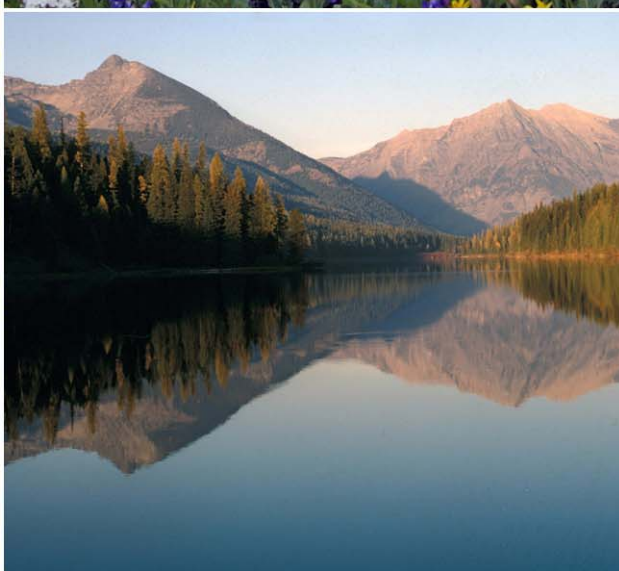




Evaluation of the Sensitivity of Inventory and Monitoring National Parks to Nutrient Enrichment Effects from Atmospheric Nitrogen Deposition

Heartland Network (HTLN)

Natural Resource Report NPS/NRPC/ARD/NRR—2011/311



ON THE COVER

Some ecosystems, such as arid shrublands, subalpine meadows, remote high elevation lakes, and wetlands, are sensitive to the effects of nutrient enrichment from atmospheric nitrogen deposition.

Photograph by: National Park Service

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February 2011

U.S. Department of the Interior
National Park Service
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Denver, Colorado

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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.

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Please cite this publication as:

Sullivan, T. J., T. C. McDonnell, G. T. McPherson, S. D. Mackey, and D. Moore. 2011. Evaluation of the sensitivity of inventory and monitoring national parks to nutrient enrichment effects from atmospheric nitrogen deposition: Heartland Network (HTLN). Natural Resource Report NPS/NRPC/ARD/NRR—2011/311. National Park Service, Denver, Colorado.

Heartland Network (HTLN)

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

There are 15 parks in the Heartland Network. Only two (Buffalo, BUFF; Ozark, OZAR) are larger than 100 square miles.

Total annual N emissions, by county, are shown in Map C for lands in and surrounding the Heartland Network. County-level emissions within the network ranged from less than 1 ton per square mile to more than 50 tons per square mile. In general, annual county N emissions within the network were between 1 and 20 tons per square mile. Point source emissions of oxidized (nitrogen oxides, NO_x) and reduced (ammonia, NH_3) N are shown in Map D. There are 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 are also many smaller point sources of both oxidized and reduced N. The reduced N point sources are primarily in the western part of the network, in Kansas and Indiana. Urban centers within the network and within a 300 mile buffer around the network are shown in Map E. The largest human population centers within the network are Indianapolis and Columbus.

Total N deposition in and around the network is shown in Map F. Included in this analysis are both wet and dry forms of N deposition and both the oxidized and reduced N species. Total N deposition within the network ranged from as low as 5 to 10 kg N/ha/yr to above 15 kg N/ha/yr at some locations. 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 G. The predominant cover types within this network are generally row crops and pasture/hay. There are also scattered forested areas and developed areas.

A map is not presented to show the distribution within the parks of the five vegetation types thought to be most responsive to nutrient N enrichment effects (arctic, alpine, grassland and meadow, wetland, and arid and semi-arid). This is because none of the parks in this network are particularly large, and the extent of park vegetative coverage is too small to see at the network scale.

Park lands requiring special protection against potential adverse impacts associated with nutrient N enrichment from atmospheric N deposition are shown in Map I. Also shown on Map I are all federal lands designated as wilderness, both lands managed by NPS and also lands managed by other federal agencies. The land designations used to identify this heightened protection included Class I designation under the CAAA 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 ranks in the middle of the second highest quintile, among networks, in N Pollutant Exposure (Figure A). Nitrogen emissions and N deposition within the network are both very relatively high. However, the network Ecosystem Sensitivity ranking is lower, below the median of the 32 I&M networks (Figure B). This is because there is limited vegetation coverage in this network that includes the vegetation types expected to be especially sensitive to nutrient enrichment effects from N deposition, and there are no high-elevation lakes. This network ranks in 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 yield an overall Network Risk ranking that is in the second lowest quintile among networks (Figure D). The overall level of concern for nutrient N enrichment effects on I&M parks within this network is considered Low.

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 B. 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.

Both of the I&M parks in this network that are larger than 100 square miles (BUFF and OZAR) are in the middle quintile in Pollutant Exposure (Figure E). Other parks in the network are ranked Moderate (three of the smaller parks) to Very High (five of the smaller parks) in Pollutant Exposure. The two larger parks are in the middle (BUFF) or second lowest quintile (OZAR) in Ecosystem Sensitivity (Figure F). Other smaller parks in the network are mainly ranked Low or Very Low in Ecosystem Sensitivity. Exceptions include Homestead (HOME) and Pipestone (PIPE), both of which are ranked High, and Tallgrass Prairie (TAPR) which is ranked Very High. The reason for the Very High ranking of TAPR for Ecosystem Sensitivity is the prevalence of grassland vegetation which is thought to be especially sensitive to nutrient enrichment impacts from atmospheric N deposition. BUFF is ranked High among parks for Park Protection (Figure G), whereas all other parks in the network ranked Moderate for that theme (Table A). The Summary Park Risk ranking placed BUFF and PIPE in the highest quintile (Very High risk). OZAR is in the second lowest quintile among parks in Summary Risk (Figure H). Cuyahoga Valley (CUVA), HOME, and TAPR were all ranked High; other parks ranged from Very Low to Moderate in overall Summary Risk.

Table A. Relative rankings of individual I&M parks within the network for Pollutant Exposure, Ecosystem Sensitivity, Park Protection, and Summary Risk from atmospheric nutrient N enrichment.

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	Very Low
Buffalo	Moderate	Moderate	High	Very High
Cuyahoga Valley	Very High	Very Low	Moderate	High
Effigy Mounds	High	Low	Moderate	Moderate
George Washington Carver	High	Very Low	Moderate	Low
Herbert Hoover	High	Low	Moderate	Moderate
Homestead	High	High	Moderate	High
Hopewell Culture	Very High	Very Low	Moderate	Moderate
Hot Springs	Moderate	Very Low	Moderate	Very Low
Lincoln Boyhood	Very High	Very Low	Moderate	Moderate
Ozark	Moderate	Low	Moderate	Low
Pea Ridge	Very High	Very Low	Moderate	Moderate
Pipestone	Very High	High	Moderate	Very High
Tallgrass Prairie	High	Very High	Moderate	High
Wilson's Creek	Moderate	Low	Moderate	Low

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.

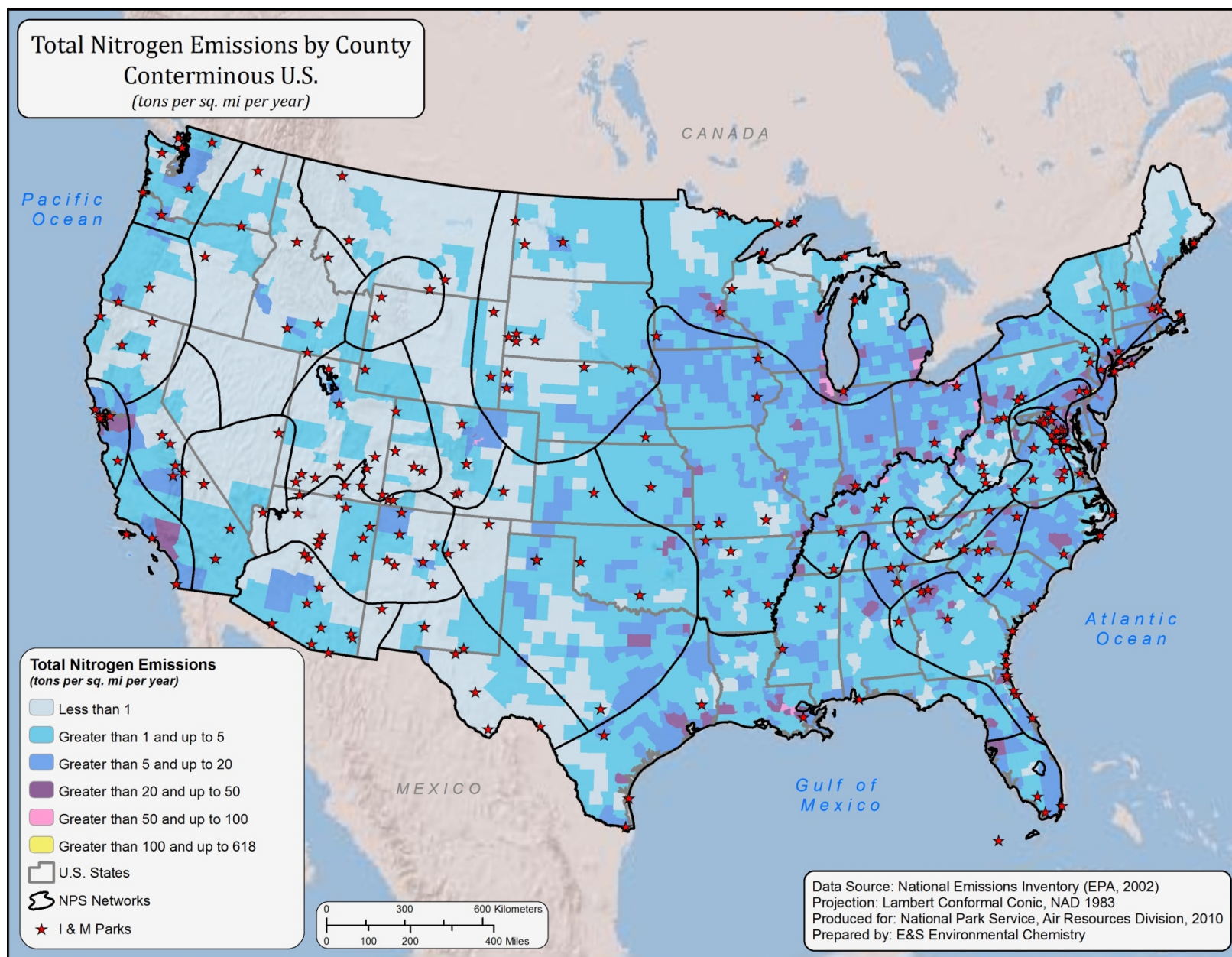
- Map A. National map of total N emissions by county for the year 2002. Both oxidized (nitrogen oxides, NO_x) and reduced (ammonia, NH₃) forms of N are included. The total is expressed in tons per square mile per year. (Source of data: EPA National Emissions Inventory, <http://www.epa.gov/ttn/chief/net/2002inventory.html>)
- Map B. 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 C. 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 D. 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 E. 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 F. 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 B above for details)
- Map G. 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 I. 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 ranking, calculated as the sum of the averages of the scores for Pollutant Exposure, Ecosystem Sensitivity, and Park Protection.
- 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.

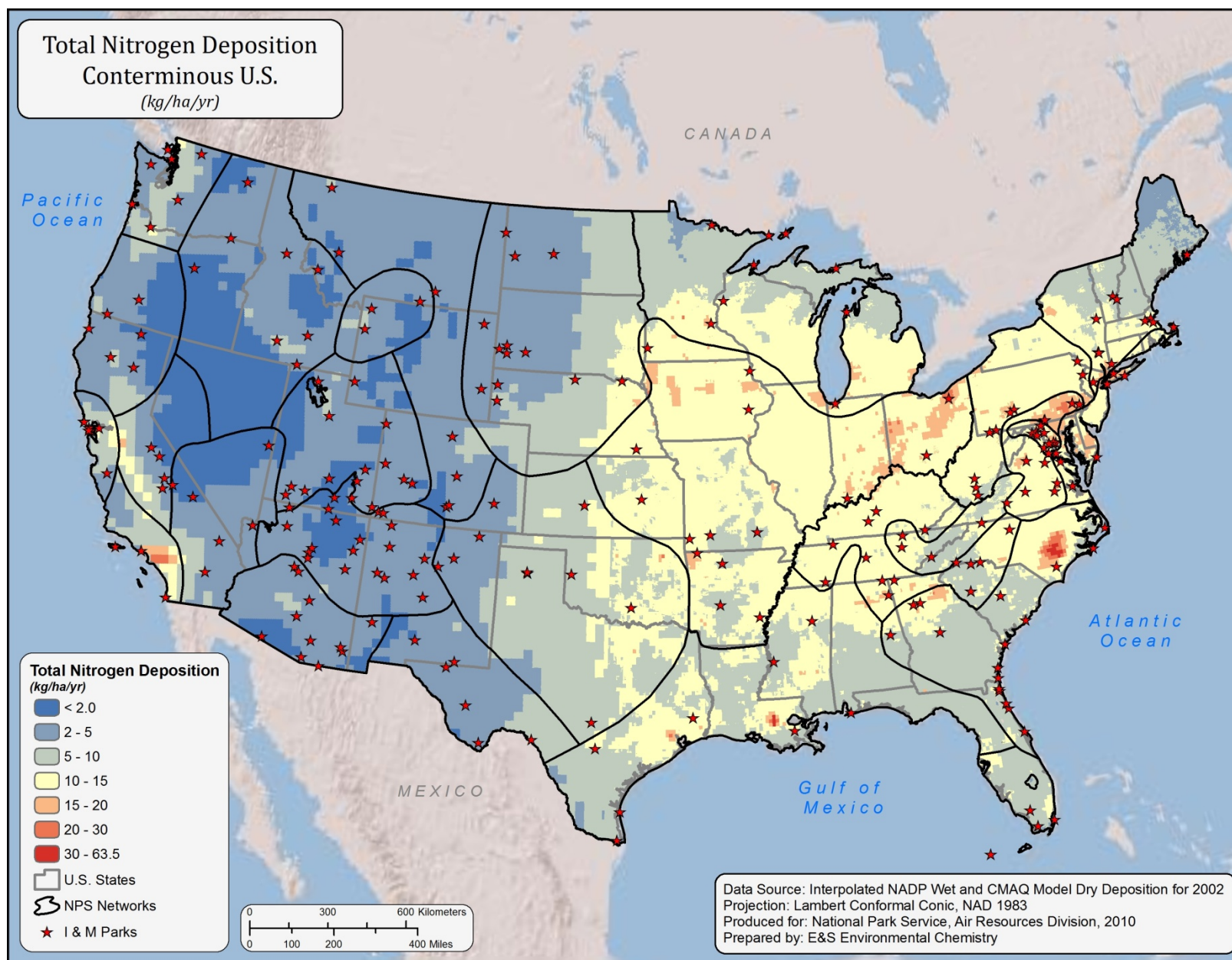
Figure F. Park rankings for Ecosystem Sensitivity for all parks larger than 100 square miles. Ranks for each park were calculated relative to all parks, regardless of size, as the average of scores for all Ecosystem Sensitivity variables.

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.

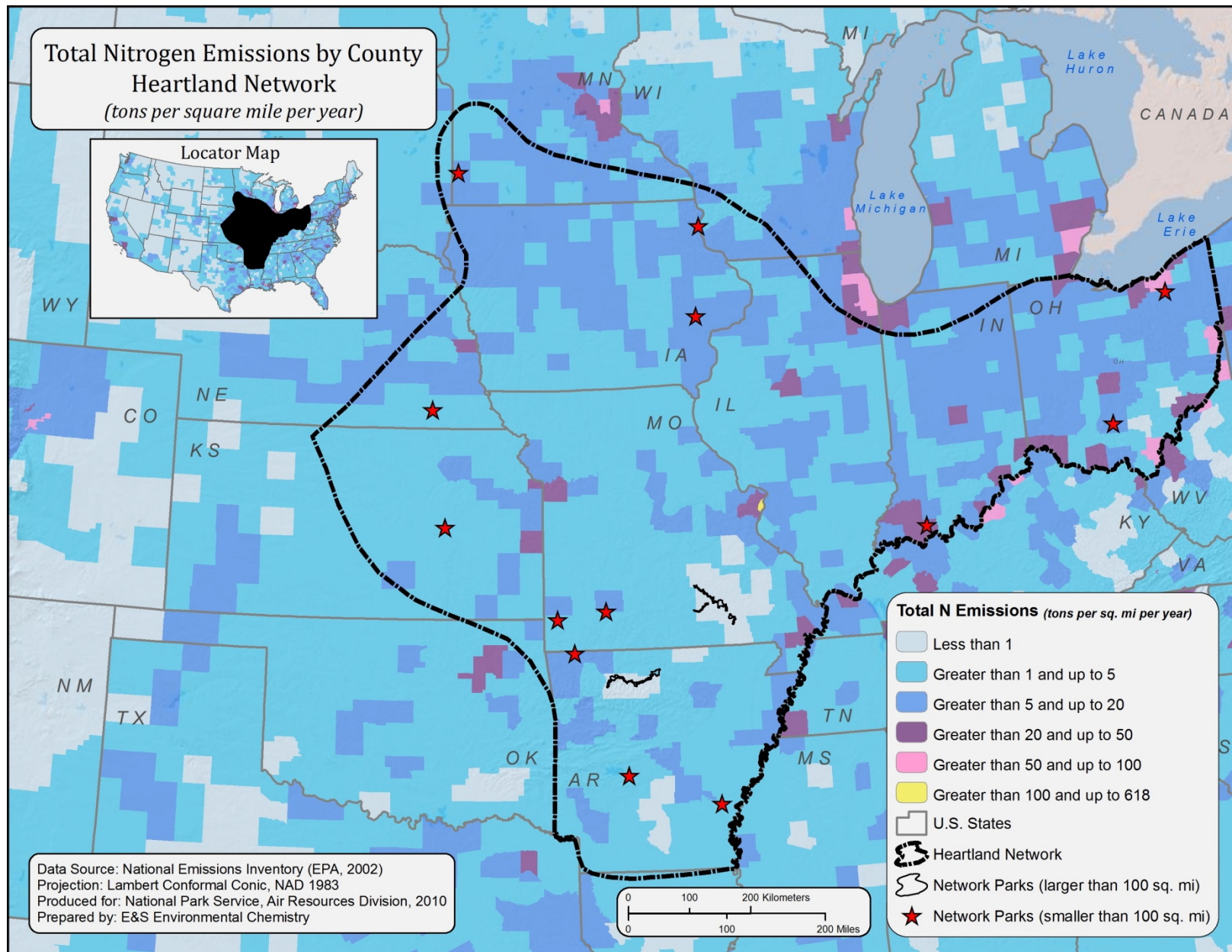
Figure H. Park rankings for Summary Risk for all parks larger than 100 square miles. Ranks for each park were calculated relative to all parks, regardless of size, as the average of scores for all Summary Risk variables.



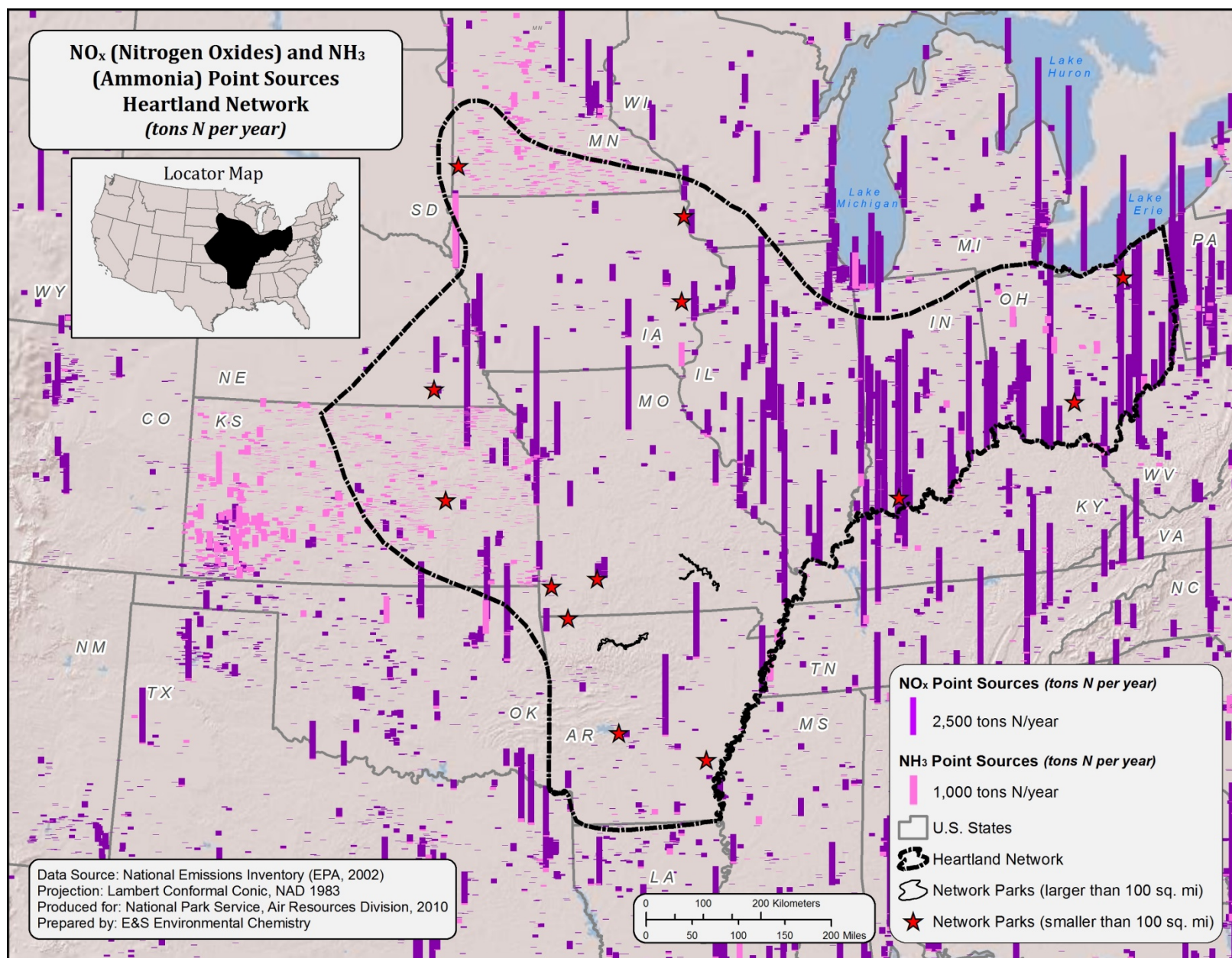
Map A



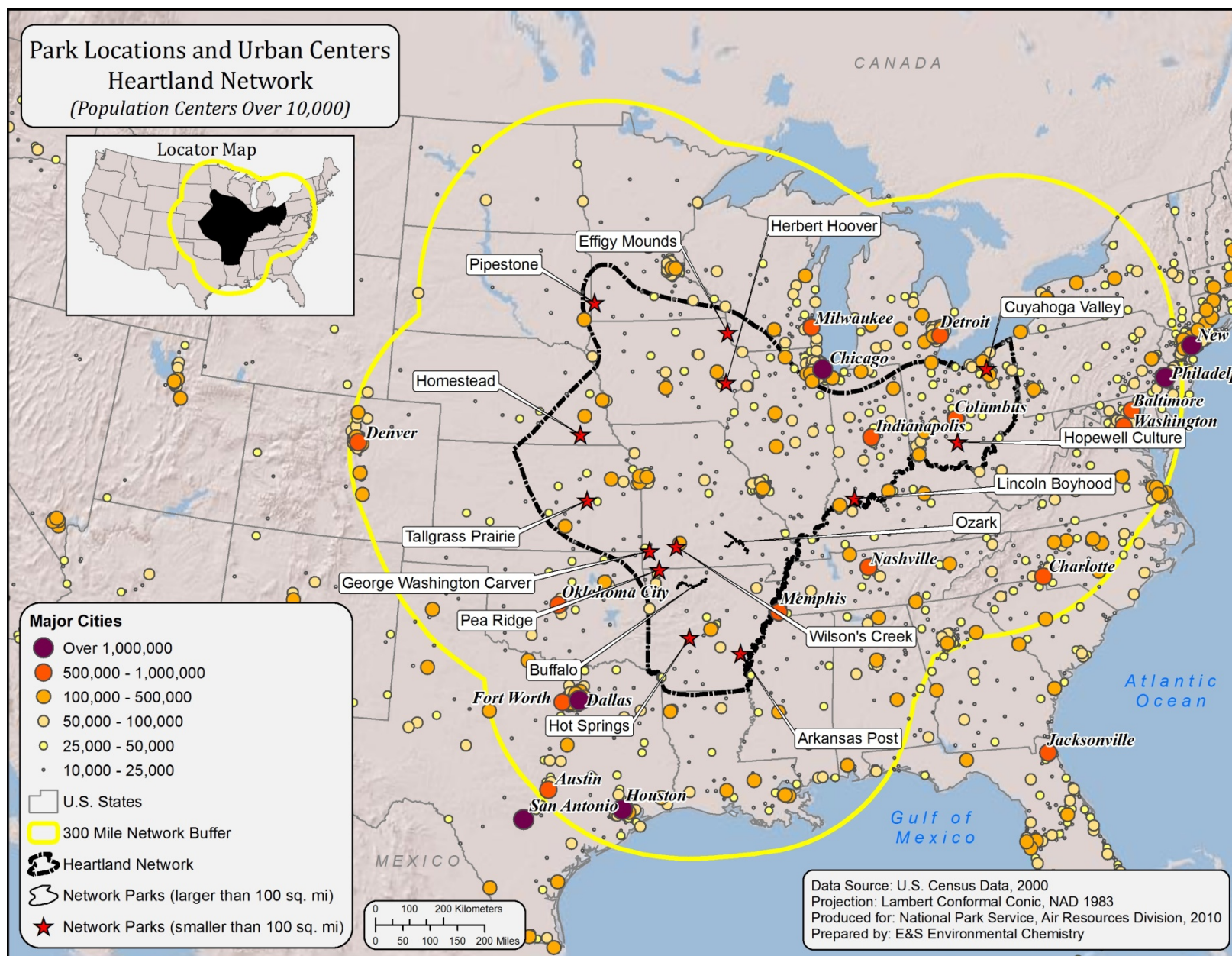
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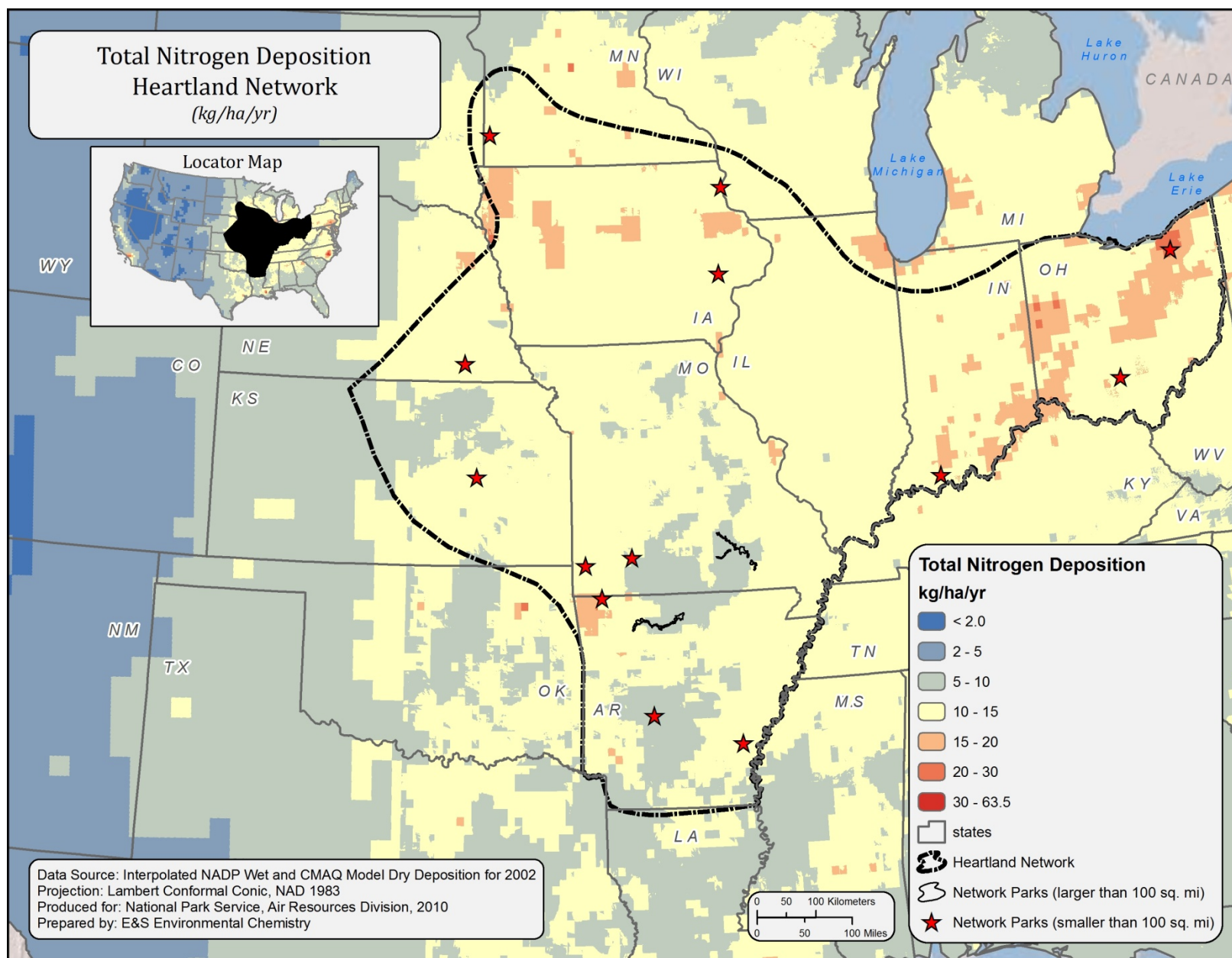
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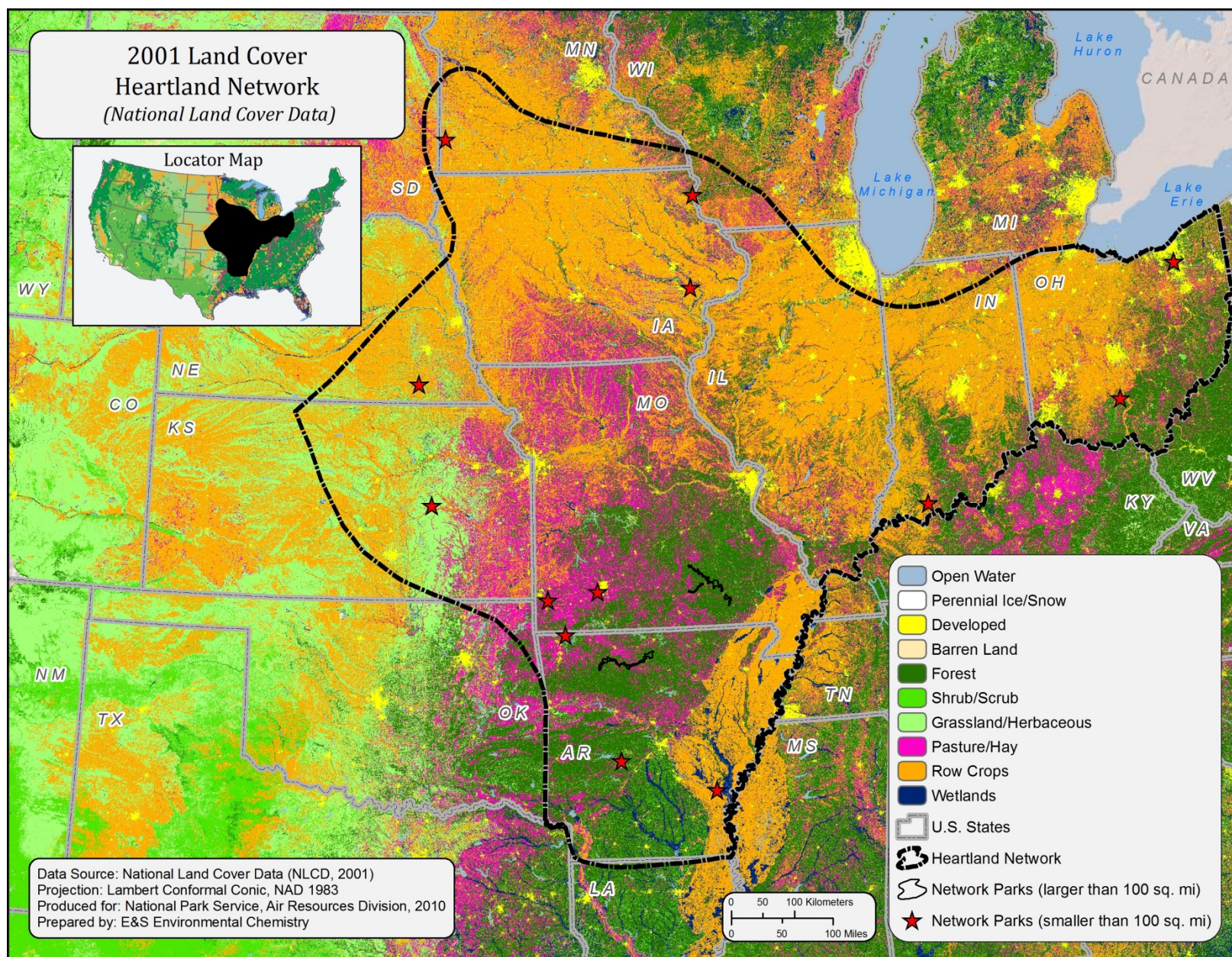
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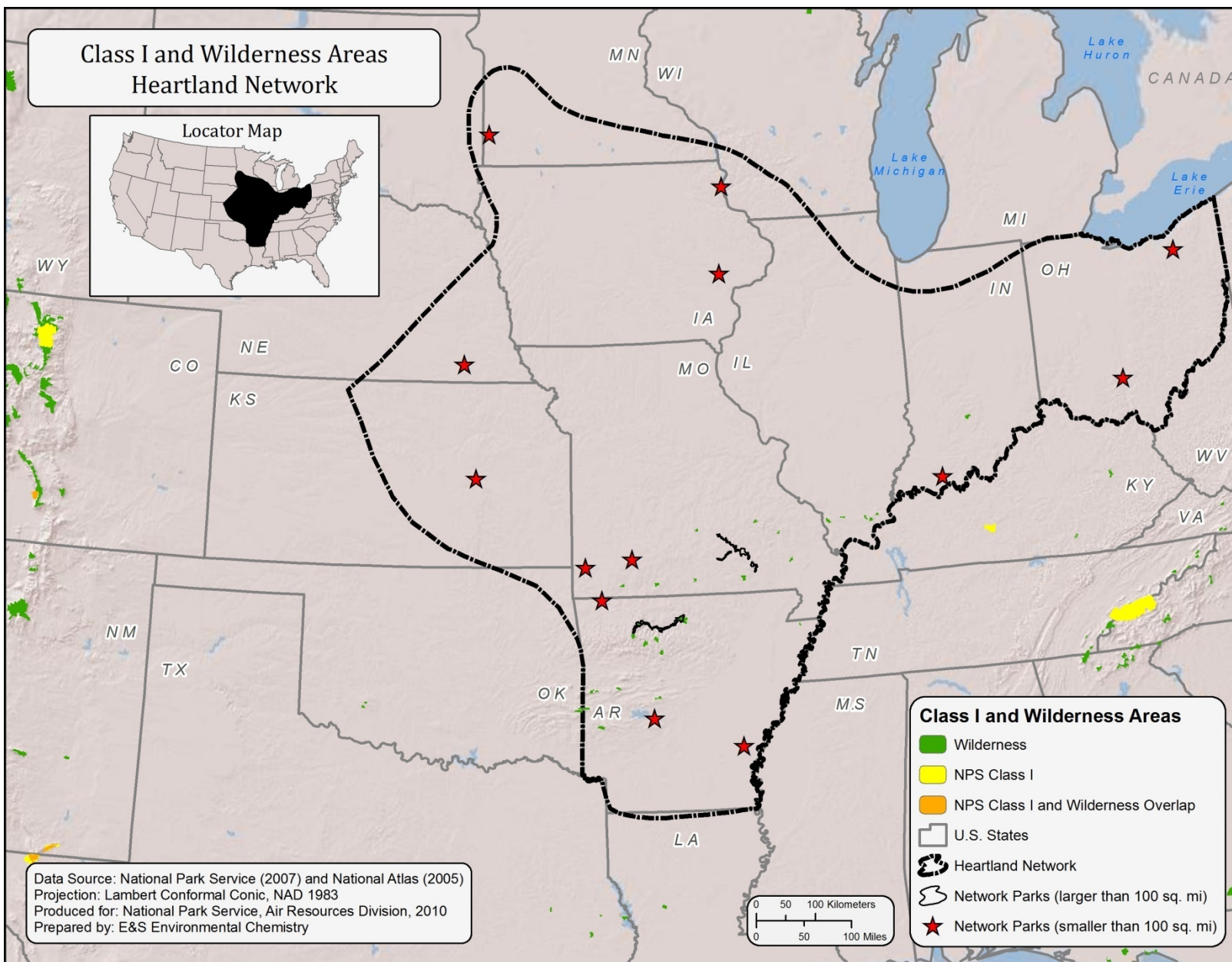
Map E



Map F



Map G



Map I

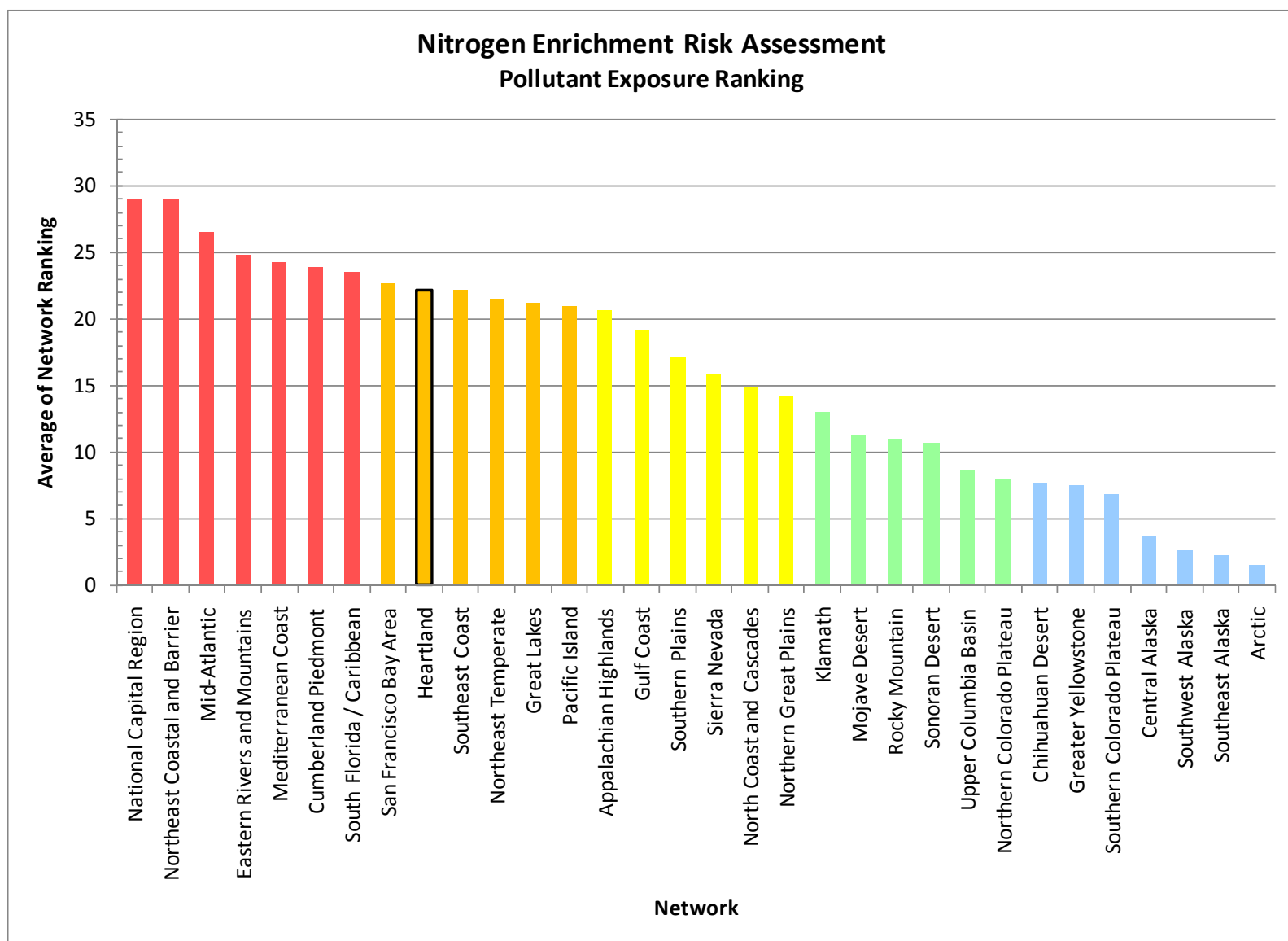


Figure A

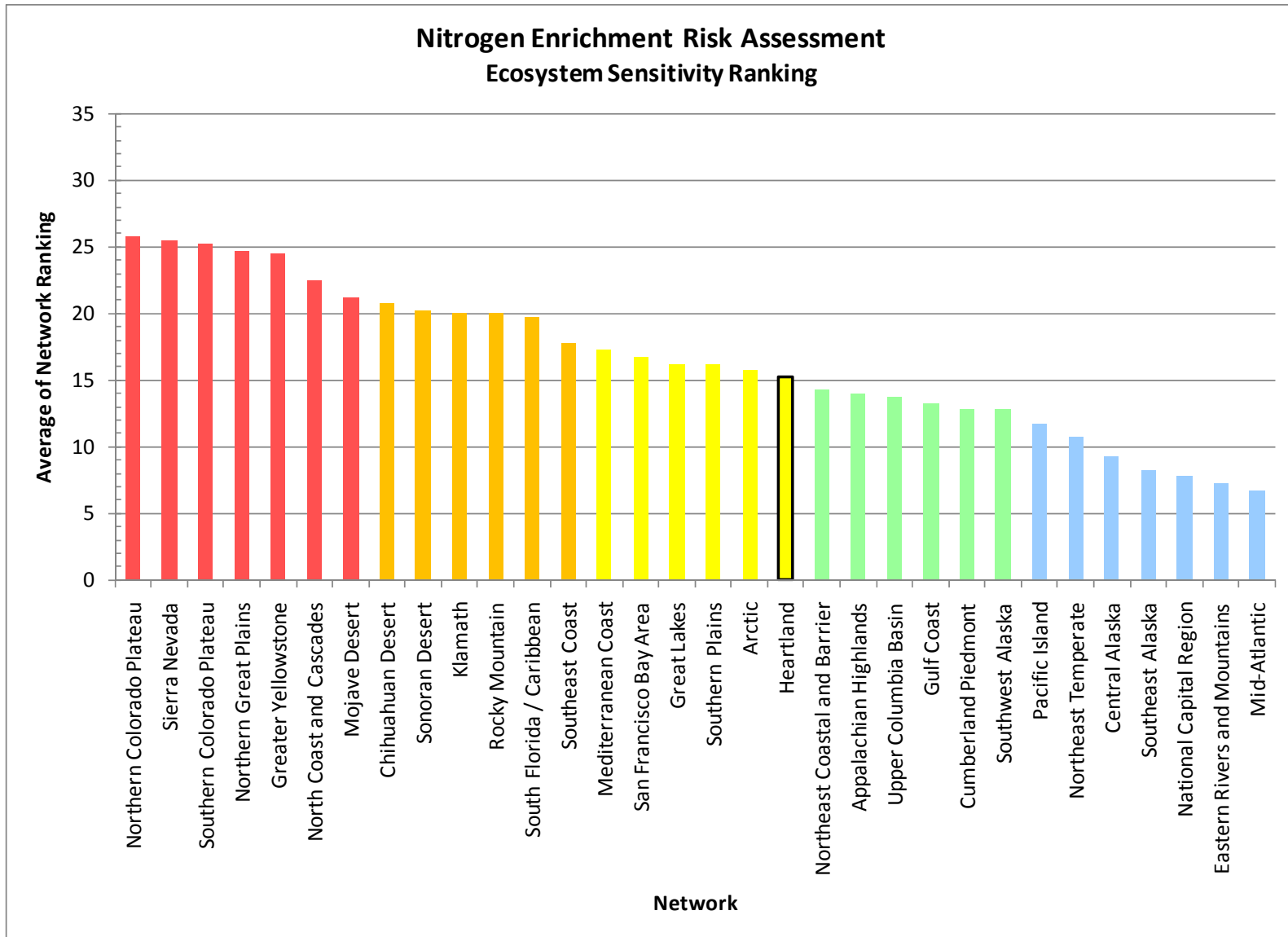


Figure B

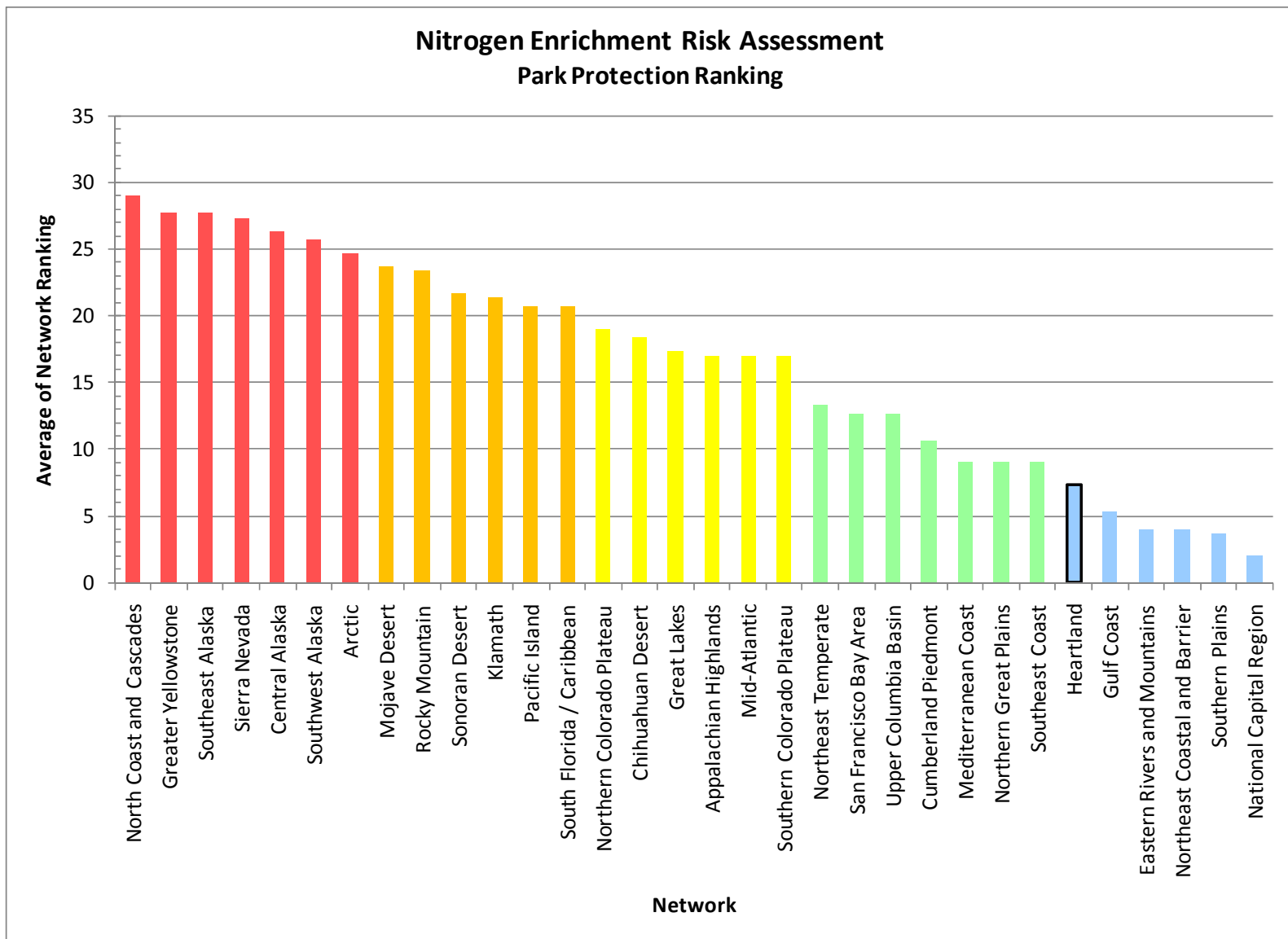


Figure C

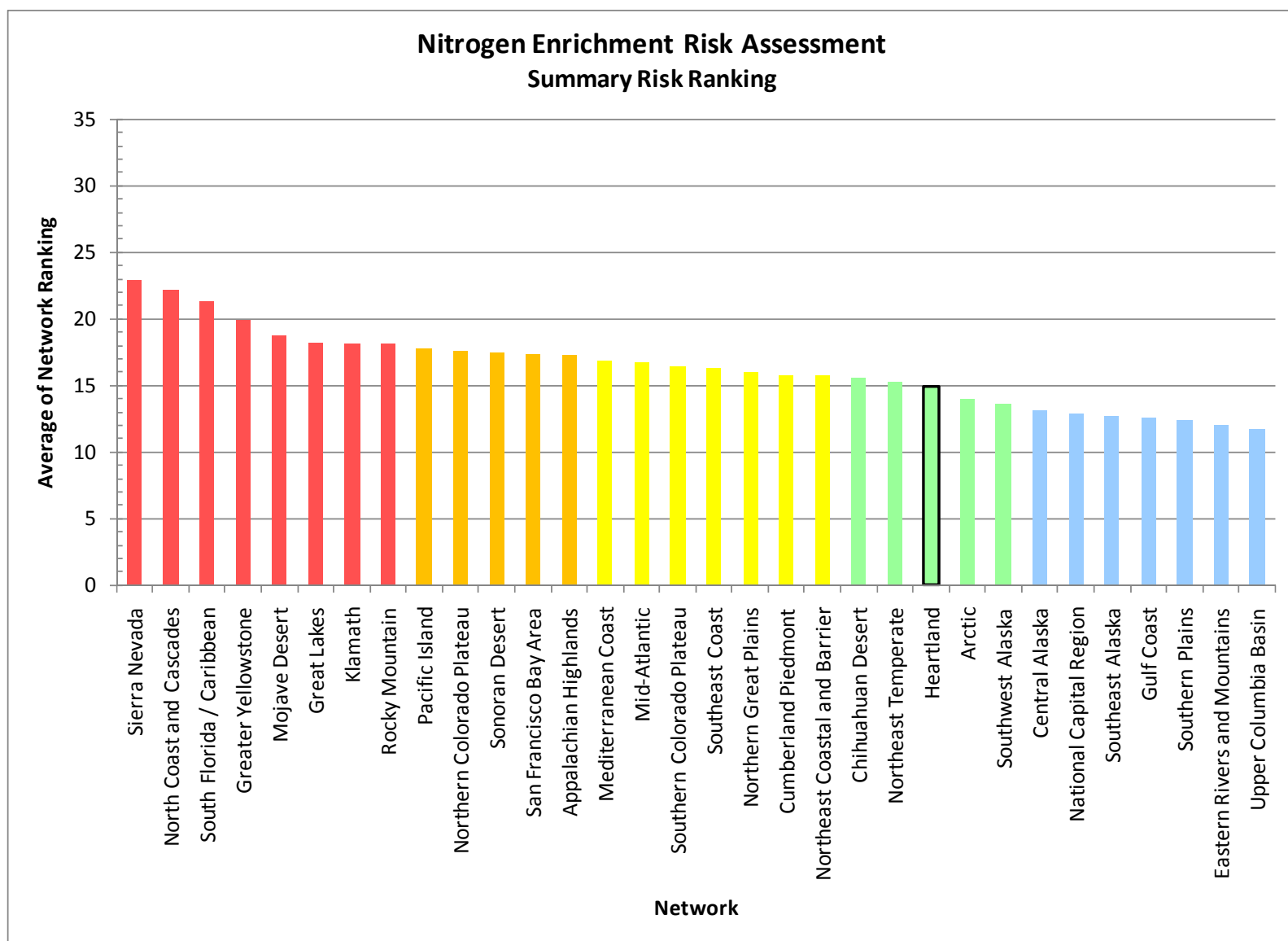


Figure D

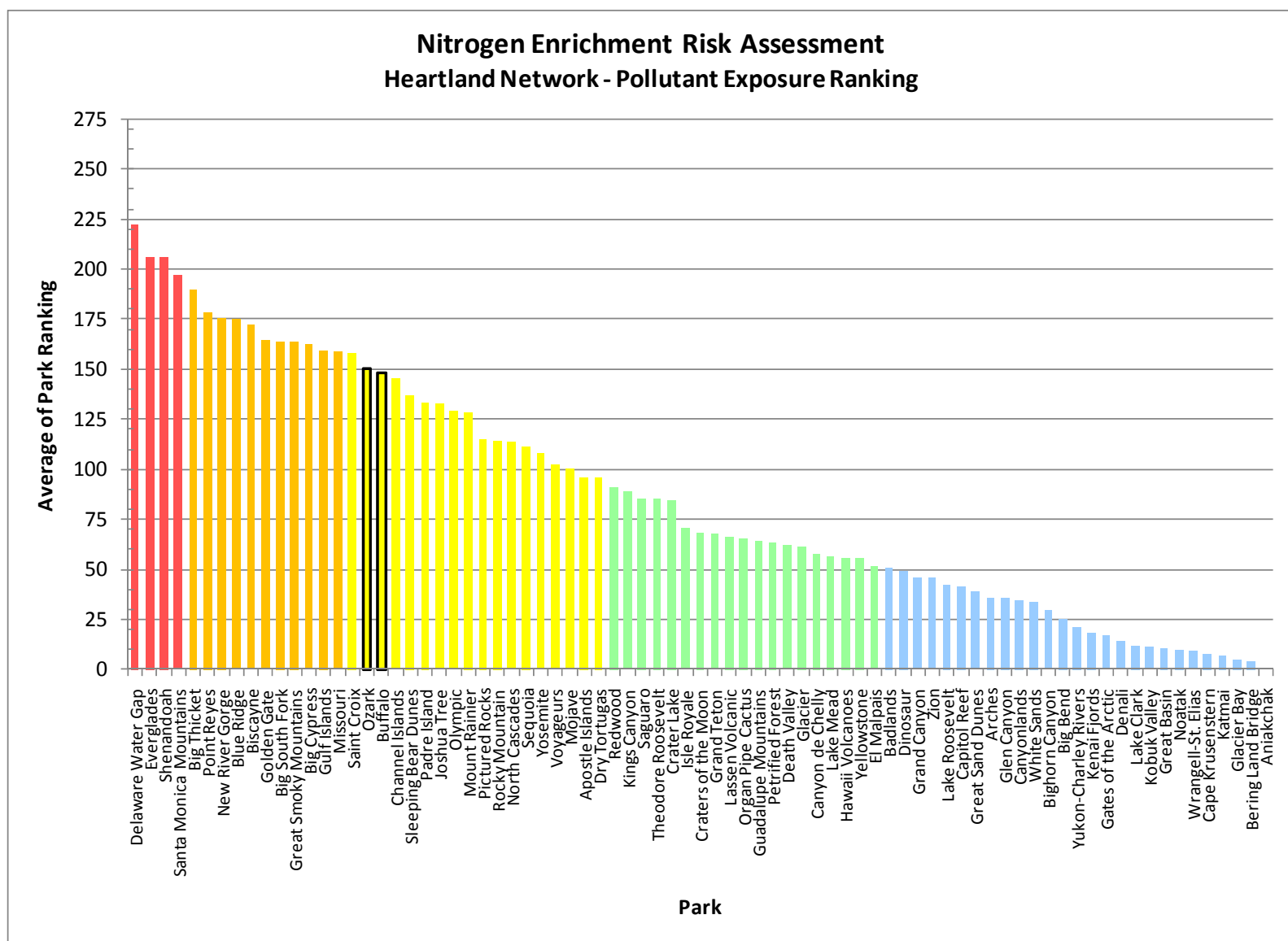


Figure E

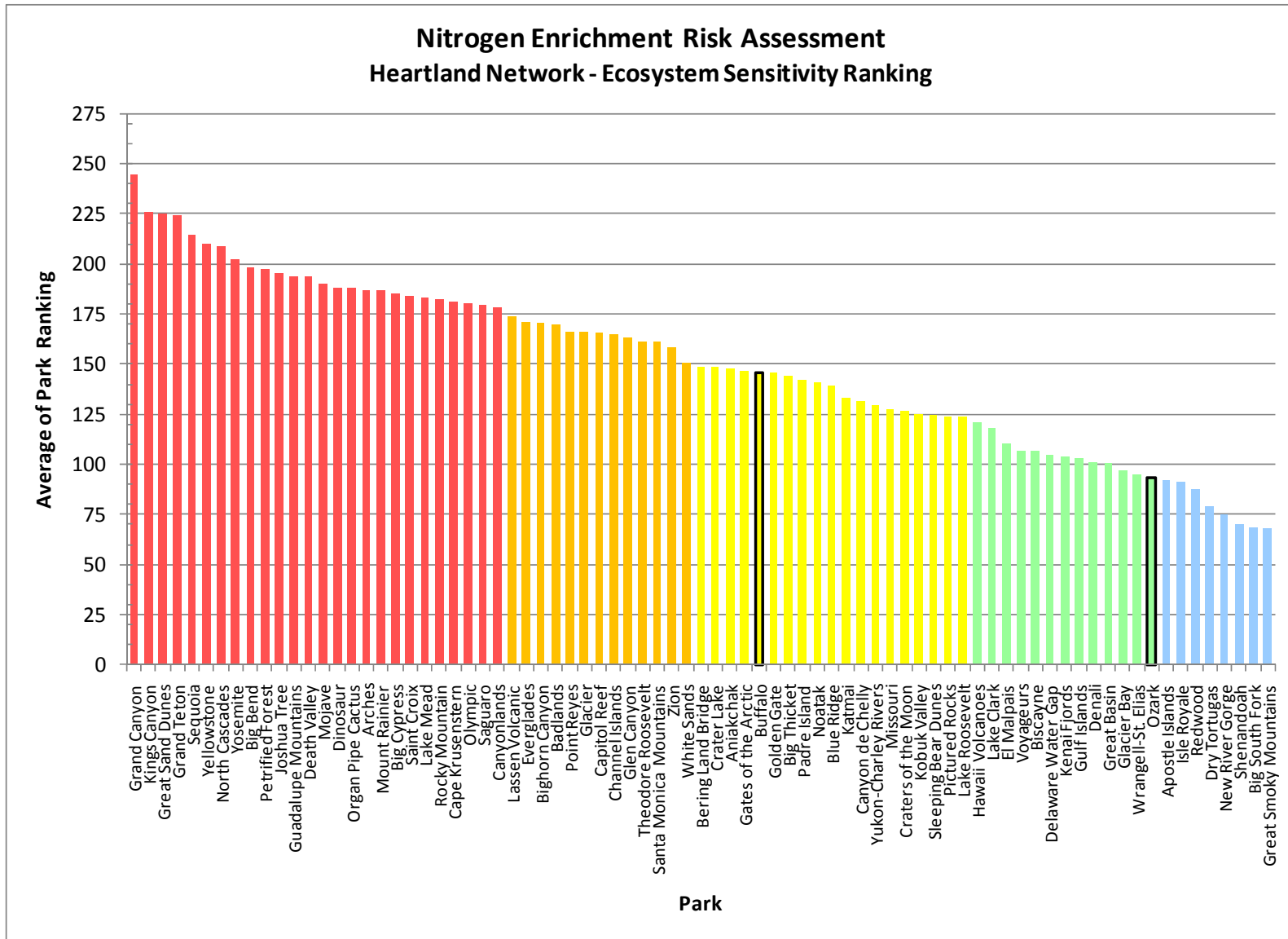


Figure F

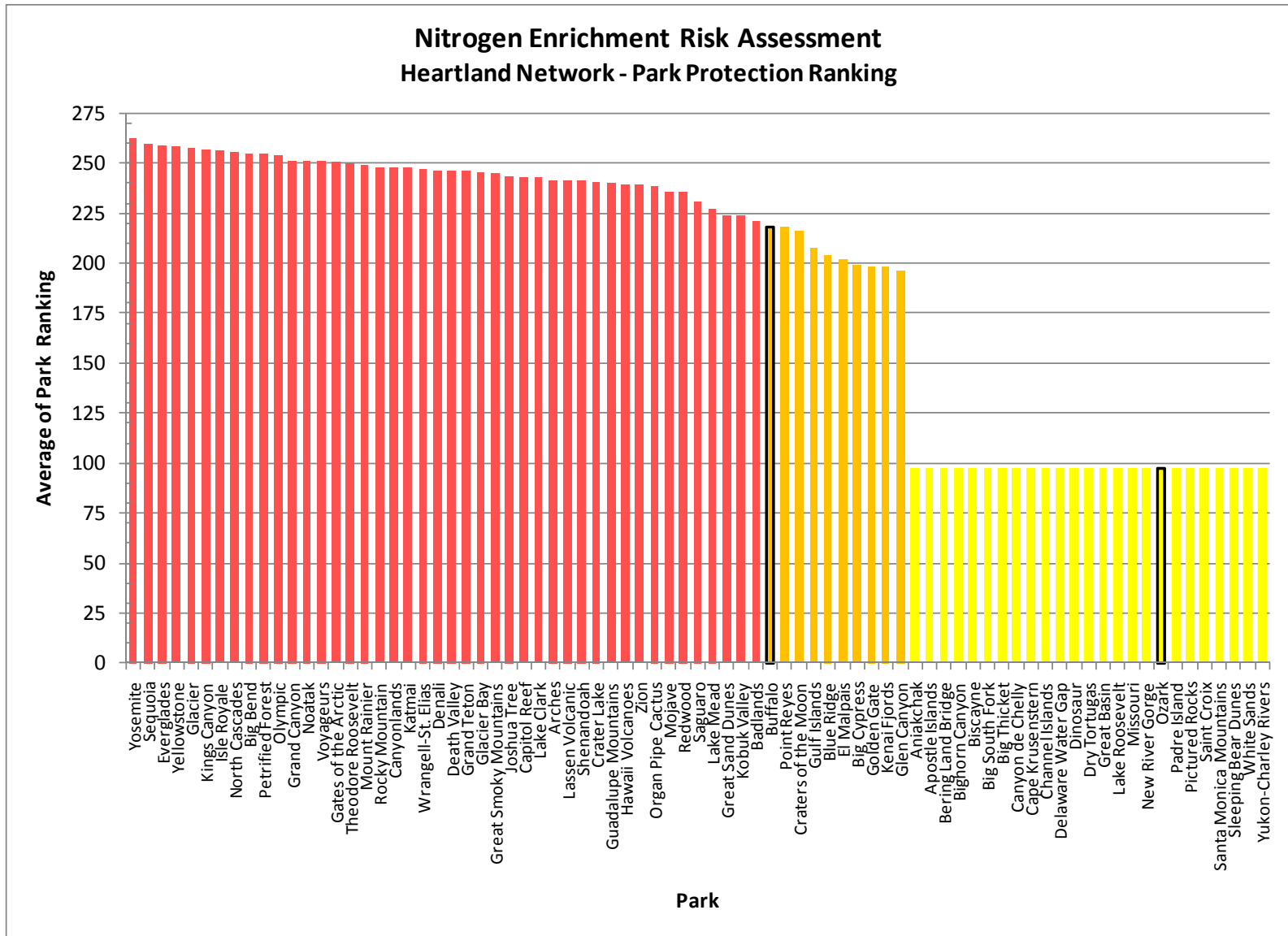


Figure G

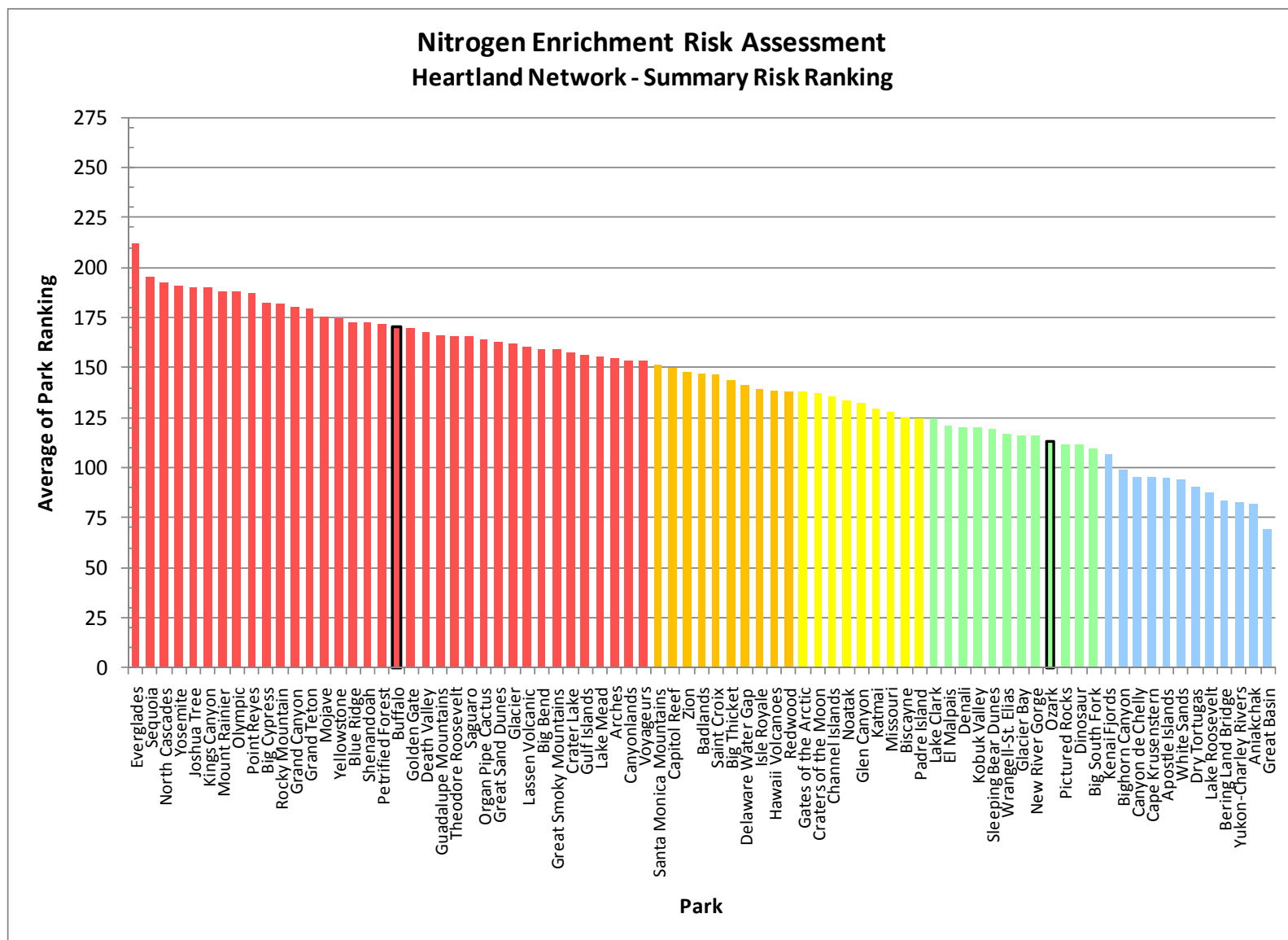


Figure H

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.

NPS 920/106669, February 2011

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