



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

Great Lakes Network (GLKN)

Natural Resource Report NPS/NRPC/ARD/NRR—2011/309



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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T. J. Sullivan
T. C. McDonnell
G. T. McPherson
S. D. Mackey
D. Moore

E&S Environmental Chemistry, Inc.
P.O. Box 609
Corvallis, OR 97339

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Great Lakes Network (GLKN)

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.

The Great Lakes Network contains six parks larger than 100 square miles: Apostle Islands (APIS), Isle Royale (ISRO), Pictured Rocks (PIRO), Saint Croix (SACN), Sleeping Bear Dunes (SLBE), and Voyageurs (VOYA). There are also three smaller parks in this network.

Total annual N emissions, by county, are shown in Map C for lands in and surrounding the Great Lakes 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, county emissions were between 1 and 20 tons per square mile, although there were isolated counties that exhibited N emissions in the range of 20 to 100 tons per square mile per year. Point source emissions of oxidized (nitrogen oxides, NO_x) and reduced (ammonia, NH_3) N are shown in Map D. Relatively large N point sources (greater than 2,500 tons per year) were consistently sources of oxidized, rather than reduced, N. Nevertheless, there were many smaller sources of reduced N within and near the network, mainly in the southern half of Minnesota. Many of the larger point sources within the network were located along the perimeter of the southern section of Lake Michigan. Urban centers within the network and within a 300-mile buffer around the network are shown in Map E. The largest urban centers are associated with Chicago, Detroit, and Milwaukee.

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 2 to 5 kg N/ha/yr in the north to as high as 15 to 20 kg N/ha/yr in association with the more heavily urbanized areas, and two small isolated counties in the range of 20 to 30 kg N/ha/yr. Throughout much of the network, total N deposition is lower, in the range of 10 to 15 kg N/ha/yr in the south and 5 to 10 kg N/ha/yr in the north.

The largest I&M parks in this network, ISRO and VOYA, are located in the northernmost portion of the network, where emissions and deposition of N are generally lowest. Several smaller parks, especially Indiana Dunes (INDU) and Mississippi (MISS), are located in the more heavily populated and industrialized portion of the network to the south.

Land cover in and around the network is shown in Map G. The predominant cover types within this network are generally forest and wetlands in the north and a mix of row crops, urban development, and pasture/hay lands in the south and in northwestern Minnesota.

A map of sensitive vegetation within the parks that occur in this network (Map H) is not provided because the parks are too small to see the vegetation patterns at the scale of the network. Although there are many lakes within the network, none are located at high elevation and these lakes are therefore not expected to be highly sensitive to eutrophication from atmospheric N inputs.

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 some wilderness and Class I areas in the northern portion of this network. VOYA and ISRO are both Class I.

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 Great Lakes Network ranks near the bottom of the second highest quintile, among networks, in N Pollutant Exposure (Figure A). Nitrogen emissions and N deposition within the network are both relatively high. The network Ecosystem Sensitivity ranking is near the median among networks (Figure B). This is mainly because this network contains some vegetation types that are expected to be especially sensitive to nutrient enrichment effects from N deposition. This network ranks in the middle quintile in Park Protection, having moderate 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 highest quintile among networks (Figure D). The overall level of concern for nutrient N enrichment effects on I&M parks within this network is considered Very High.

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.

Pollutant Exposure in five of the six larger parks is ranked Moderate; the sixth large park (ISRO) is ranked Low. Pollutant Exposure rankings are higher in the smaller parks that are located in the more populated and industrialized portions of the network (INDU, MISS); both of these parks are ranked Very High (Table A). The larger parks show very diverse rankings for Ecosystem Sensitivity (Figure F). SACN is ranked in the highest quintile for Ecosystem Sensitivity; other large parks are ranked in the middle quintile (SLBE), second lowest quintile (VOYA), or lowest quintile (APIS, ISRO) among parks. The smaller parks also show considerable variation in Ecosystem Sensitivity ranking from the second lowest (GRPO) to the second highest (INDU) quintiles. Both VOYA and ISRO contain appreciable amounts of protected land and are ranked Very High in Park Protection (Figure G); the other parks in this network are all ranked Moderate in Park Protection. The Summary Park Risk is Very High (highest quintile among parks) for VOYA and INDU, High for ISRO, MISS, and SACN (in the second highest quintile), and variable for the other parks in this network (Figure H, Table A).

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.

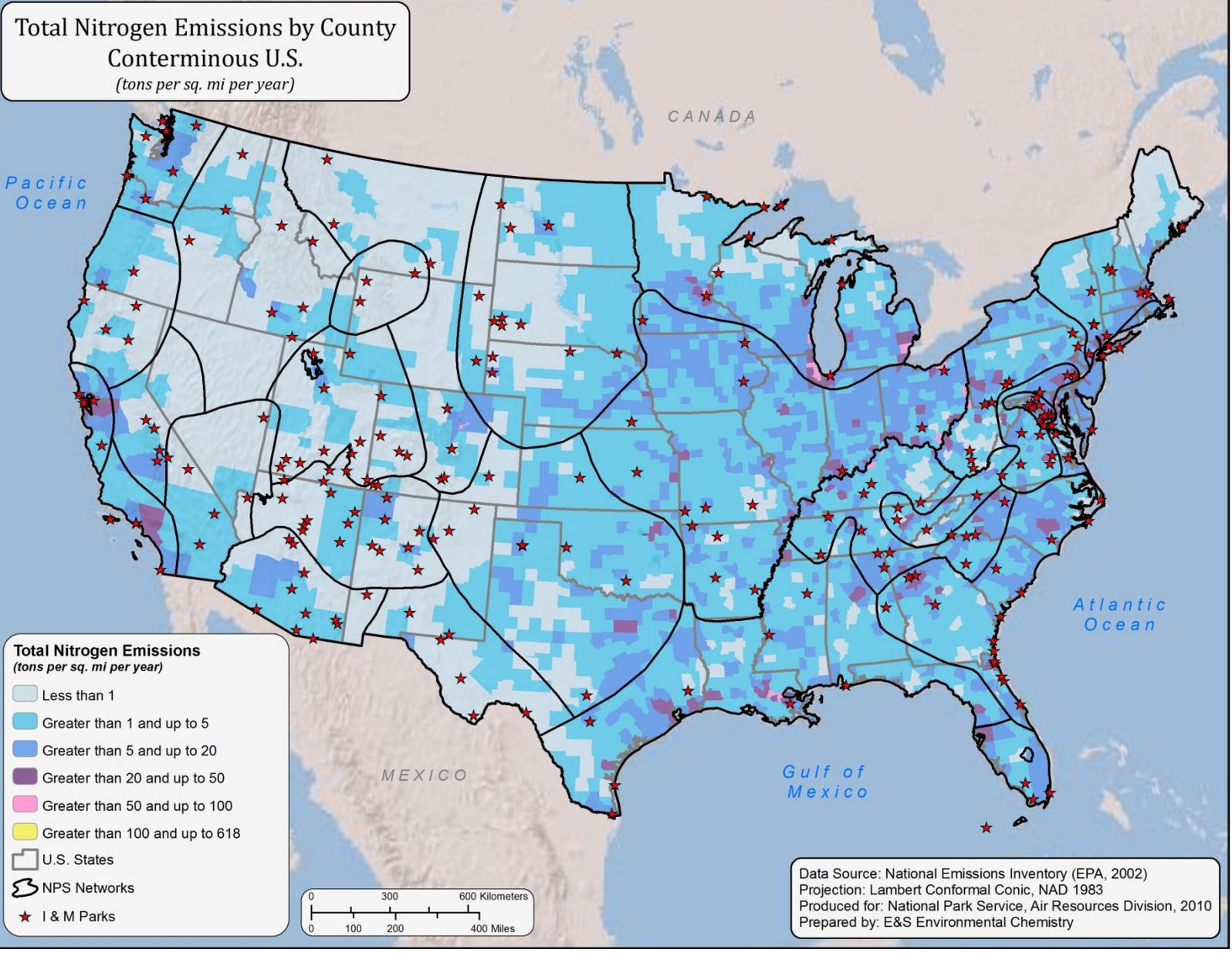
I&M Parks² in Network	Relative Ranking of Individual Parks¹			
	Pollutant Exposure	Ecosystem Sensitivity	Park Protection	Summary Risk
Apostle Islands	Moderate	Very Low	Moderate	Very Low
Grand Portage	Low	Low	Moderate	Very Low
Indiana Dunes	Very High	High	Moderate	Very High
Isle Royale	Low	Very Low	Very High	High
Mississippi	Very High	Moderate	Moderate	High
Pictured Rocks	Moderate	Moderate	Moderate	Low
Saint Croix	Moderate	Very High	Moderate	High
Sleeping Bear Dunes	Moderate	Moderate	Moderate	Low
Voyageurs	Moderate	Low	Very High	Very High

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

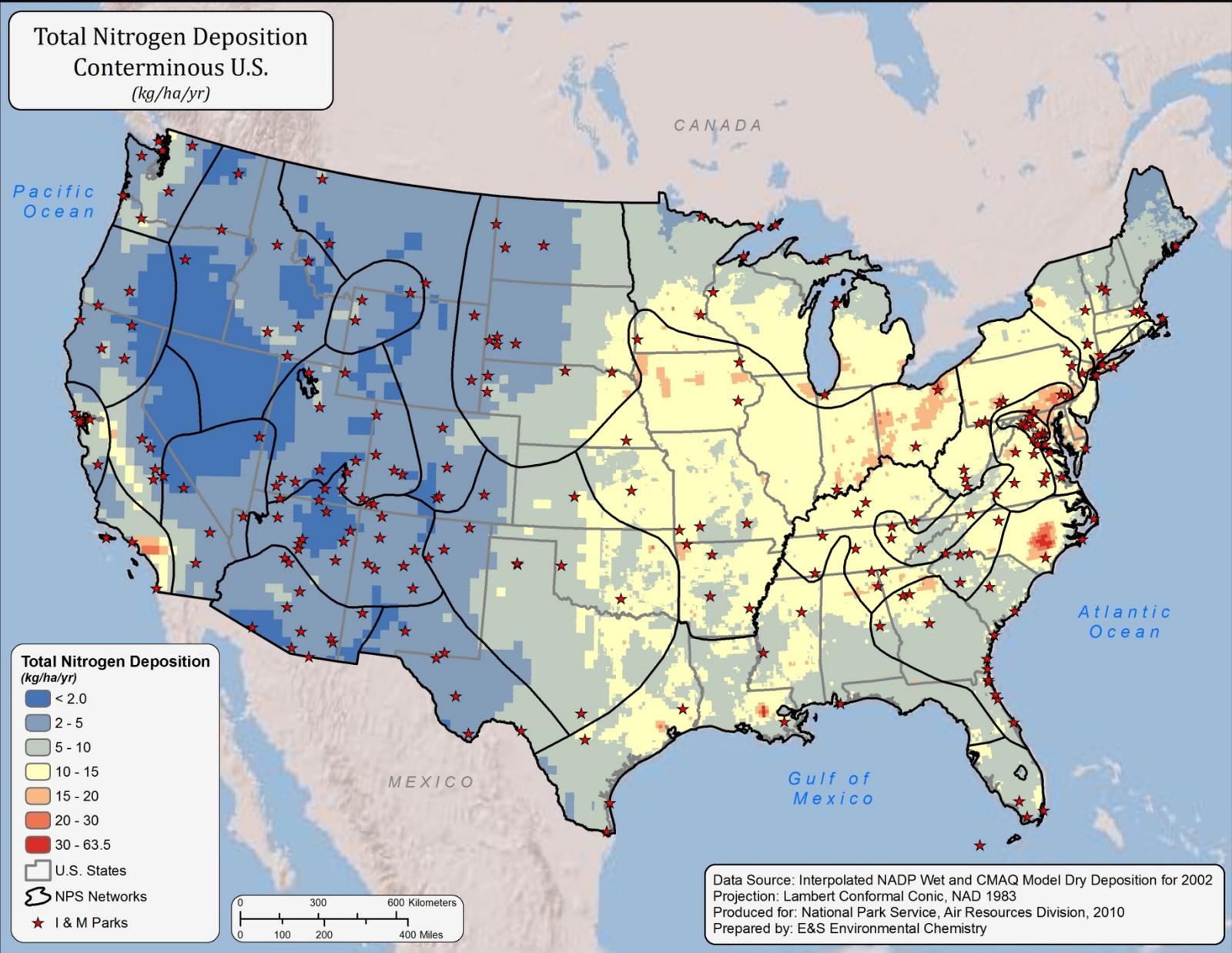
is proportional to the magnitude of the source. (Source of data: EPA National Emissions Inventory, <http://www.epa.gov/ttn/chief/net/2002inventory.html>)

- 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.



GLKN-5

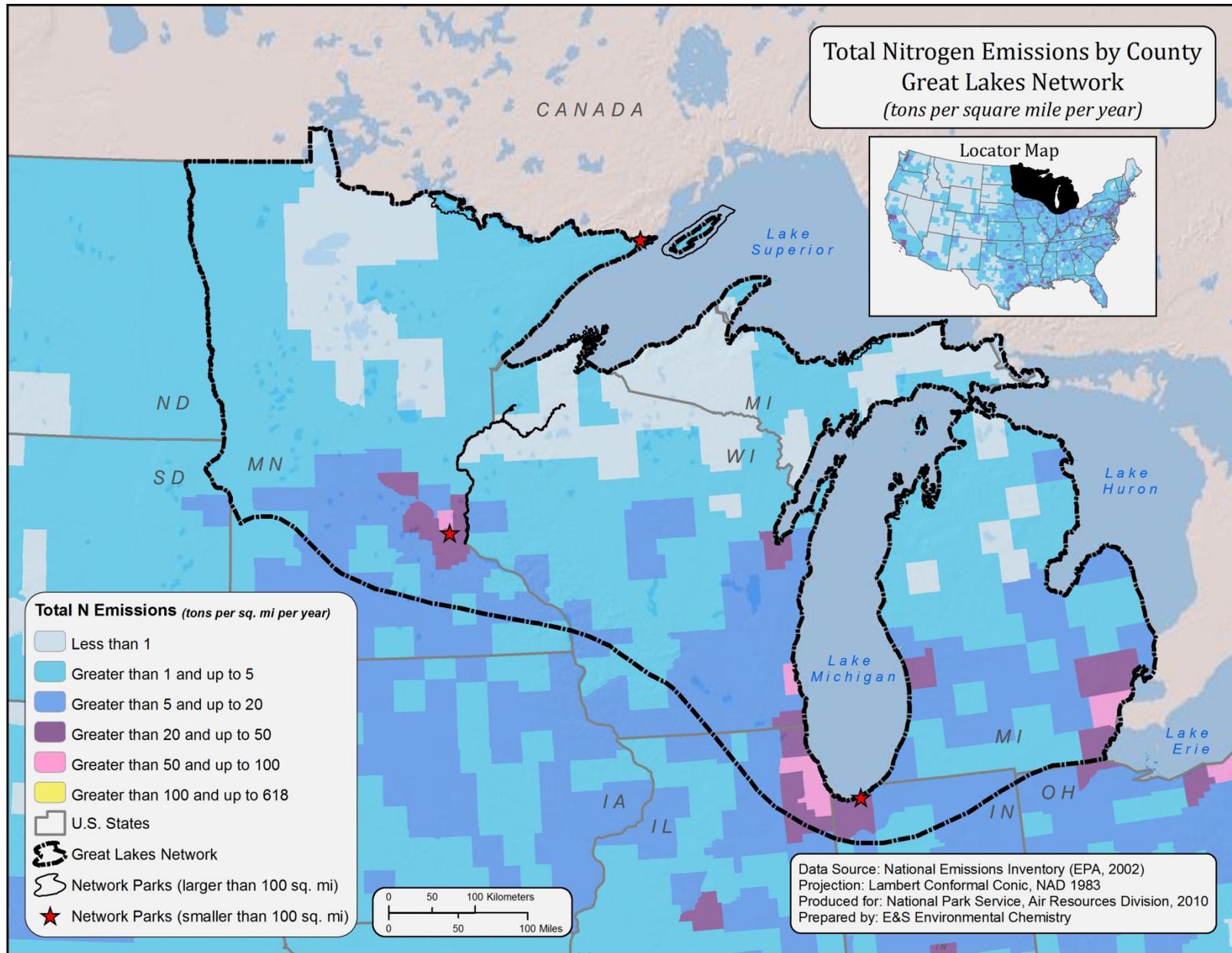
Map A



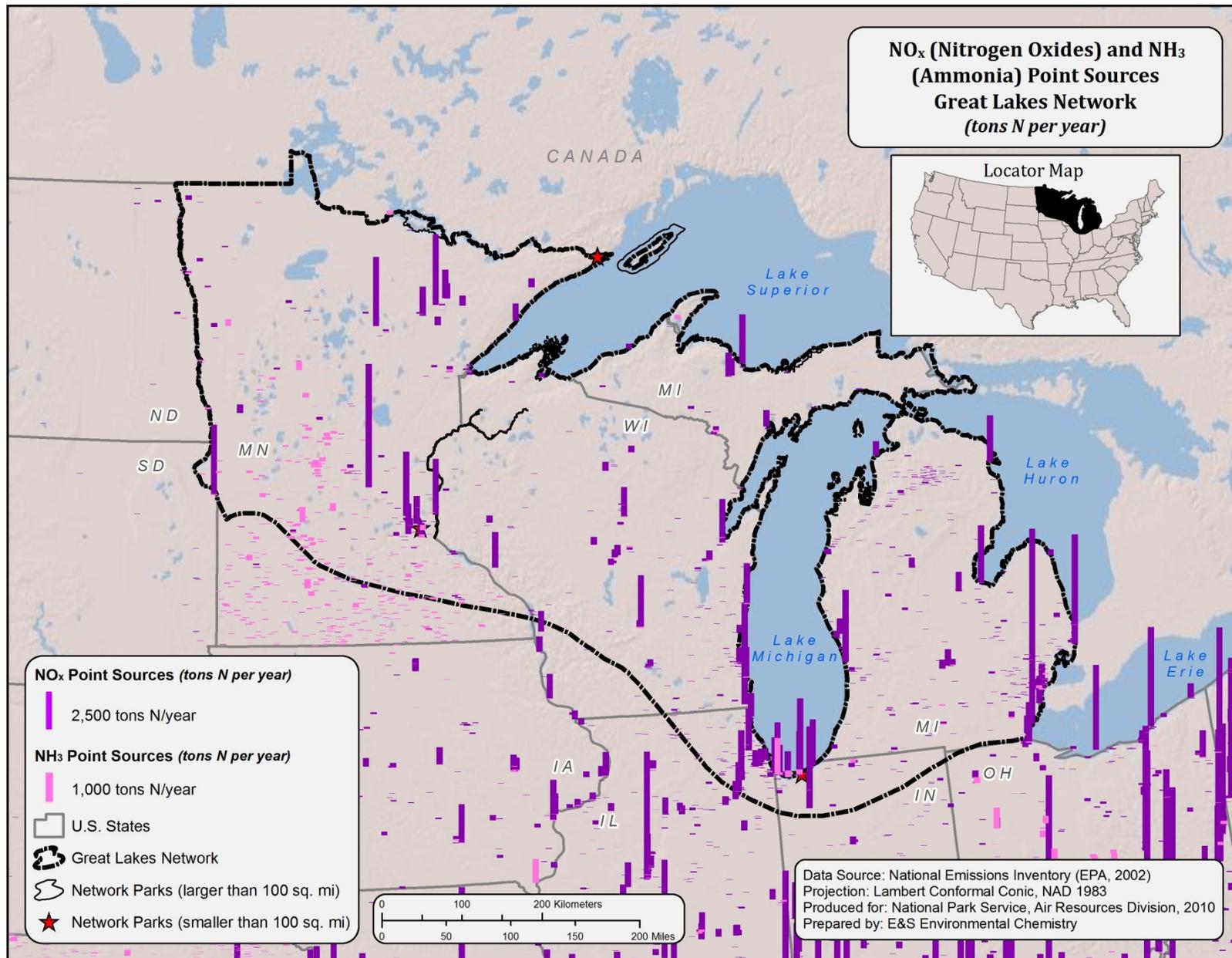
GLKN-6

Map B

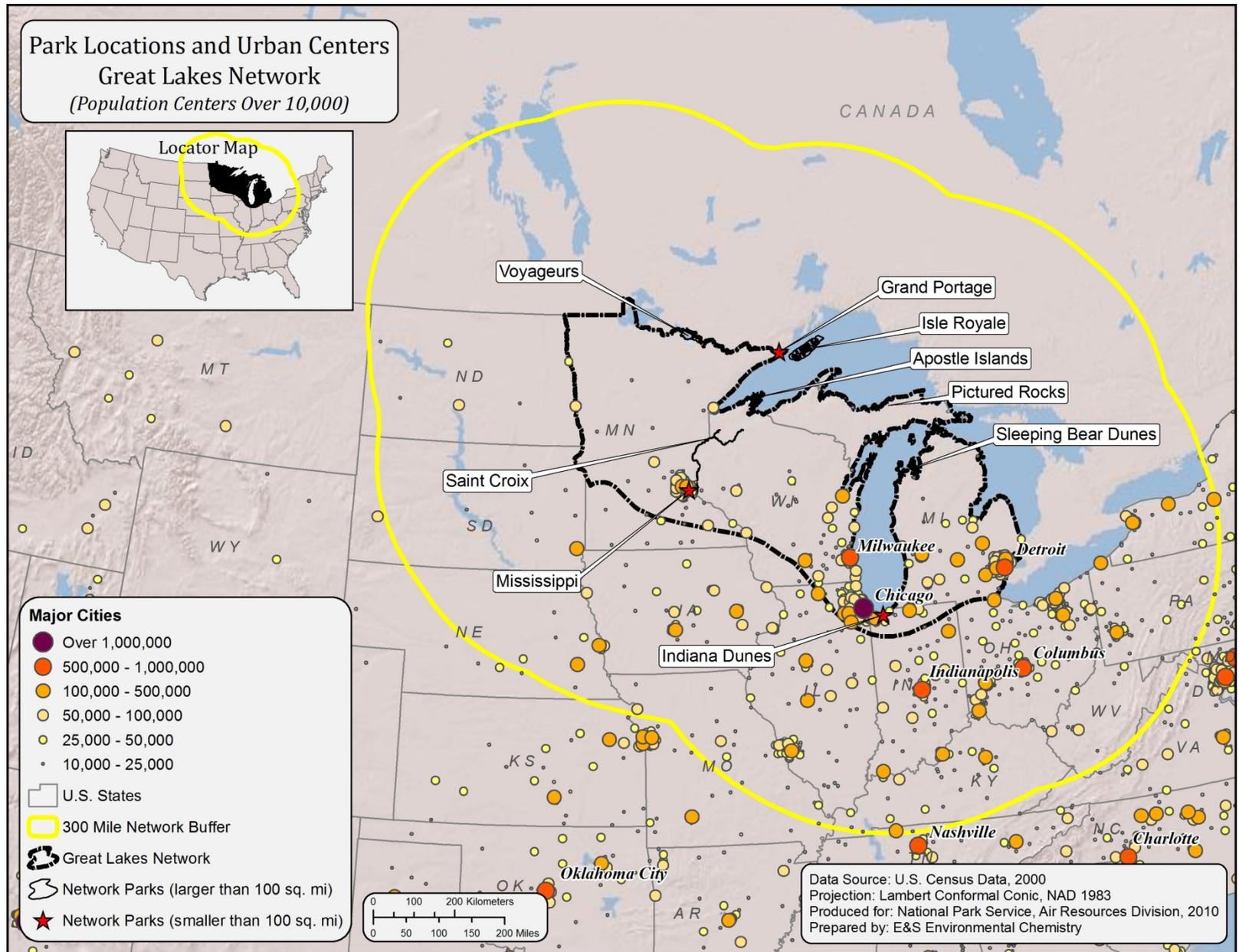
GLKN-7



Map C

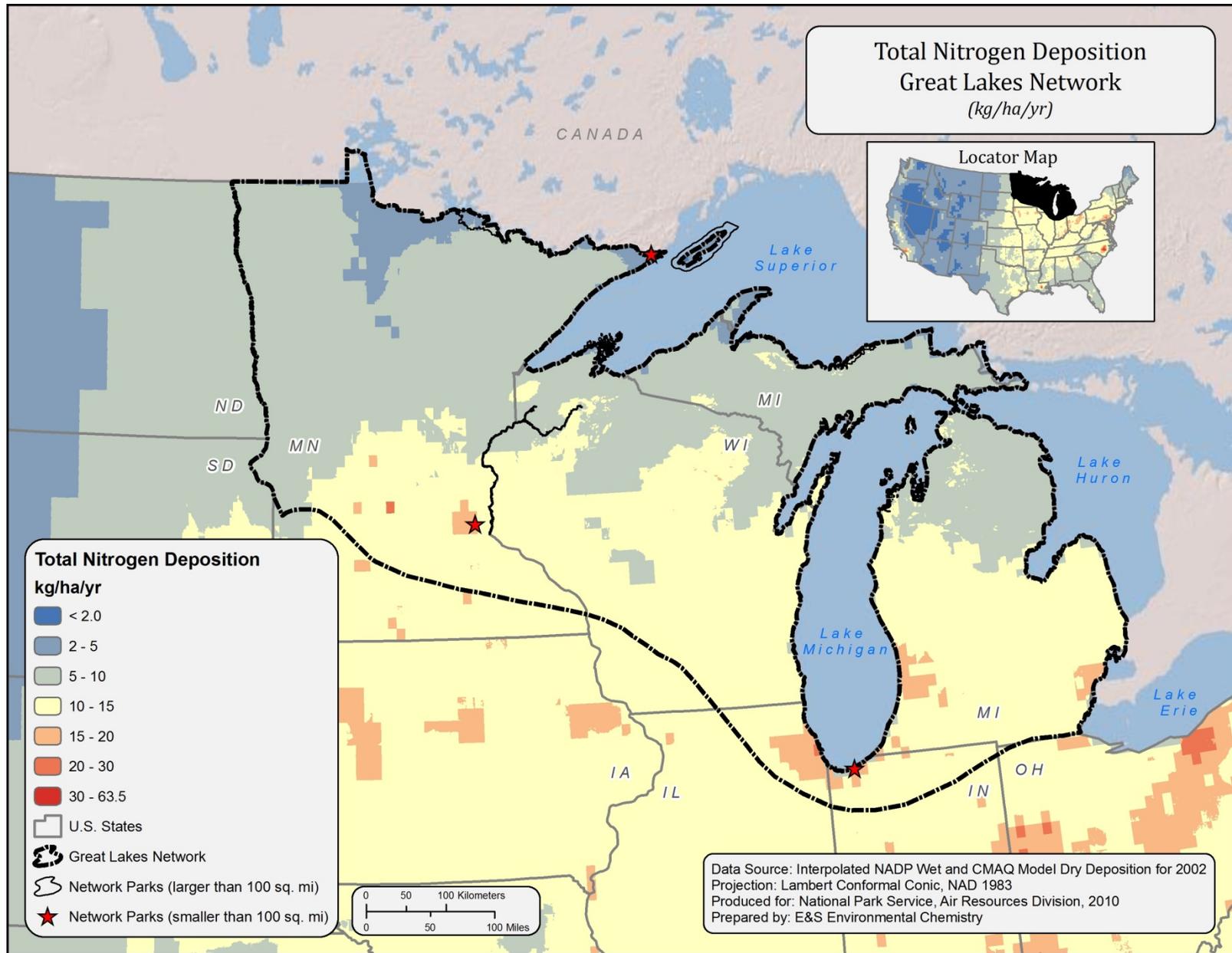


Map D



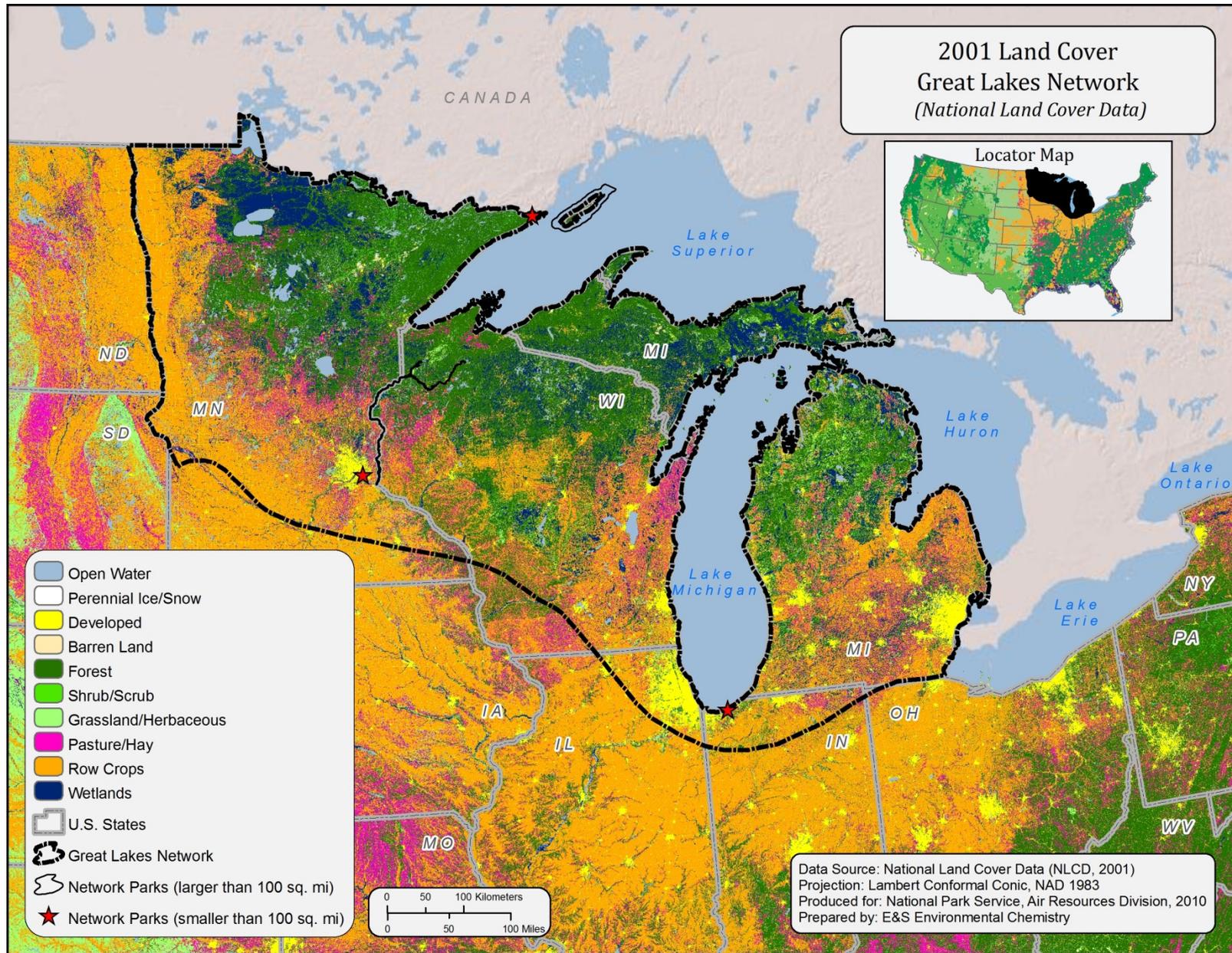
Map E

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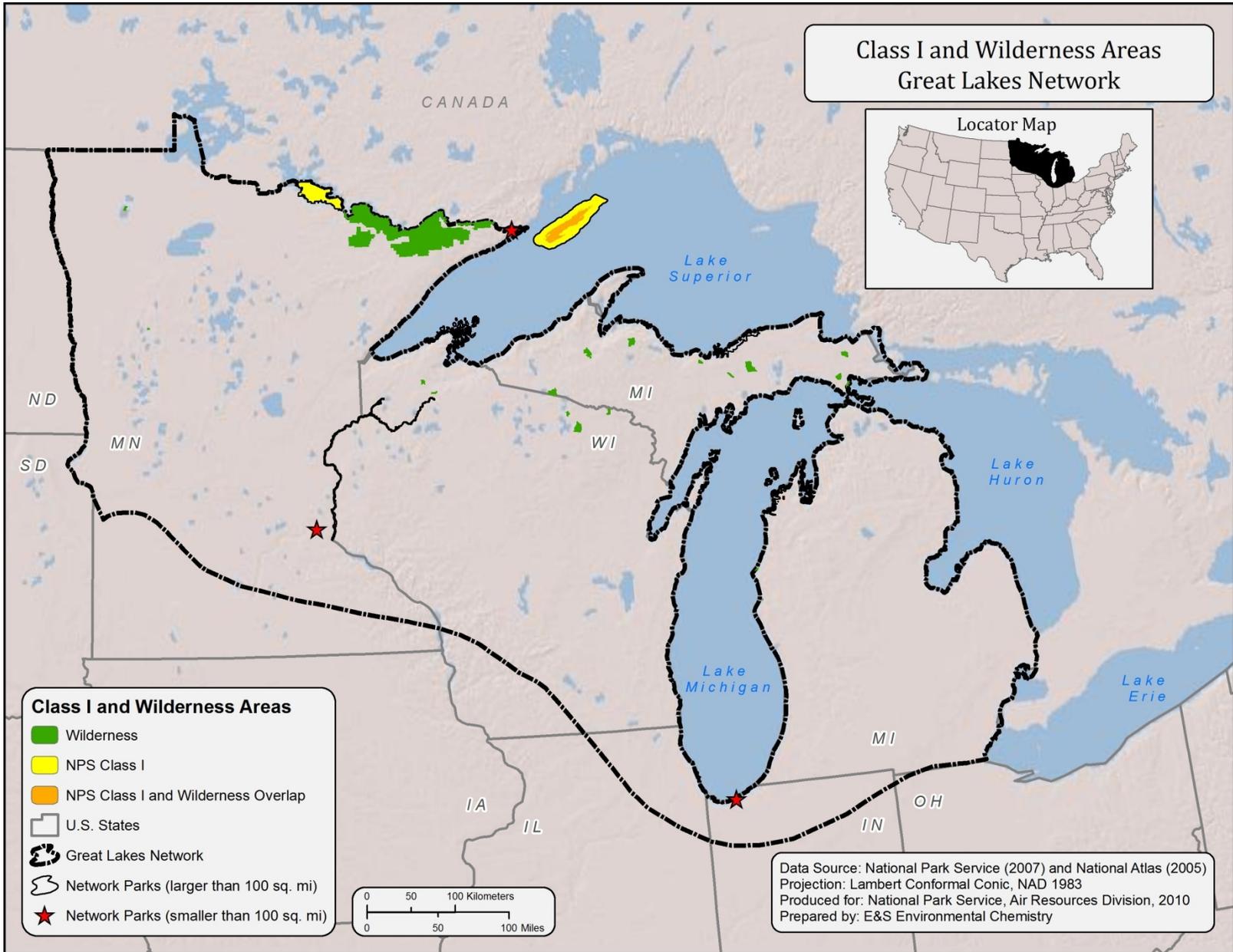


Map F

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Map G



Map I

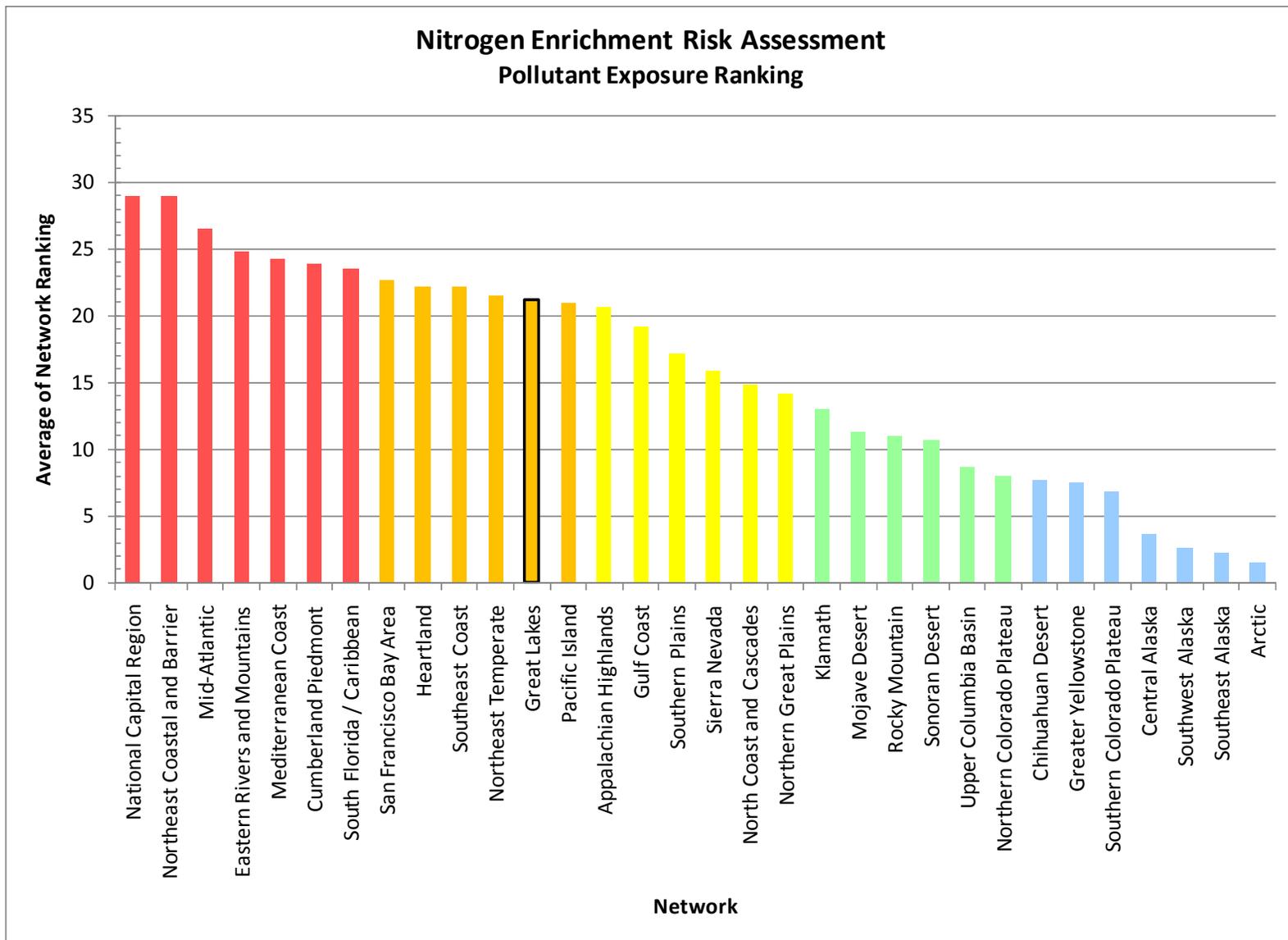


Figure A

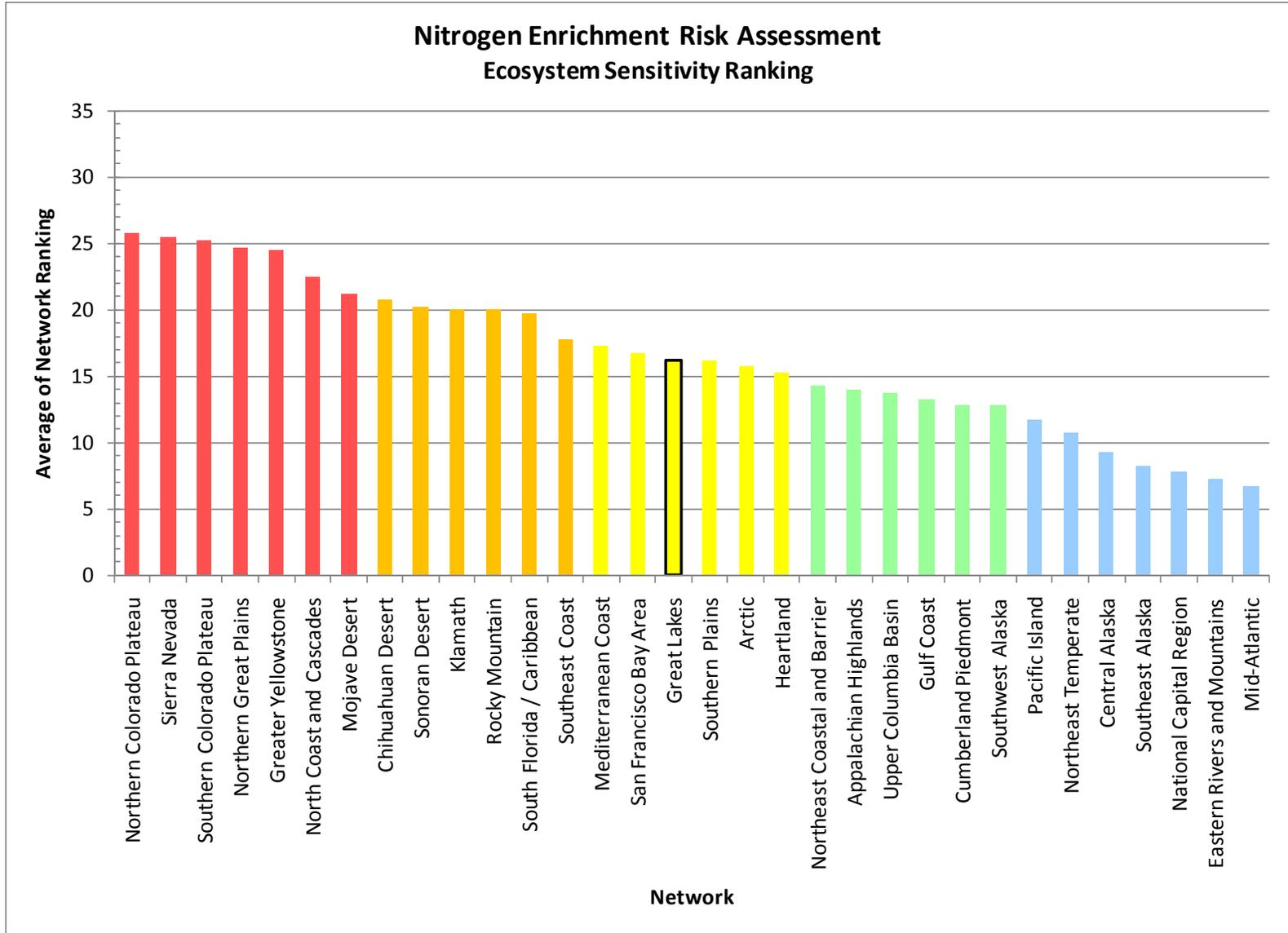


Figure B

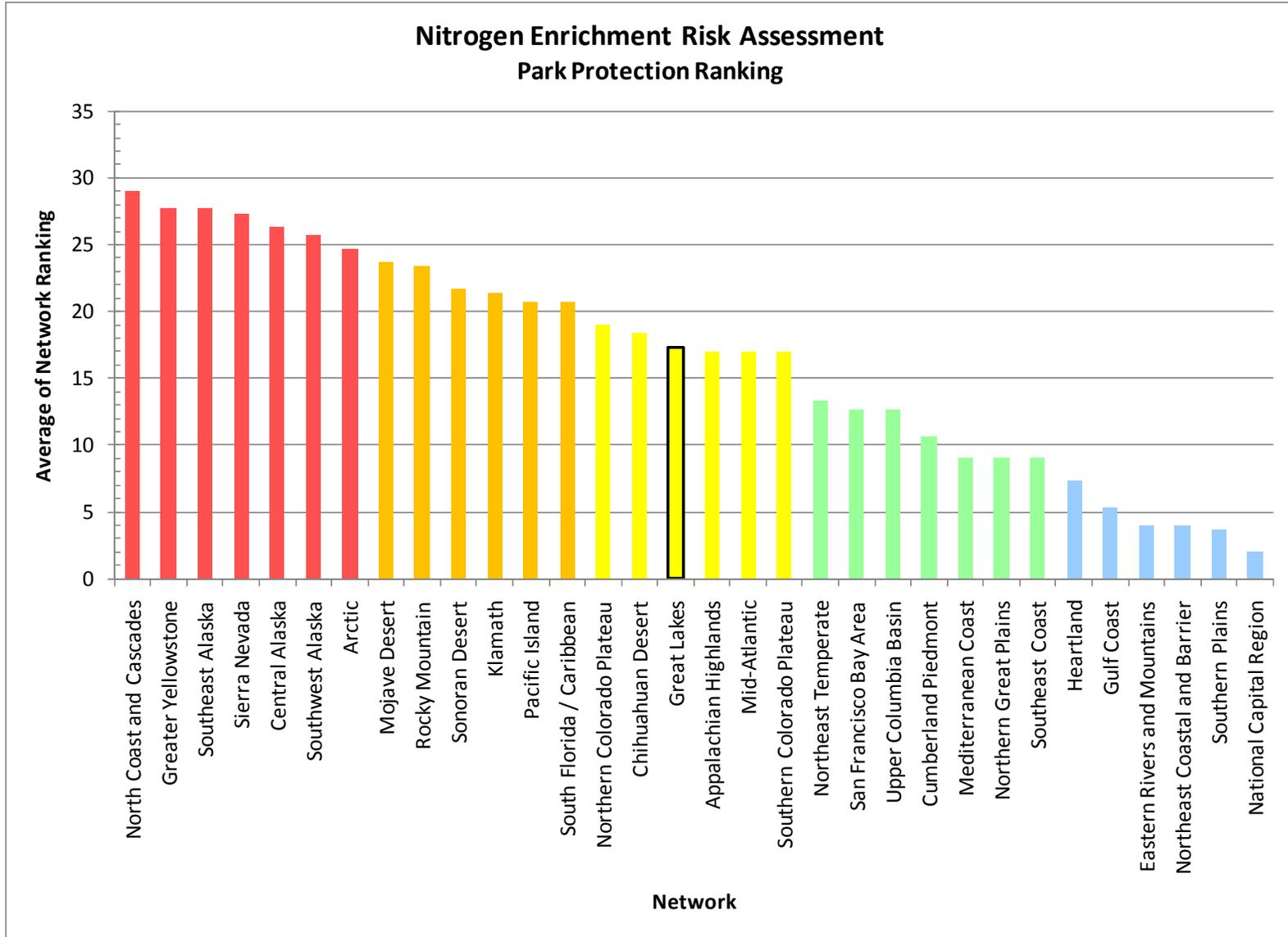


Figure C

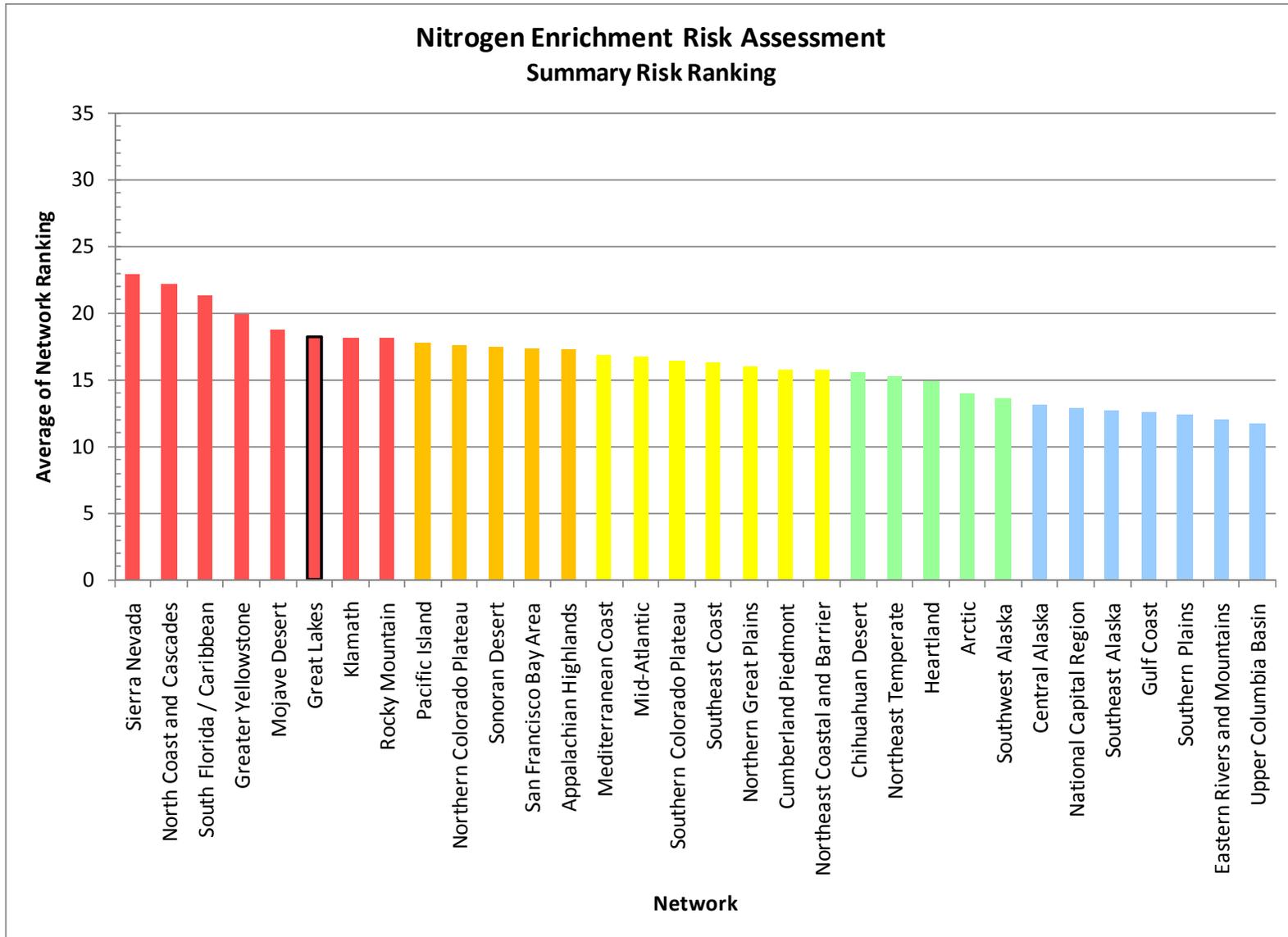


Figure D

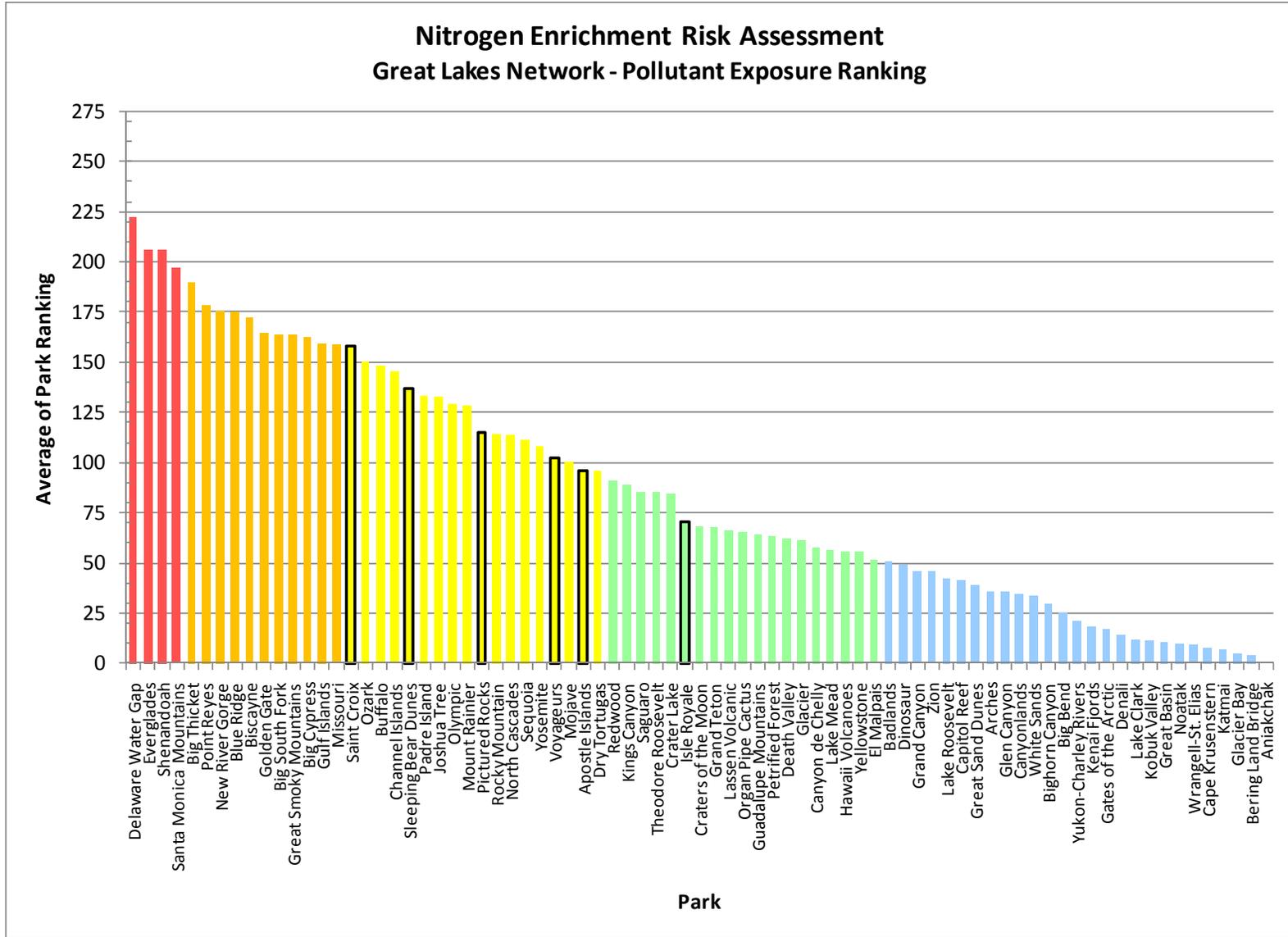


Figure E

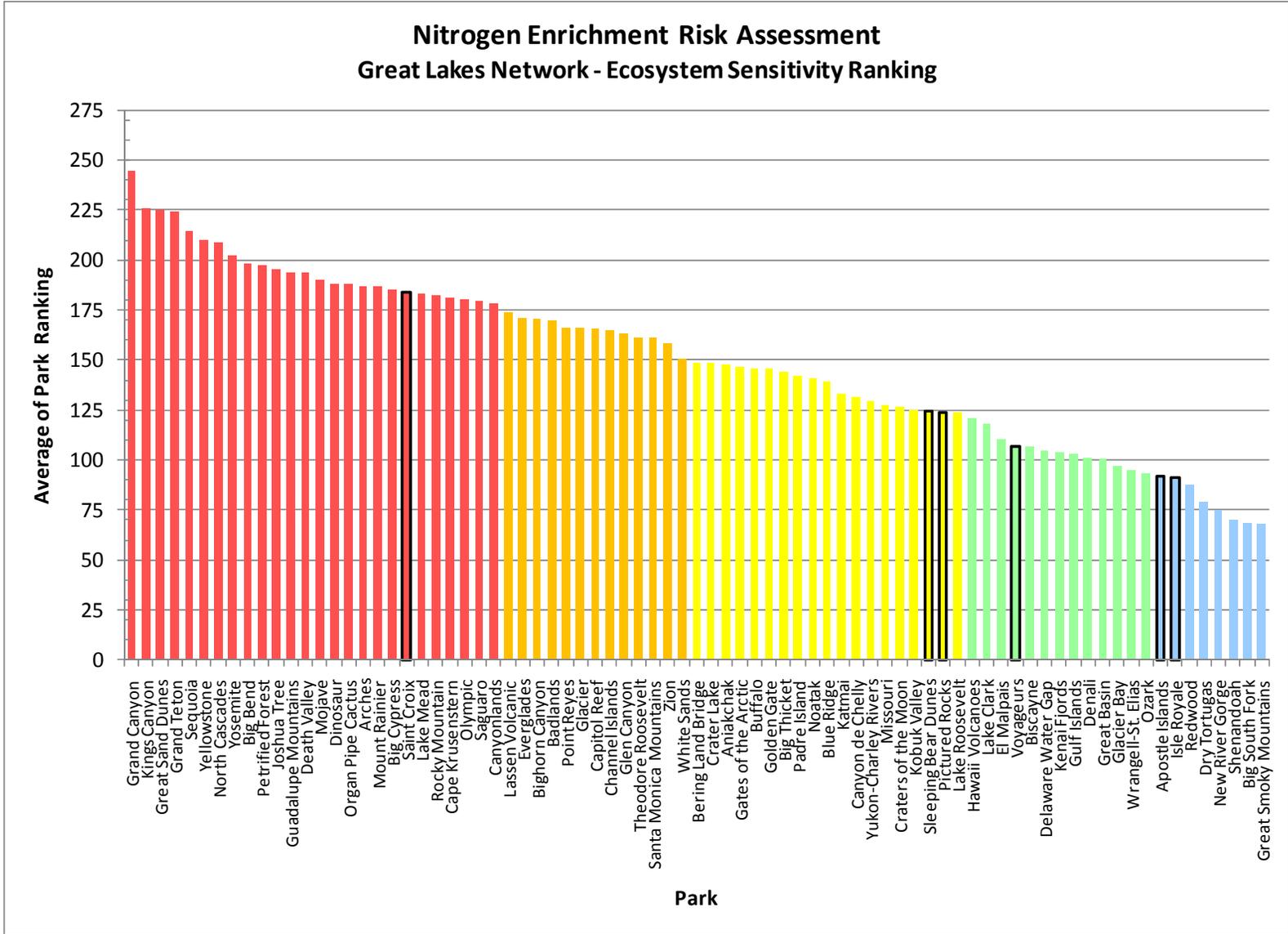


Figure F

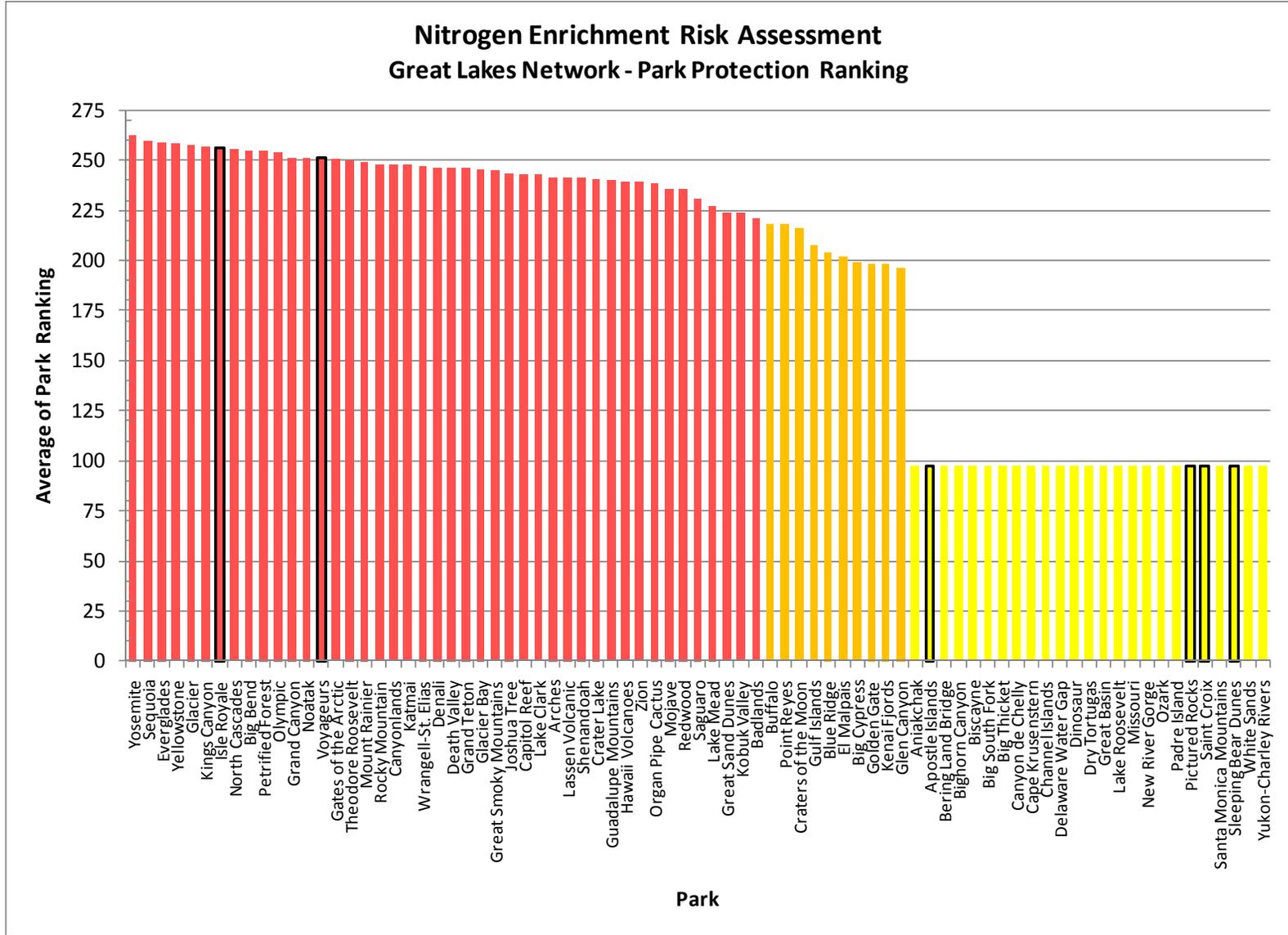


Figure G

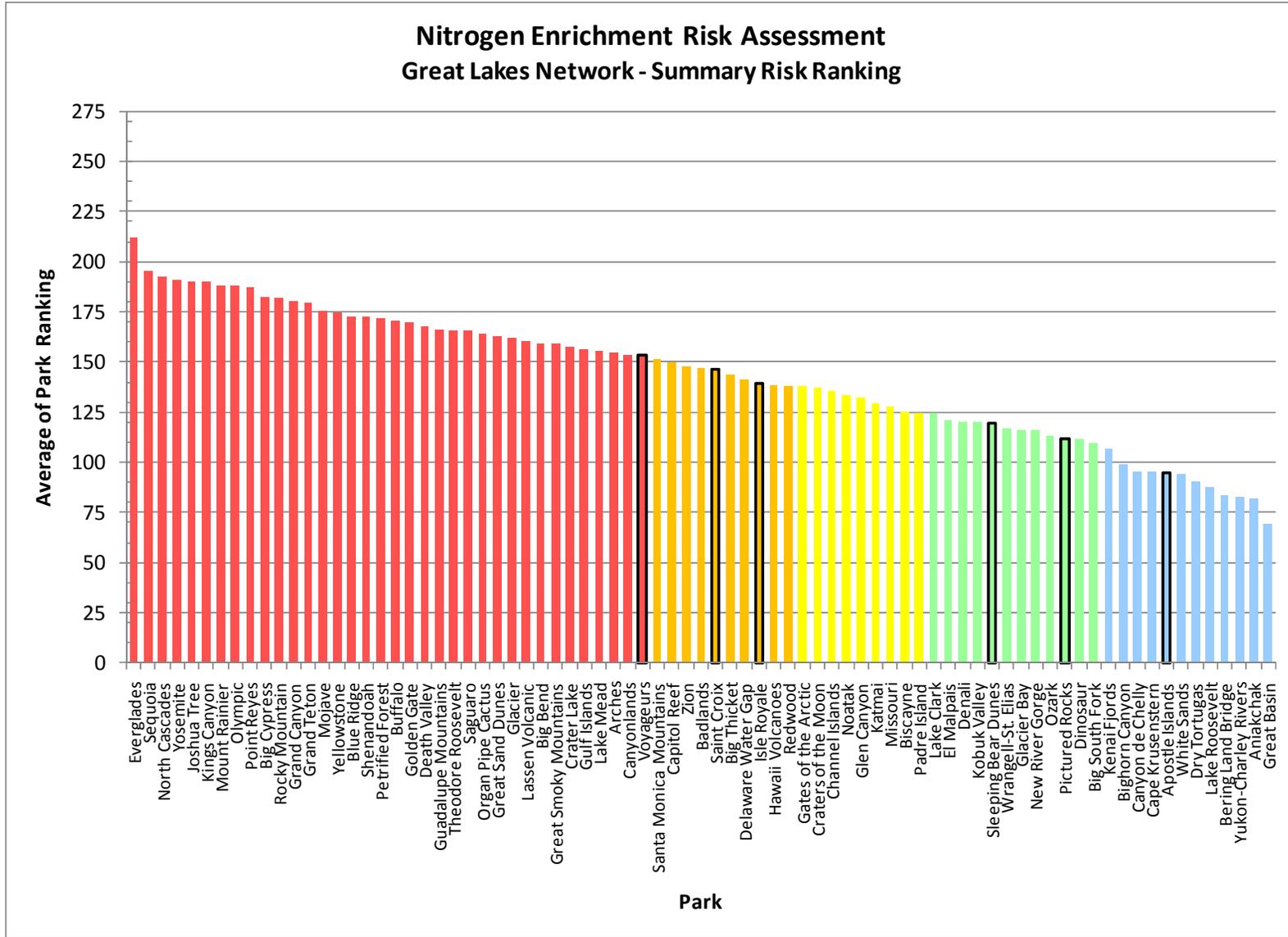


Figure H

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.

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National Park Service
U.S. Department of the Interior



Natural Resource Program Center

Air Resources Division

PO Box 25287

Denver, CO 80225

www.nature.nps.gov/air