



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

San Francisco Bay Area Network (SFAN)

Natural Resource Report NPS/NRPC/ARD/NRR—2011/325



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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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.

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San Francisco Bay Area Network (SFAN)

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 two parks in the San Francisco Bay Area Network that are larger than 100 square miles: Golden Gate (GOGA) and Point Reyes (PORE). In addition, there are four smaller parks: Fort Point (FOPO), John Muir (JOMU), Muir Woods (MUWO), and Pinnacles (PINN).

Total annual N emissions, by county, are shown in Map C for lands in and surrounding the San Francisco Bay Area Network. County-level emissions within the network ranged from less than 1 to 5 tons per square mile in both the north and the south, and greater than 20 tons per square mile in the center portion of the network. Some smaller areas had N emissions levels higher than that. In general, annual county N emissions were between 1 and 50 tons per square mile, but were spatially quite variable. Point source emissions of oxidized (nitrogen oxides, NO_x) and reduced (ammonia, NH_3) N are shown in Map D. There are few point sources of any magnitude in this network. Urban centers within the network and within a 300 mile buffer around the network are shown in Map E. There is a high density of relatively large human population centers in this network, but they are restricted to the middle half of the network, with none in the far north or south.

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 2 to 5 kg N/ha/yr to more than 10 kg N/ha/yr. Atmospheric N deposition in and near the parks in this network was generally between 2 and 10 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 mixed, with substantial areas of forest, developed land, row crops, shrubland, and grassland/herbaceous. Scattered areas of pasture/hay are also found, especially to the east.

Map H shows the distribution within the parks that occur in this network 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). The predominant sensitive vegetation type within these parks is arid and semi-arid.

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. PORE is Class I and contains some wilderness area. The only other wilderness areas are located in the southern portion of the network, outside NPS jurisdiction.

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 San Francisco Bay Network ranks at the top 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 moderate, within the third quintile among networks (Figure B). This is because there are no high elevation lakes, and there is moderate coverage of vegetation types in this network that are among those expected to be especially sensitive to nutrient enrichment effects from N deposition. This network ranks in the second 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 highest quintile among all networks (Figure D). The overall level of concern for nutrient N enrichment effects on I&M parks within this network is considered 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.

The two I&M parks in the San Francisco Bay Area Network that are larger than 100 square miles (PORE and GOGA) are both in the second highest quintile in Pollutant Exposure (Figure E). PORE is also ranked High in Ecosystem Sensitivity (Figure F) and Park Protection (Figure G), whereas GOGA is ranked Moderate in Ecosystem Sensitivity, but High in Park Protection (Figure G). Among the smaller parks, two are ranked Low and two are ranked High for Ecosystem Sensitivity. For Park Protection, PINN is ranked High; the other small parks are ranked Moderate for this theme (Table A).

The Summary Park Risk ranking places GOGA, PINN, and PORE in the highest quintile (Figure H). The overall level of concern for nutrient N enrichment effects is Very High for these three parks. Among the smaller parks, the overall level of concern is High for JOMU, but lower for the other two smaller parks.

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
Fort Point	Moderate	Low	Moderate	Low
<i>Golden Gate</i>	High	Moderate	High	Very High
John Muir	High	High	Moderate	High
Muir Woods	High	Low	Moderate	Moderate
Pinnacles	Moderate	High	High	Very High
<i>Point Reyes</i>	High	High	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.

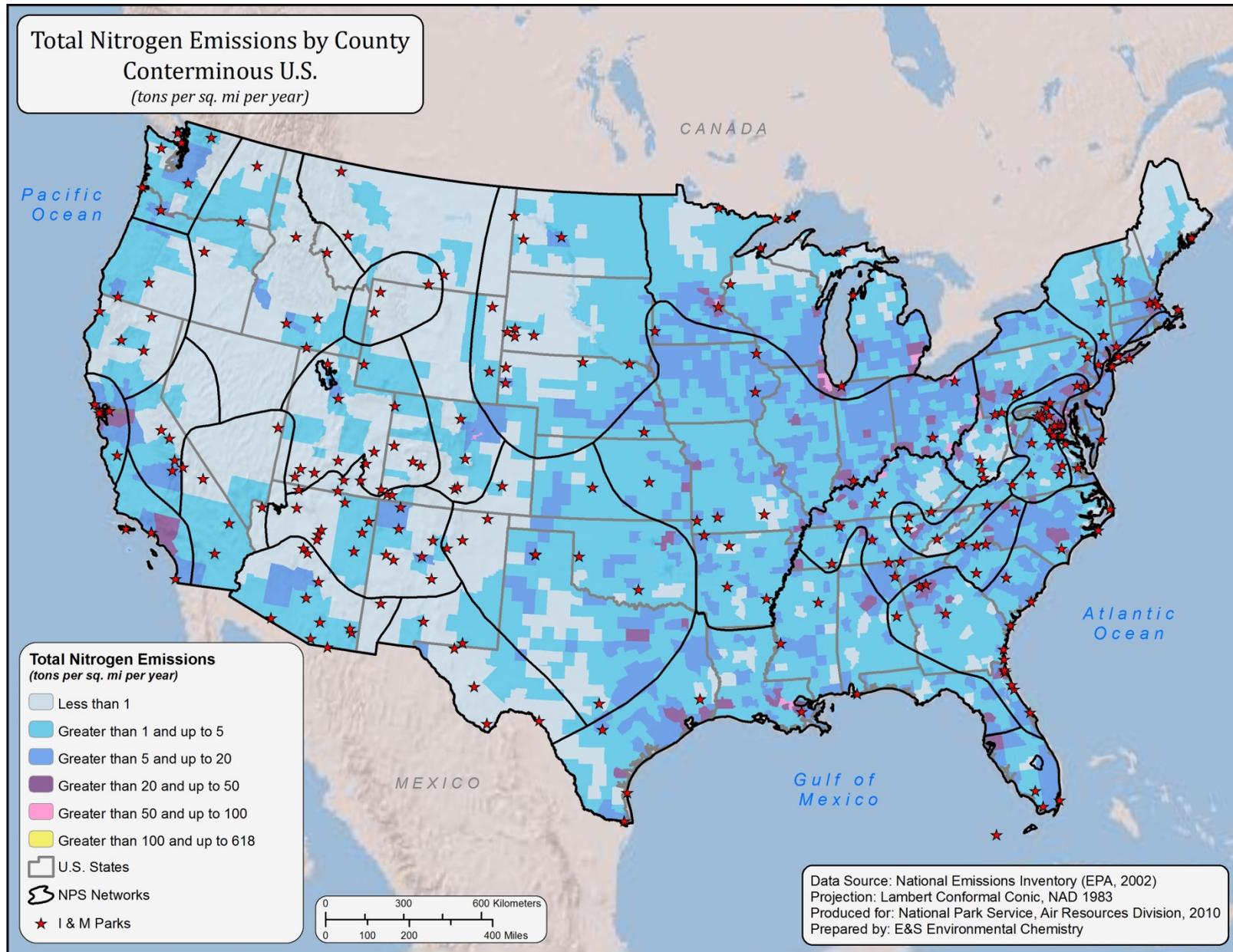
Map A. National map of total N emissions by county for the year 2002. Both oxidized (nitrogen oxides, NO_x) and reduced (ammonia, NH₃) forms of N are included. The total is expressed in tons per square mile per year. (Source of data: EPA National Emissions Inventory, <http://www.epa.gov/ttn/chief/net/2002inventory.html>)

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>)

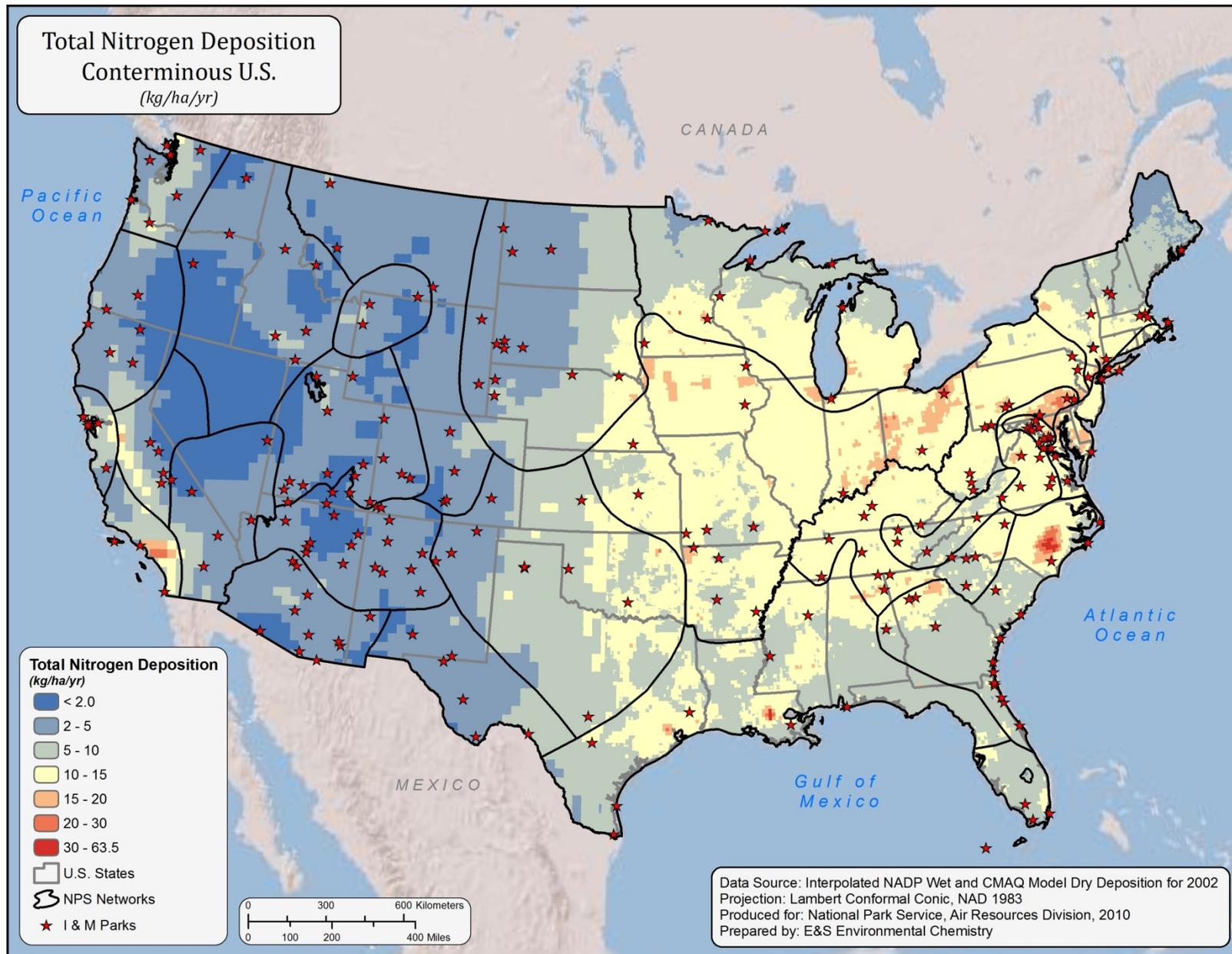
Map D. Major point source emissions of oxidized (nitrogen oxides, NO_x) and reduced (ammonia, NH₃) N in and around the network. The base of each vertical bar is positioned in the map at the approximate location of the source. The height of the bar is proportional to the magnitude of the source. (Source 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: CMAQ Model wet and 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 H. Distribution within the larger parks that occur in this network of the five terrestrial vegetation types thought to be most sensitive to N-nutrient enrichment effects: arctic, alpine, meadow, wetland, and arid and semi-arid. (Source of data: See Appendix A)
- 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.

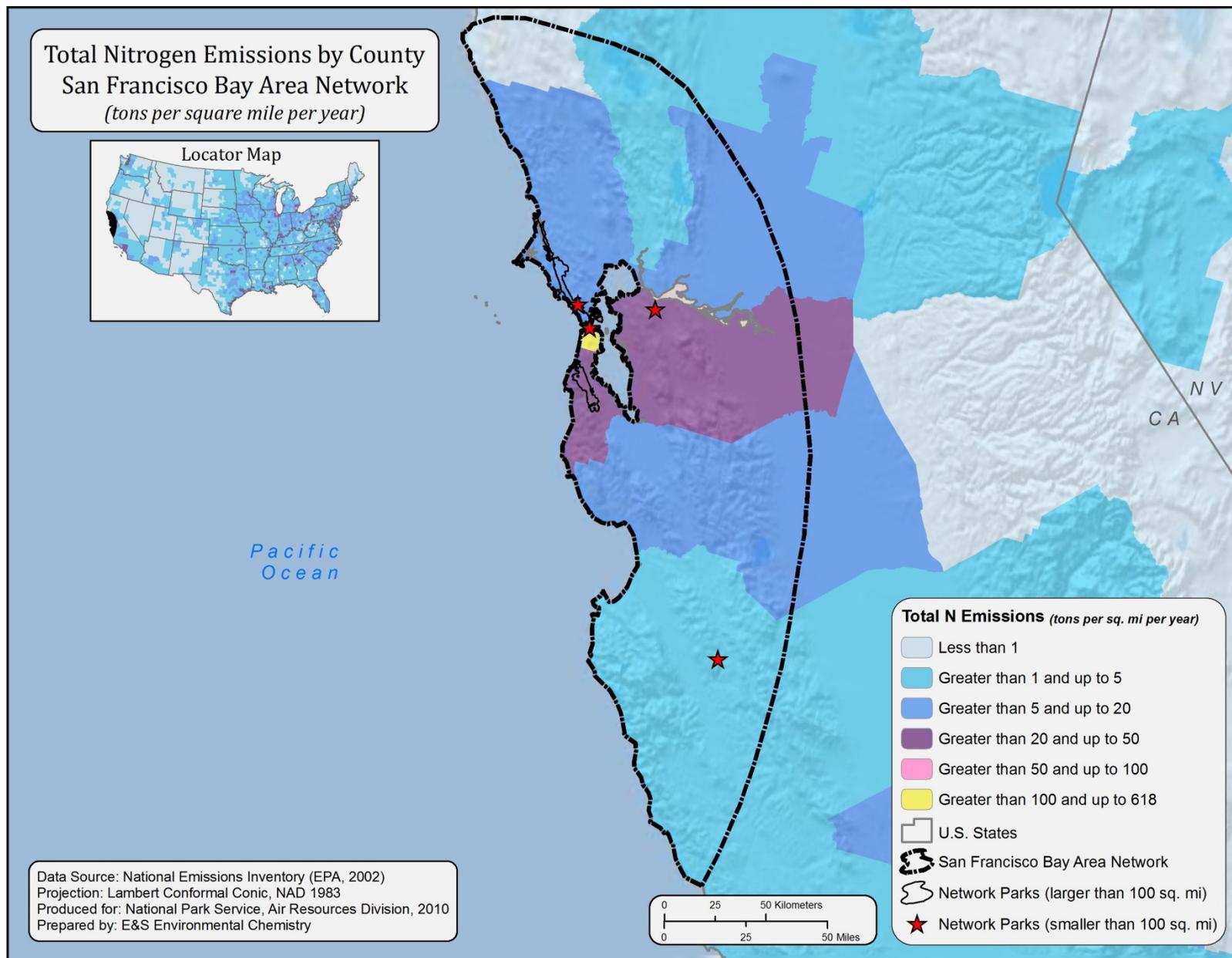


Map A

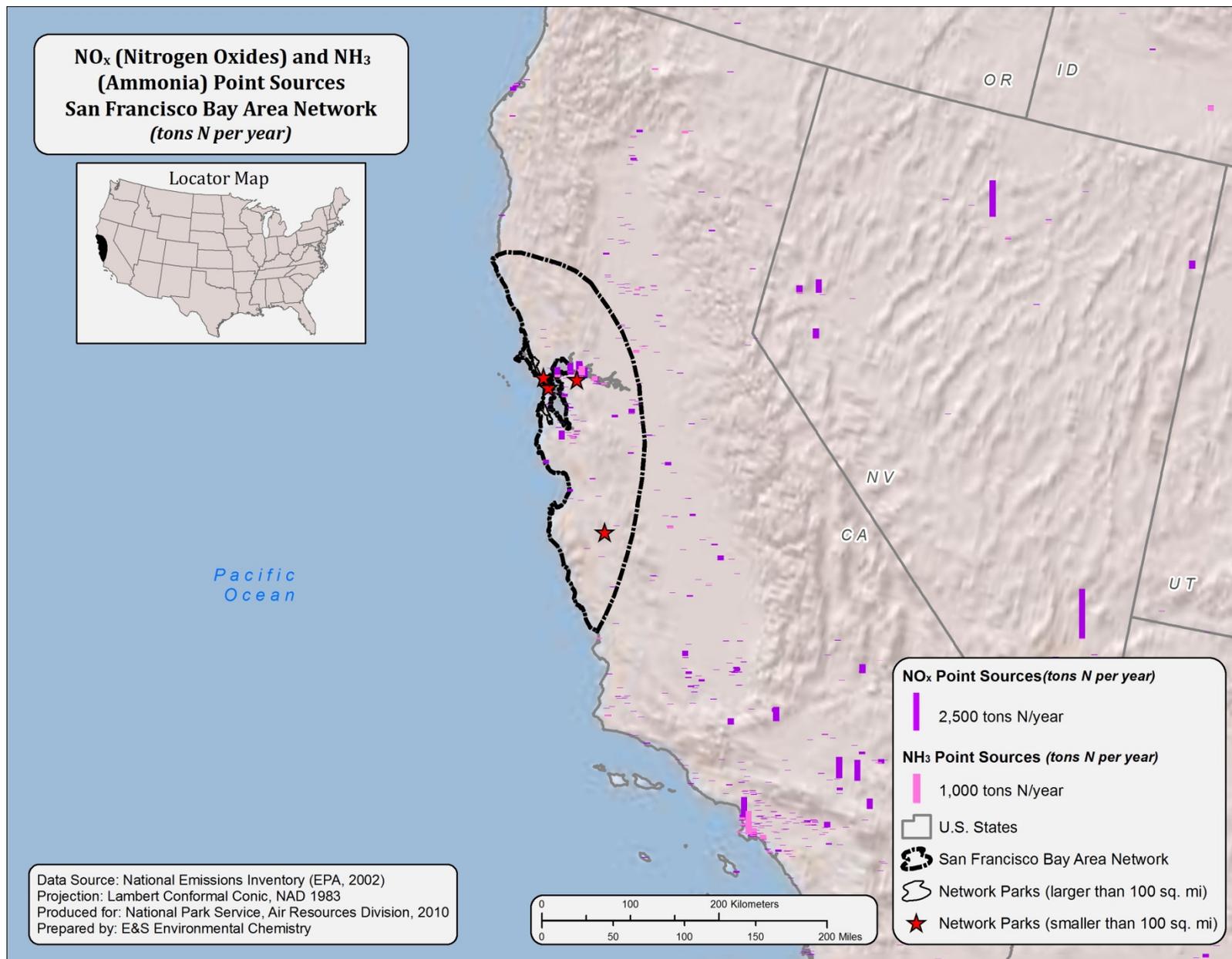
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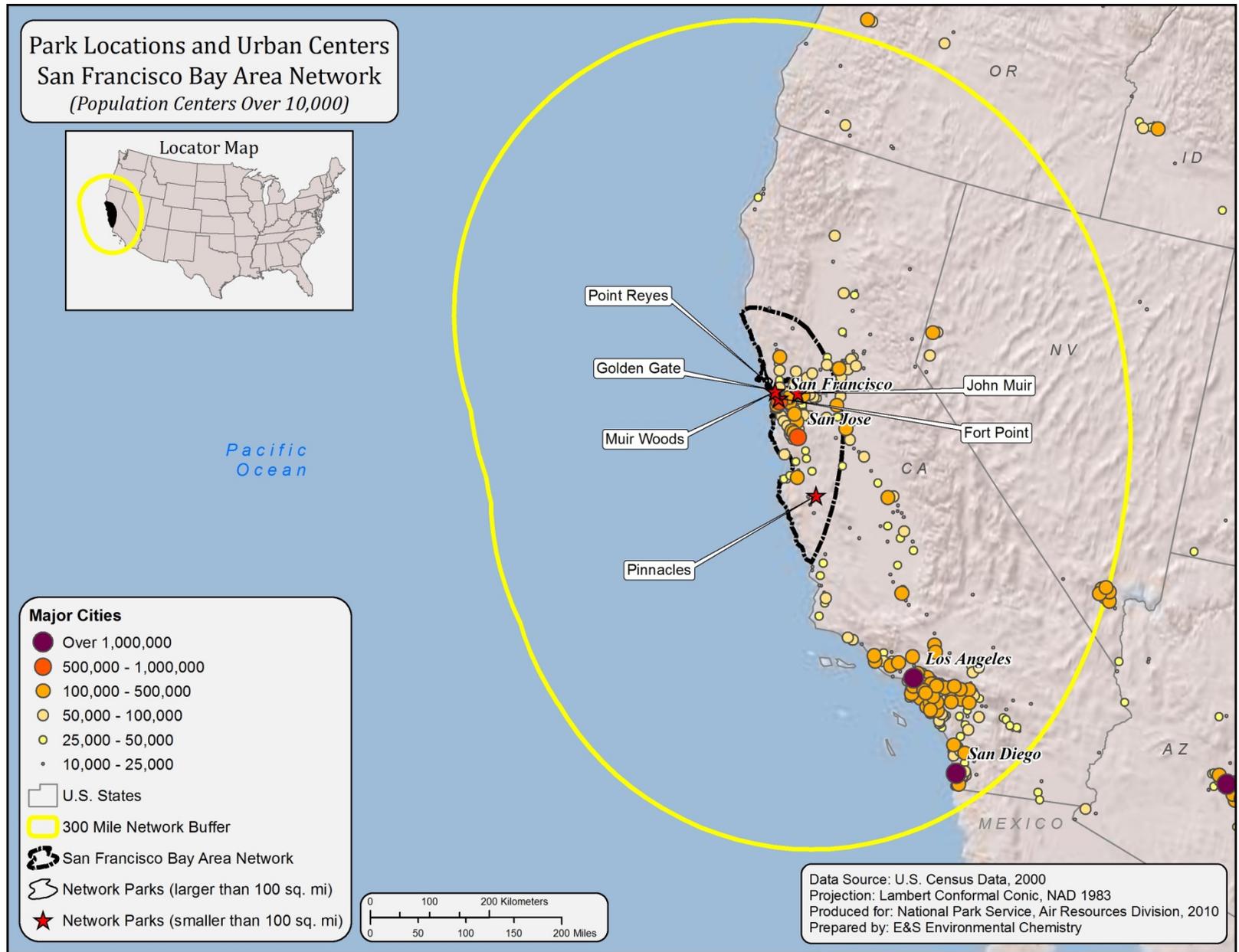
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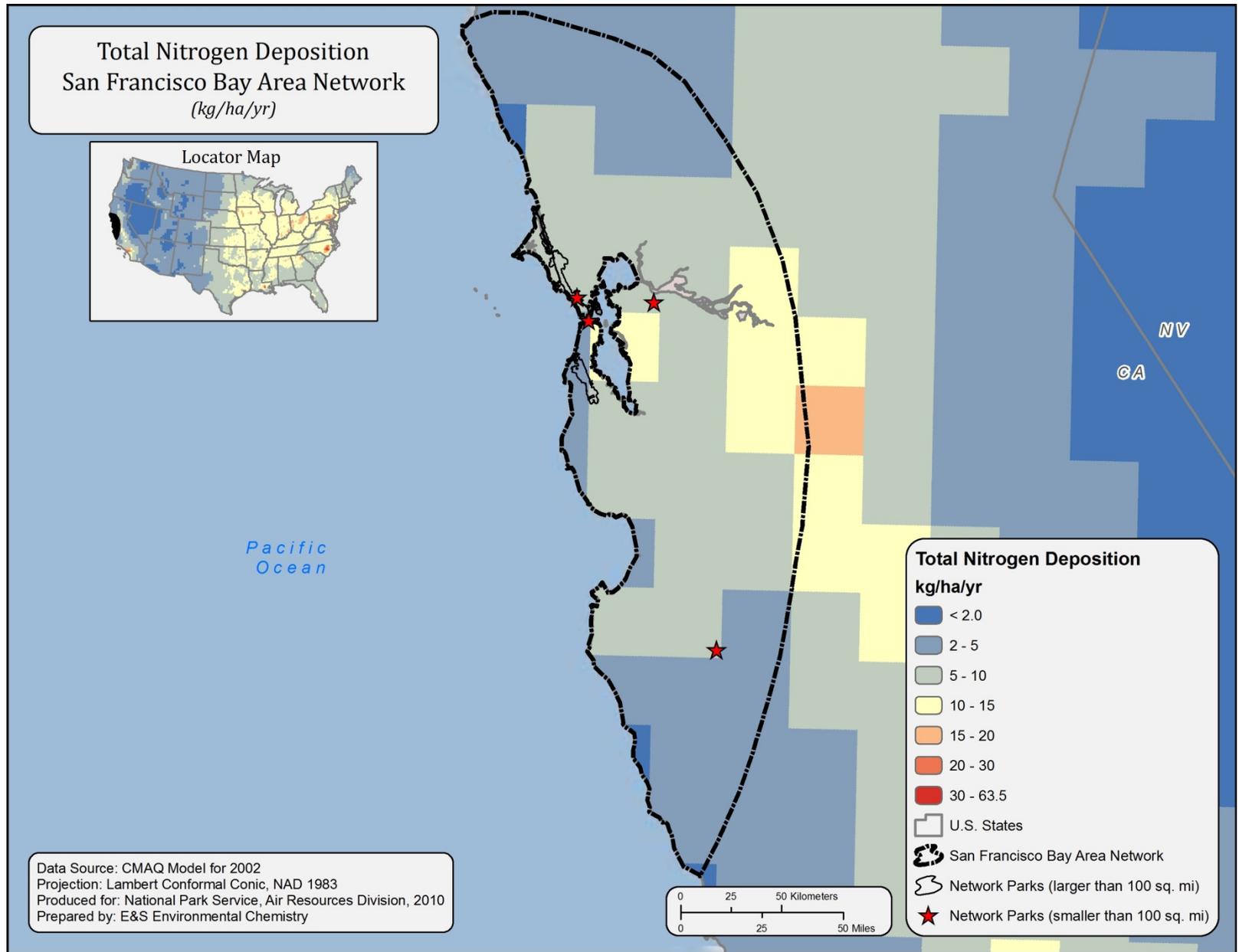
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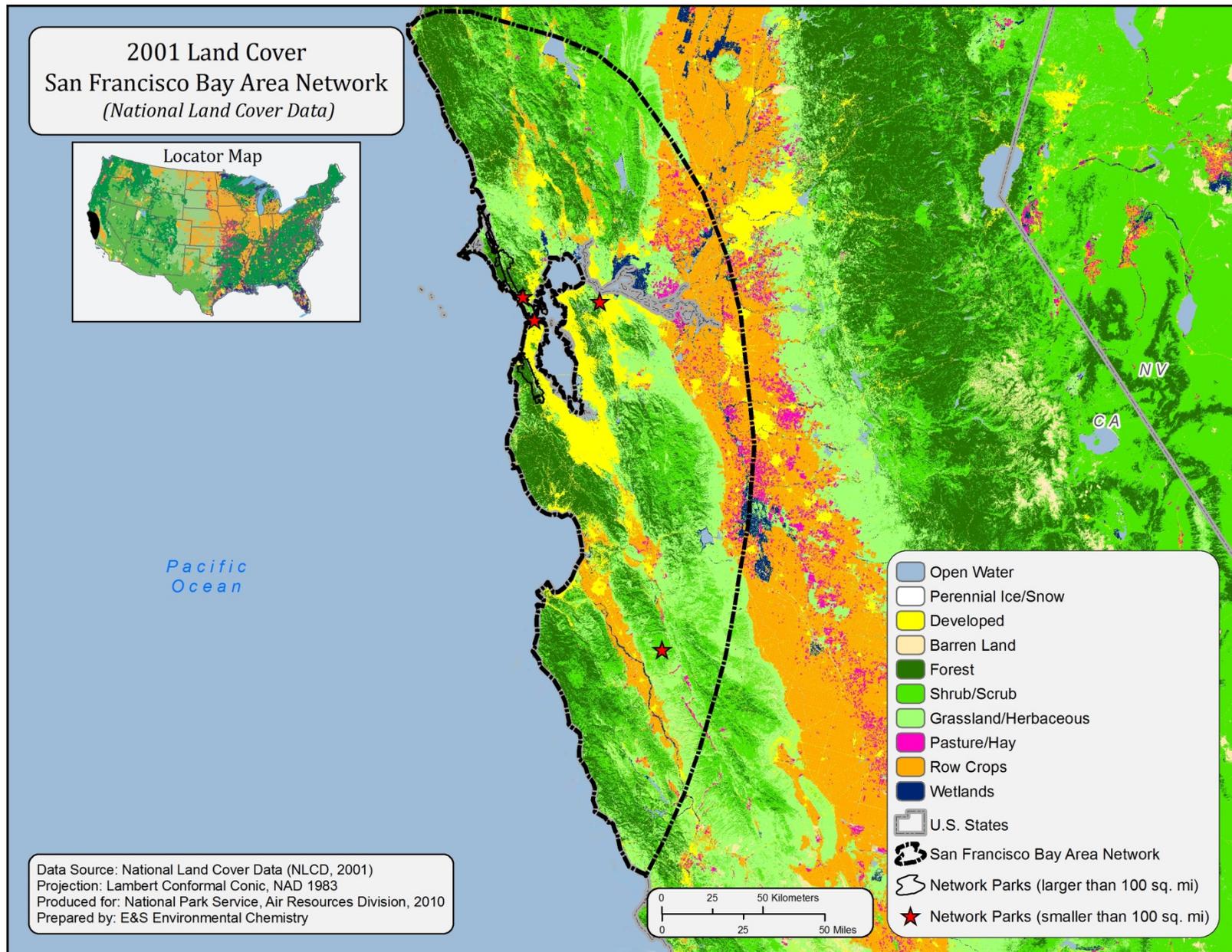
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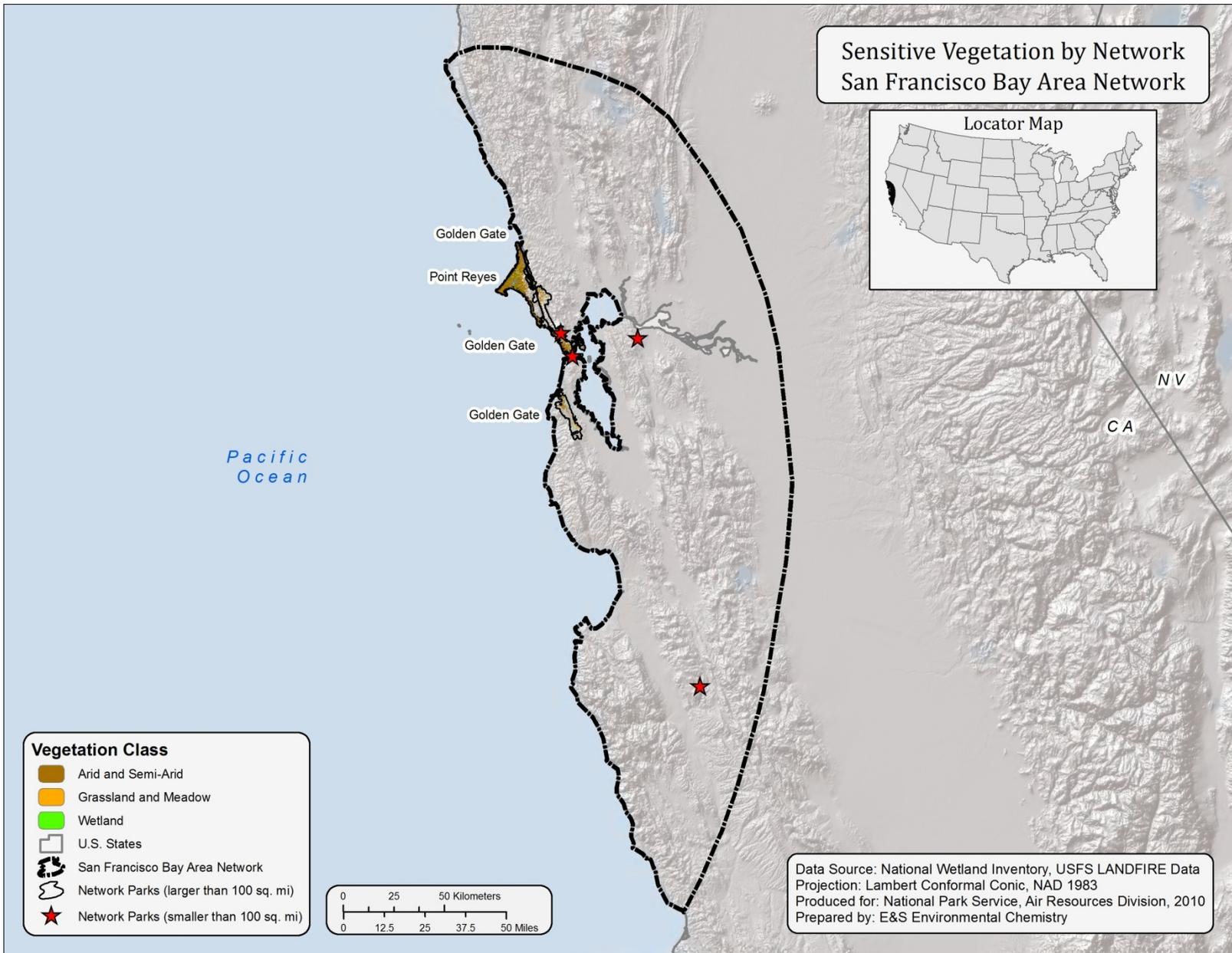
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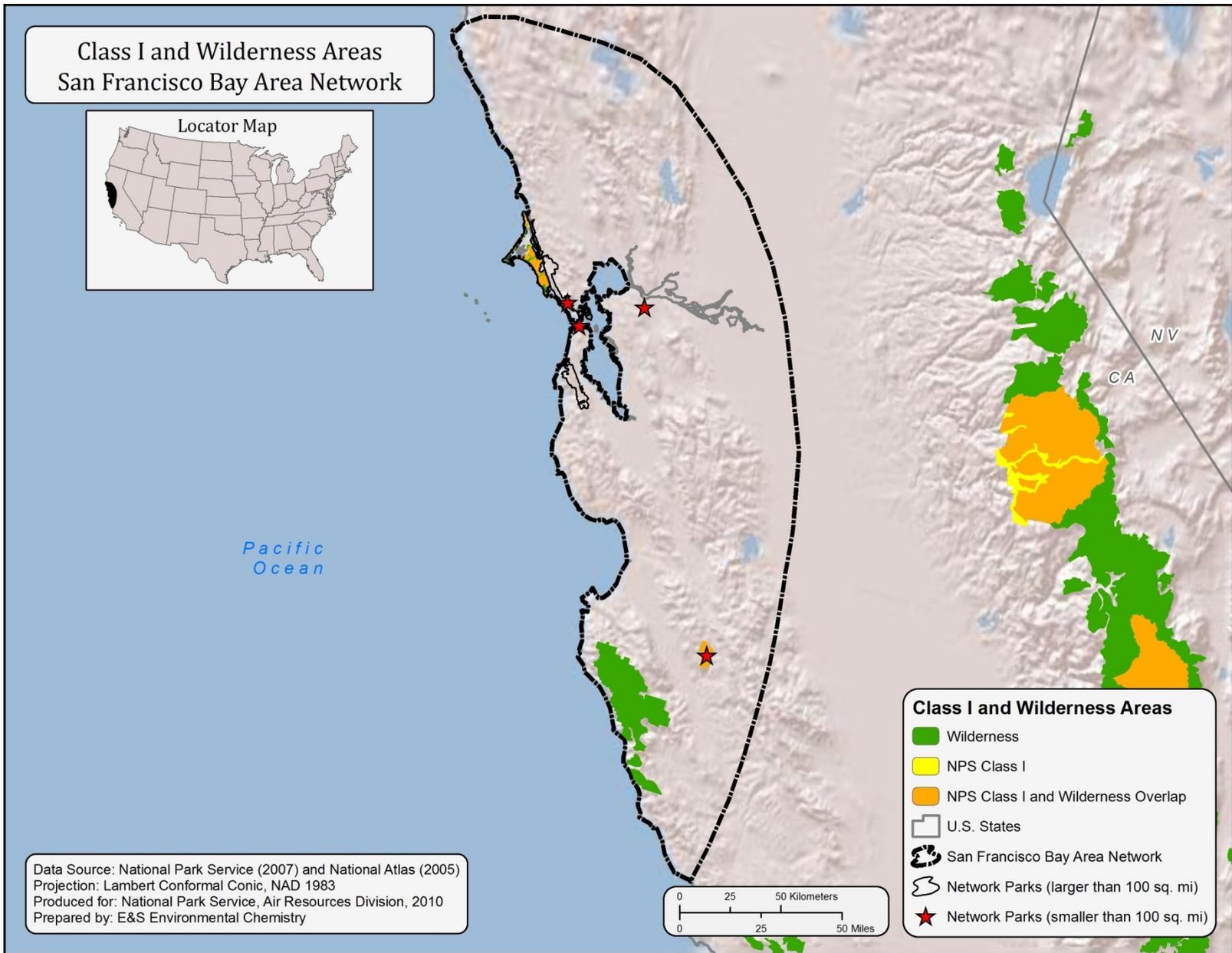
Map F



Map G



Map H



Map I

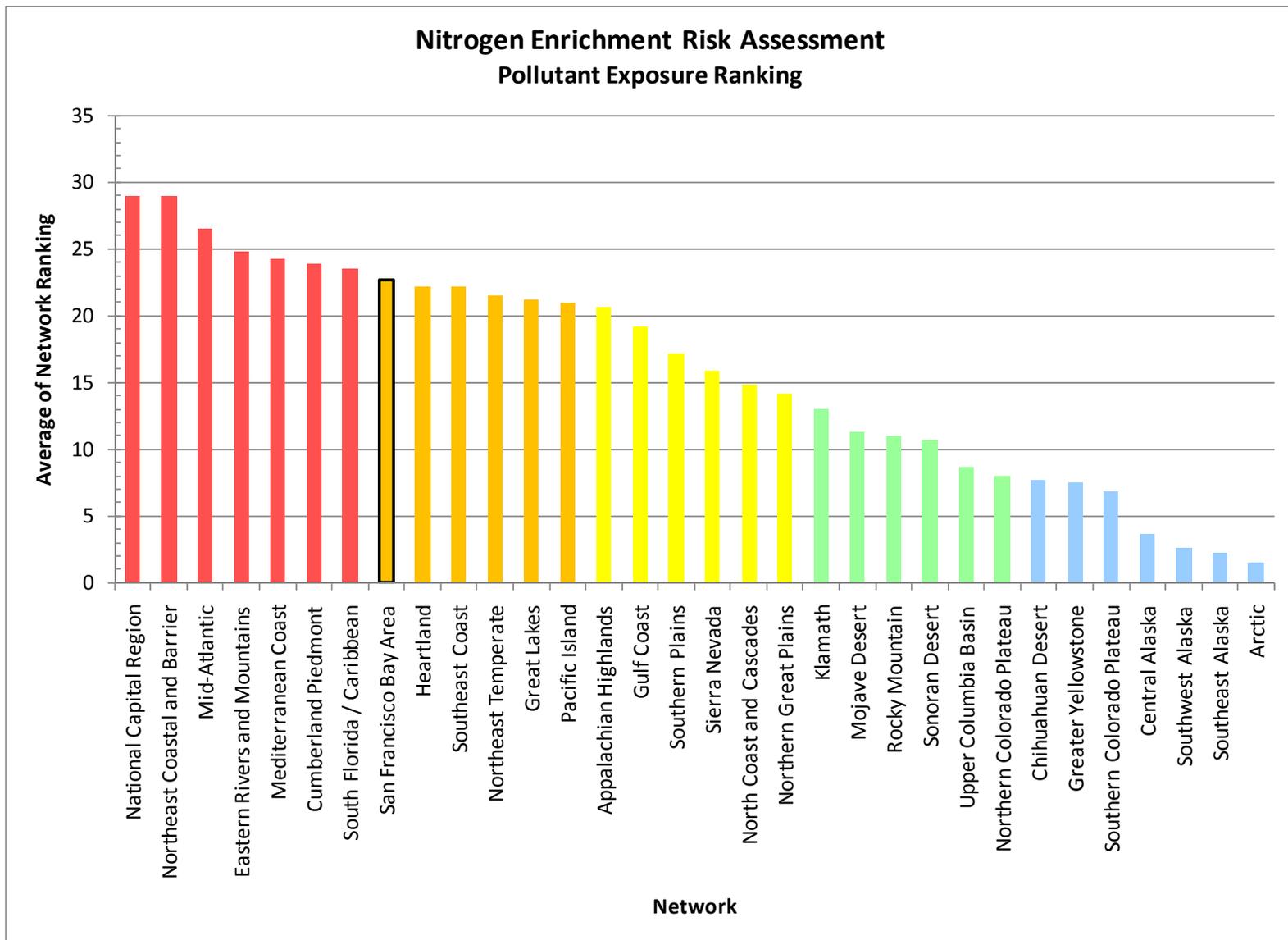


Figure A

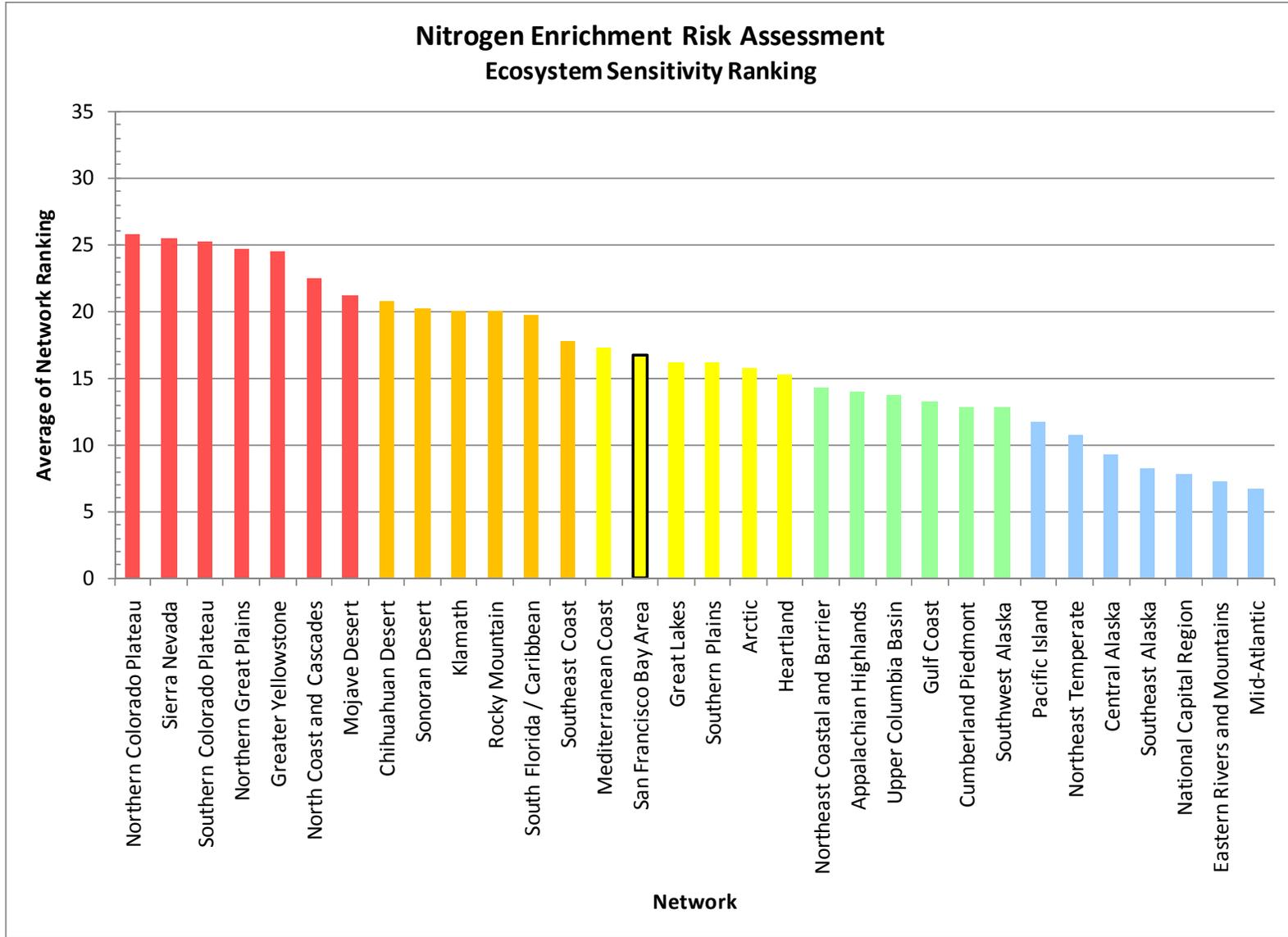


Figure B

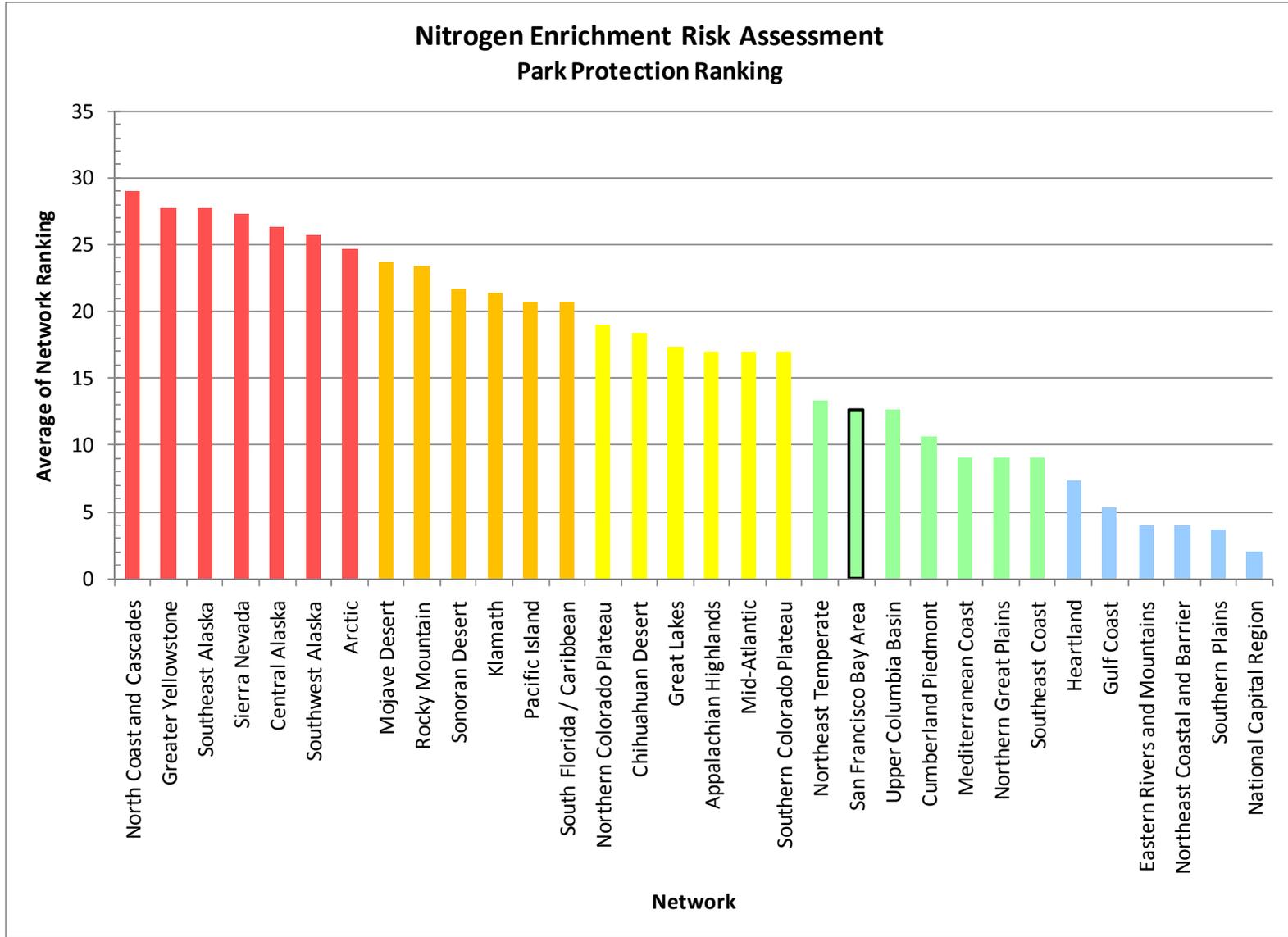


Figure C

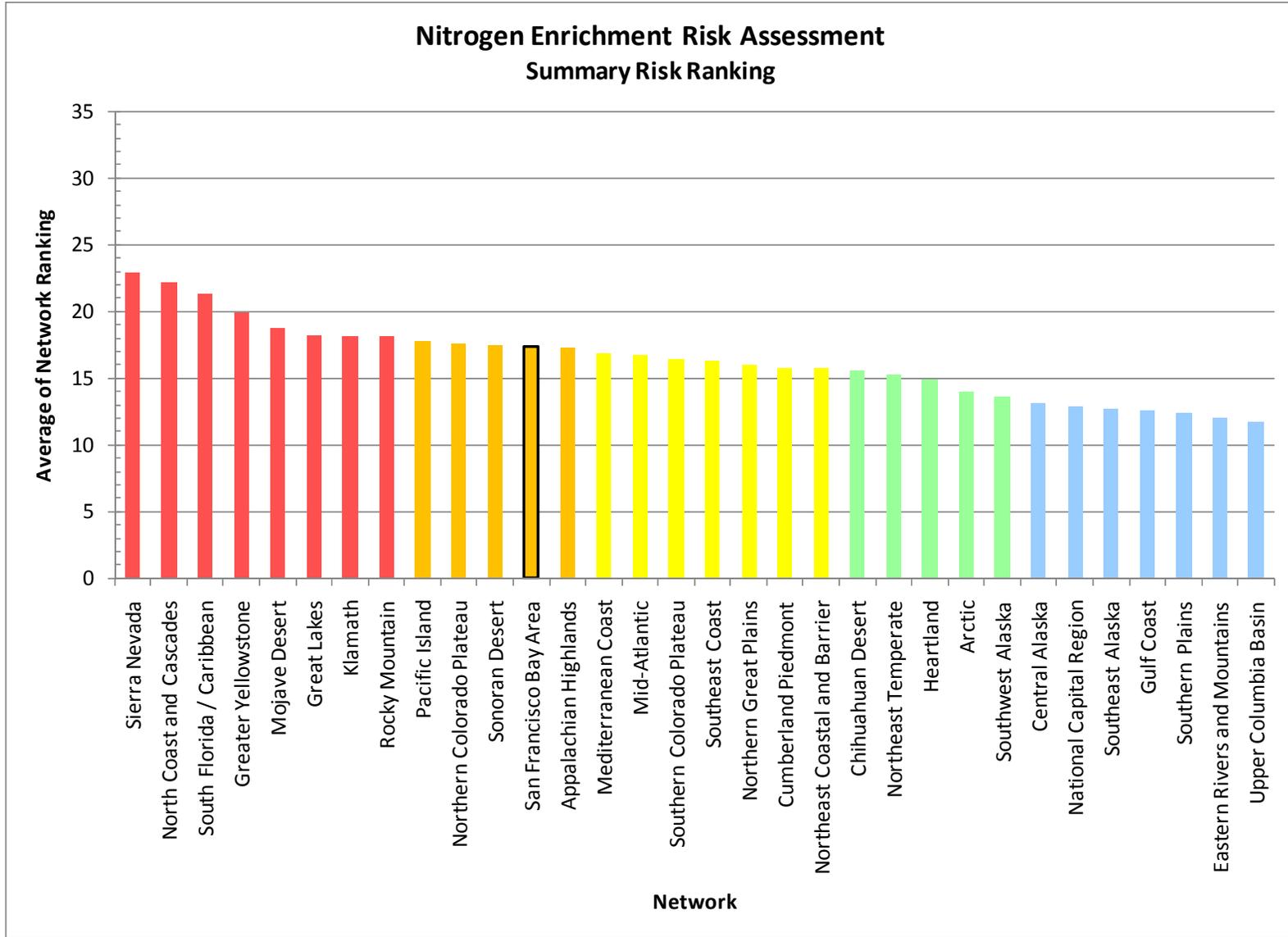


Figure D

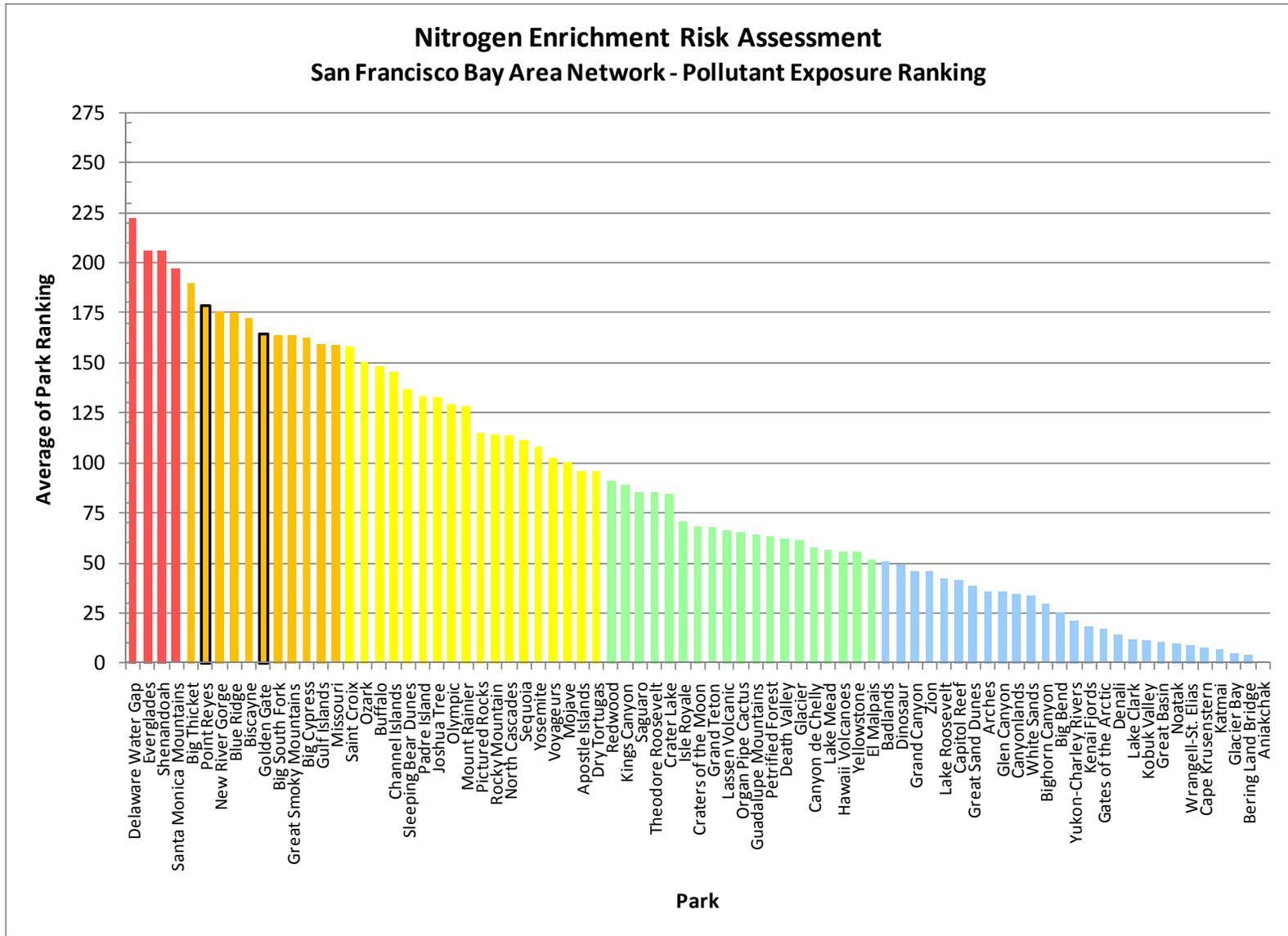


Figure E

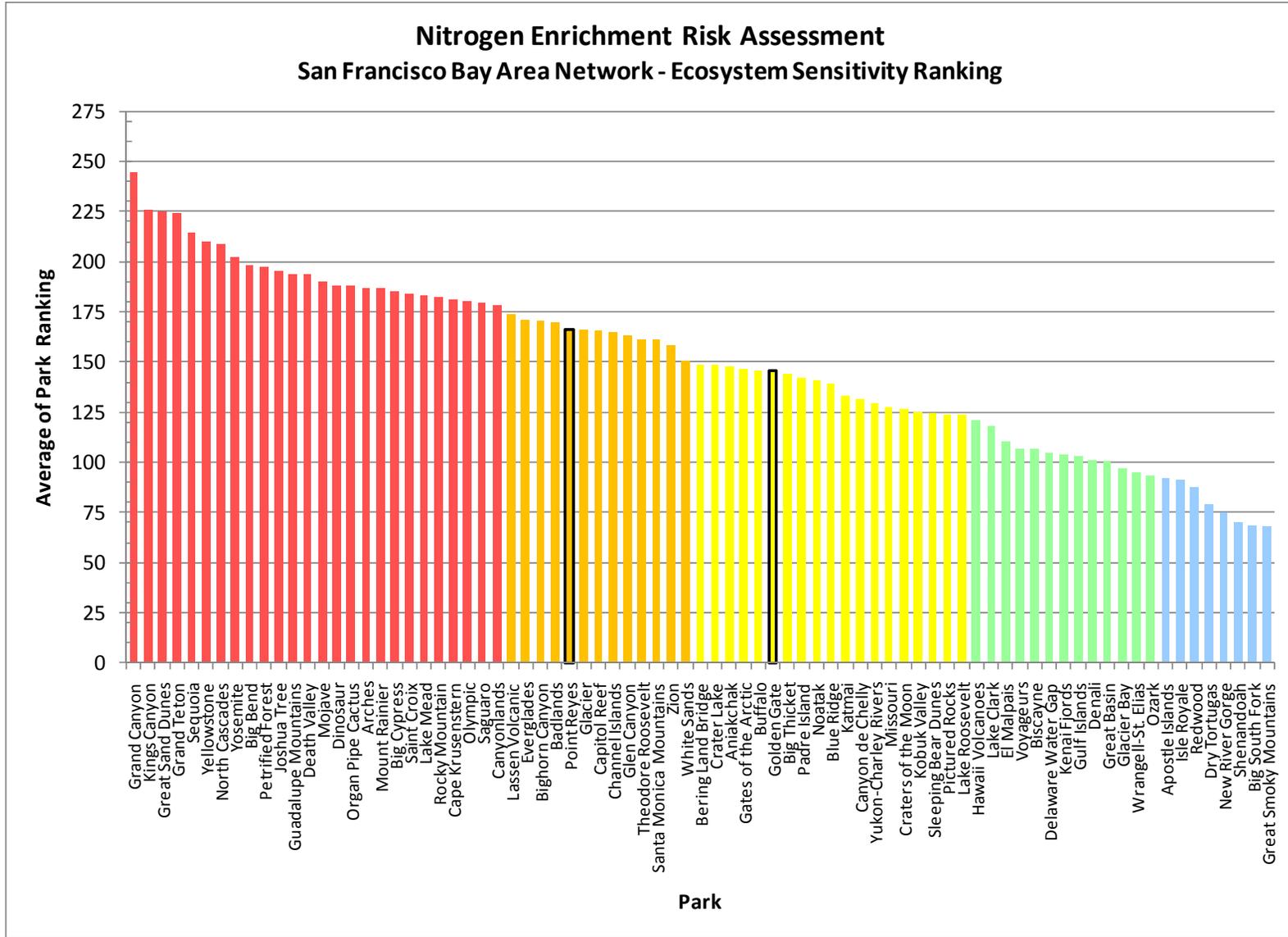


Figure F

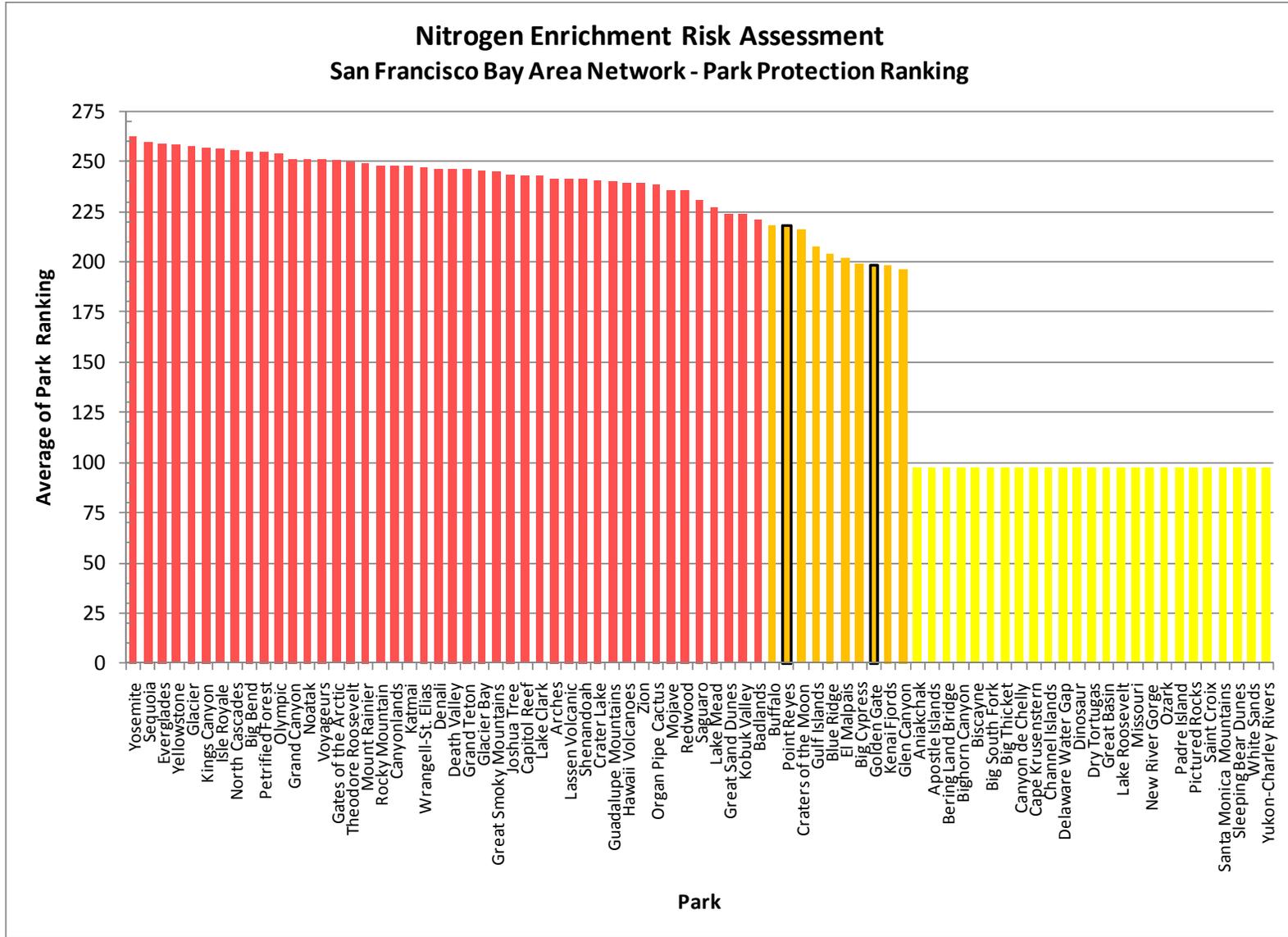


Figure G

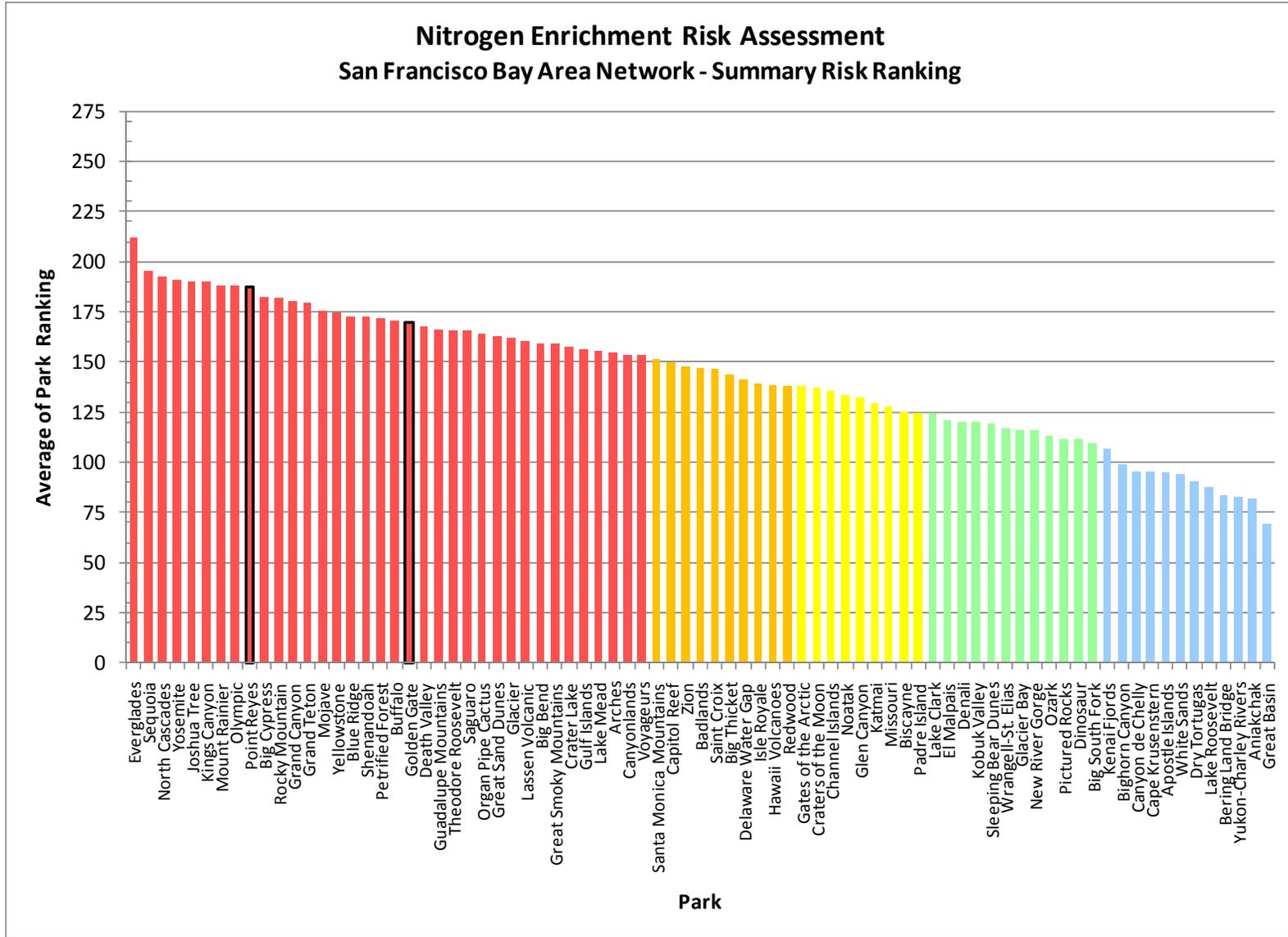


Figure H

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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