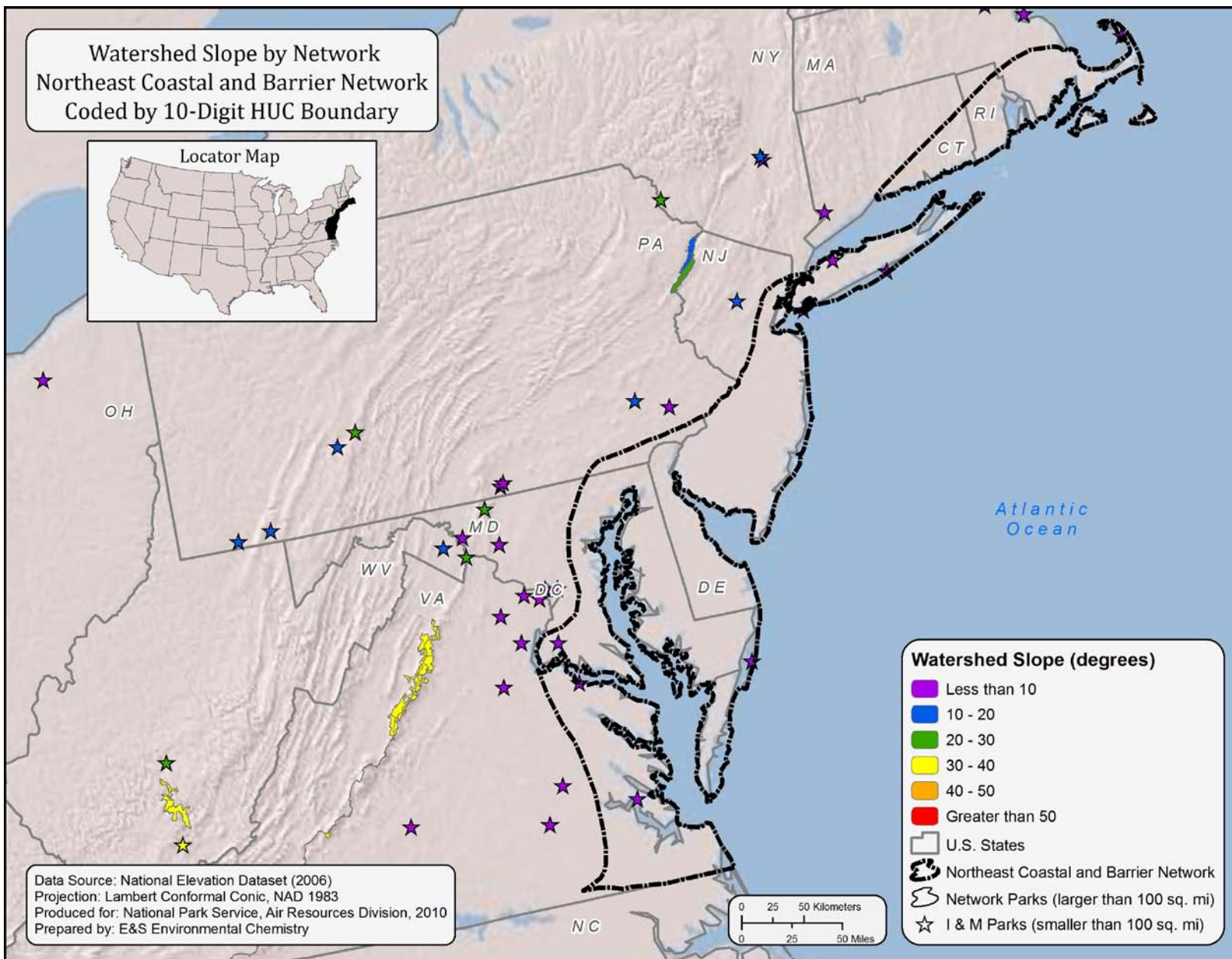
Map J



Map K



Map L



Map M

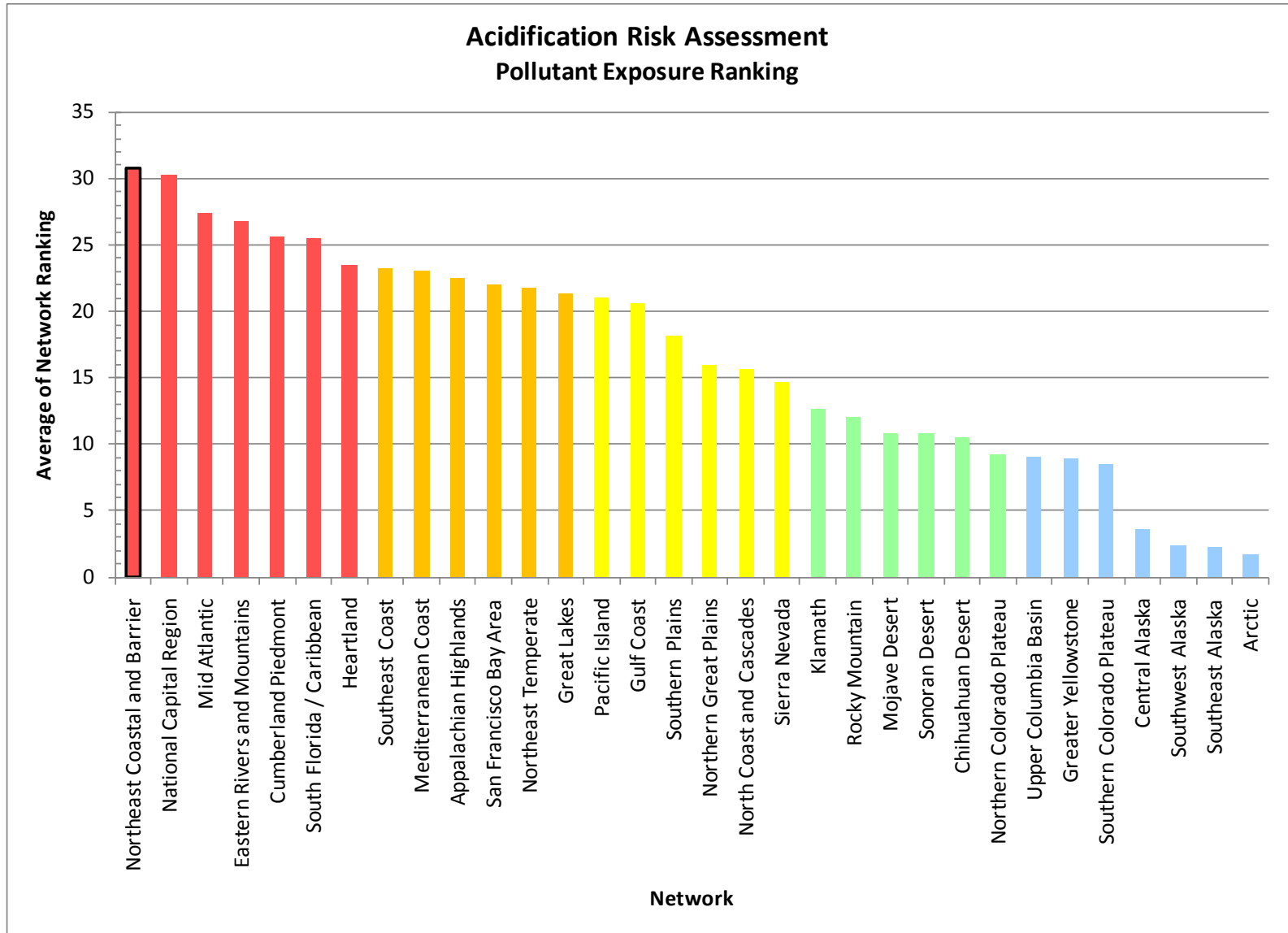


Figure A

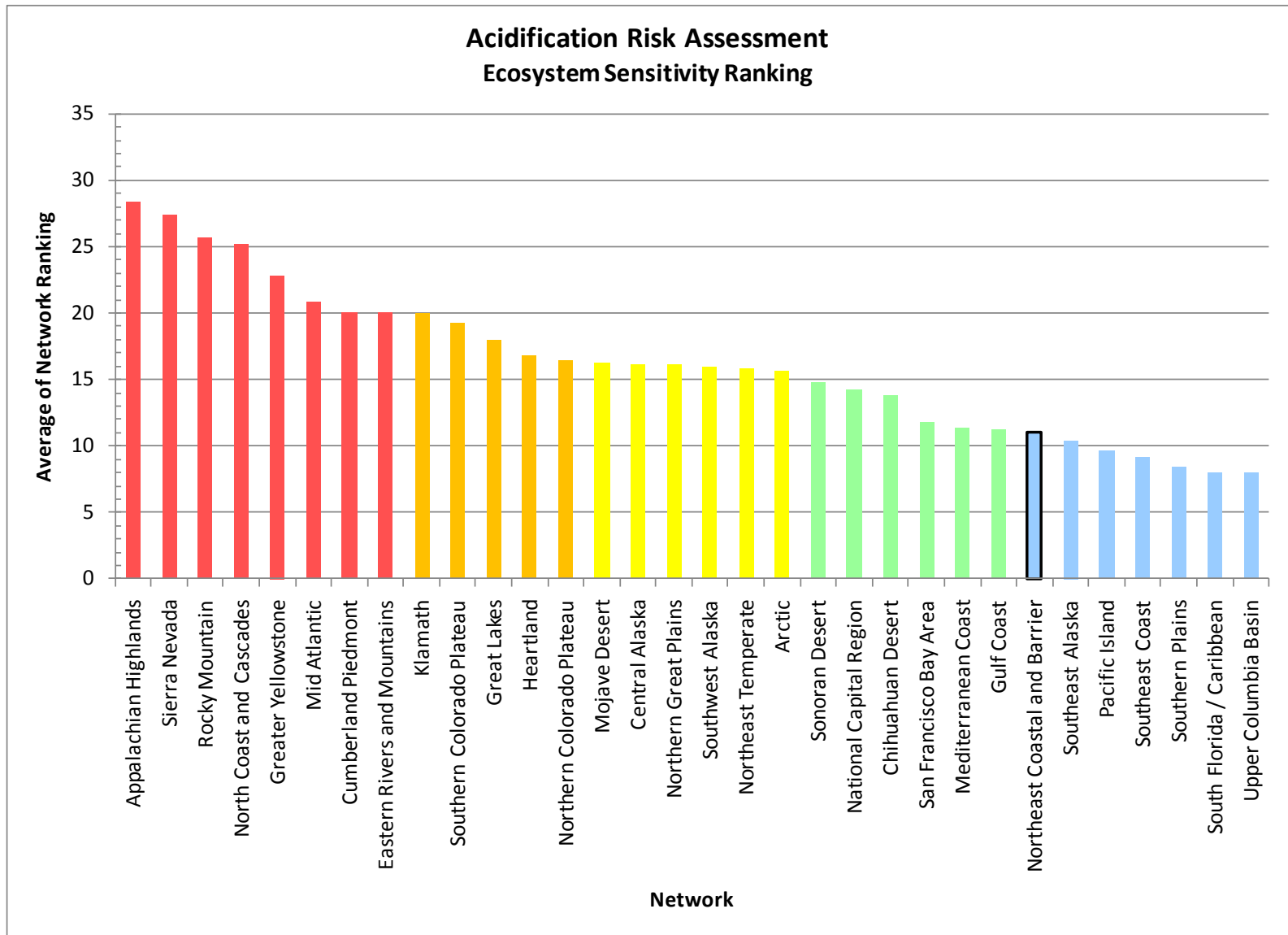


Figure B



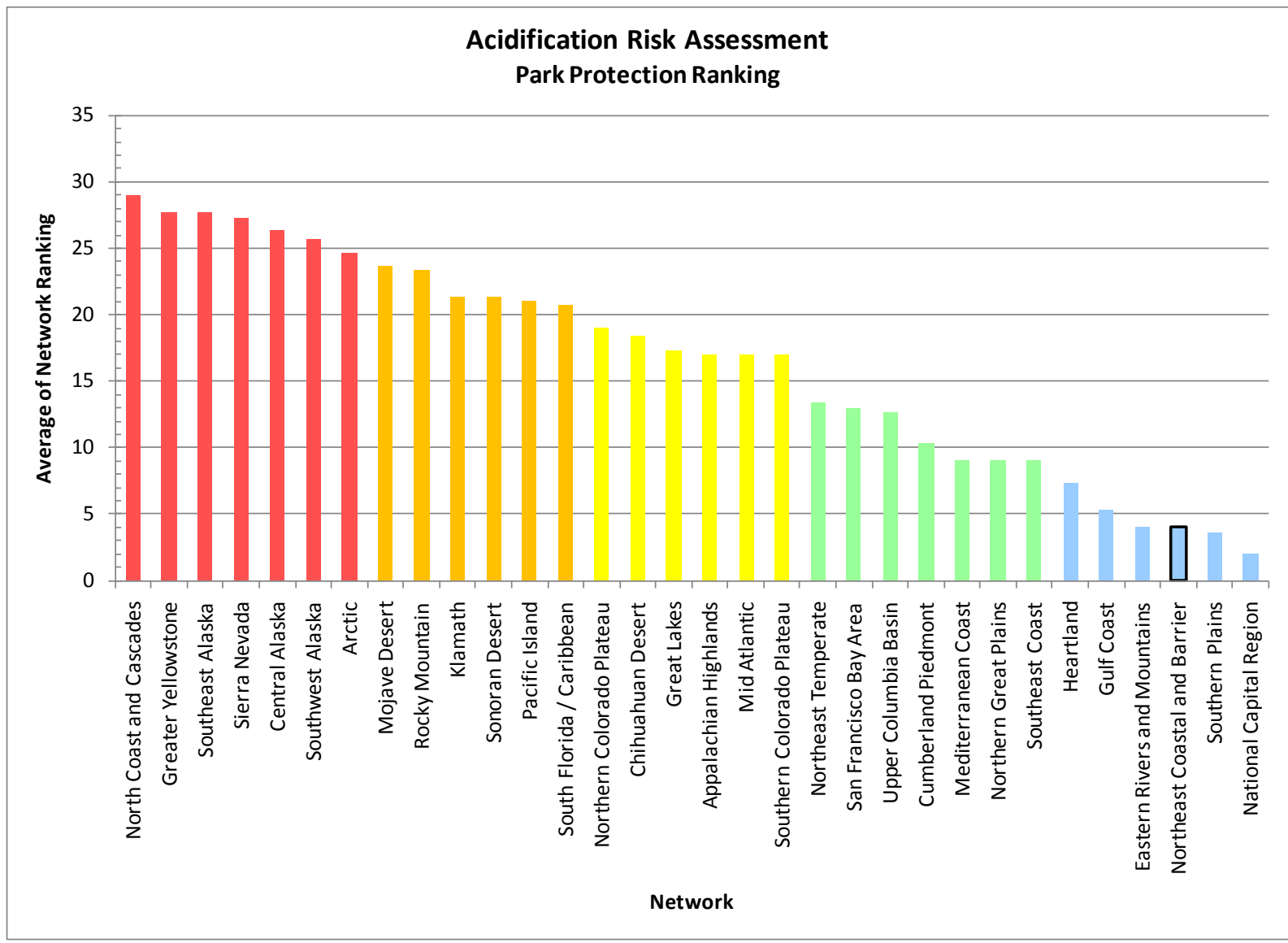


Figure C

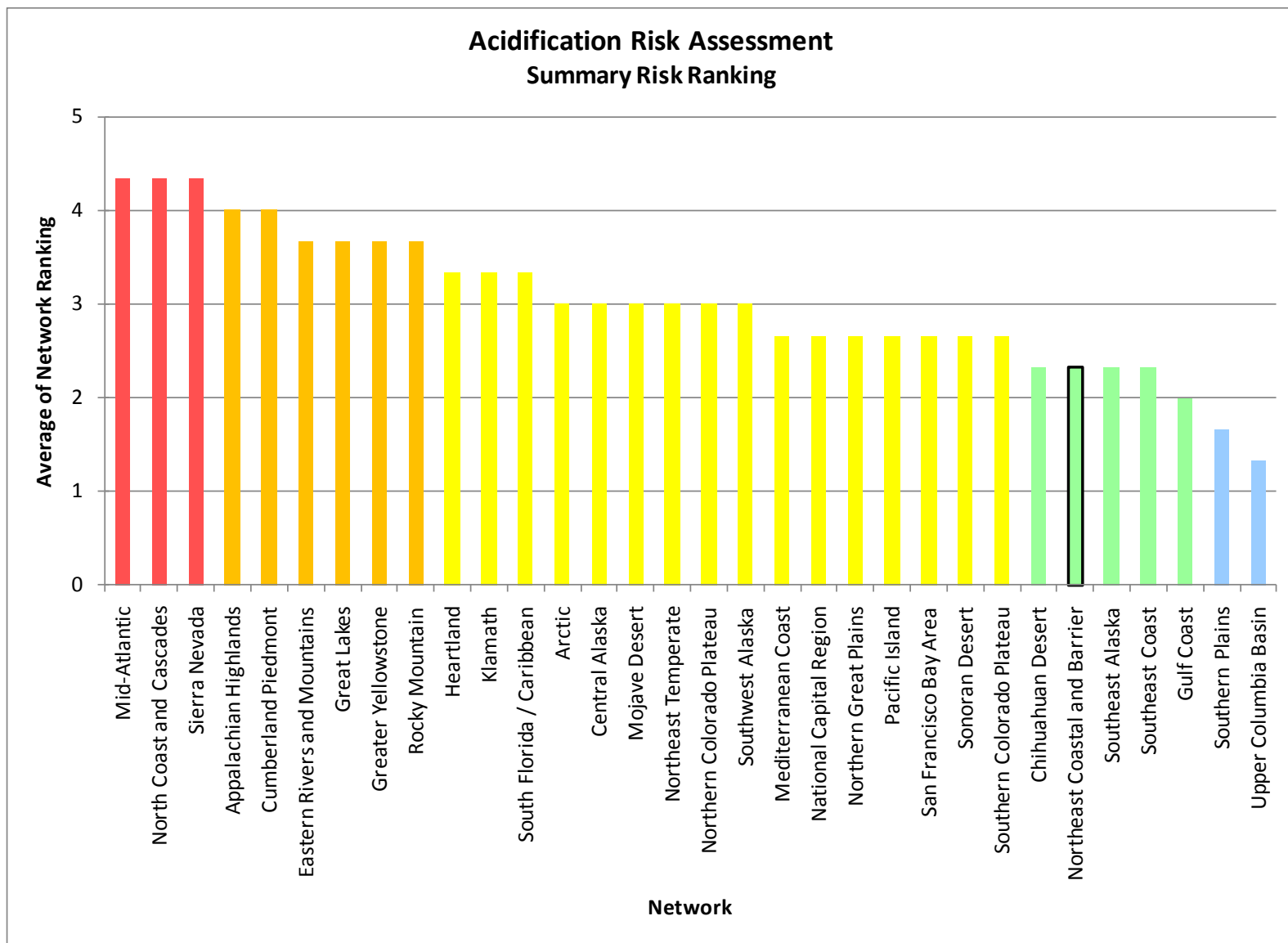


Figure D

The Department of the Interior protects and manages the nation's natural resources and cultural heritage; provides scientific and other information about those resources; and honors its special responsibilities to American Indians, Alaska Natives, and affiliated Island Communities.

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**National Park Service**  
**U.S. Department of the Interior**



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