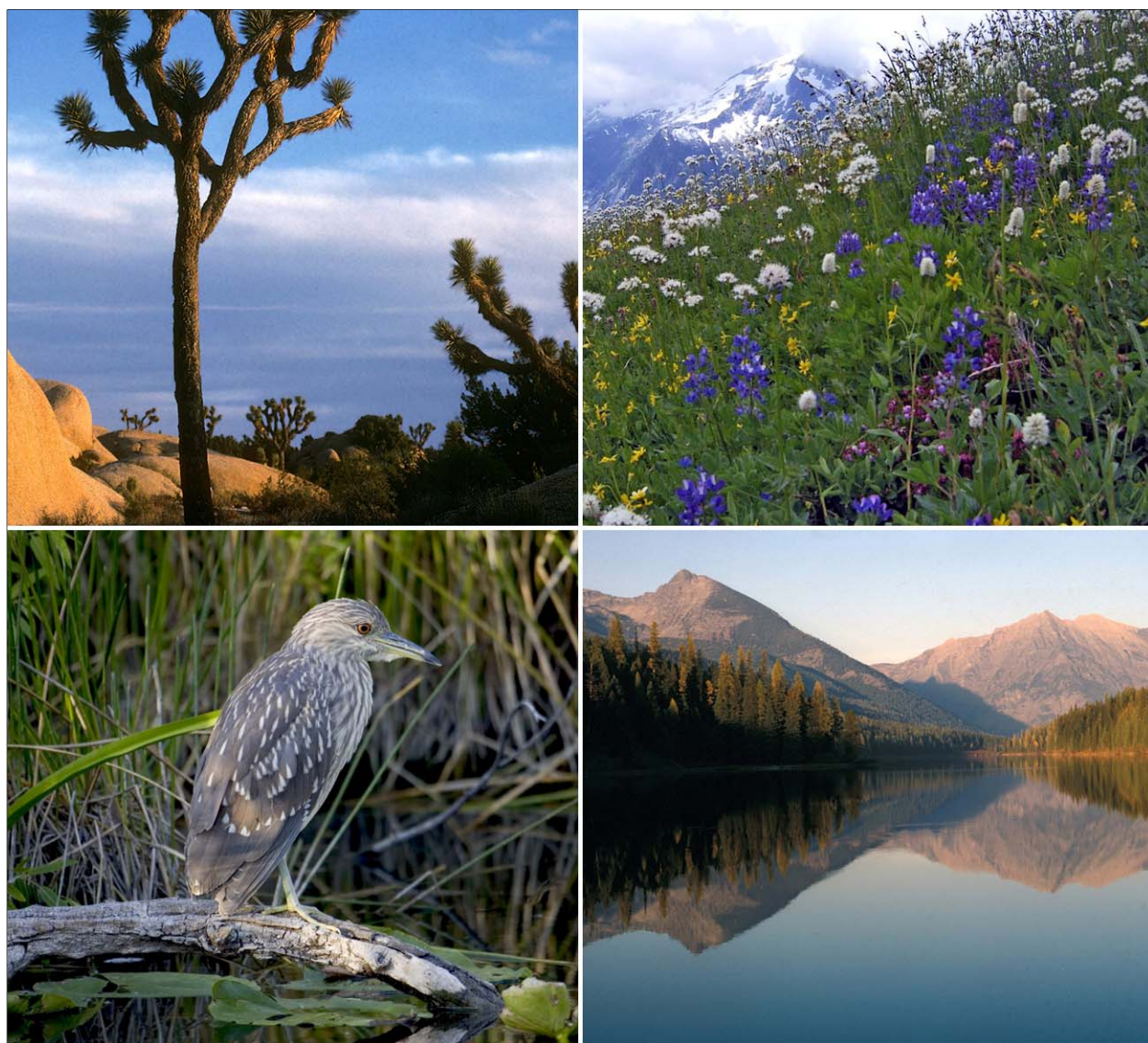




Evaluation of the Sensitivity of Inventory and Monitoring National Parks to Nutrient Enrichment Effects from Atmospheric Nitrogen Deposition

Sierra Nevada Network (SIEN)

Natural Resource Report NPS/NRPC/ARD/NRR—2011/326



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.

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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Sierra Nevada Network (SIEN)

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 four parks in the Sierra Nevada Network. Three of them (Kings Canyon, KICA; Sequoia, SEQU; and Yosemite, YOSE) are larger than 100 square miles. The one smaller park is Devils Postpile (DEPO).

Total annual N emissions, by county, are shown in Map C for lands in and surrounding the Sierra Nevada Network. County-level emissions within the network generally ranged from less than 1 ton per square mile in and around YOSE to 1 to 20 tons per square mile in and around Sequoia and Kings Canyon N.P. (SEKI). A small area of higher emissions occurs to the west. Annual county N emissions were less than 5 tons per square mile throughout much of the network. Emissions near SEQU were somewhat higher than that. Point source emissions of oxidized (nitrogen oxides, NO_x) and reduced (ammonia, NH_3) N are shown in Map D. There are very few point sources of N 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 are several human populations centers larger than 100,000 people within the network. There are also several large population centers outside of, but in proximity to, the network, including San Francisco, San Jose, and Los Angeles.

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 less than 2 kg N/ha/yr to higher than 10 kilograms N per hectare per year. Lands occupied by the I&M parks largely receive an estimated 2 to 5 kg N/ha/yr of total N deposition. Deposition in the western portion of SEQU is somewhat higher.

Land cover in and around the network is shown in Map G. The predominant cover types within this network are generally arranged in bands that run from north to south. Lands in and around the I&M parks are largely forested. To the west is a band of largely grassland/herbaceous land cover. To the west of that is a mix of row crops, pasture/hay, and developed areas.

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 grassland and meadow.

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. The three largest parks in the network are all Class I, and each is largely comprised of designated wilderness. In addition, most of the higher elevation areas of the Sierra Nevada within this network are designated wilderness, mostly managed by the USDA Forest Service.

Park-specific maps for YOSE and SEKI are shown in Maps J-1 through J-4. There are large areas of sensitive vegetation, including grassland and meadow, arid and semi-arid, and alpine vegetation types.

High-elevation lakes within these national parks, which might be more prone than lakes at lower elevation to N-limitation, and therefore potentially more susceptible to eutrophication in response to atmospheric N input, are shown in Maps J-3 and J-4. There are many high-elevation lakes in these parks. Many of those might be expected to be N-limited.

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 Sierra Nevada Network ranks near the median, in the third quintile, among networks, in N Pollutant Exposure (Figure A). Nitrogen emissions and N deposition within the network are both moderate. However, the network Ecosystem Sensitivity ranking is very high, the second highest among the 32 I&M networks (Figure B). This is mainly because there are many high elevation lakes in the parks that occur in this network, and there is considerable vegetation coverage in the I&M parks in the network that includes some vegetation types that are among those expected to be especially sensitive to nutrient enrichment effects from N deposition. This network ranks in the highest quintile in Park Protection, having substantial 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 the highest of the 32 I&M 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.

The four I&M parks in the Sierra Nevada Network are ranked low (DEPO, KICA) or Moderate (SEQU and YOSE) in Pollutant Exposure (Figure E, Table A). Ecosystem Sensitivity for all three of the larger parks is ranked in the highest quintile (Figure F), in part because all three contain high elevation lakes. The smaller park (DEPO) is ranked in the second lowest quintile for Ecosystem Sensitivity (Table A). Park Protection rankings for all four parks are in the highest quintile (Figure G, Table A).

In combination, the Pollutant Exposure, Ecosystem Sensitivity, and Park Protection rankings yield an overall Summary Park Risk ranking for each of these three large parks that is among the highest of all of the larger I&M parks (Figure H). The Summary Risk ranking for DEPO is only Moderate (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.

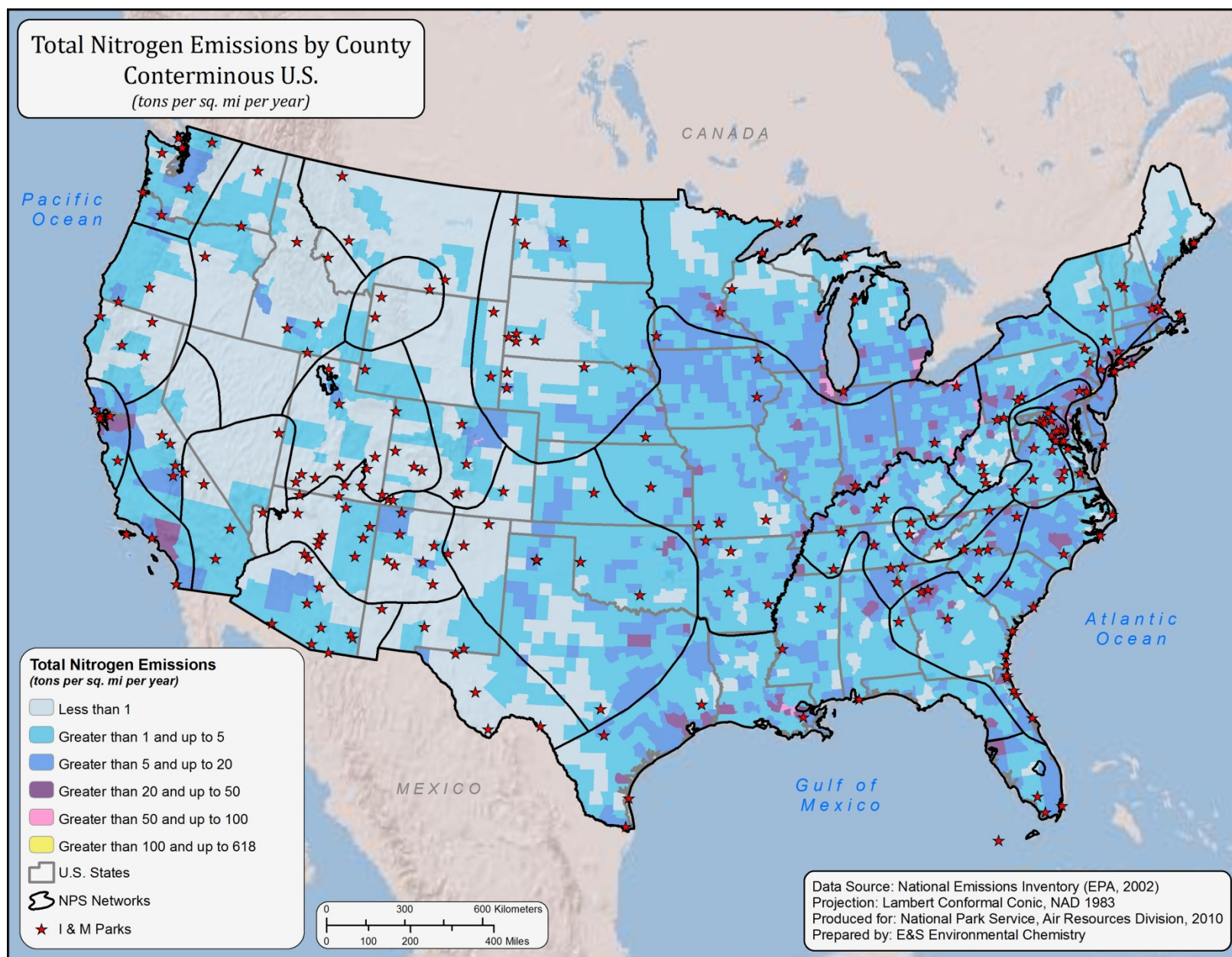
I&M Parks ² in Network	Relative Ranking of Individual Parks ¹			
	Pollutant Exposure	Ecosystem Sensitivity	Park Protection	Summary Risk
Devils Postpile	Low	Low	Very High	Moderate
<i>Kings Canyon</i>	Low	Very High	Very High	Very High
<i>Sequoia</i>	Moderate	Very High	Very High	Very High
<i>Yosemite</i>	Moderate	Very High	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.

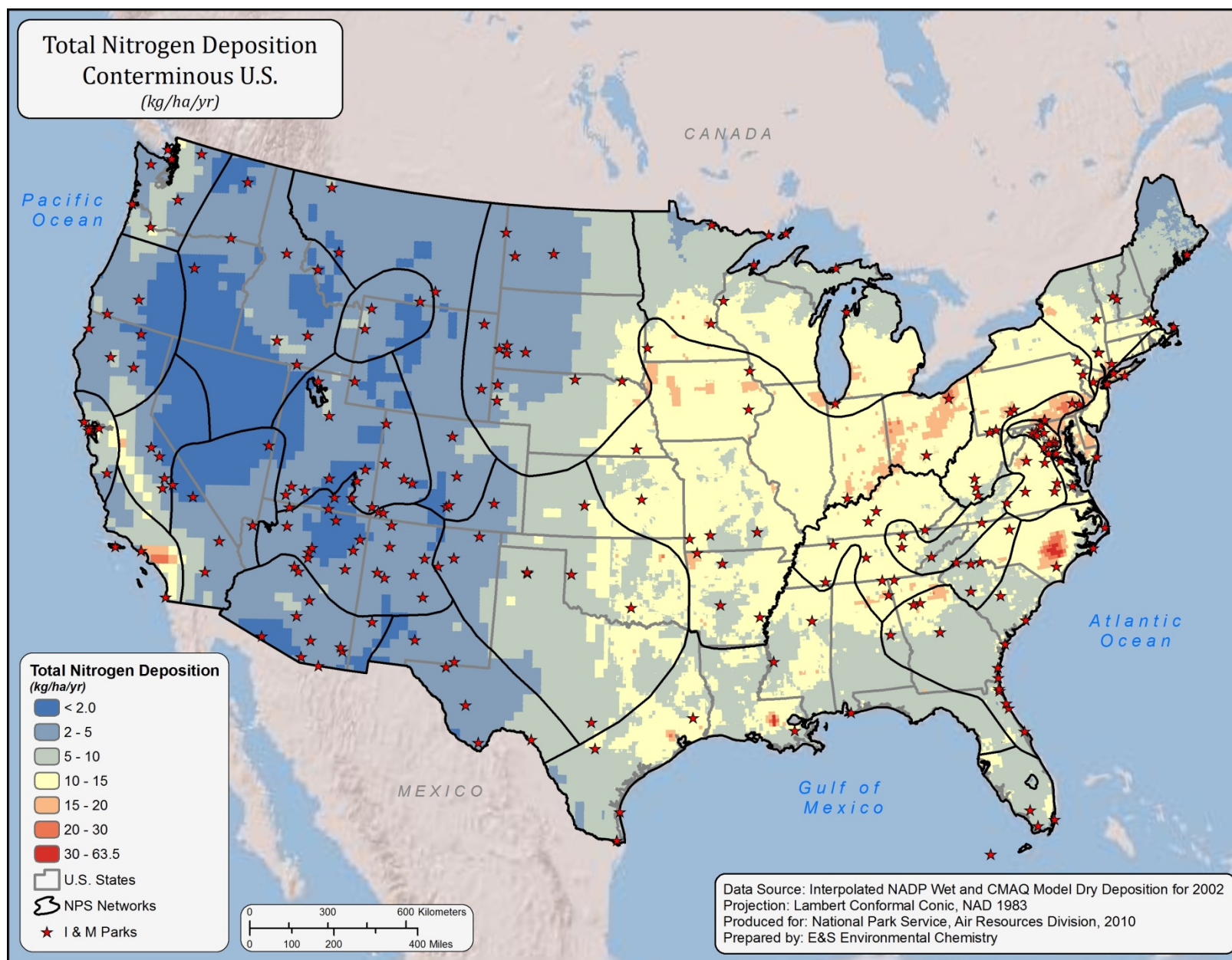
- Map A. National map of total N emissions by county for the year 2002. Both oxidized (nitrogen oxides, NO_x) and reduced (ammonia, NH₃) forms of N are included. The total is expressed in tons per square mile per year. (Source of data: EPA National Emissions Inventory, <http://www.epa.gov/ttn/chief/net/2002inventory.html>)
- 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: 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)
- Map J-1. Park-specific map: sensitive vegetation types in YOSE. (Source of data: See Appendix A)
- Map J-2. Park-specific map: sensitive vegetation types in SEKI. (Source of data: See Appendix A)
- Map J-3. Park-specific map: high-elevation lakes in YOSE. (Source of data: U.S. EPA National Elevation Dataset and U.S. EPA/USGS National Hydrography Dataset Plus [<http://www.horizon-systems.com/nhdplus/>])
- Map J-4. Park-specific map: high-elevation lakes in SEKI. (Source of data: U.S. EPA National Elevation Dataset and U.S. EPA/USGS National Hydrography Dataset Plus [<http://www.horizon-systems.com/nhdplus/>])
- 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.

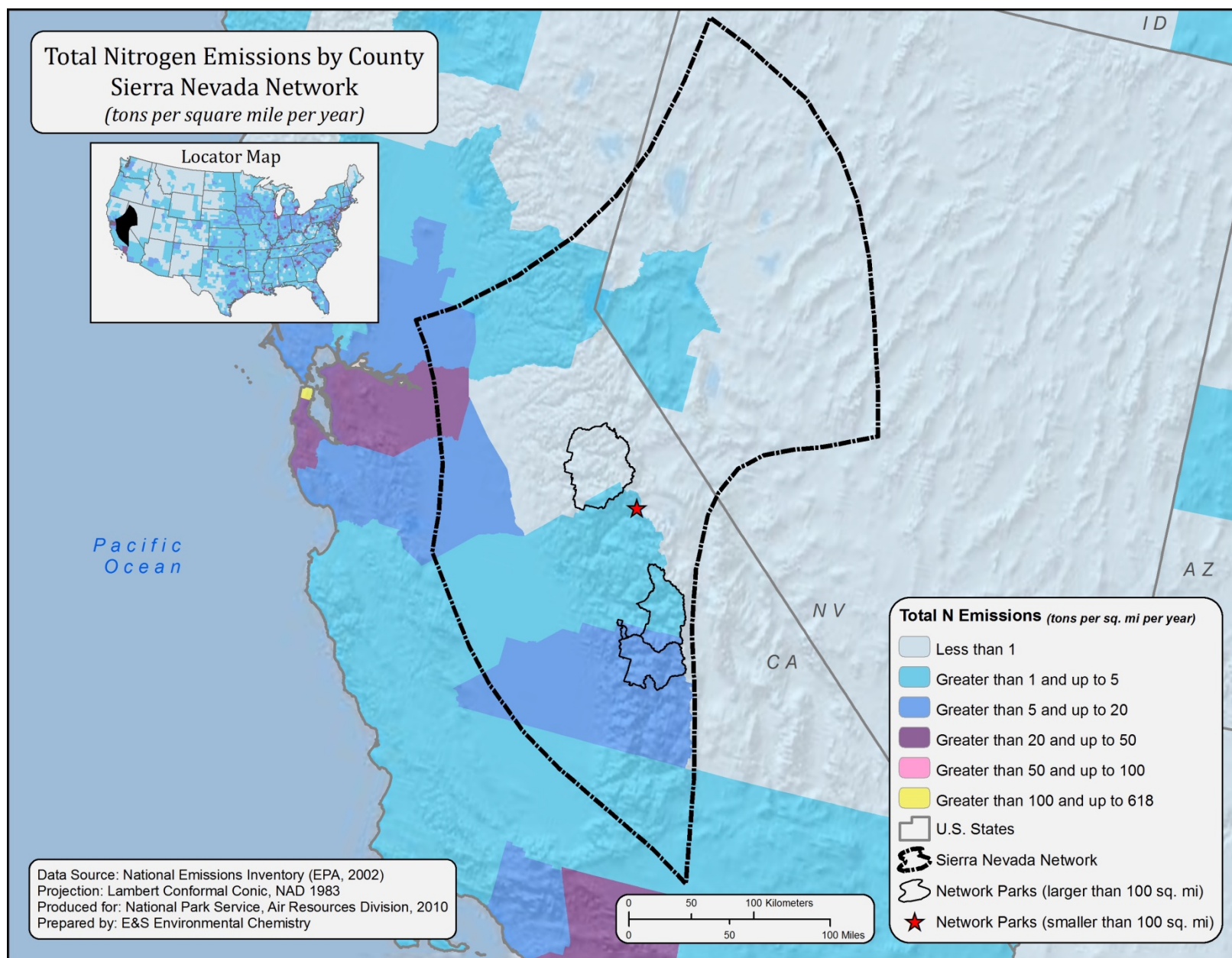
- Figure F. Park rankings for Ecosystem Sensitivity for all parks larger than 100 square miles. Ranks for each park were calculated relative to all parks, regardless of size, as the average of scores for all Ecosystem Sensitivity variables.
- Figure G. Park rankings for Park Protection for all parks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



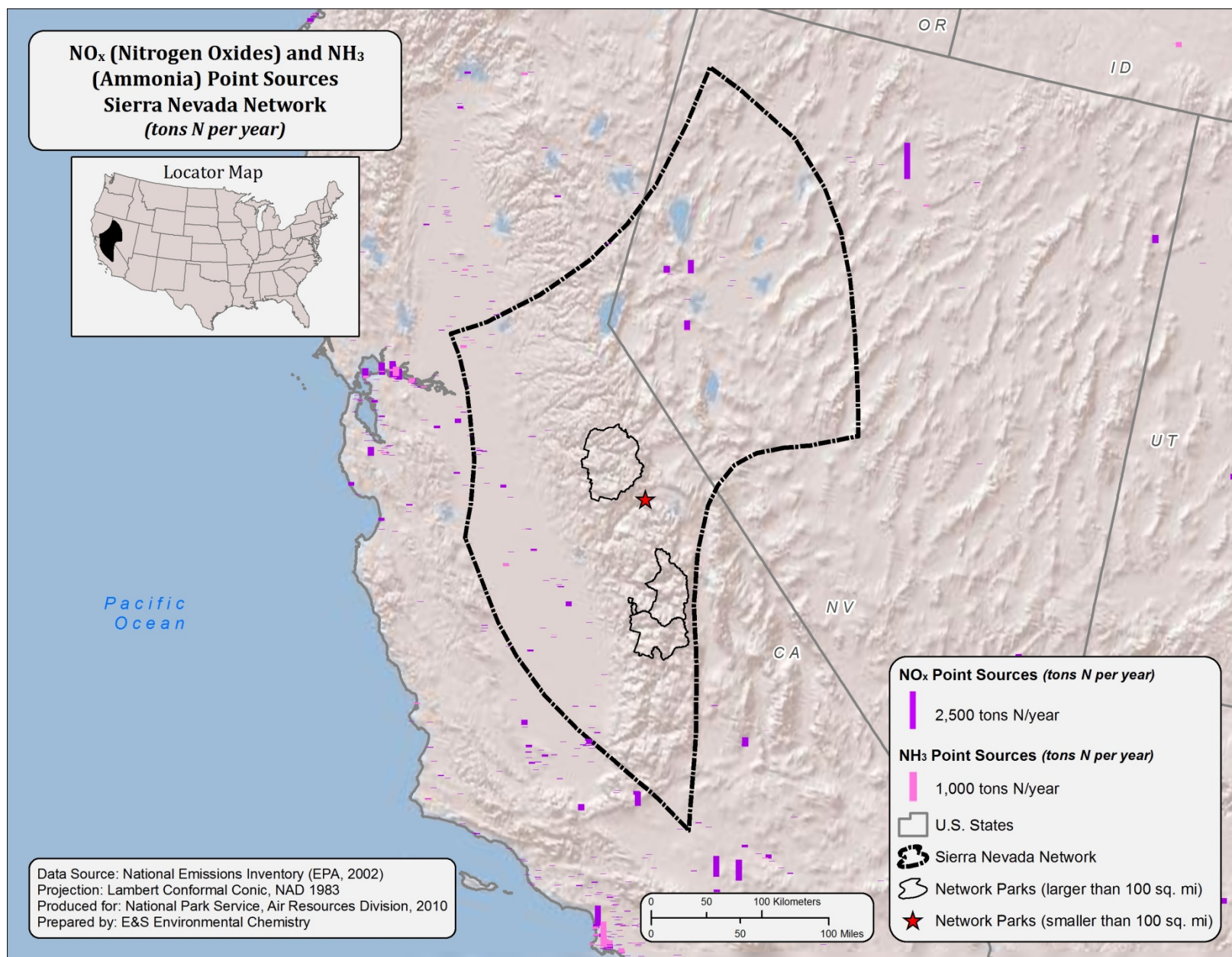
Map A



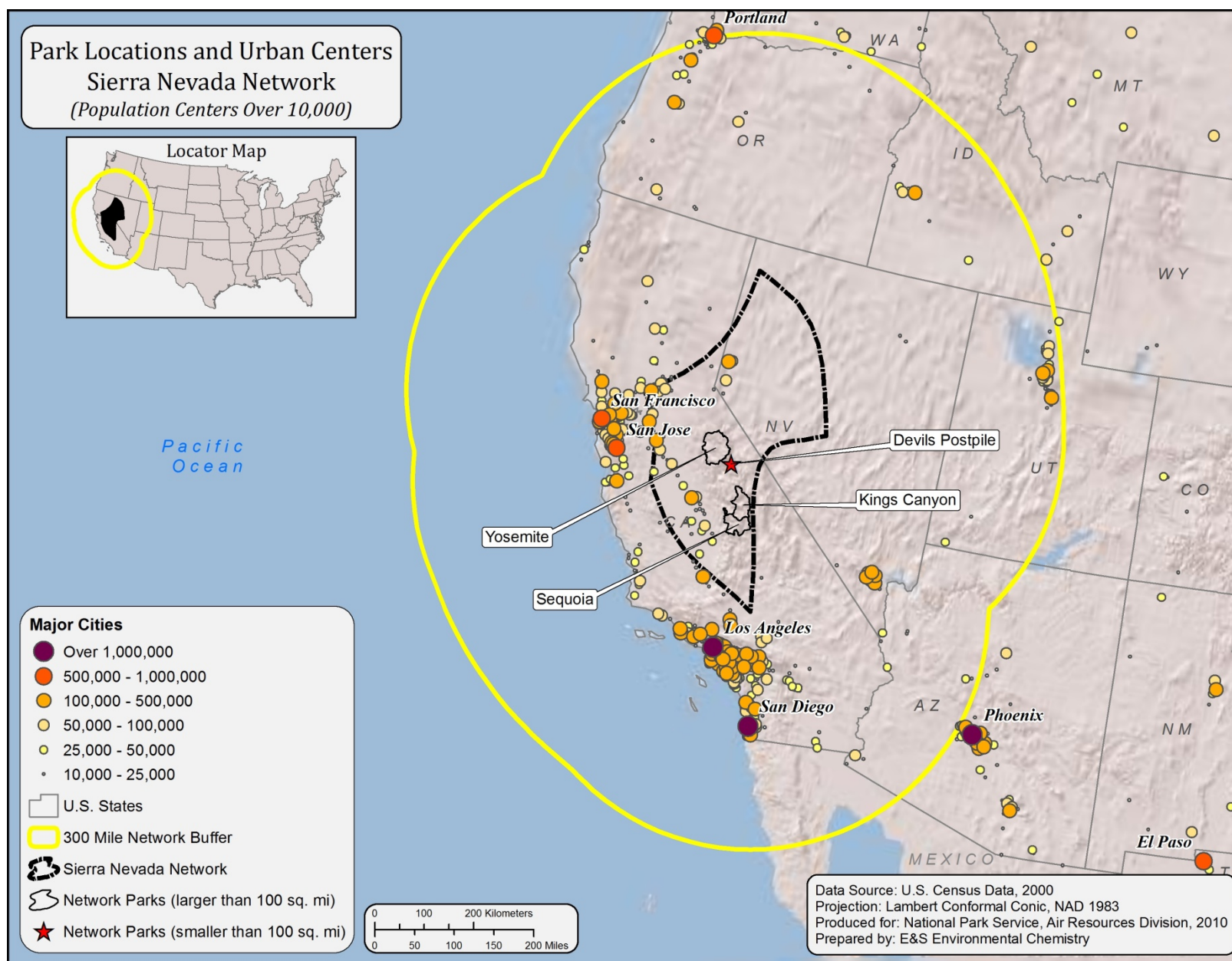
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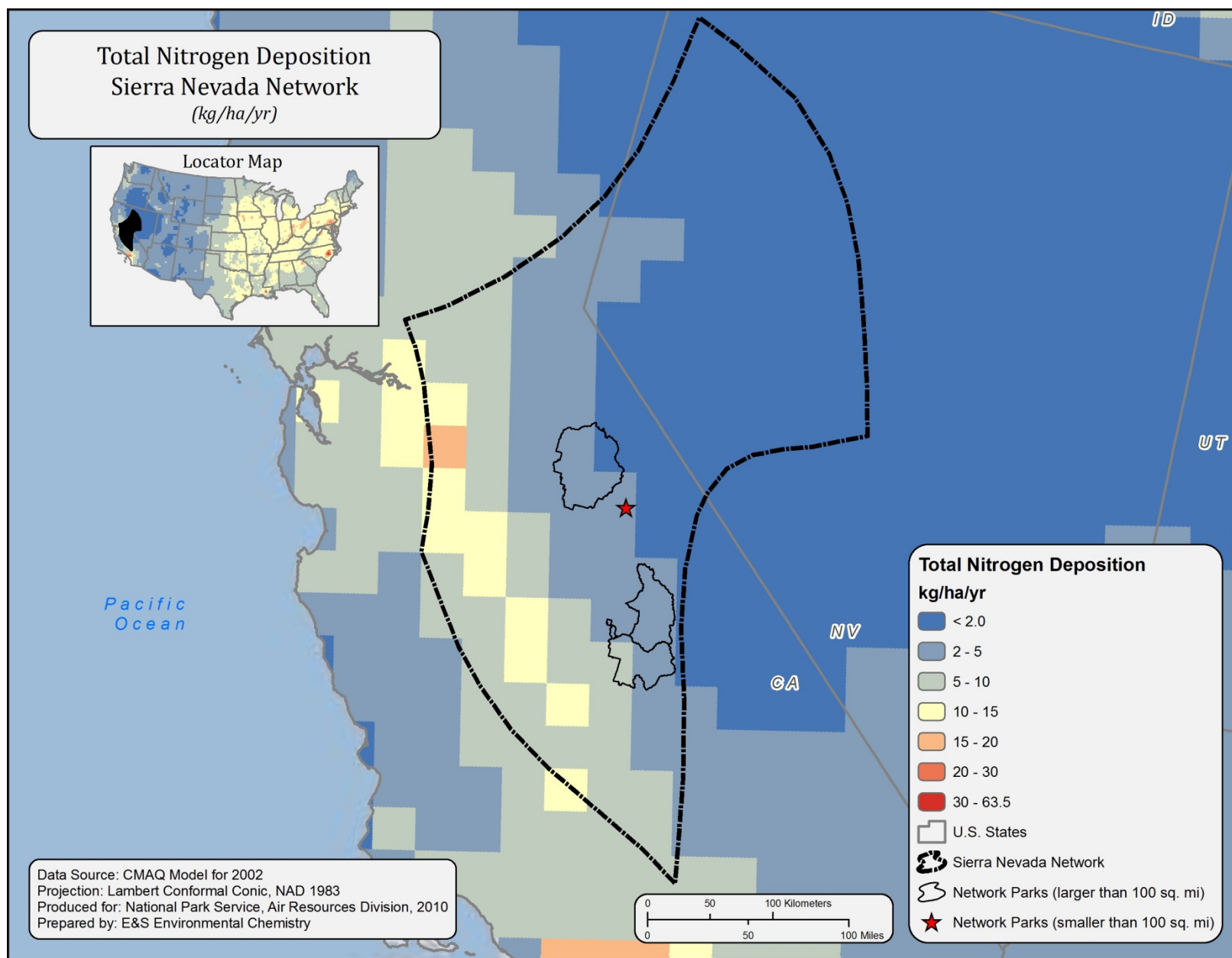
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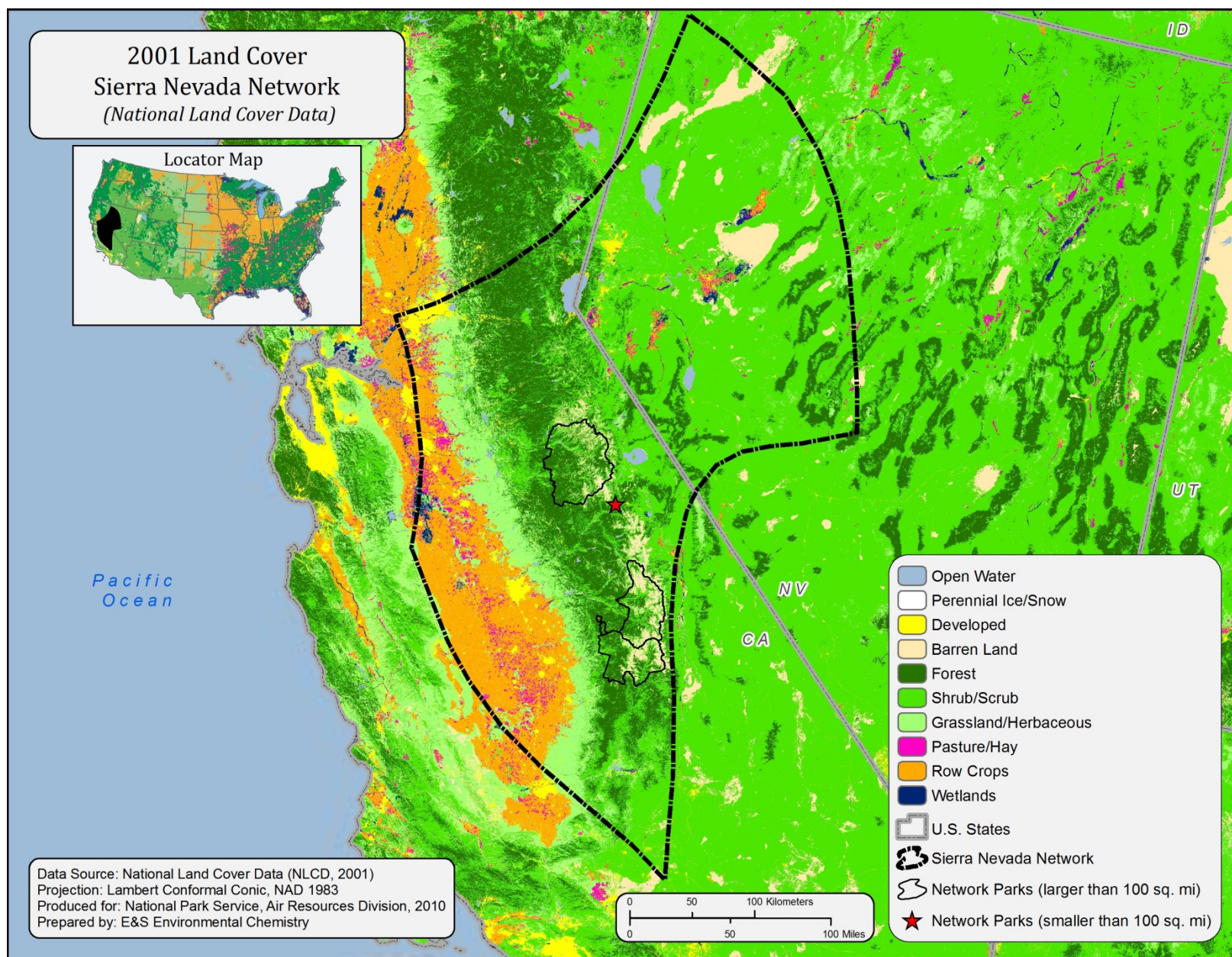
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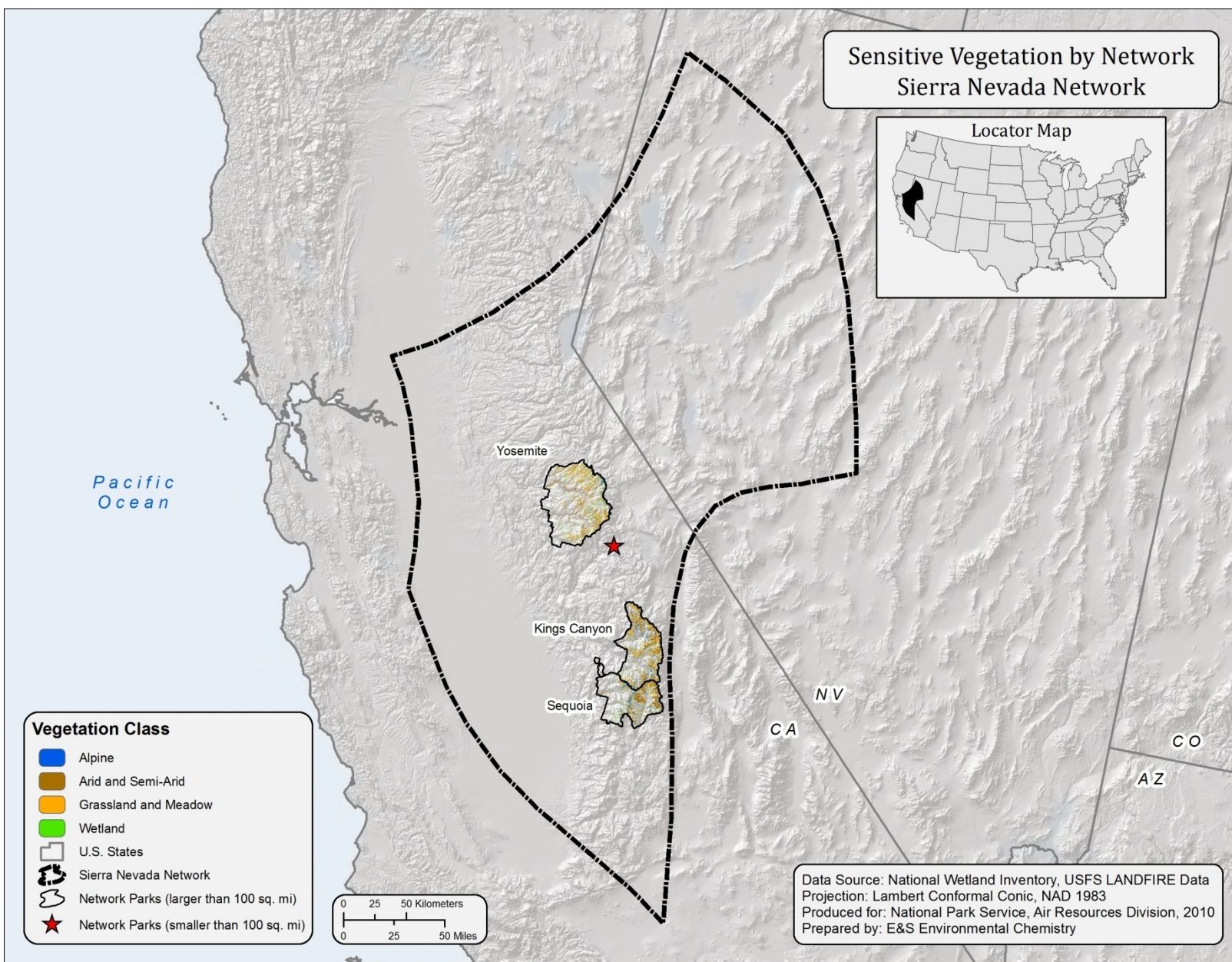
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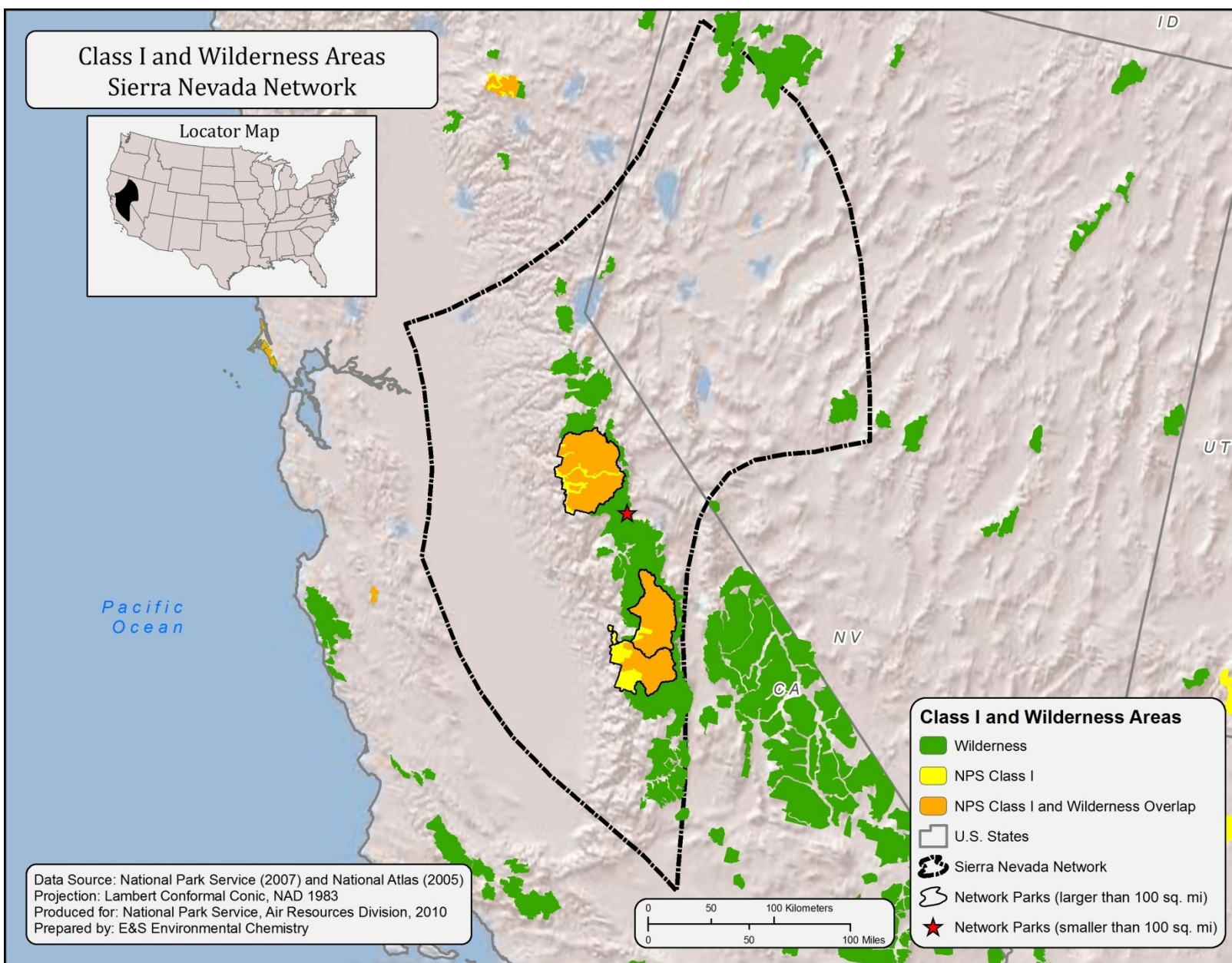
Map F



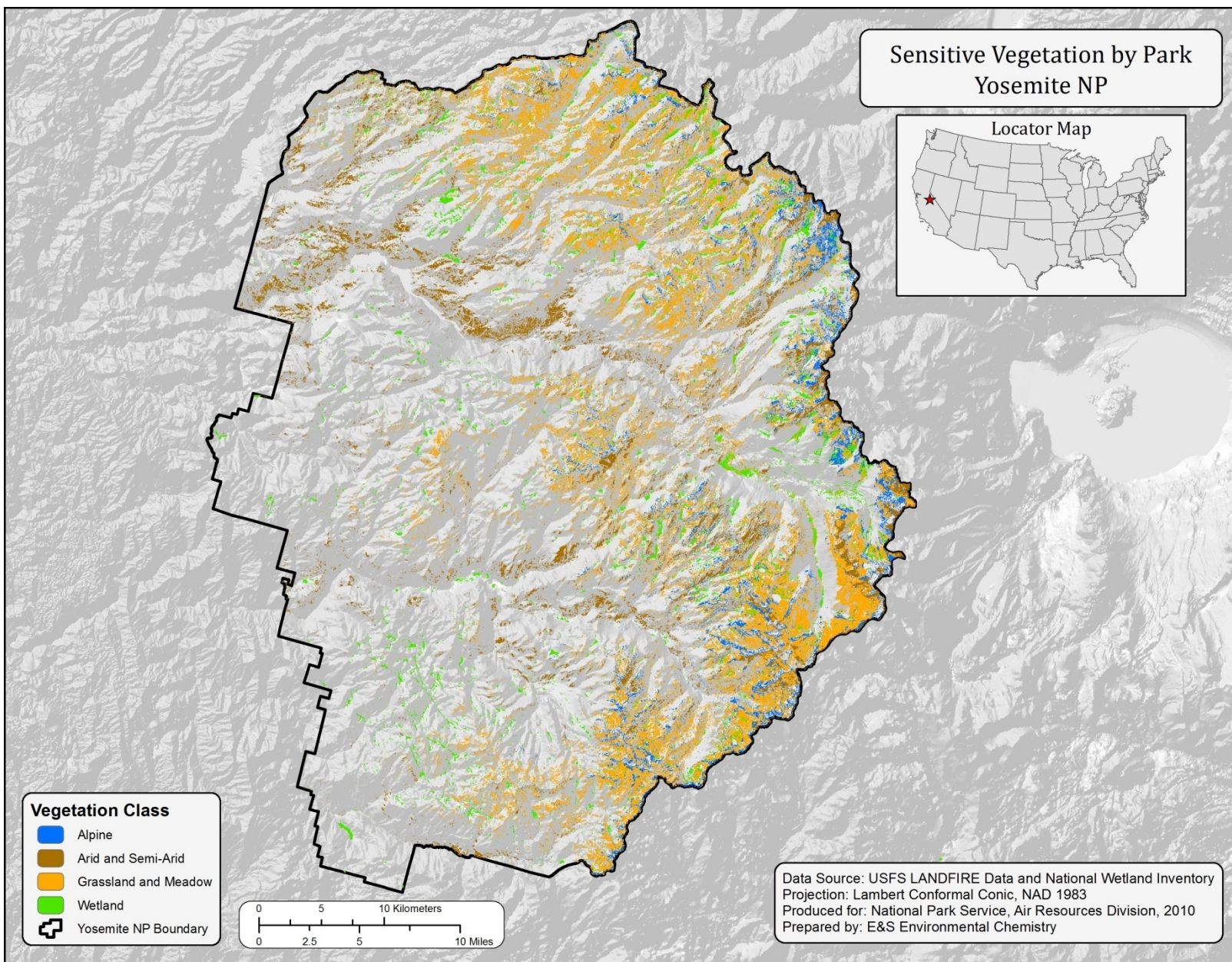
Map G



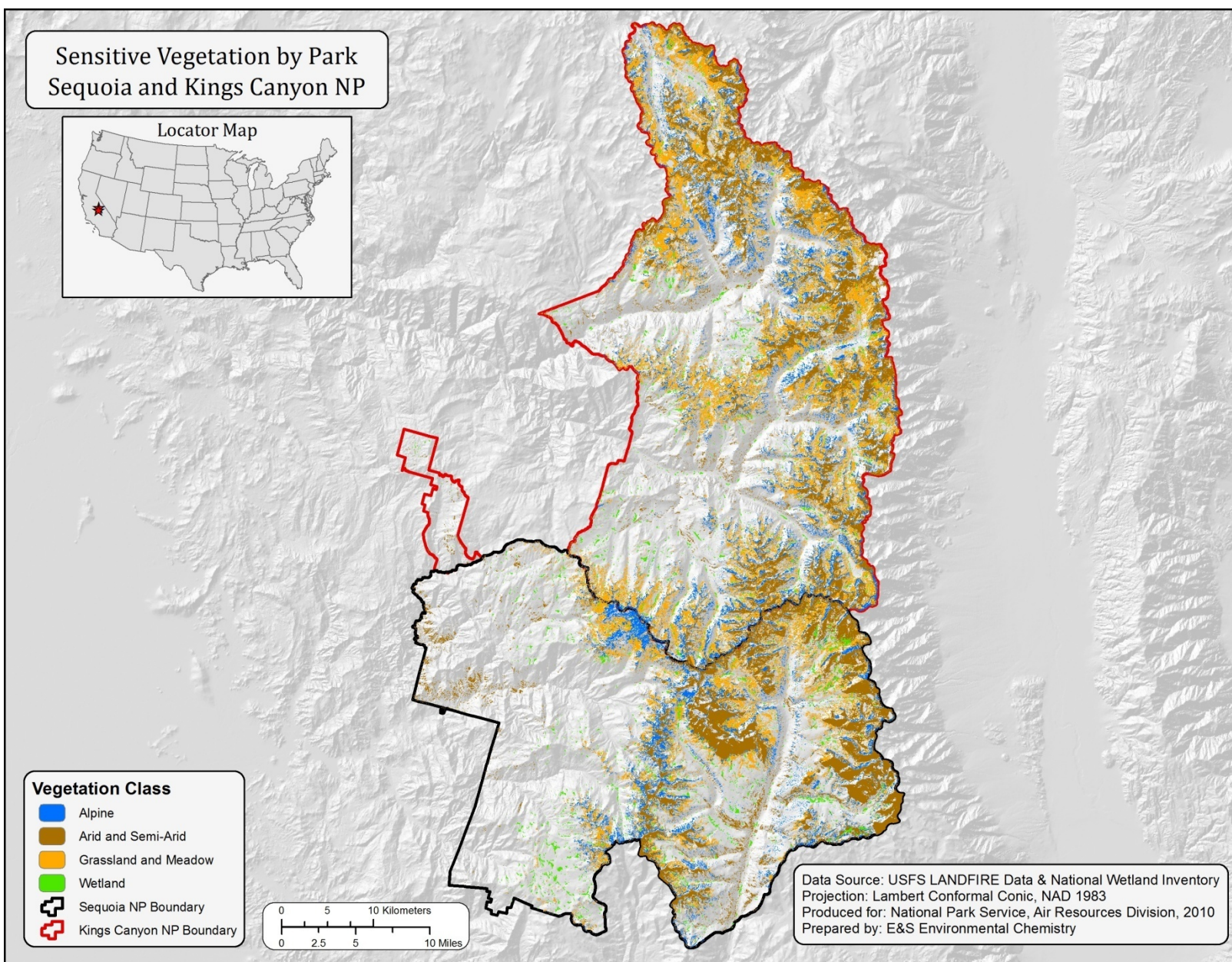
Map H



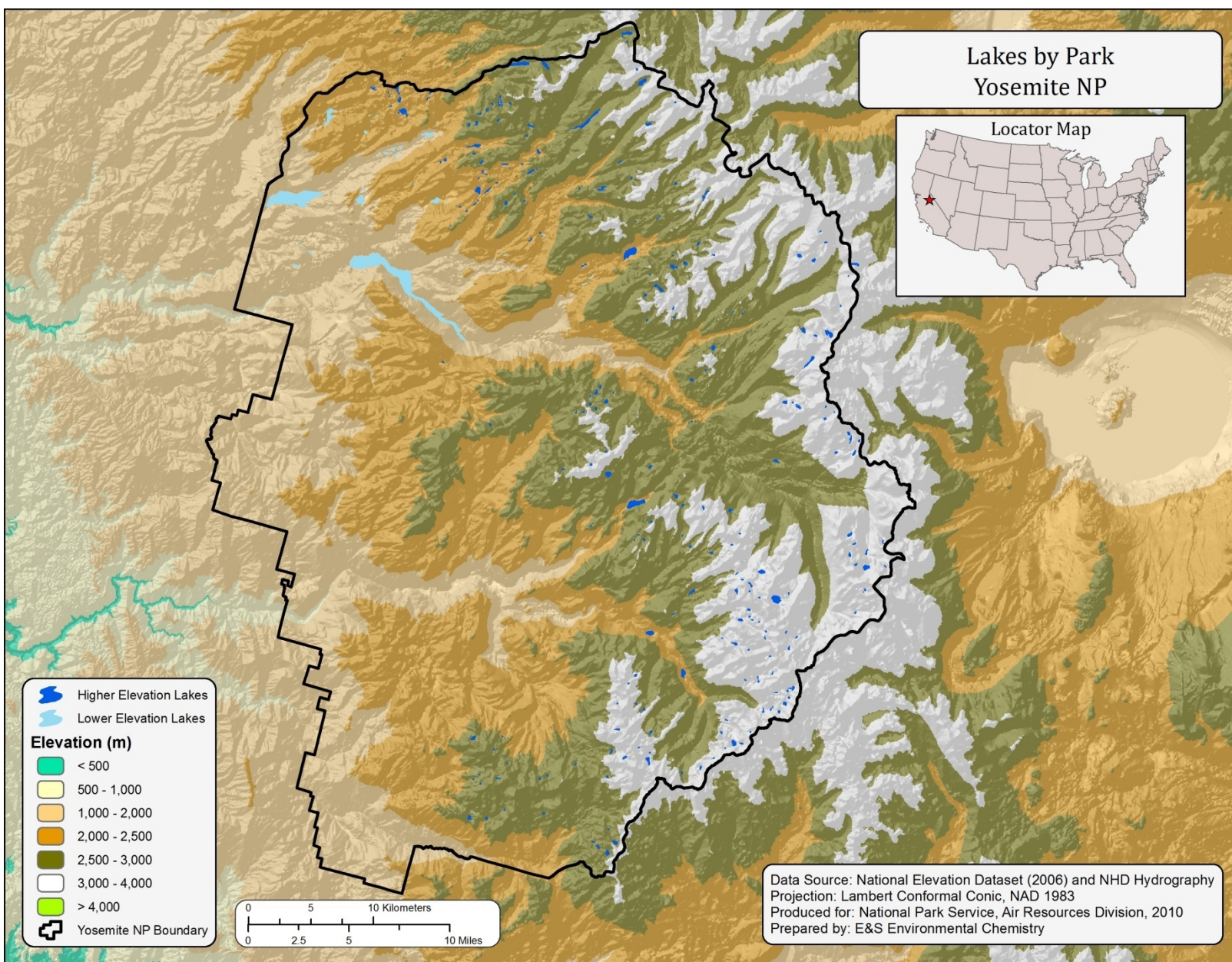
Map I



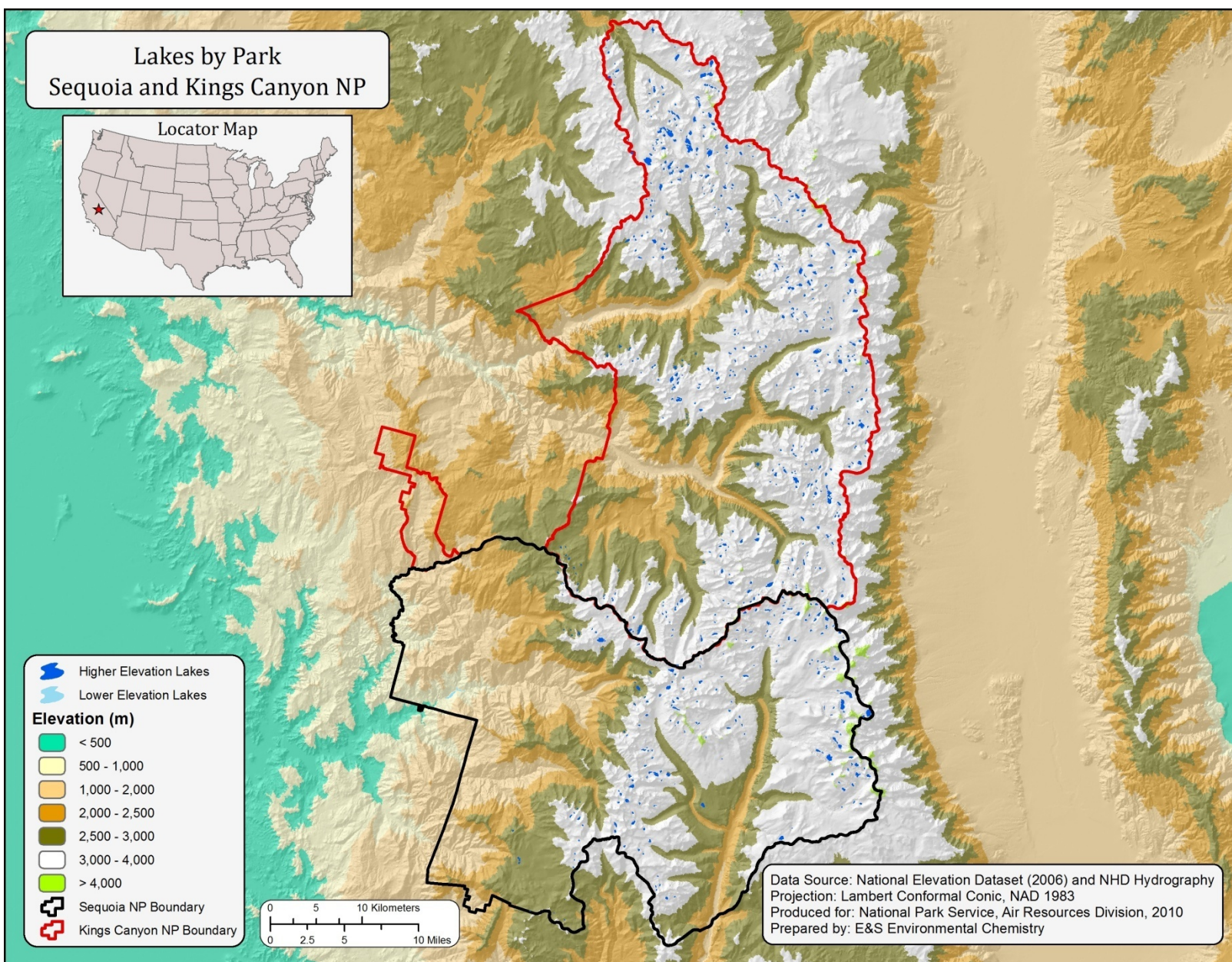
Map J-1



Map J-2



Map J-3



Map J-4

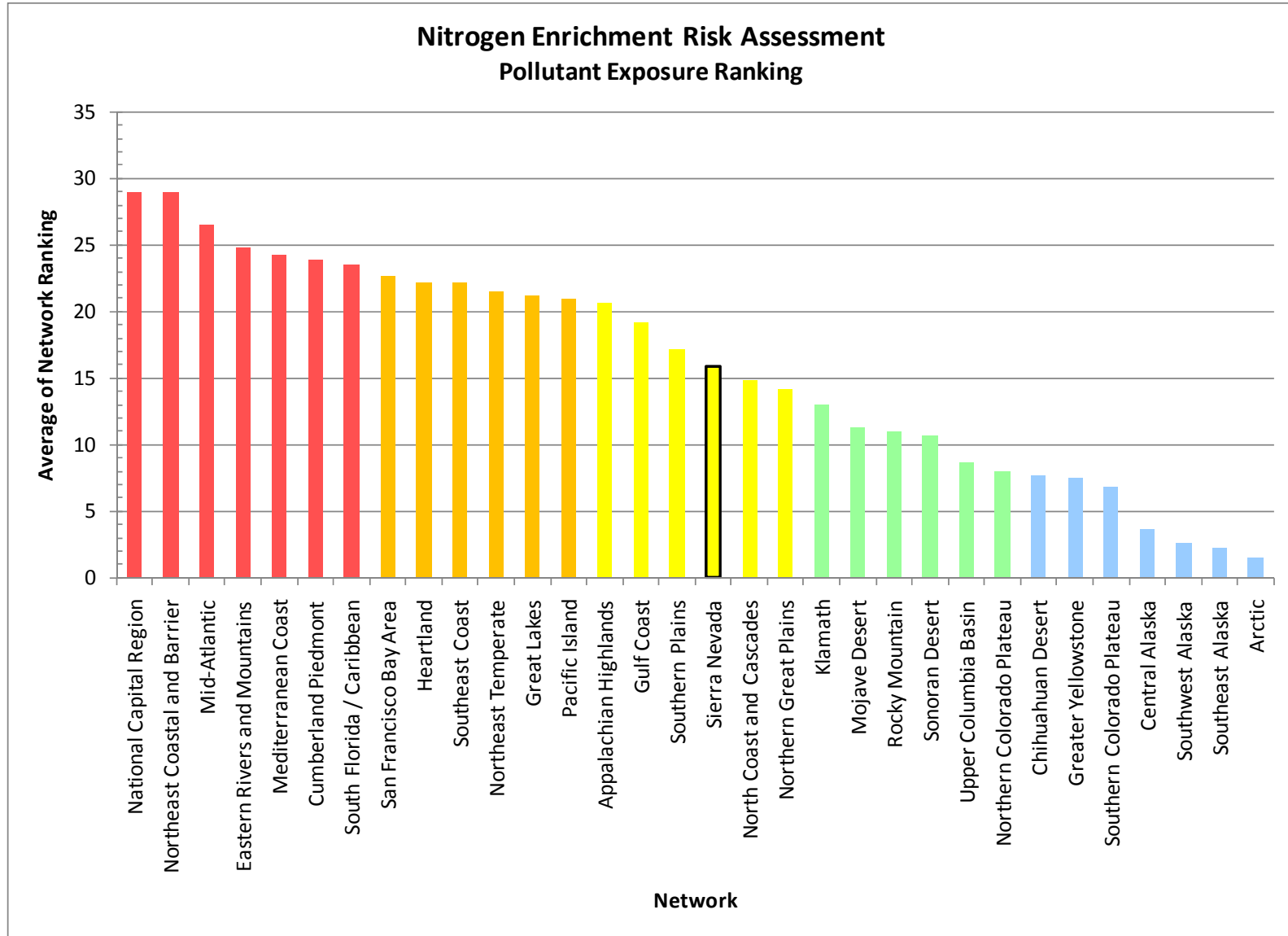


Figure A

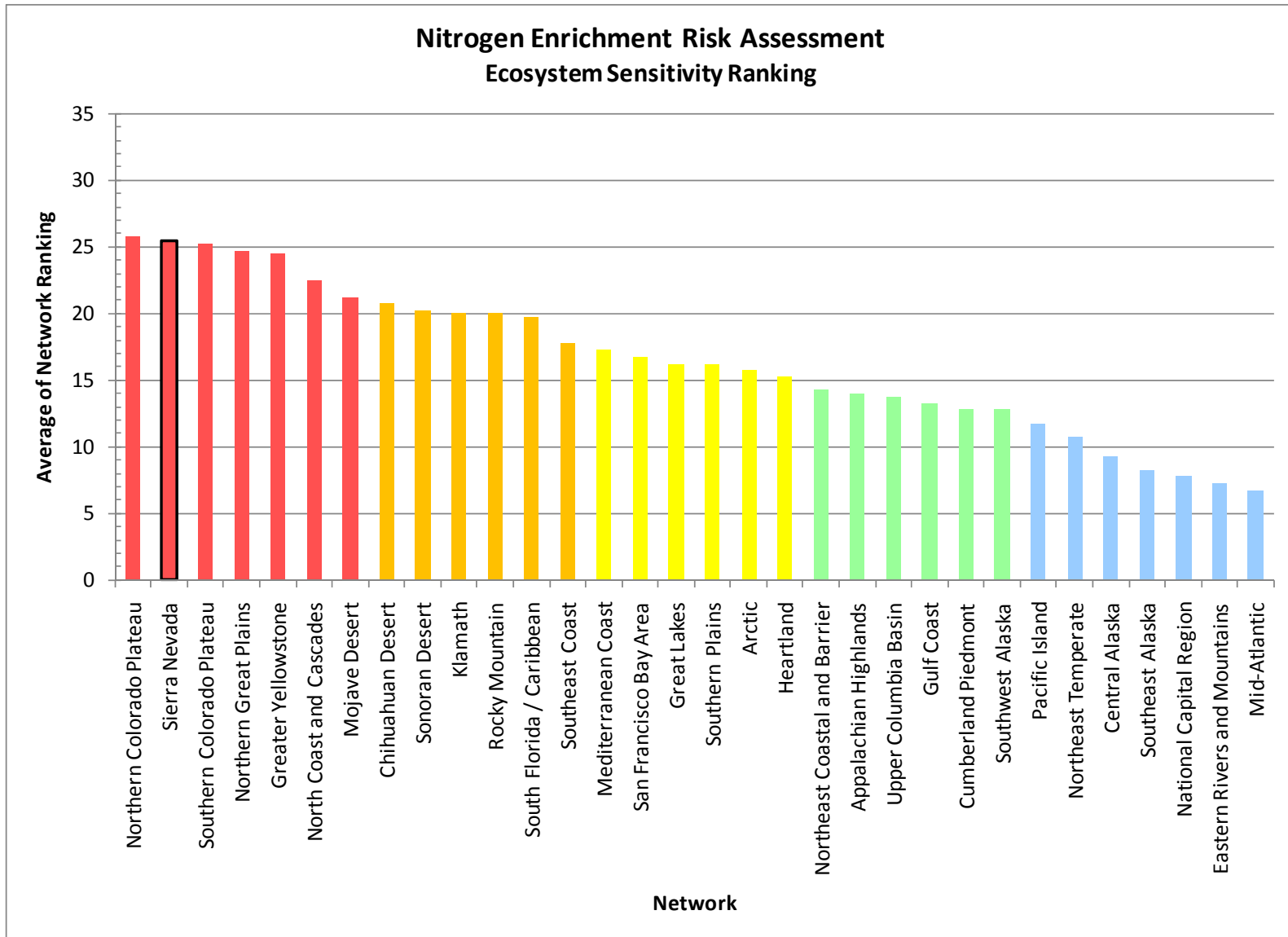


Figure B

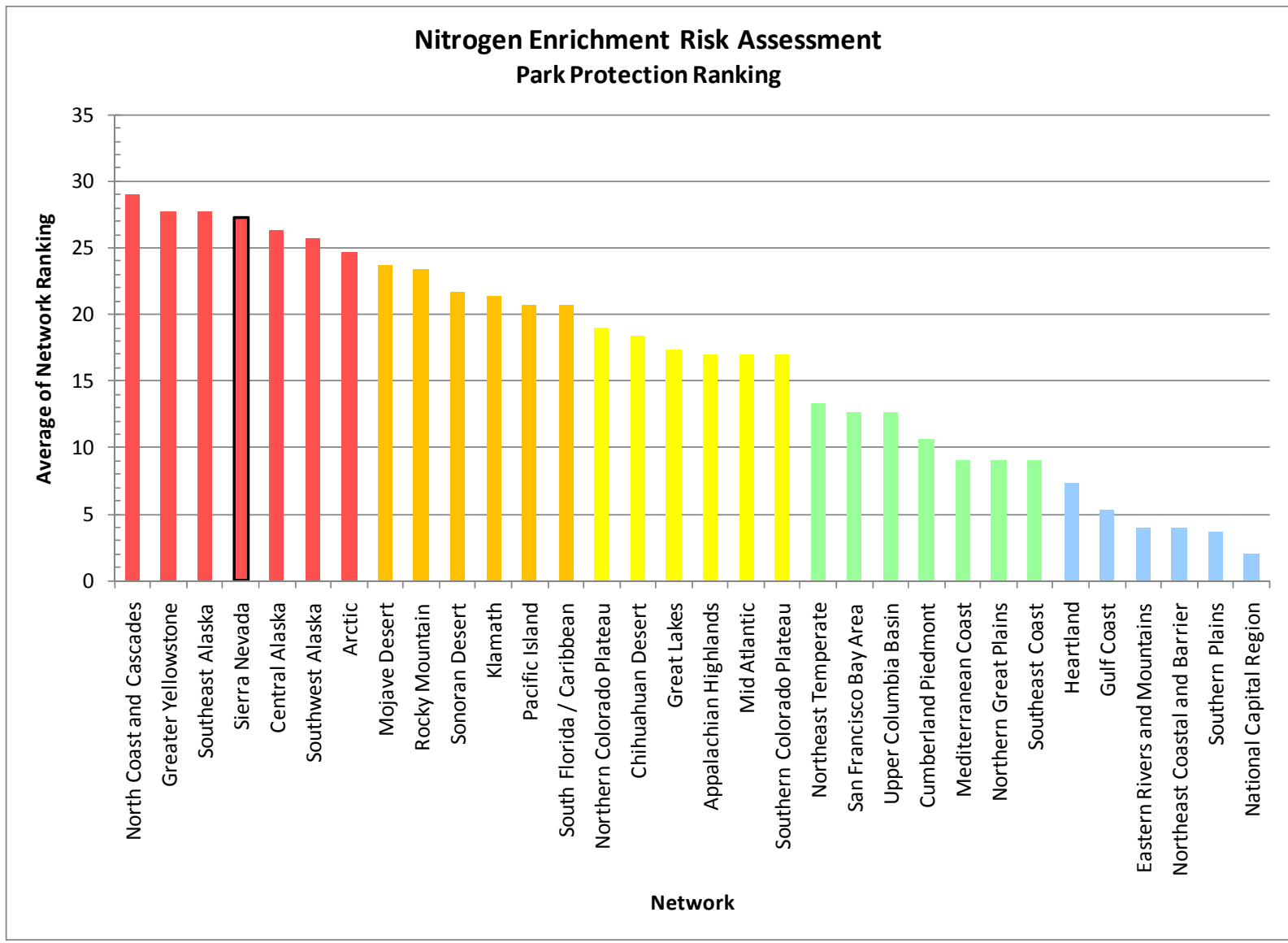


Figure C

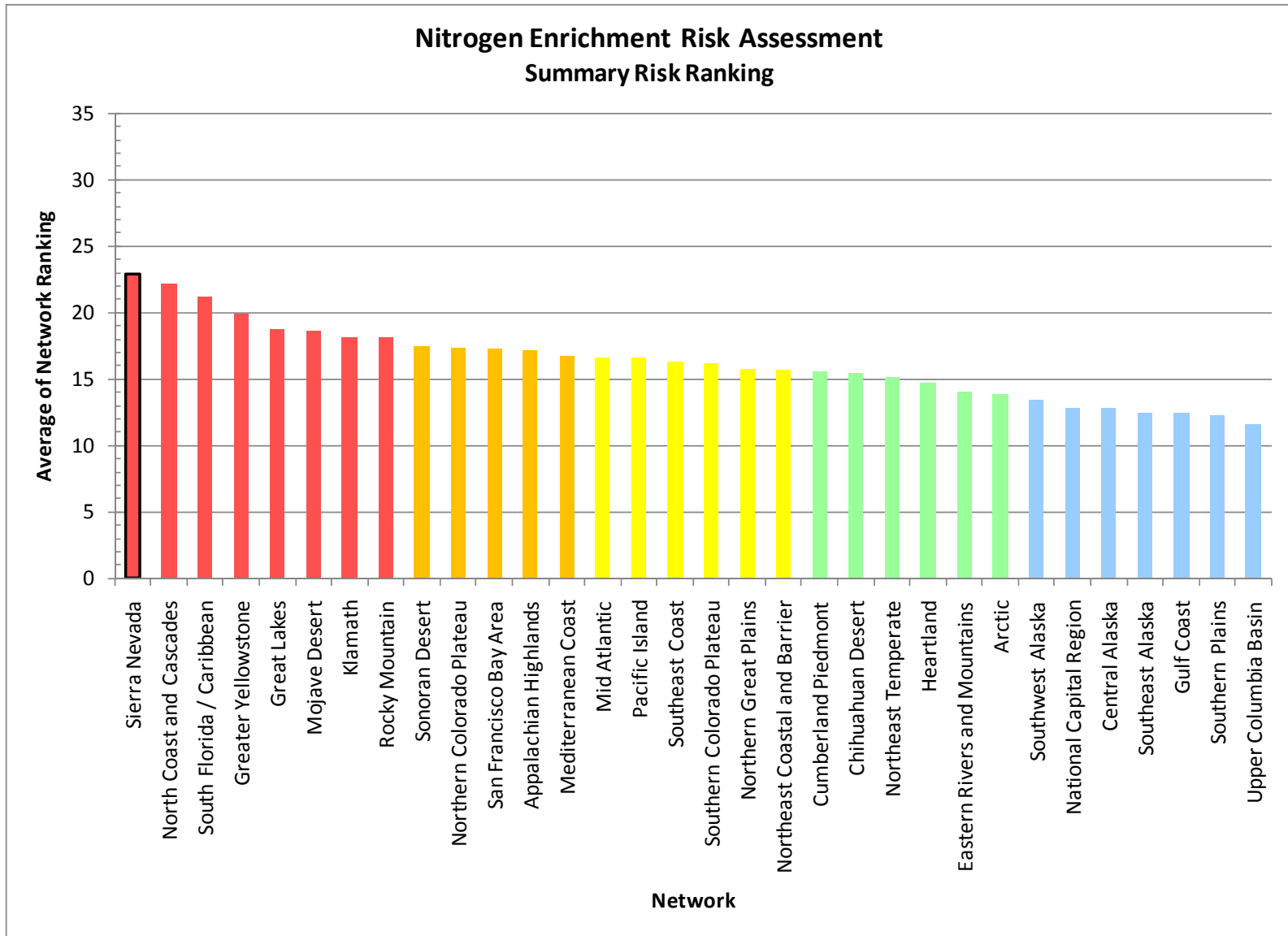


Figure D

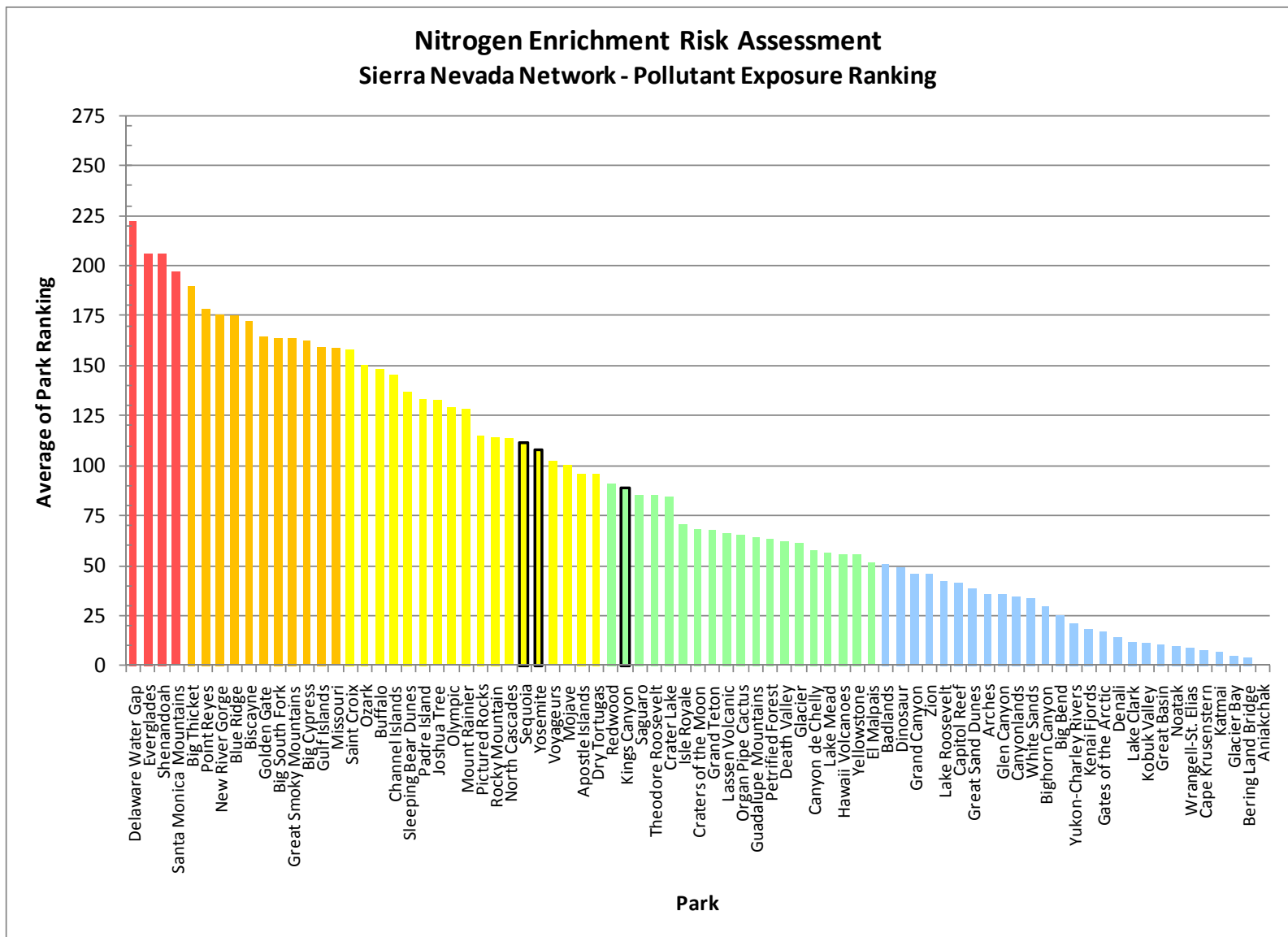


Figure E

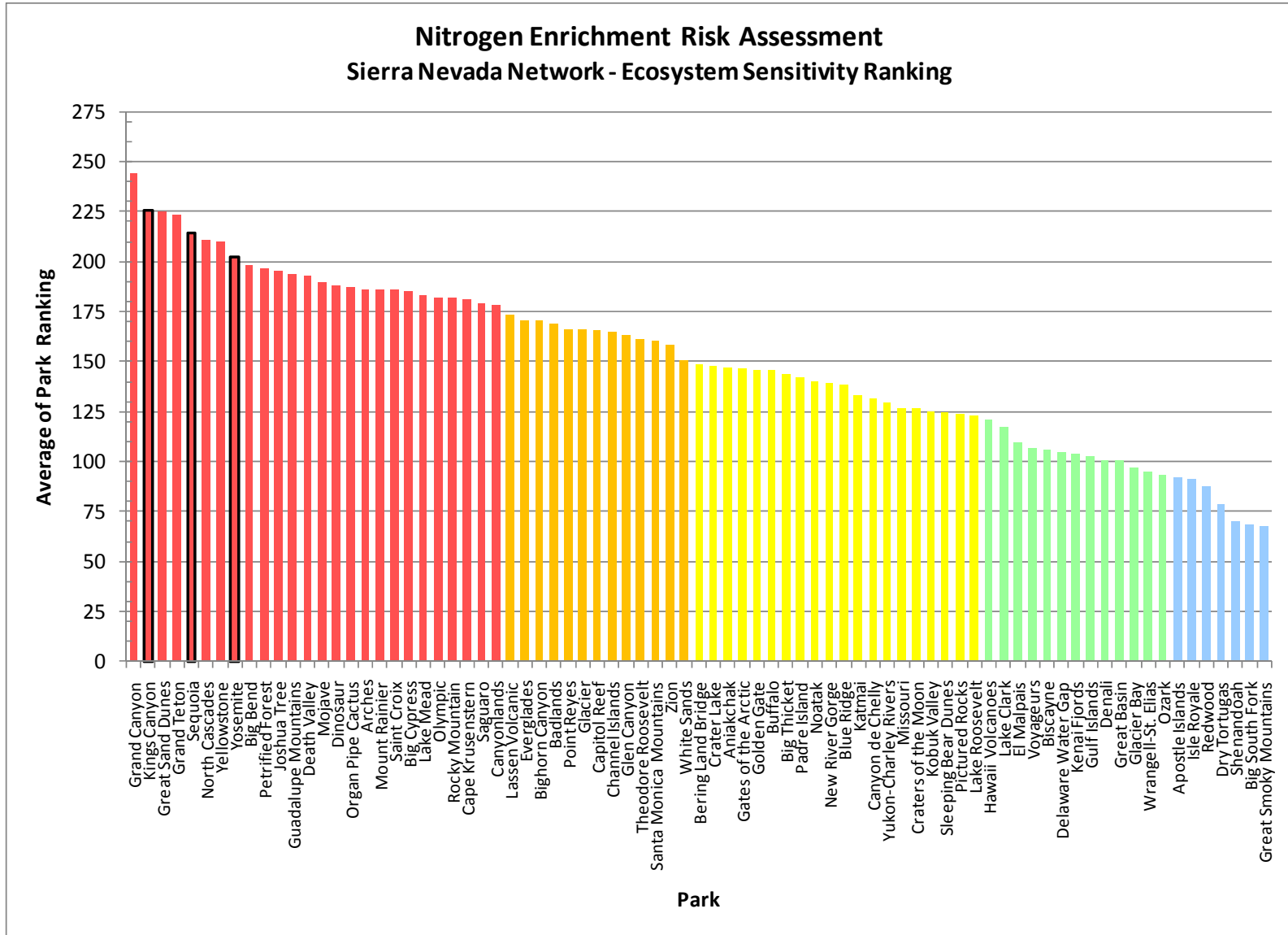


Figure F

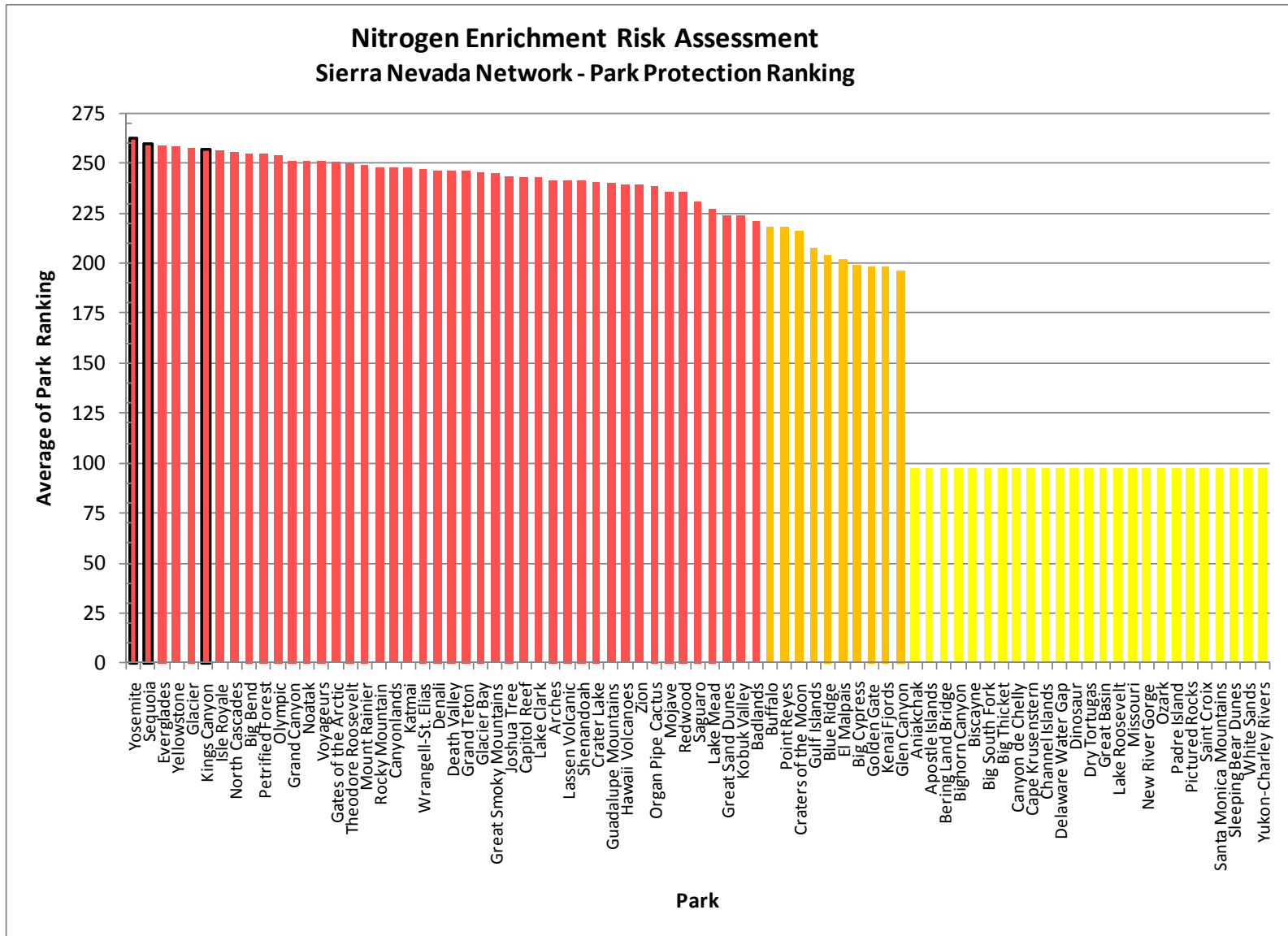


Figure G

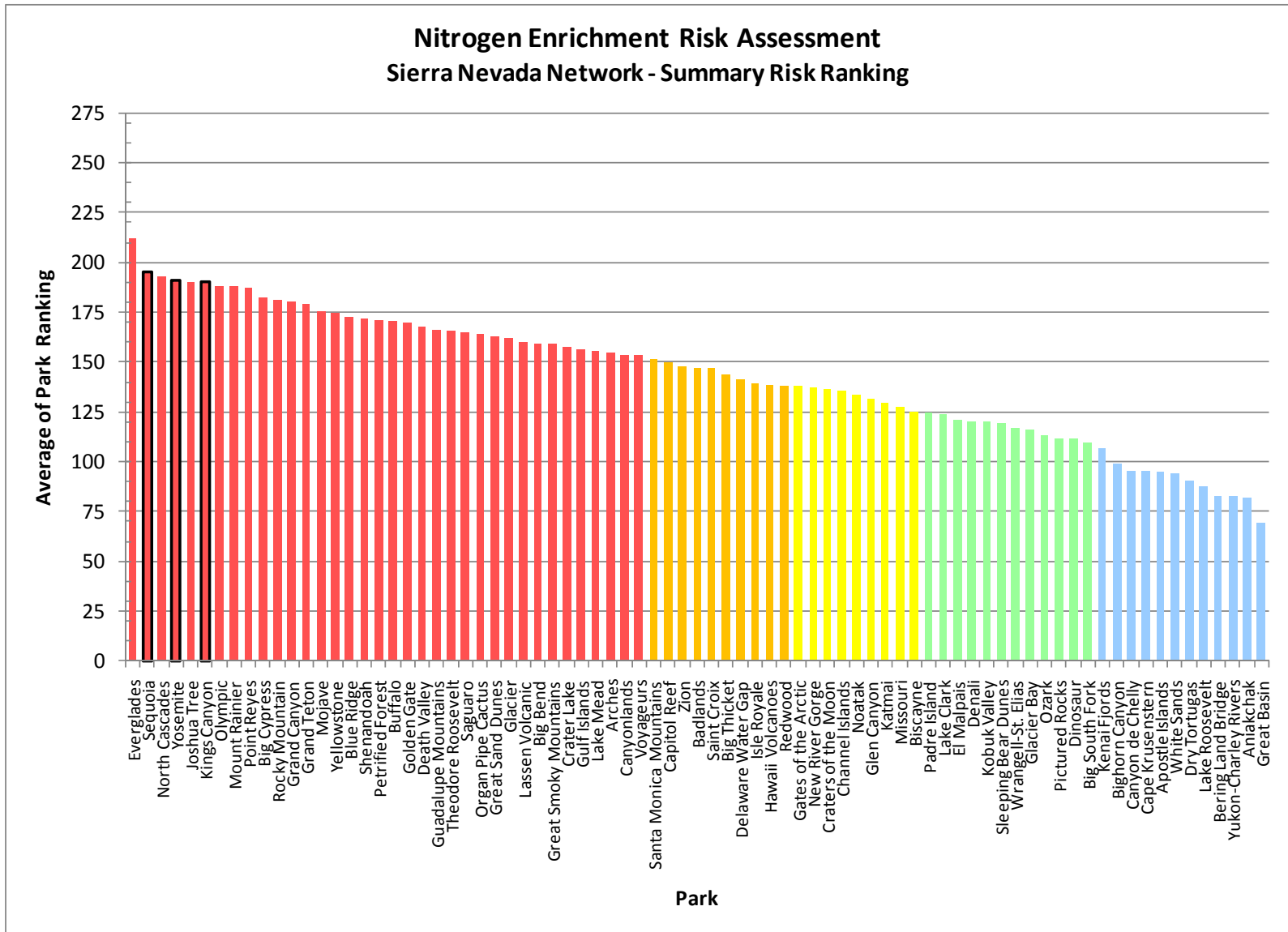


Figure H

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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