



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

Heartland Network (HTLN)

Natural Resource Report NPS/NRPC/ARD/NRR—2011/359



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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Heartland Network (HTLN)

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 15 parks in the Heartland Network. Only two (Buffalo [BUFF] and Ozark [OZAR]) are larger than 100 square miles.

Total annual S and N emissions, by county, are shown in Maps E and F, respectively, for lands in and surrounding the Heartland Network. County-level S emissions within most of the network ranged from less than 1 to up to 50 tons per square mile per year (Map E). There were several counties that had higher S emissions, some more than 100 tons of S per square mile per year. These high S emissions counties were located in the eastern part of the network, predominately in Ohio and Indiana. However, in most of the network, annual S emissions were less than 20 tons per square mile. County-level N emissions within the network generally ranged from less than 1 ton per square mile to between 20 and 50 tons per square mile (Map F). There was one county, located in eastern Missouri, that had N emissions greater than 100 tons per square mile per year, but in most of the network, county N emissions were less than 20 tons per square mile per year. Individual point source emissions of S are shown in Map G. There were numerous point sources of considerable magnitude. Many emitted more than 20,000 tons of S per year (Map G). Most of the largest S emission point sources were in Ohio and Indiana. Point source emissions of oxidized (nitrogen oxides, NO_x) and reduced (ammonia, NH_3) N are shown in Map H. There were many relatively large (larger than about 4,000 tons per year) point sources of oxidized N in and around the eastern portion of the network. There were also many smaller point sources of both oxidized and reduced N. The reduced N point sources were primarily in the western part of the network, in Kansas and Minnesota.

Urban centers within the network and within a 300-mile buffer around the network are shown in Map I. The largest population centers within the network are Indianapolis and Columbus. However, there are numerous large urban centers within the 300-mile buffer around the network, including Philadelphia, Houston, Dallas, and Chicago.

Total S and N deposition in and around the network are shown on Maps J and K, respectively. Included in this analysis are both wet and dry forms of acidic deposition and both the oxidized and reduced N species. Total S deposition within the network generally ranged from 2 to 5 kg S/ha/yr to between 20 and 30 kg S/ha/yr, with small areas exceeding 30 kg S/ha/yr (Map J). Total S deposition increased from relatively low values in the west to high levels of deposition in the east. Total N deposition within the network ranged from as low as 5 to 10 kg N/ha/yr to above 20 kg N/ha/yr at some locations (Map K). Throughout most of the network, total N deposition was between about 10 and 15 kg N/ha/yr.

Land cover in and around the network is shown in Map L. The predominant cover types within this network are generally row crops and pasture/hay. There are also forested and developed areas scattered throughout the network, and a considerable amount of wetland in the southern part of the network.

Land slope across the park lands within and surrounding the network is displayed on Map M. Park lands within the network generally have low relief, with slopes less than 20° across most of the parks (Map M). One park, Hot Springs (HOSP), has average slope in the range of 20° to 30°.

Park lands requiring special protection against potential adverse impacts associated with acidification from atmospheric S and N deposition are shown on Map N. Also shown on Map N are all federal lands designated as wilderness, both lands managed by NPS and lands managed by other federal agencies. The land designations used to identify this heightened protection included Class I designation under the Clean Air Act Amendments and wilderness designation. There are no NPS Class I areas in this network and only scattered small areas designated as wilderness, none of which is managed by NPS.

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 Heartland Network ranked at the bottom of the highest quintile, Very High among networks, in Pollutant Exposure (Figure A). Sulfur and N emissions and deposition within the network were relatively high. However, the network Ecosystem Sensitivity ranking was slightly lower, ranked as High, in the second highest quintile among networks (Figure B). This was partly because there is vegetation coverage in this network that includes the vegetation types expected to be especially sensitive to acidification effects from S and N deposition, and there is one high-elevation lake and some high-elevation streams. This network ranked at the top of the lowest quintile in Park Protection, having limited amounts of protected lands (Figure C).

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

Similarly, park rankings are given in Figures E through H for the same metrics. In the case of the park rankings, we only show in the figures the parks that are larger than 100 square miles. Relative ranks for all parks, including the smaller parks, are given in Table A and Appendix A. As for the network ranking figures, the park ranking figures highlight those parks that occur in this network to show their relative position compared with parks in the other 31 networks. Note that the rankings shown in Figures E through H reflect the rank of a given park compared with all other parks, irrespective of size.

The I&M parks in this network that are larger than 100 square miles (BUFF and OZAR) were ranked as Moderate and High, respectively, in Pollutant Exposure (Figure E). Smaller parks in the network were ranked Moderate (four parks), High (six parks), and Very High (three parks) for this theme. BUFF was ranked Very High, the only park in the network with that ranking, and OZAR was ranked Moderate, in Ecosystem Sensitivity (Figure F). The smaller parks in the network varied, and were ranked from Very Low to High in Ecosystem Sensitivity. BUFF was ranked High among parks for Park Protection (Figure G), whereas all other parks in the network were ranked Moderate for this theme (Table A). Four parks, including BUFF, were ranked High for overall Summary Risk. The other parks were ranked Moderate in overall Summary Risk, except for Arkansas Post (ARPO), which was ranked low.

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.

I&M Parks ² in Network	Relative Ranking of Individual Parks ¹			
	Pollutant Exposure	Ecosystem Sensitivity	Park Protection	Summary Risk
Arkansas Post	Moderate	Very Low	Moderate	Low
Buffalo	Moderate	Very High	High	High
Cuyahoga Valley	Very High	High	Moderate	High
Effigy Mounds	High	High	Moderate	High
George Washington Carver	High	Very Low	Moderate	Moderate
Herbert Hoover	High	Very Low	Moderate	Moderate
Homestead	High	Low	Moderate	Moderate
Hopewell Culture	Very High	Low	Moderate	Moderate
Hot Springs	Moderate	Moderate	Moderate	Moderate
Lincoln Boyhood	Very High	Low	Moderate	Moderate
Ozark	High	Moderate	Moderate	Moderate
Pea Ridge	High	Moderate	Moderate	Moderate
Pipestone	Moderate	Low	Moderate	Moderate
Tallgrass Prairie	High	High	Moderate	High
Wilson's Creek	Moderate	Low	Moderate	Moderate

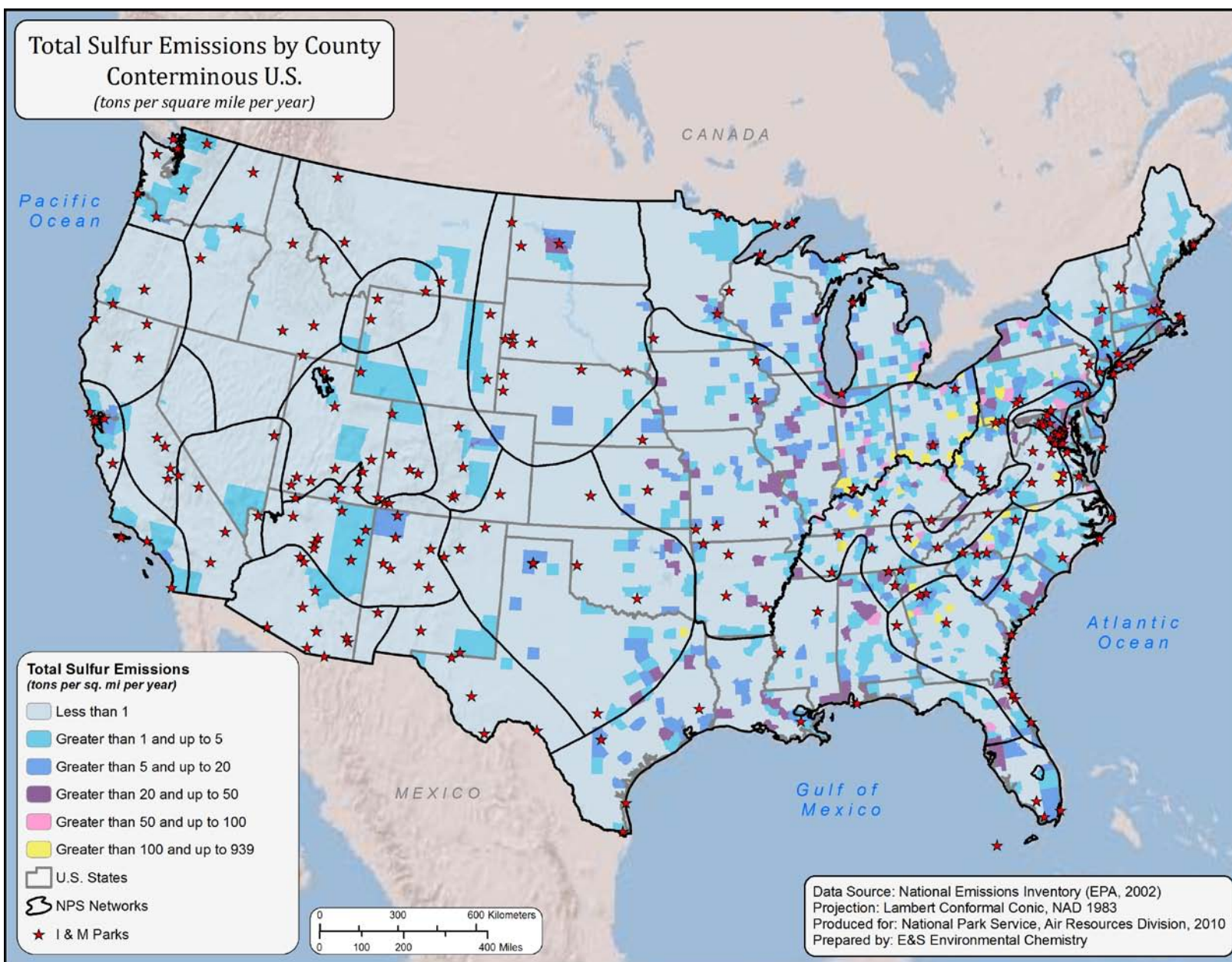
¹ Relative park rankings are designated according to quintile ranking, among all I&M Parks, from the lowest quintile (very low risk) to the highest quintile (very high risk).

² Park name is printed in bold italic for parks larger than 100 square miles.

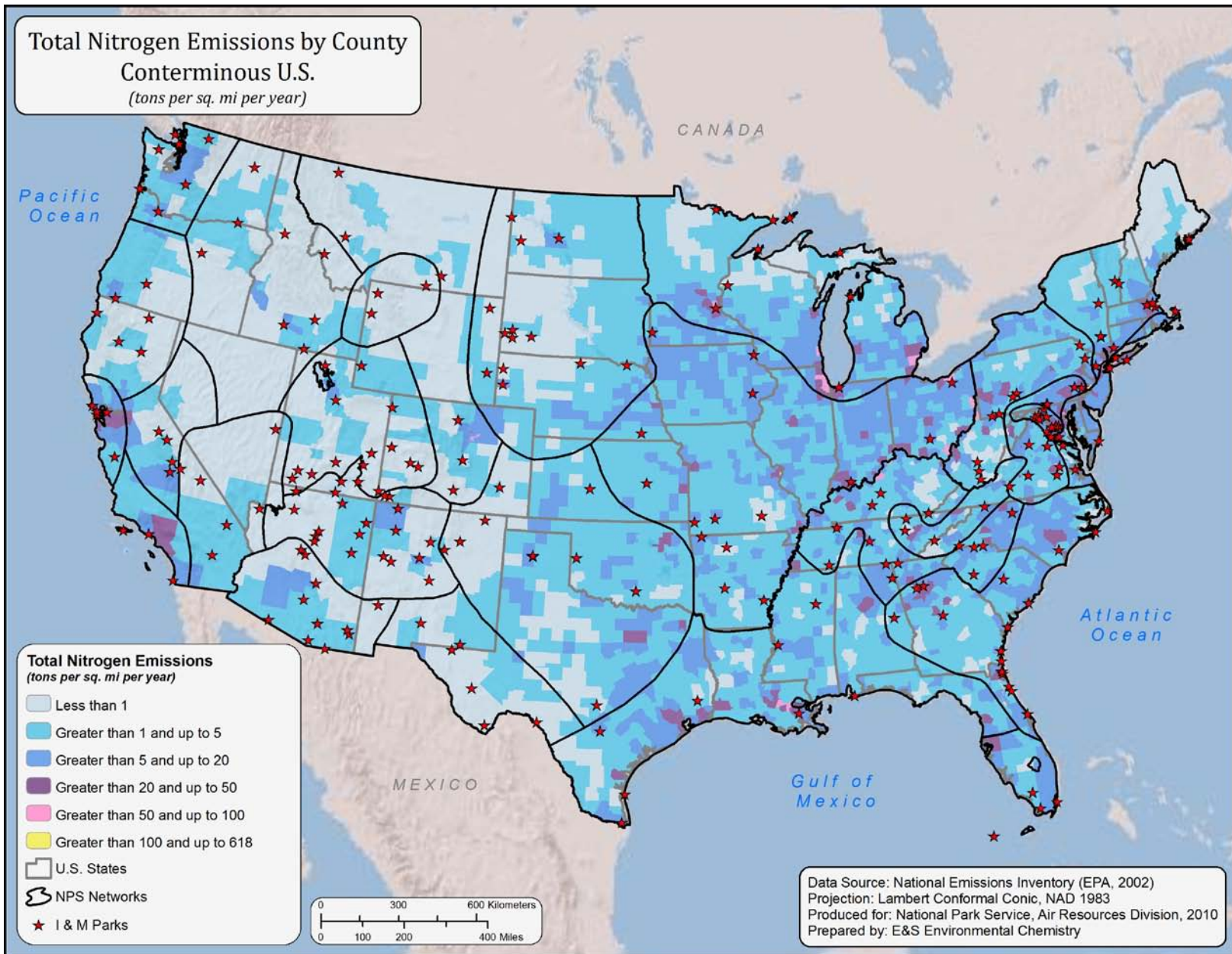
- Map A. National map of total S emissions by county for the year 2002, in units of tons of S per square mile per year. (Source of data: EPA National Emissions Inventory, <http://www.epa.gov/ttn/chief/net/2002inventory.html>)
- Map B. National map of total N emissions by county for the year 2002. Both oxidized (nitrogen oxides, NO_x) and reduced (ammonia, NH₃) 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_x) and reduced (ammonia, NH₃) 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_x) and reduced (ammonia, NH₃) N. (Source of data: EPA National Emissions Inventory, <http://www.epa.gov/ttn/chief/net/2002inventory.html>)
- Map G. Major point source emissions of SO₂ 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_x) and reduced (ammonia, NH₃) 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_x) and reduced (ammonia, NH₃) 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)

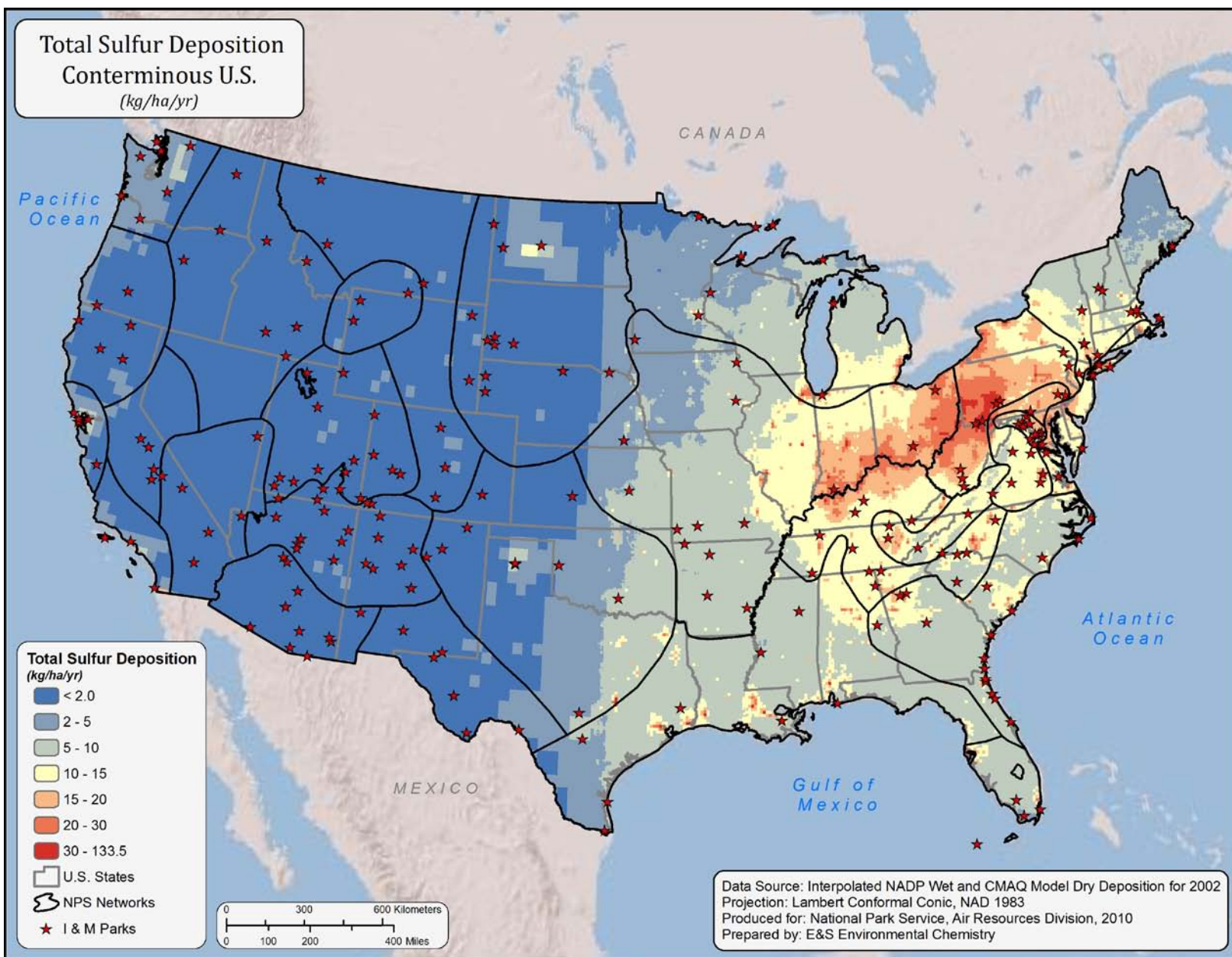
- Map L. Land cover types in and around the network, based on the National Land Cover dataset. (Source of data: National Land Cover Dataset, http://www.mrlc.gov/nlcd_multizone_map.php)
- Map M. Average land slope within park units that occur within the network, by 10-digit HUC. Some parks in this network are slightly larger than 100 mi², but yet too small to readily see the color within the park outline. These parks are represented on the map with a colored circle and a line from the circle indicating the park location. (Source of data: U.S. EPA National Elevation Dataset [<http://ned.usgs.gov/>])
- Map N. Lands within the network that are classified as Class I or wilderness area. (Source of data: USGS 2005 [National Atlas; <http://nationalatlas.gov>] and NPS)
- 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.
- Figure E. Park rankings for Pollutant Exposure for all parks larger than 100 square miles. Ranks for each park were calculated relative to all parks, regardless of size, as the average of scores for all Pollutant Exposure variables.
- Figure F. Park rankings for Ecosystem Sensitivity for all parks larger than 100 square miles. Ranks for each park were calculated relative to all parks, regardless of size, as the average of scores for all Ecosystem Sensitivity variables.
- Figure G. Park rankings for Park Protection for all parks larger than 100 square miles. Ranks for each park were calculated relative to all parks, regardless of size, as the average of scores for all Park Protection variables.
- Figure H. Park rankings for Summary Risk for all parks larger than 100 square miles. Ranks for each park were calculated relative to all parks, regardless of size, as the average of the quintile ranks for the Pollutant Exposure, Ecosystem Sensitivity, and Park Protection themes.



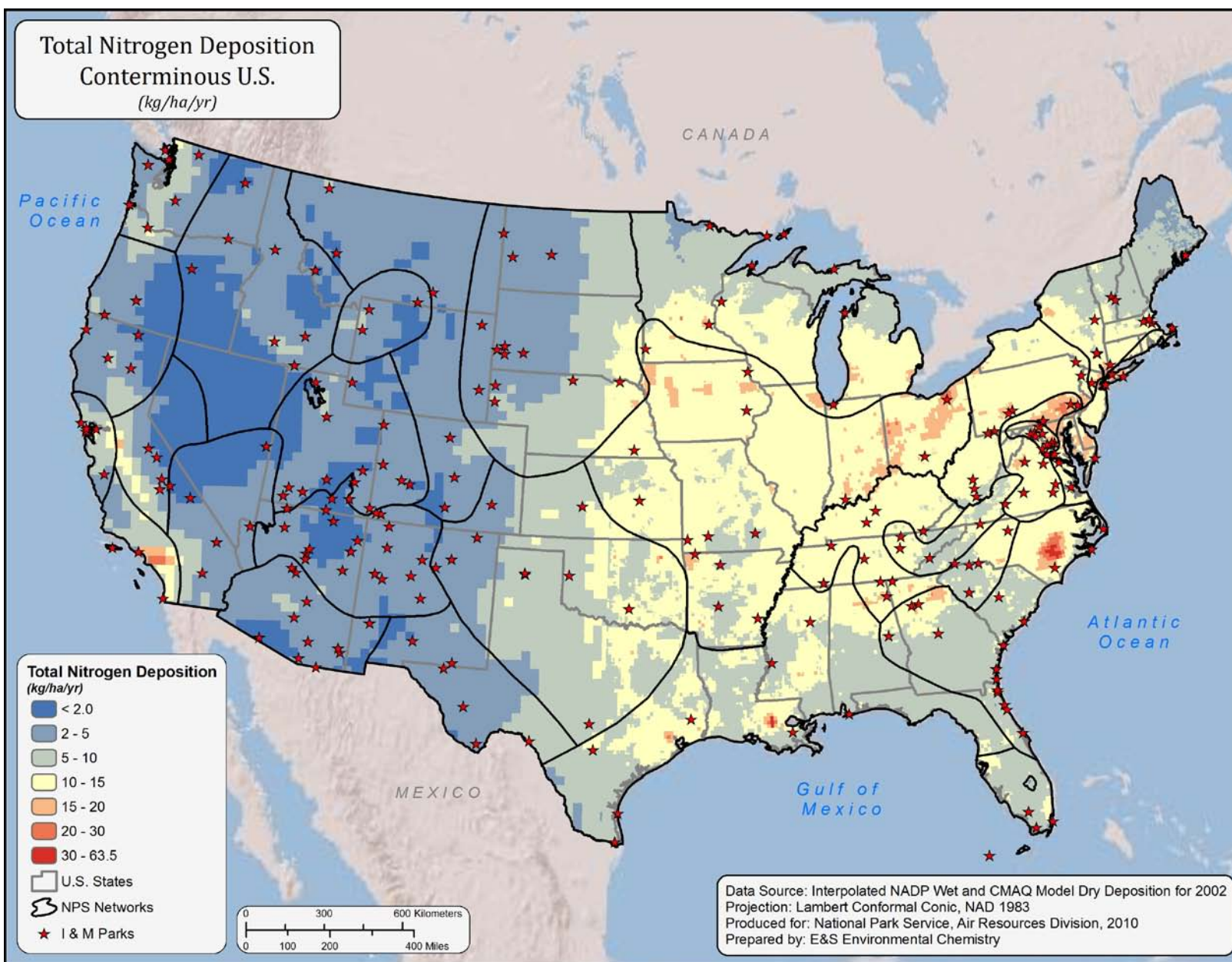
Map A



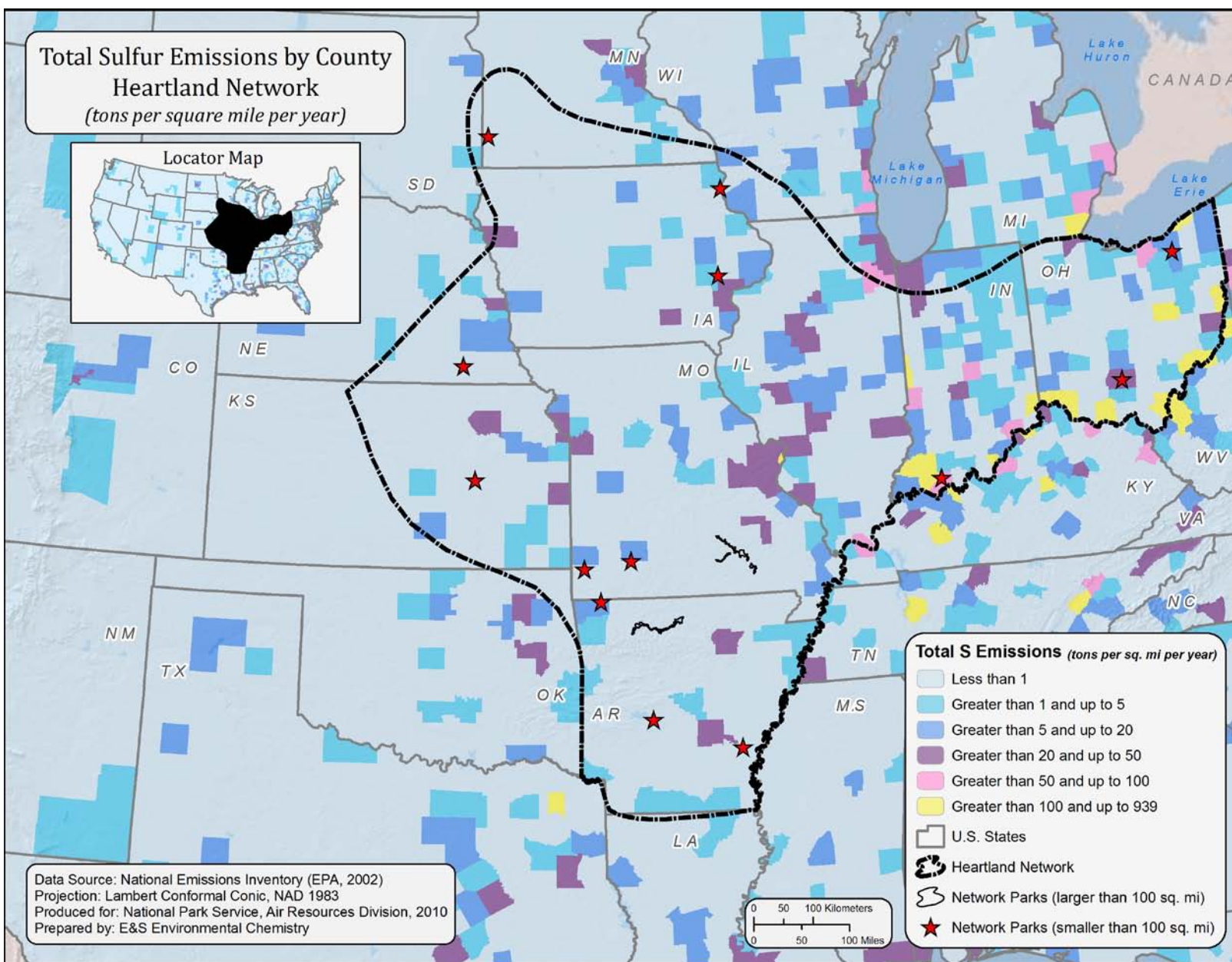
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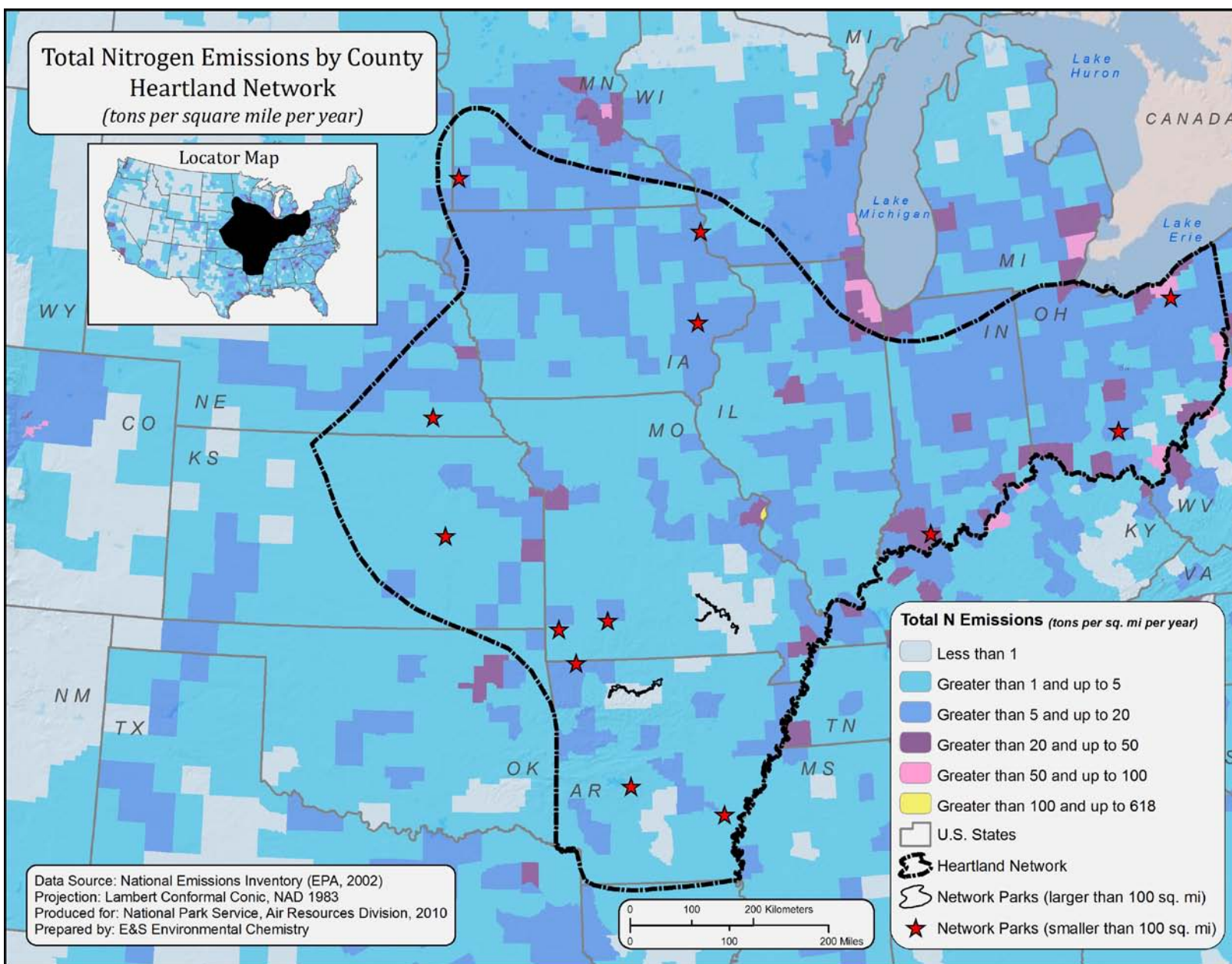
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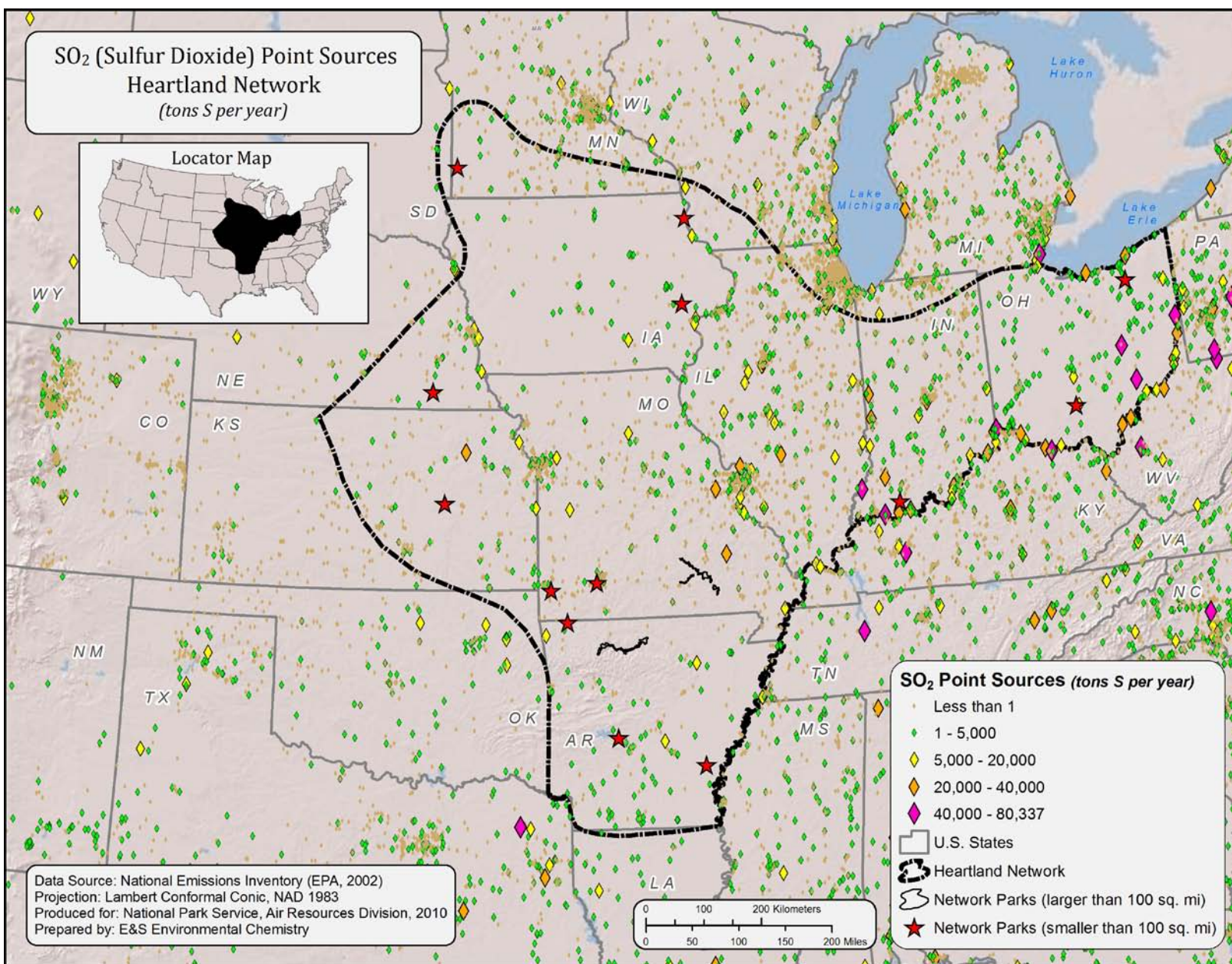
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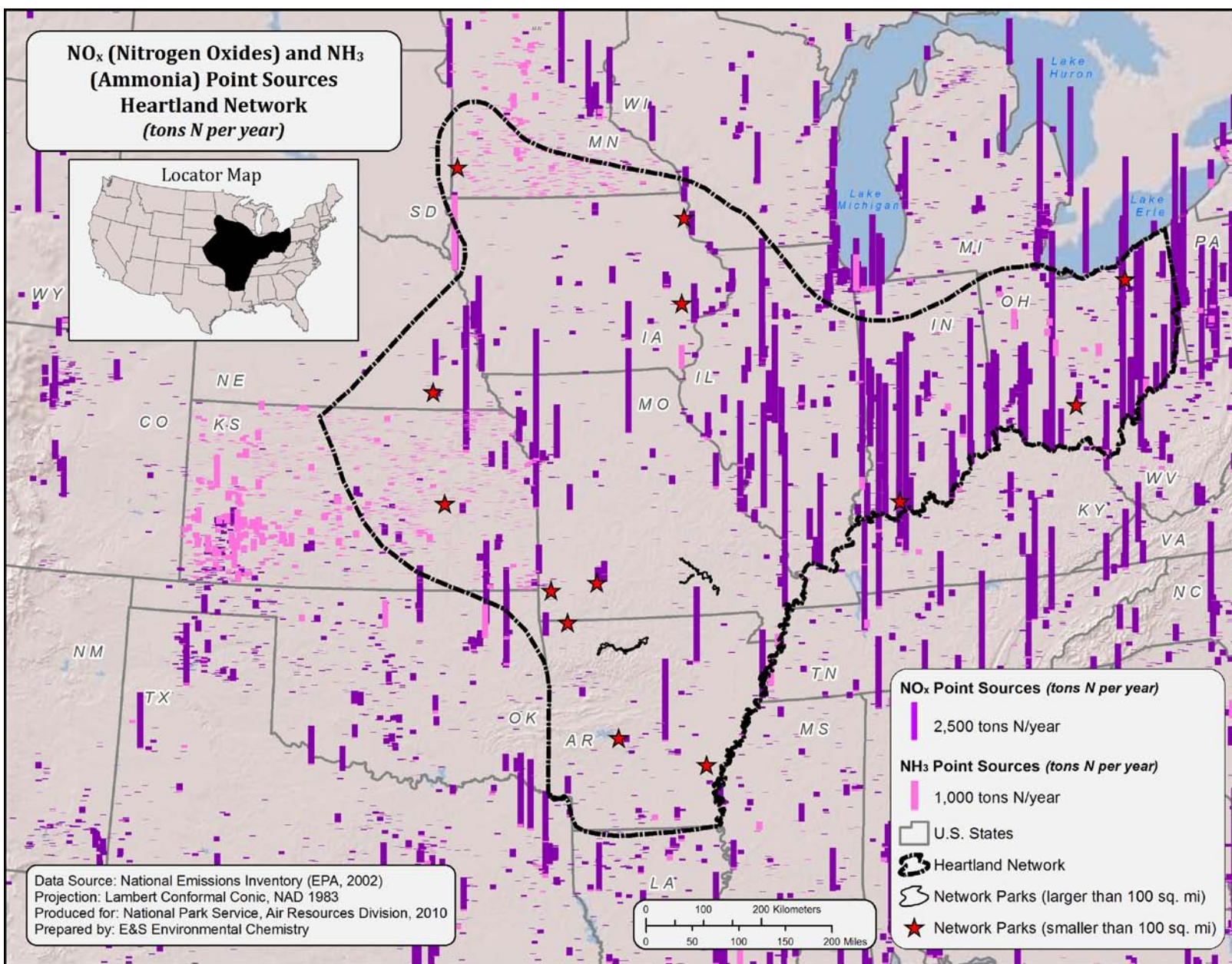
Map E



Map F

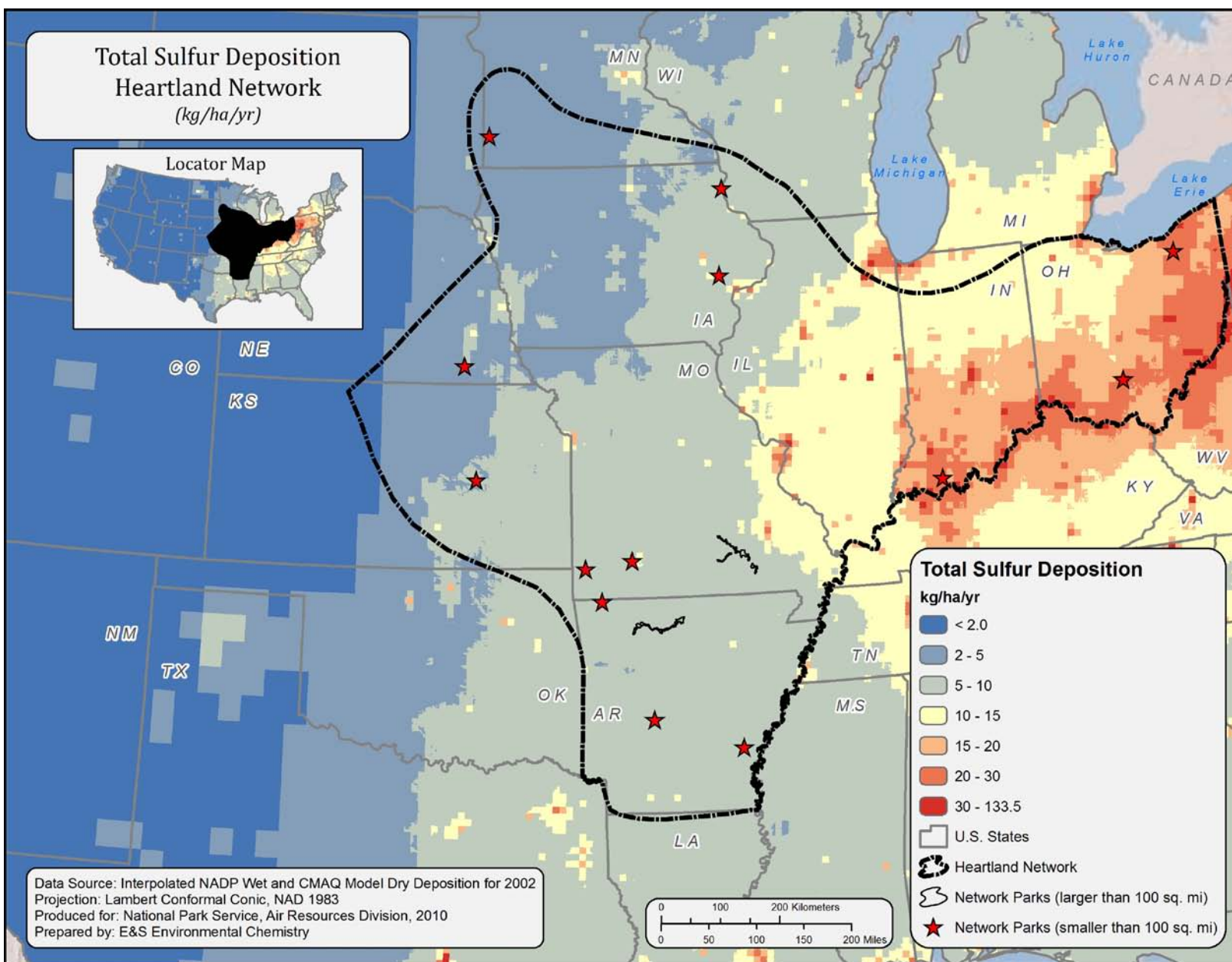


Map G

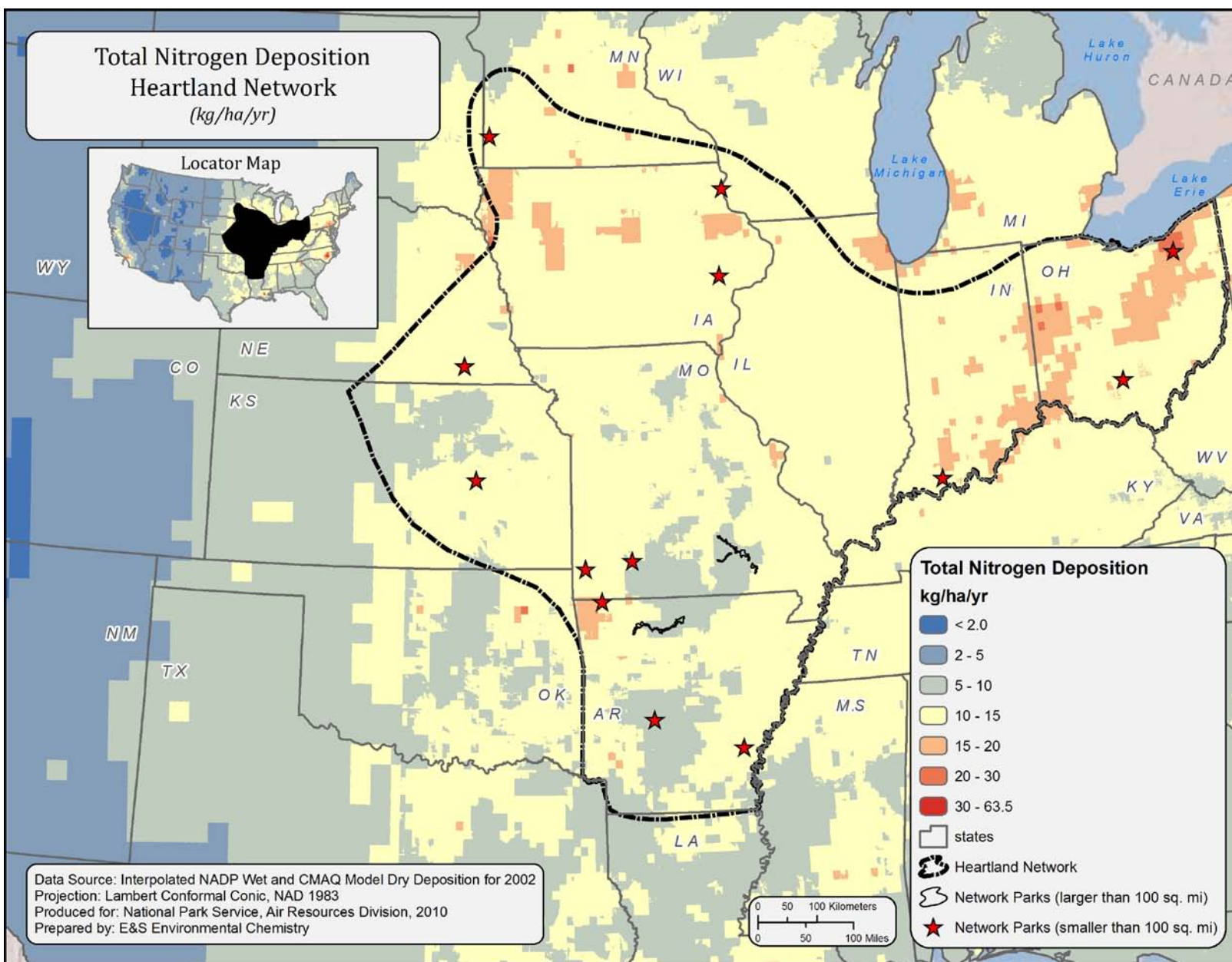


Map H

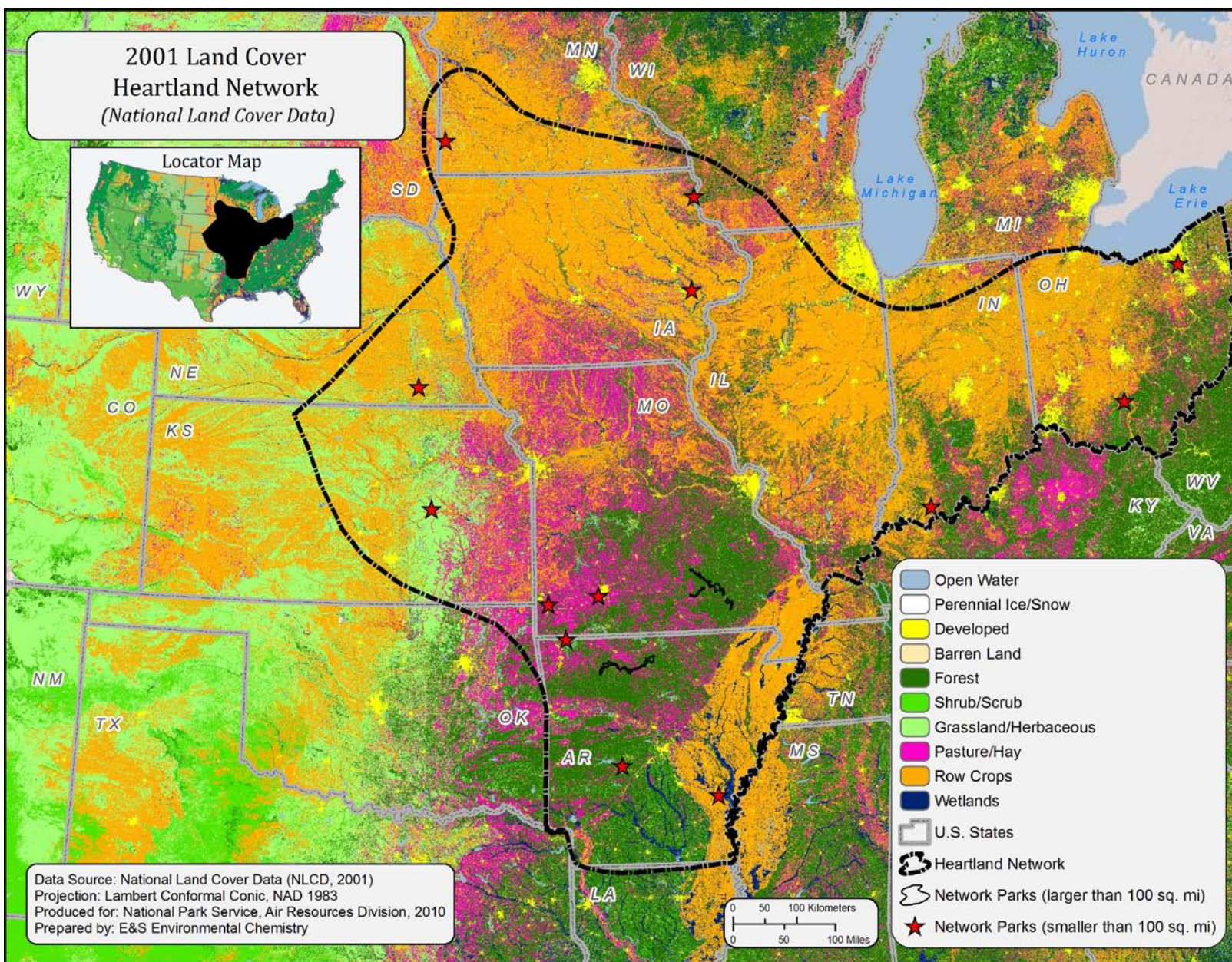
Map I



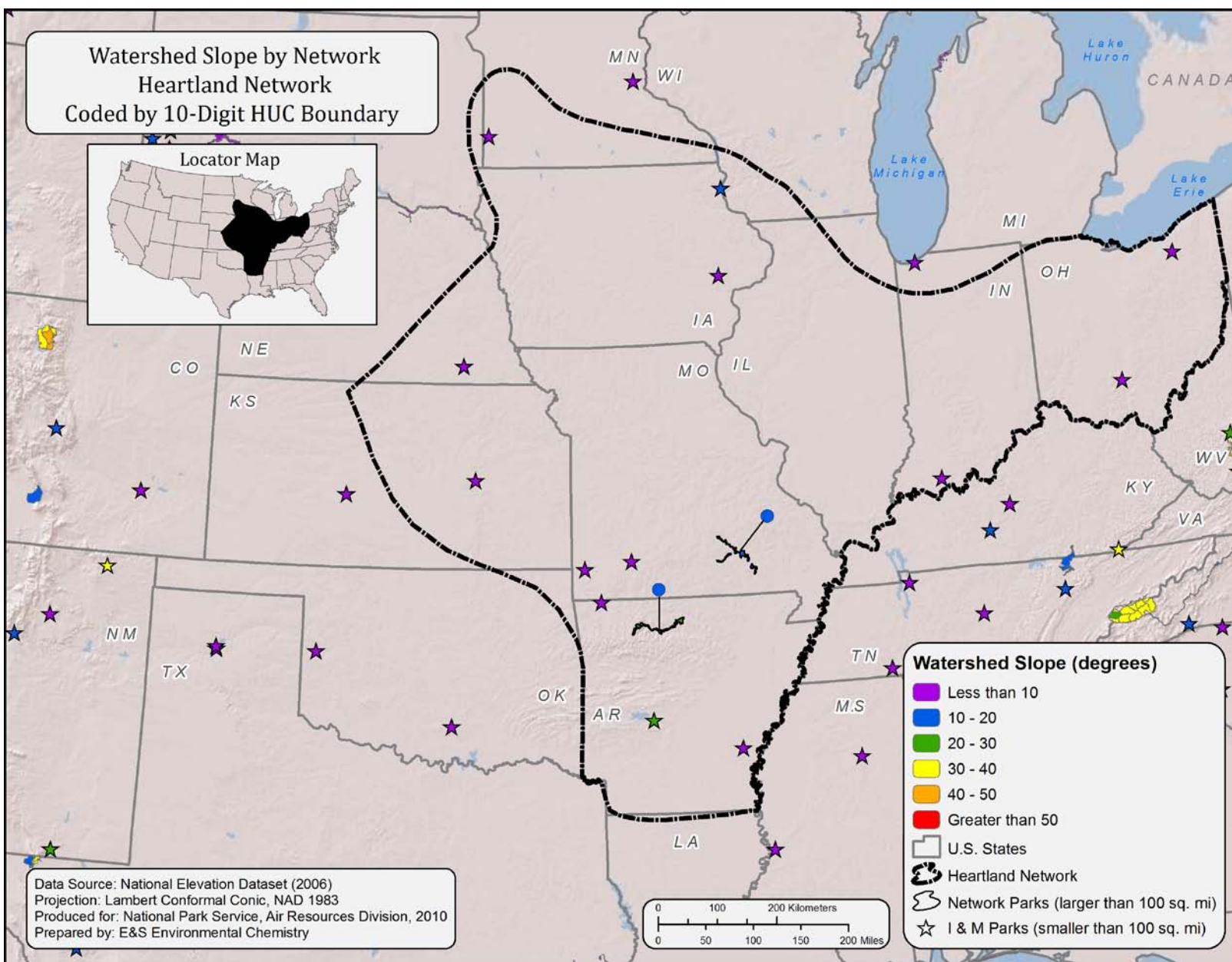
Map J



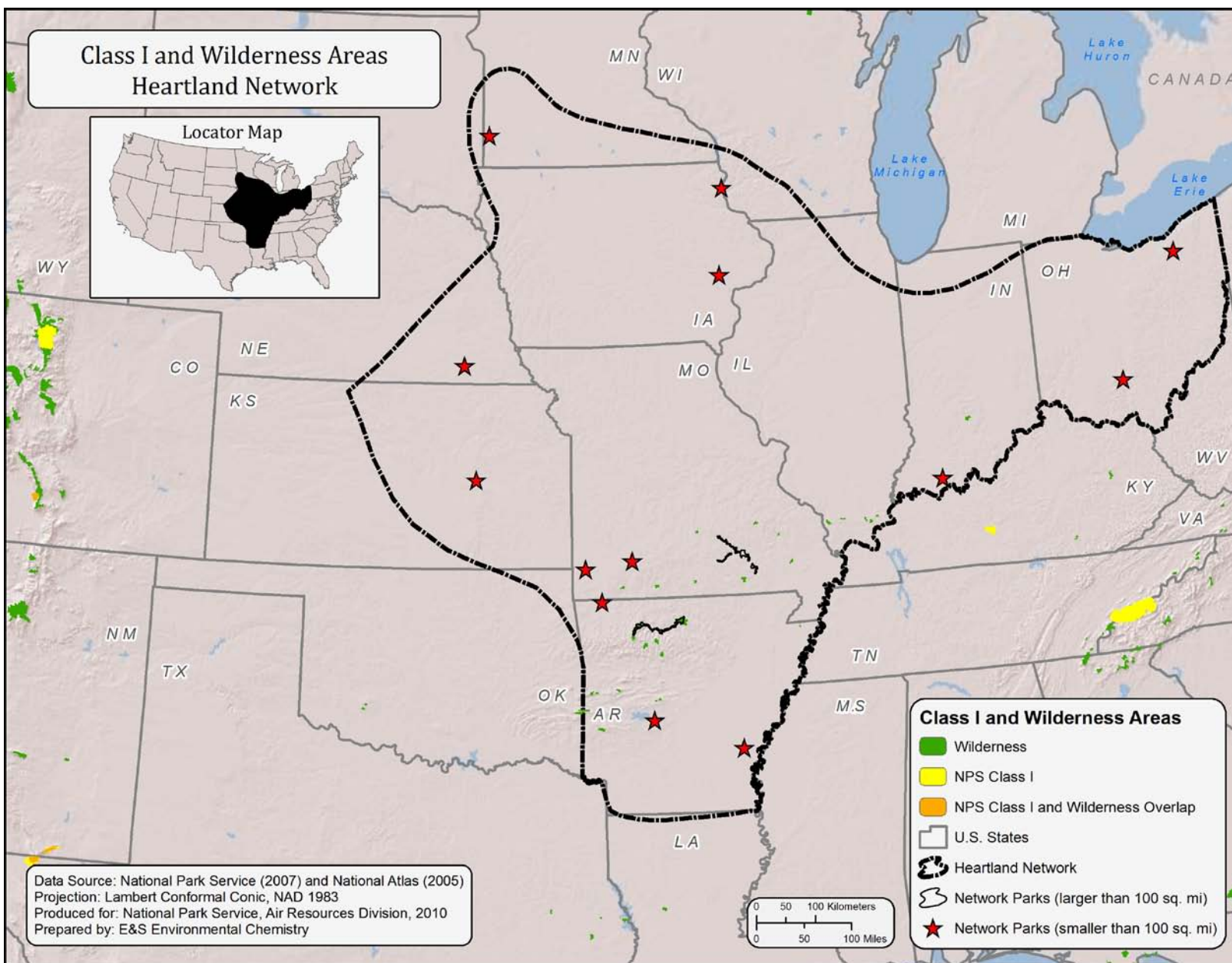
Map K



Map L



Map M



Map N

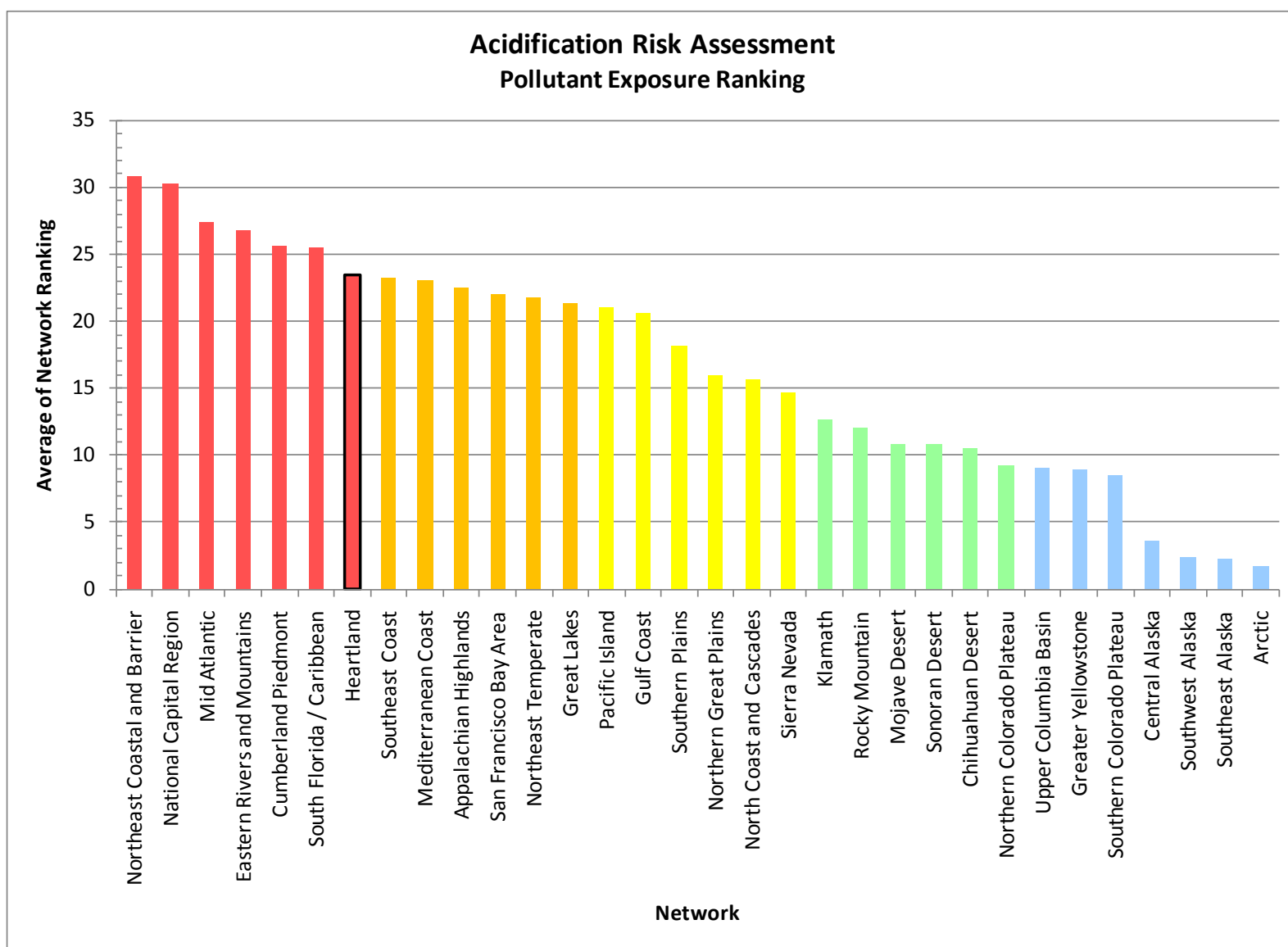


Figure A

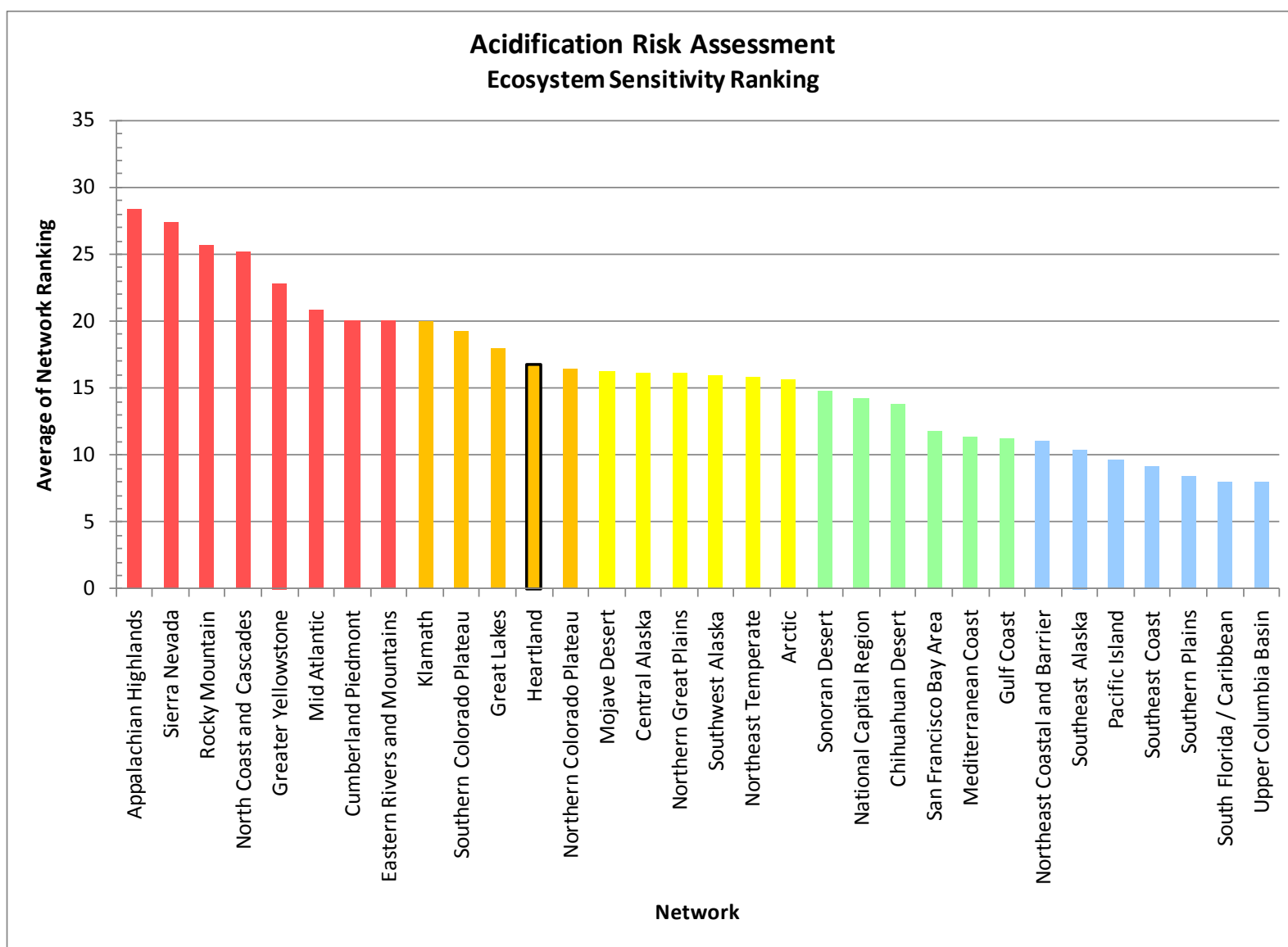


Figure B

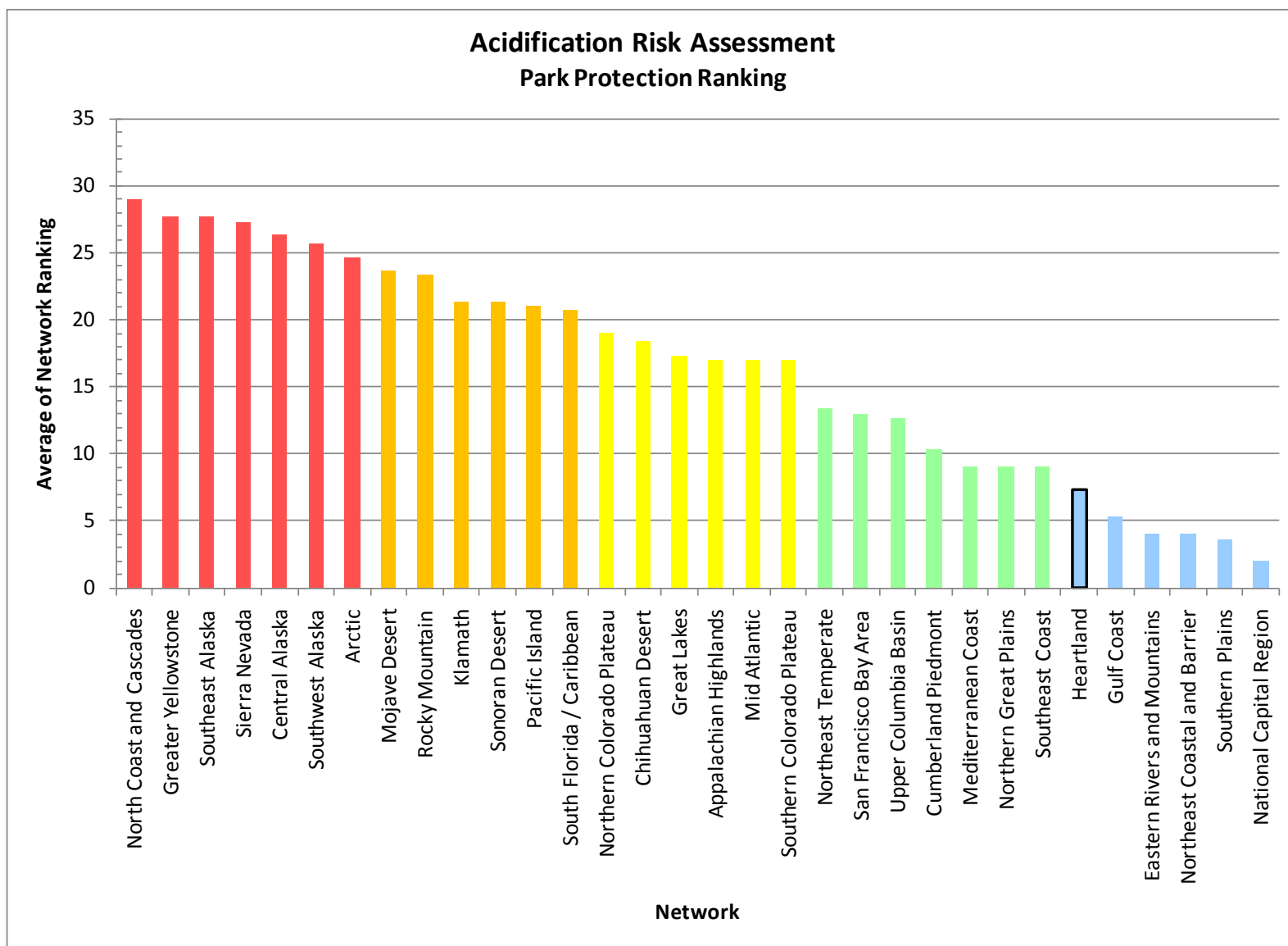


Figure C

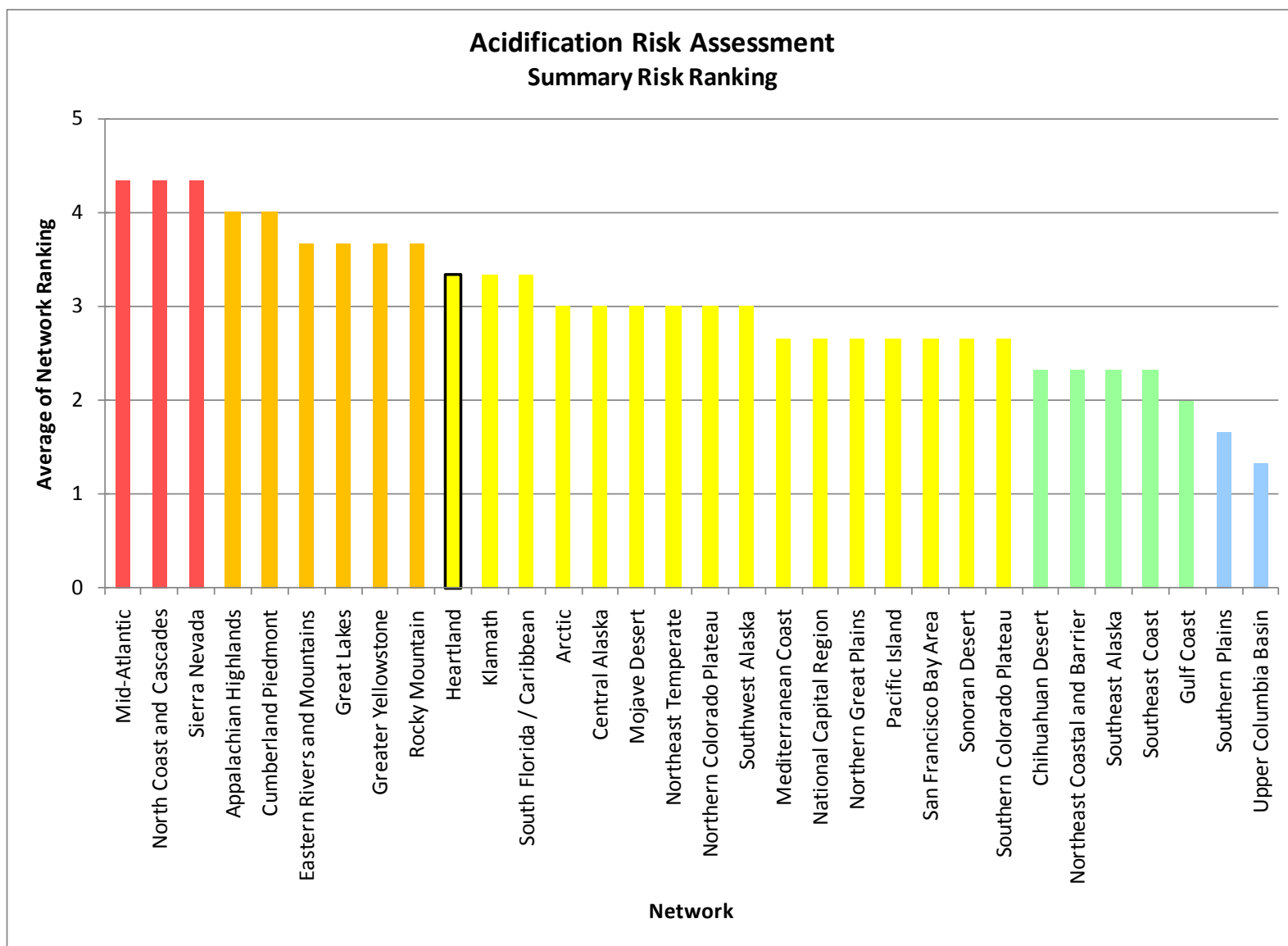


Figure D

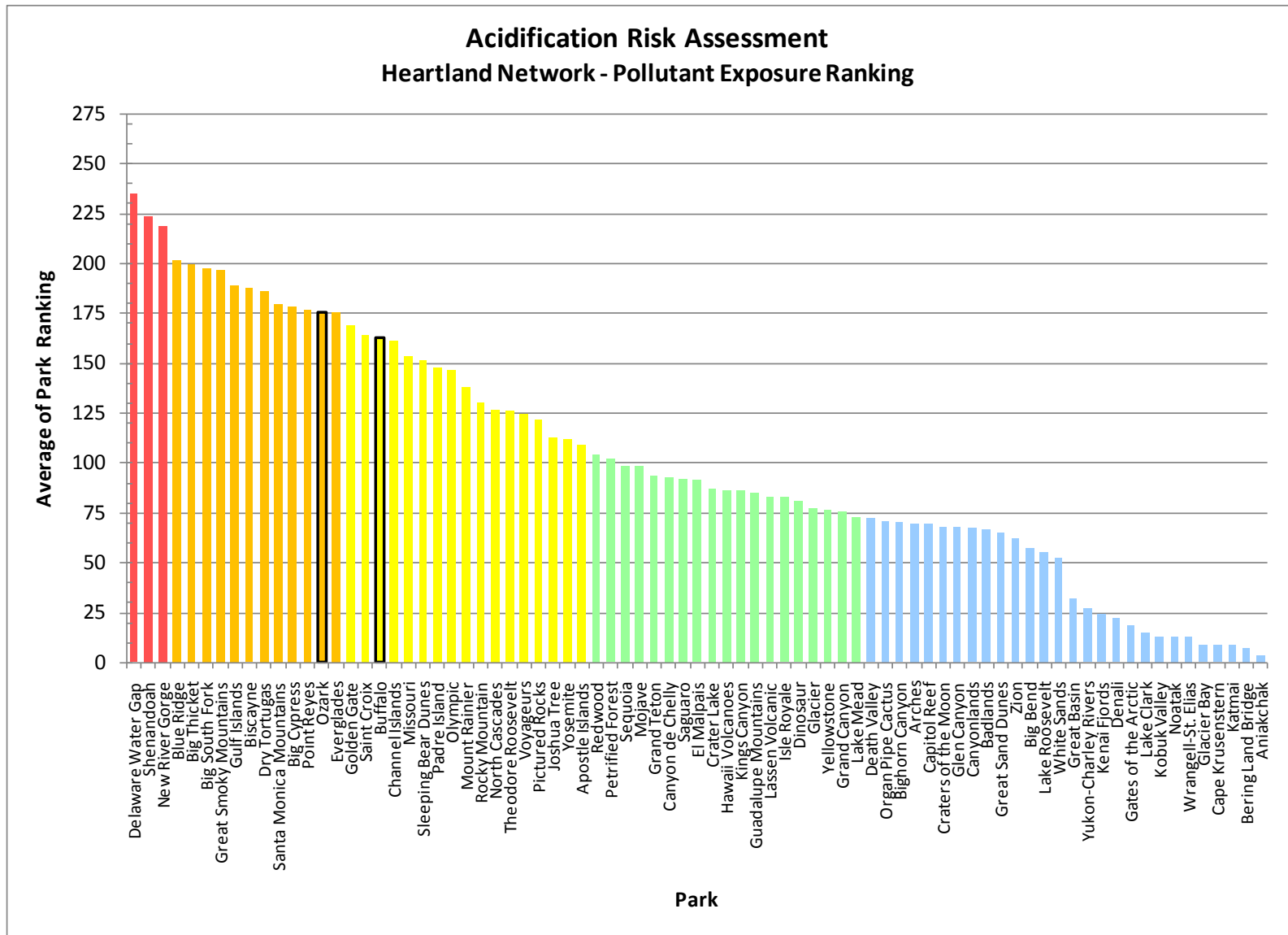


Figure E

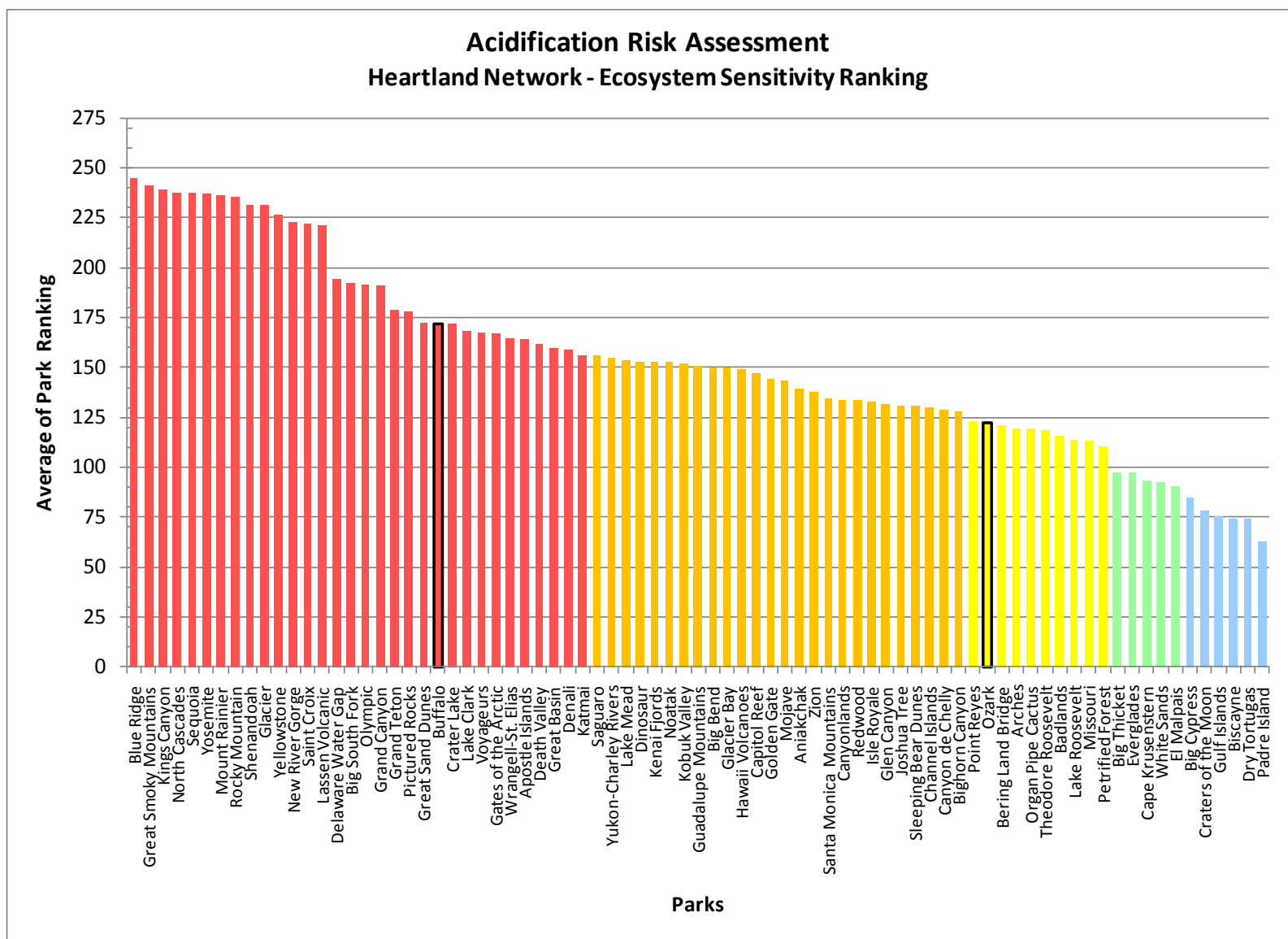


Figure F

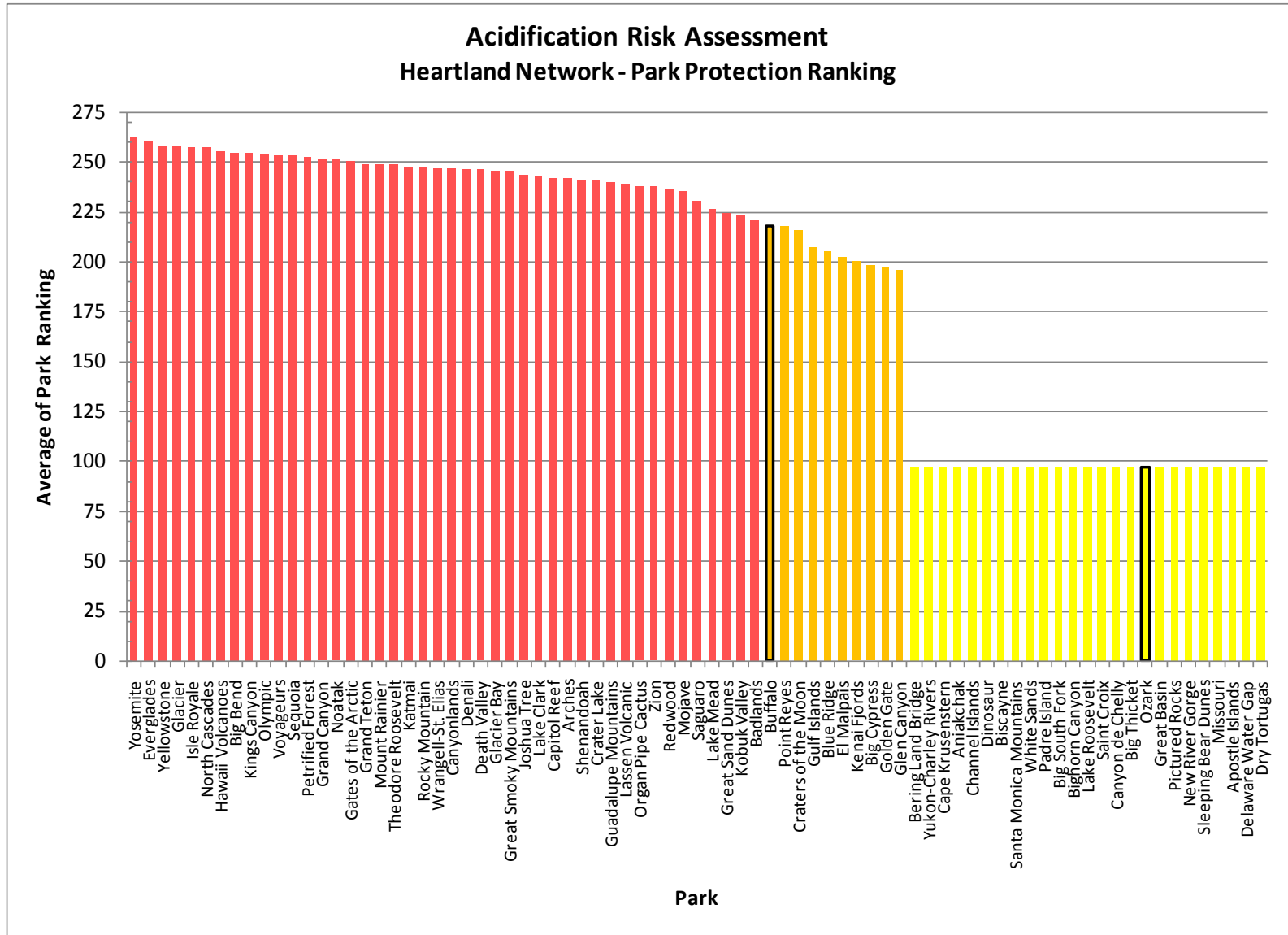


Figure G

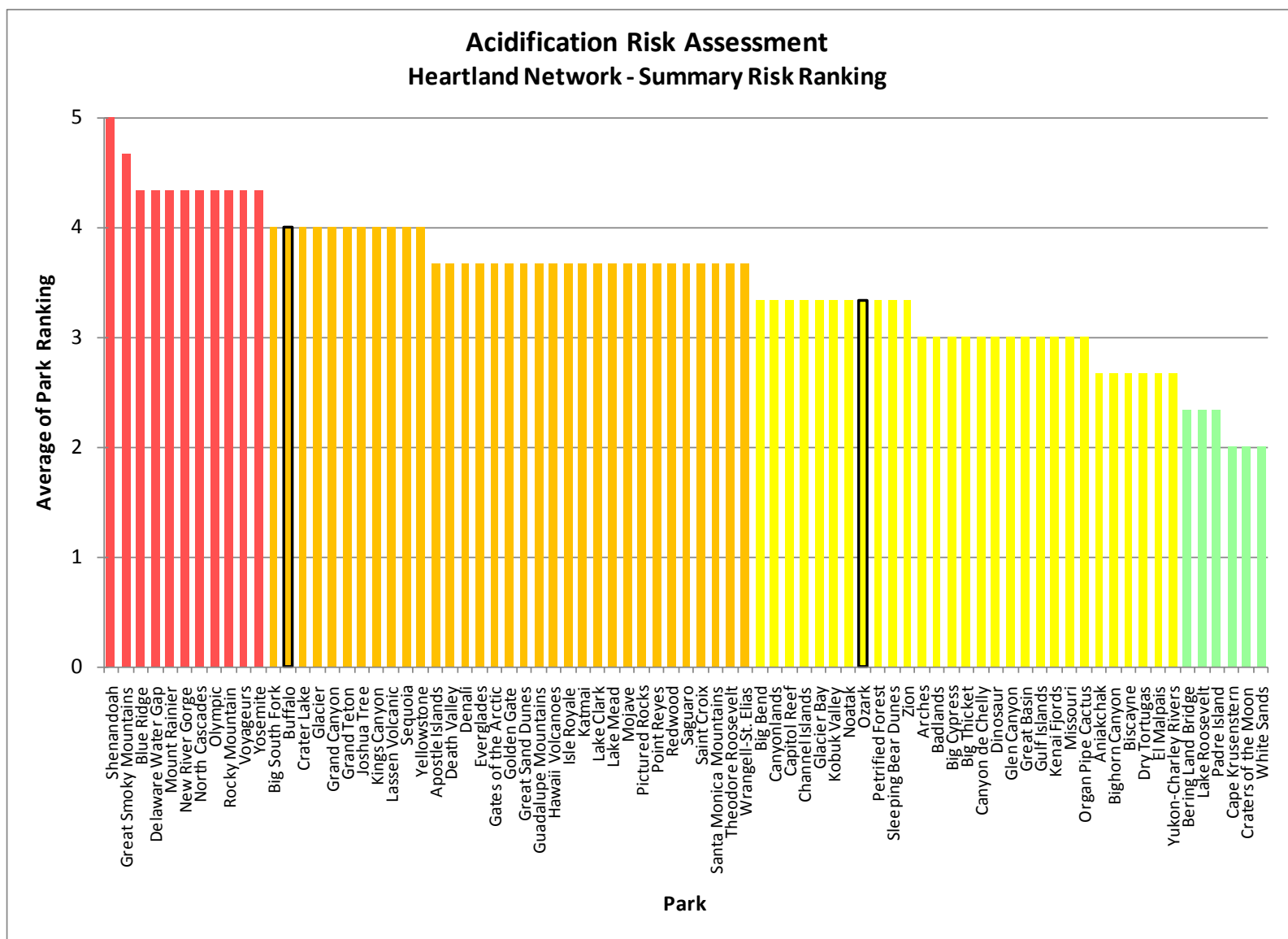


Figure H

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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