National Park Service
U.S. Department of the Interior

Natural Resource Program Center

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

North Coast and Cascades Network (NCCN)

Natural Resource Report NPS/NRPC/ARD/NRR—2011/365




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

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

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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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Denver, Colorado

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The Natural Resource Report Series is used to disseminate high-priority, current natural resource management information with managerial application. The series targets a general, diverse audience, and may contain NPS policy considerations or address sensitive issues of management applicability.

All manuscripts in the series receive the appropriate level of peer review to ensure that the information is scientifically credible, technically accurate, appropriately written for the intended audience, and designed and published in a professional manner.

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.

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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NPS 963/107401, April 2011

North Coast and Cascades Network (NCCN)

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 three parks larger than 100 square miles in the North Coast and Cascades Network: Mount Rainier (MORA), North Cascades (NOCA), and Olympic (OLYM). There are also four parks smaller 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 North Coast and Cascades Network. County level S emissions within the network ranged from less than 1 ton per square mile to between 5 and 20 tons per square mile. In general, county S emissions were less than 5 tons per square mile throughout the network with only one county in the 5 to 20 tons per square mile range (Map E). County-level N emissions within the network ranged from less than 1 ton per square mile to between 5 and 20 tons per square mile throughout most of the network. Annual county N emissions in the vicinity of the Columbia Gorge were higher than 20 tons per square mile. In general, annual county N emissions were less than 5 tons per square mile in most areas. Individual point sources of S are shown in Map G. Emission levels, in general, were below 5,000 tons S per year with only one point source in the range of 5,000 to 20,000 tons per year (Map G). Point source emissions of oxidized (nitrogen oxides, NO_x) and reduced (ammonia, NH_3) N are shown in Map H. Only one relatively large N point source (larger than 2,500 tons per year) occurs in this network.

Urban centers within the network and within a 300-mile buffer around the network are shown in Map I. The major urban centers (larger than 500,000 people) are Seattle and Portland.

Total S and N deposition in and around the network are shown in 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, in general, ranged from less than 2 kg S/ha/yr in the eastern part of the network to the range of 2 to 5 kg S/ha/yr in the west. Some smaller sections received S deposition in the 5 to 10 kg S/ha/yr range (Map J). Total N deposition within the network ranged from less than 2 kg N/ha/yr in the northeastern corner of the network to over 10 kg N/ha/yr in parts of the Columbia Gorge and along a portion of the Canadian border. Total N deposition ranged between 2 and 10 kg N/ha/yr throughout most of the network.

Land cover in and around the network is shown in Map L. The predominant cover type is generally forest, but pasture/hay and row crops are common in the south-central portion of the network, and developed land is extensive around Portland and in the corridor between Seattle and Olympia.

Land slope within the parks that occur in this network is shown on Map M. NOCA is very steep, with slopes averaging above 50º. MORA and OLYM are also steep, with a large portion of OLYM and small portion of MORA having average slope above 50º and the rest in the range of

40° to 50°. Part of OLYM along the coast and the parks smaller than 100 square miles are much less steep, with average slopes below 20º.

Park lands requiring special protection against potential adverse impacts associated with acidic 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 many relatively large Class I and wilderness areas in this network. All of the larger (larger than 100 square miles) I&M parks are Class I and also contain substantial wilderness. Numerous wilderness areas outside NPS jurisdiction extend along the length of the Cascade Mountains within the network.

There are three large, and fairly acid-sensitive, parks within this network: NOCA, MORA, and OLYM. Maps are shown at the park scale for high-elevation lakes and streams (Maps P-1 through P-3) and low-order streams (Maps P-4 through P-6).

High-elevation lakes are common within NOCA, MORA, and OLYM. These lakes might be more prone to acidification than lakes at lower elevation and therefore potentially more susceptible to acidic atmospheric S and N input. Each of these parks also contains an extensive length of high-elevation and low-order streams.

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 North Coast and Cascades Network ranked in the third quintile, just below the median, among networks in Pollutant Exposure (Figure A). Emissions and deposition of S and N within the network are both moderate. However, the network Ecosystem Sensitivity ranking was in the highest quintile among the 32 I&M networks (Figure B). This is because there are many high-elevation lakes and streams on base-poor soils in some of the parks that occur in this network and because there are substantial low-order streams and steep terrain. This network ranked the highest in Park Protection, having substantial amounts of protected lands (Figure C).

In combination, the network rankings for Pollutant Exposure, Ecosystem Sensitivity, and Park Protection yielded an overall Network Summary Risk ranking that was among the highest of all networks (Figure D). The overall level of concern for acidification 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 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.

All of the I&M parks within this network were in the third quintile in Pollutant Exposure (Figure E, Table A). The three large parks were all ranked in the highest quintile in Ecosystem Sensitivity (Figure F); the smaller parks were lower in Ecosystem Sensitivity, ranging from Very Low (Ebey's Landing, EBLA; Fort Vancouver, FOVA; and San Juan Island, SAJH) to Low (Lewis and Clark, LEWI). All three of the large parks contain high-elevation lakes and streams on steep terrain. All three large parks in this network were also ranked in the highest quintile in Park Protection (Figure G), and received a Very High park Summary Risk ranking (Figure H). The smaller parks were ranked Moderate in Park Protection and Low to Moderate in Summary Risk (Table A).

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
Ebey's Landing	Moderate	Very Low	Moderate	Low
Fort Vancouver	Moderate	Very Low	Moderate	Low
Lewis and Clark	Moderate	Low	Moderate	Moderate
Mount Rainier	Moderate	Very High	Very High	Very High
North Cascades	Moderate	Very High	Very High	Very High
Olympic	Moderate	Very High	Very High	Very High
San Juan Island	Moderate	Very 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 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, NH_3) 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, NH_3) 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, NH_3) N. (Source of data: EPA National Emissions Inventory, http://www.epa.gov/ttn/chief/net/2002inventory.html)

Map G. Major point source emissions of SO_2 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, NH_3) 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: CMAQ Model wet and 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, NH_3) 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 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. (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)

Map P-1. Park-specific map: high-elevation lakes and streams in MORA. (Source of data: Landfire [http://www.landfire.gov/] and NPS Vegetation Survey)

Map P-2. Park-specific map: high-elevation lakes and streams in NOCA. (Source of data: Landfire [http://www.landfire.gov/] and NPS Vegetation Survey)

Map P-3. Park-specific map: high-elevation lakes and streams in OLYM. (Source of data: Landfire [http://www.landfire.gov/] and NPS Vegetation Survey)

Map P-4. Park-specific map: low-order streams in MORA. (Source of data: U.S. EPA/USGS National Hydrography Dataset Plus [http://www.horizon-systems.com/nhdplus/])

Map P-5. Park-specific map: low-order streams in NOCA. (Source of data: U.S. EPA/USGS National Hydrography Dataset Plus [http://www.horizon-systems.com/nhdplus/])

Map P-6. Park-specific map: low-order streams in OLYM. (Source of data: 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.

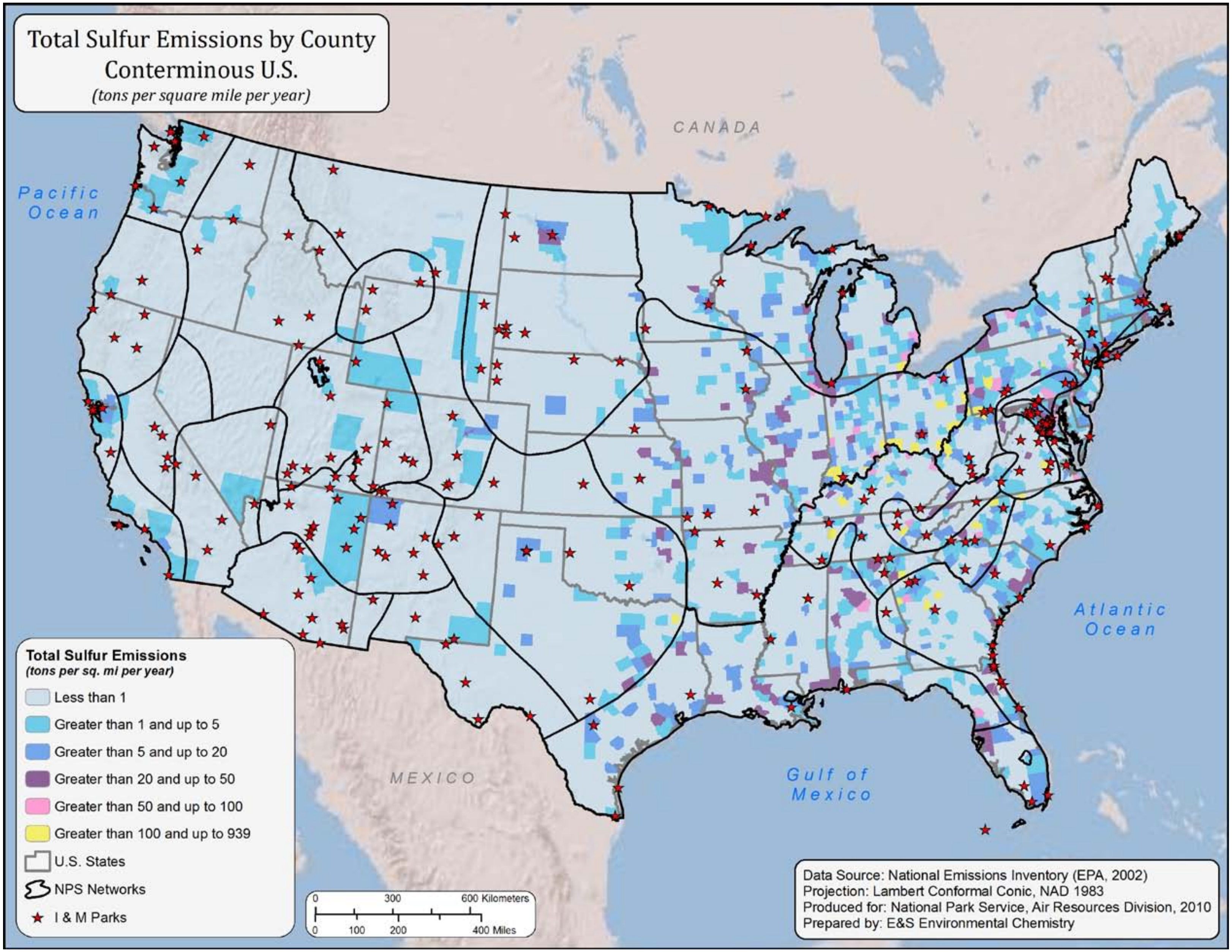
Figure D. Network Summary Risk rankings, calculated as the average of the quintile ranks for the Pollutant Exposure, Ecosystem Sensitivity, and Park Protection themes.

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.

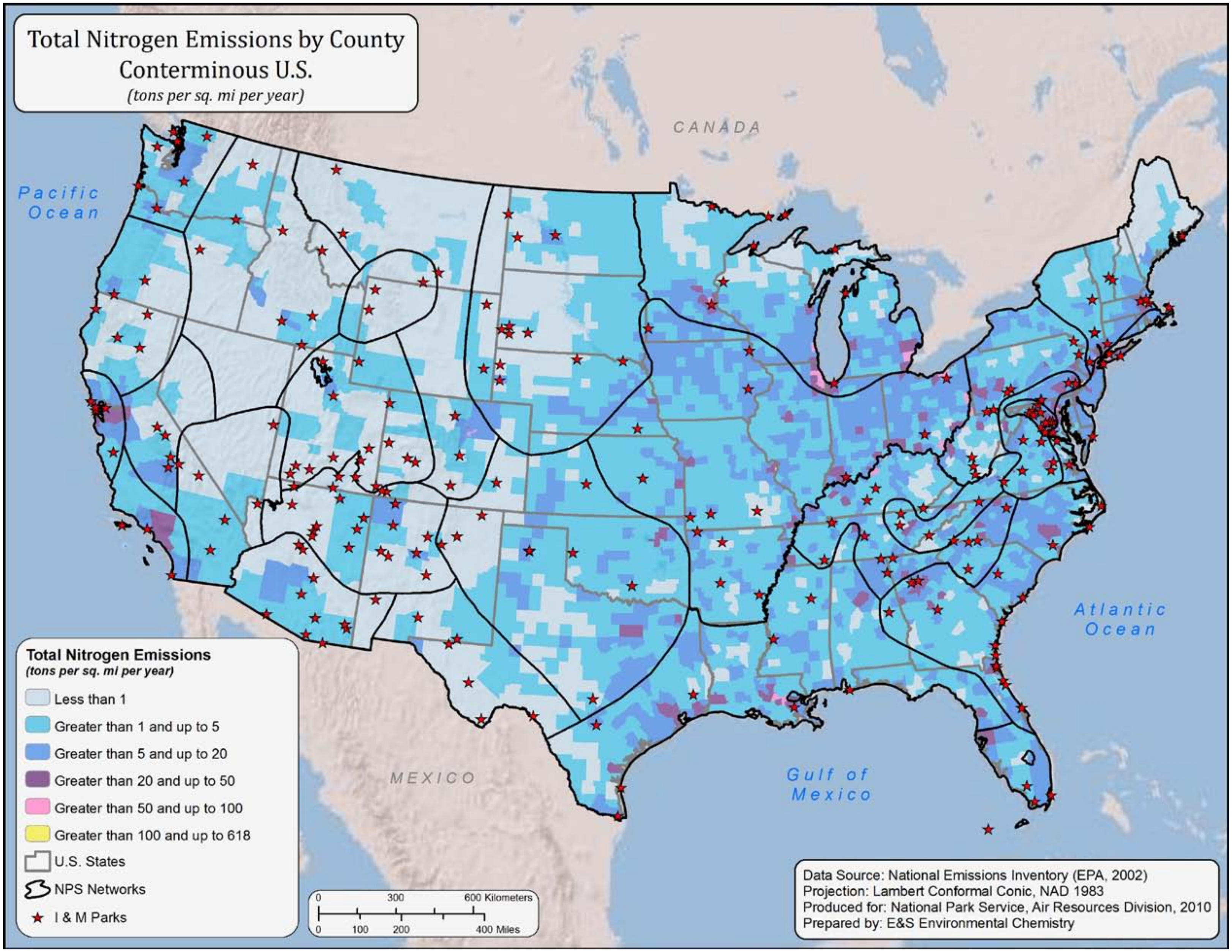
Figure F. Park rankings for Ecosystem Sensitivity for all parks larger than 100 square miles. Ranks for each park were calculated relative to all parks, regardless of size, as the average of scores for all Ecosystem Sensitivity variables.

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.

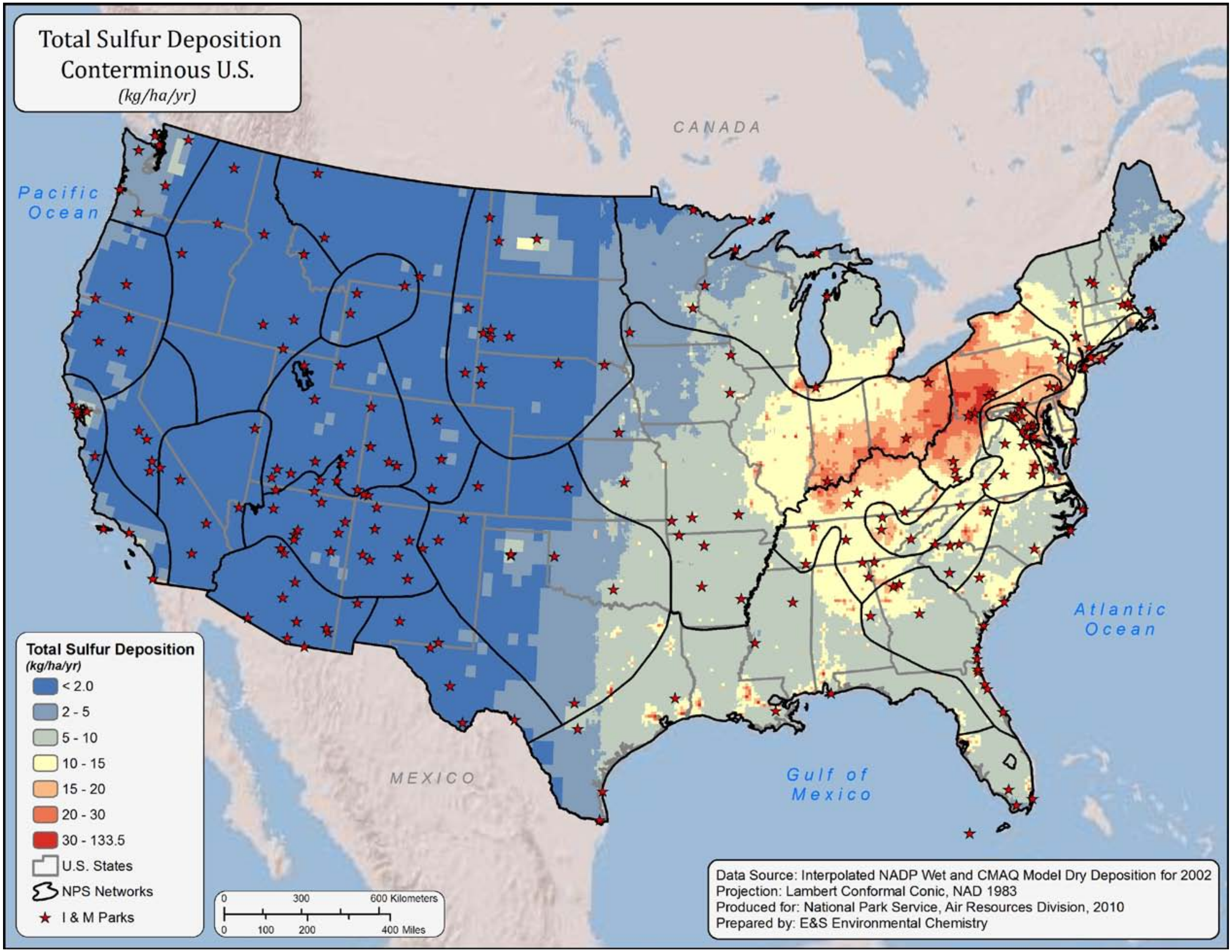

Total Sulfur Emissions by County
Conterminous U.S.
(tons per square mile per year)
CANADA
Pacific Ocean
Atlantic Ocean
Gulf of Mexico
MEXICO
Total Sulfur Emissions
(tons per sq. mi per year)
Less than 1
Greater than 1 and up to 5
Greater than 5 and up to 20
Greater than 20 and up to 50
Greater than 50 and up to 100
Greater than 100 and up to 939
U.S. States
NPS Networks
I & M Parks
0 300 600 Kilometers
0 100 200 400 Miles
Data Source: National Emissions Inventory (EPA, 2002)
Projection: Lambert Conformal Conic, NAD 1983
Produced for: National Park Service, Air Resources Division, 2010
Prepared by: E&S Environmental Chemistry

Map A


Total Nitrogen Emissions by County
Conterminous U.S.
(tons per sq. mi per year)
CANADA
Pacific Ocean
Atlantic Ocean
Gulf of Mexico
MEXICO
Total Nitrogen Emissions
(tons per sq. mi per year)
Less than 1
Greater than 1 and up to 5
Greater than 5 and up to 20
Greater than 20 and up to 50
Greater than 50 and up to 100
Greater than 100 and up to 618
U.S. States
NPS Networks
I & M Parks
0 300 600 Kilometers
0 100 200 400 Miles
Data Source: National Emissions Inventory (EPA, 2002)
Projection: Lambert Conformal Conic, NAD 1983
Produced for: National Park Service, Air Resources Division, 2010
Prepared by: E&S Environmental Chemistry

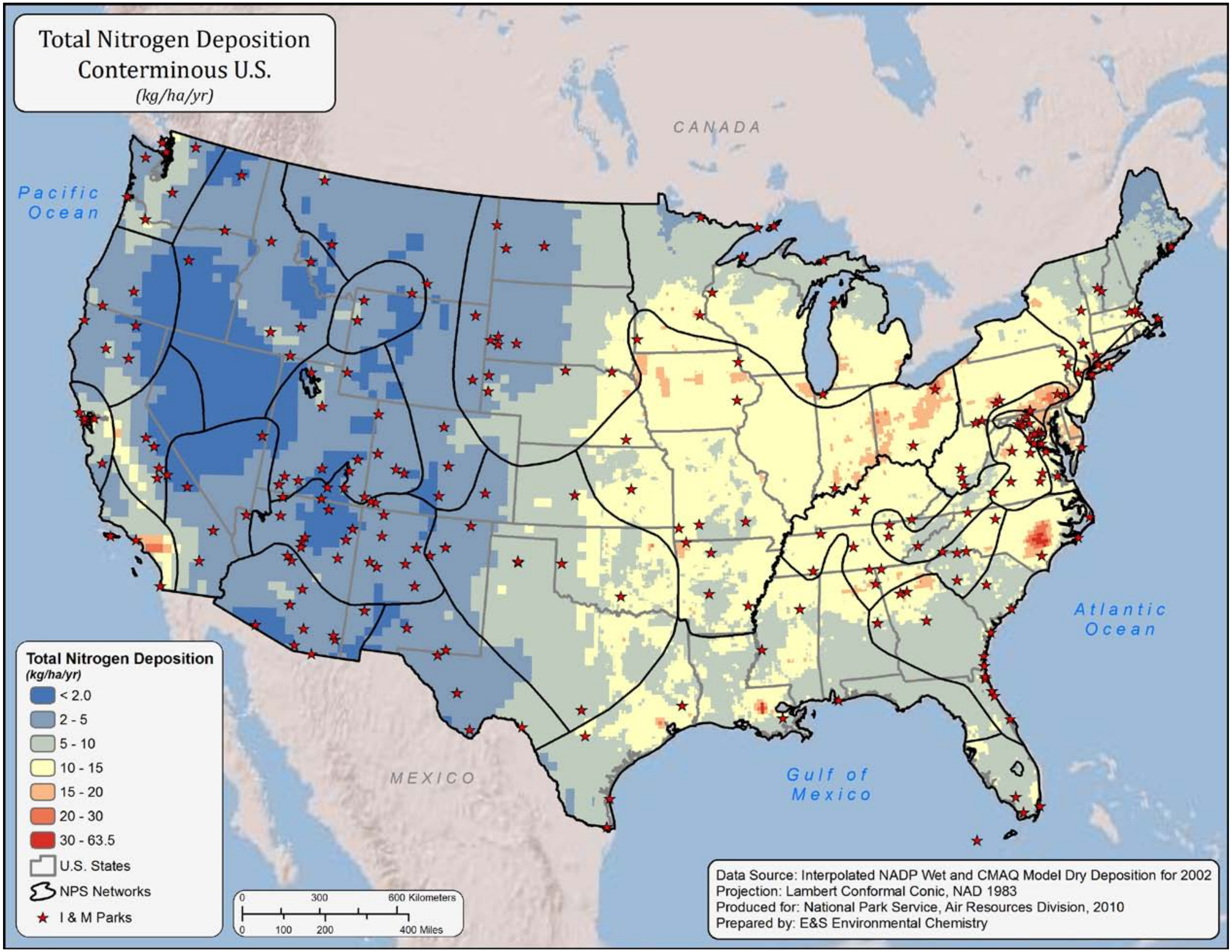
Map B

NCCN-9

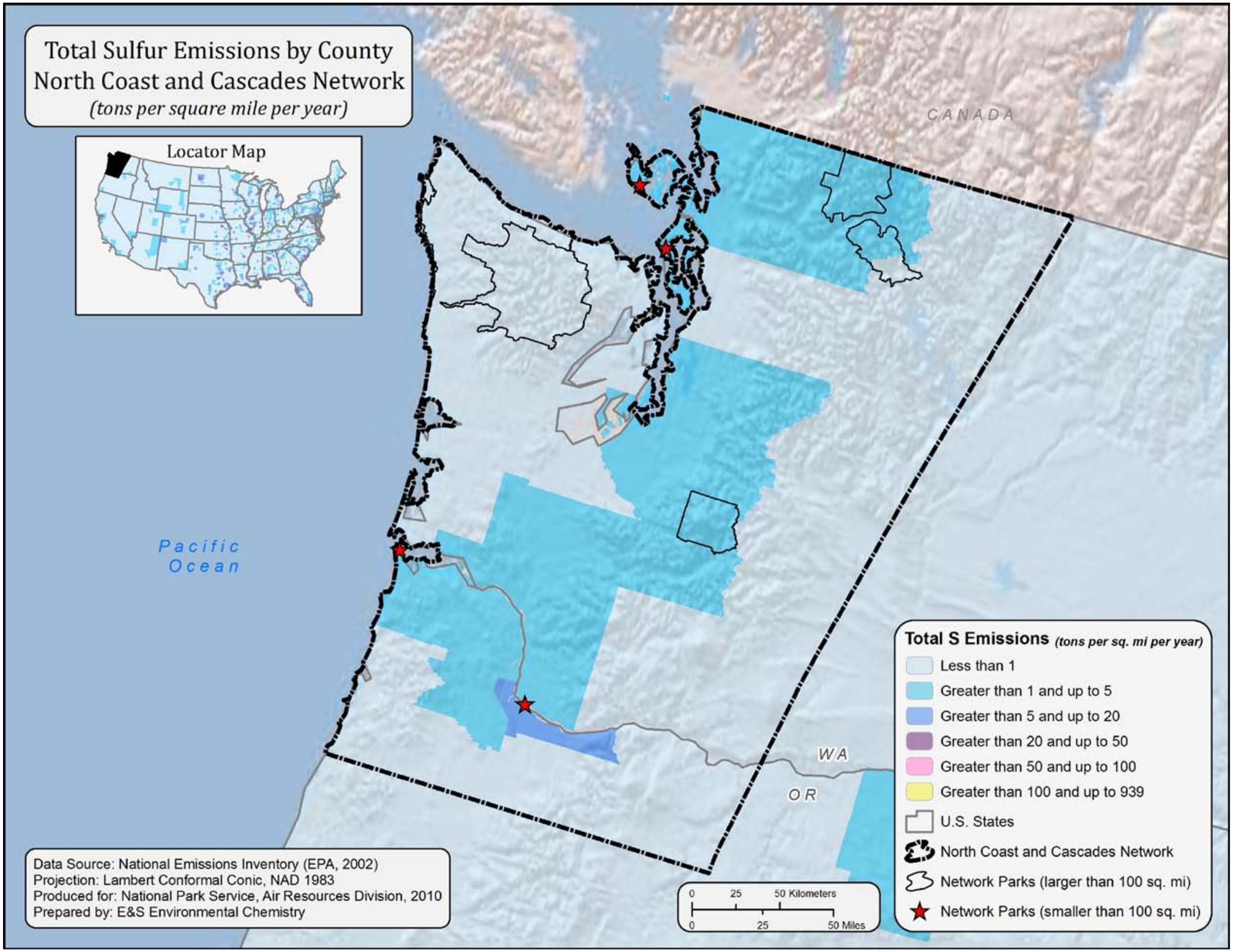


Total Sulfur Deposition
Conterminous U.S.
(kg/ha/yr)
CANADA
Pacific Ocean
Atlantic Ocean
Gulf of Mexico
MEXICO
Total Sulfur Deposition
(kg/ha/yr)
< 2.0
2 - 5
5 - 10
10 - 15
15 - 20
20 - 30
30 - 133.5
U.S. States
NPS Networks
I & M Parks
0 300 600 Kilometers
0 100 200 400 Miles
Data Source: Interpolated NADP Wet and CMAQ Model Dry Deposition for 2002
Projection: Lambert Conformal Conic, NAD 1983
Produced for: National Park Service, Air Resources Division, 2010
Prepared by: E&S Environmental Chemistry

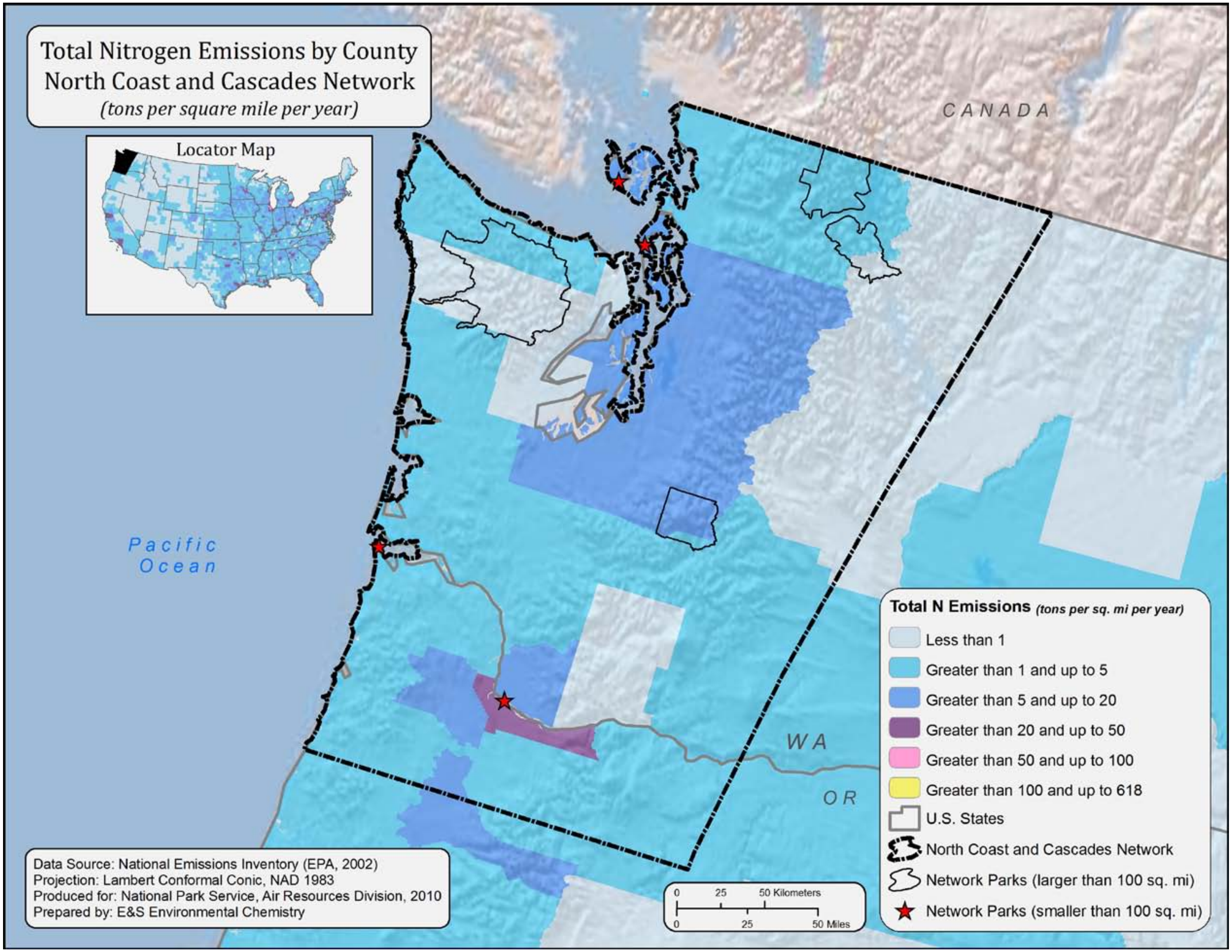
Map C


Total Nitrogen Deposition
Conterminous U.S.
(kg/ha/yr)
CANADA
Pacific Ocean
Atlantic Ocean
Gulf of Mexico
MEXICO
Total Nitrogen Deposition
(kg/ha/yr)
< 2.0
2 - 5
5 - 10
10 - 15
15 - 20
20 - 30
30 - 63.5
U.S. States
NPS Networks
I & M Parks
0 300 600 Kilometers
0 100 200 400 Miles
Data Source: Interpolated NADP Wet and CMAQ Model Dry Deposition for 2002
Projection: Lambert Conformal Conic, NAD 1983
Produced for: National Park Service, Air Resources Division, 2010
Prepared by: E&S Environmental Chemistry

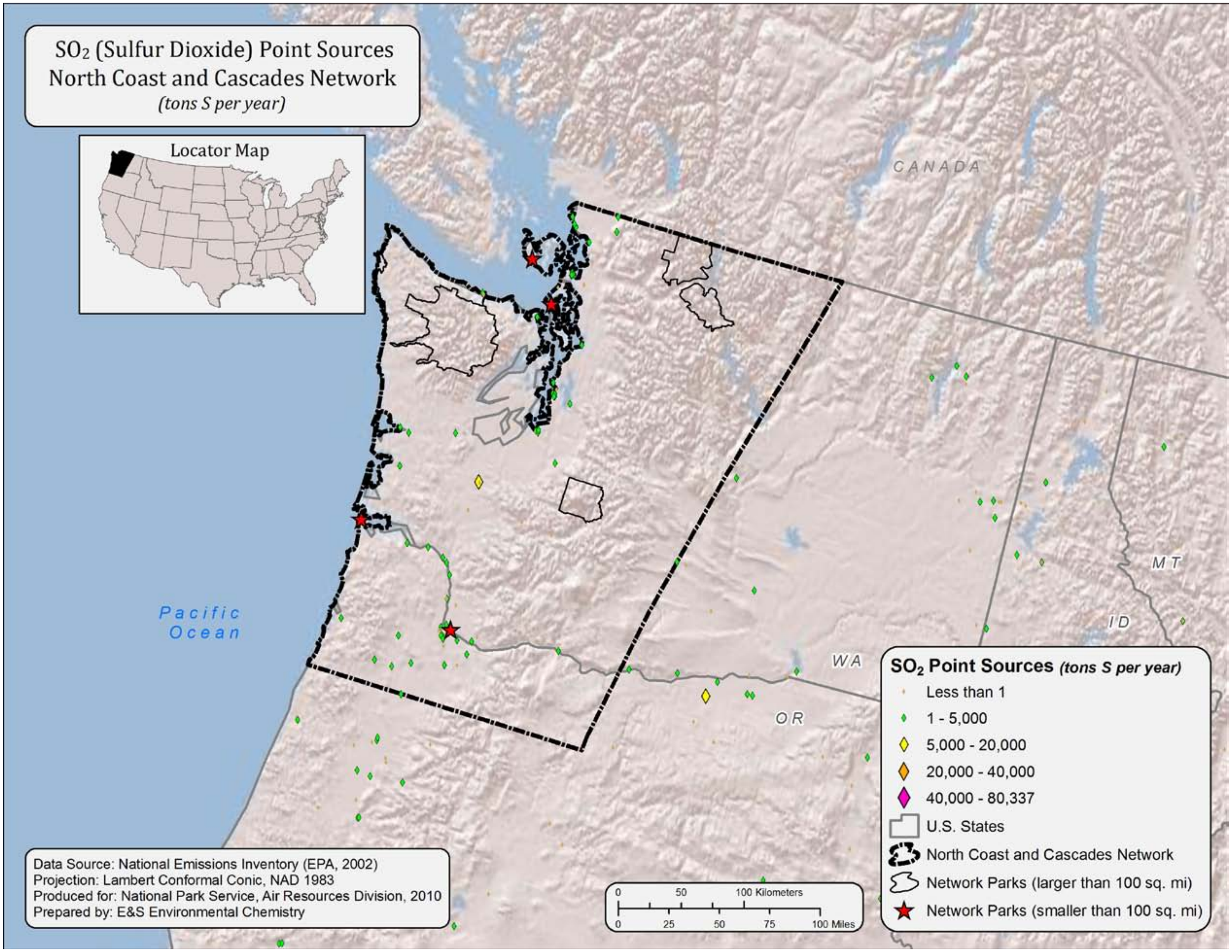
Map D


Total Sulfur Emissions by County
North Coast and Cascades Network
(tons per square mile per year)
Locator Map
CANADA
Pacific Ocean
WA
OR
Total S Emissions (tons per sq. mi per year)
Less than 1
Greater than 1 and up to 5
Greater than 5 and up to 20
Greater than 20 and up to 50
Greater than 50 and up to 100
Greater than 100 and up to 939
U.S. States
North Coast and Cascades Network
Network Parks (larger than 100 sq. mi)
Network Parks (smaller than 100 sq. mi)
0 25 50 Kilometers
0 25 50 Miles
Data Source: National Emissions Inventory (EPA, 2002)
Projection: Lambert Conformal Conic, NAD 1983
Produced for: National Park Service, Air Resources Division, 2010
Prepared by: E&S Environmental Chemistry

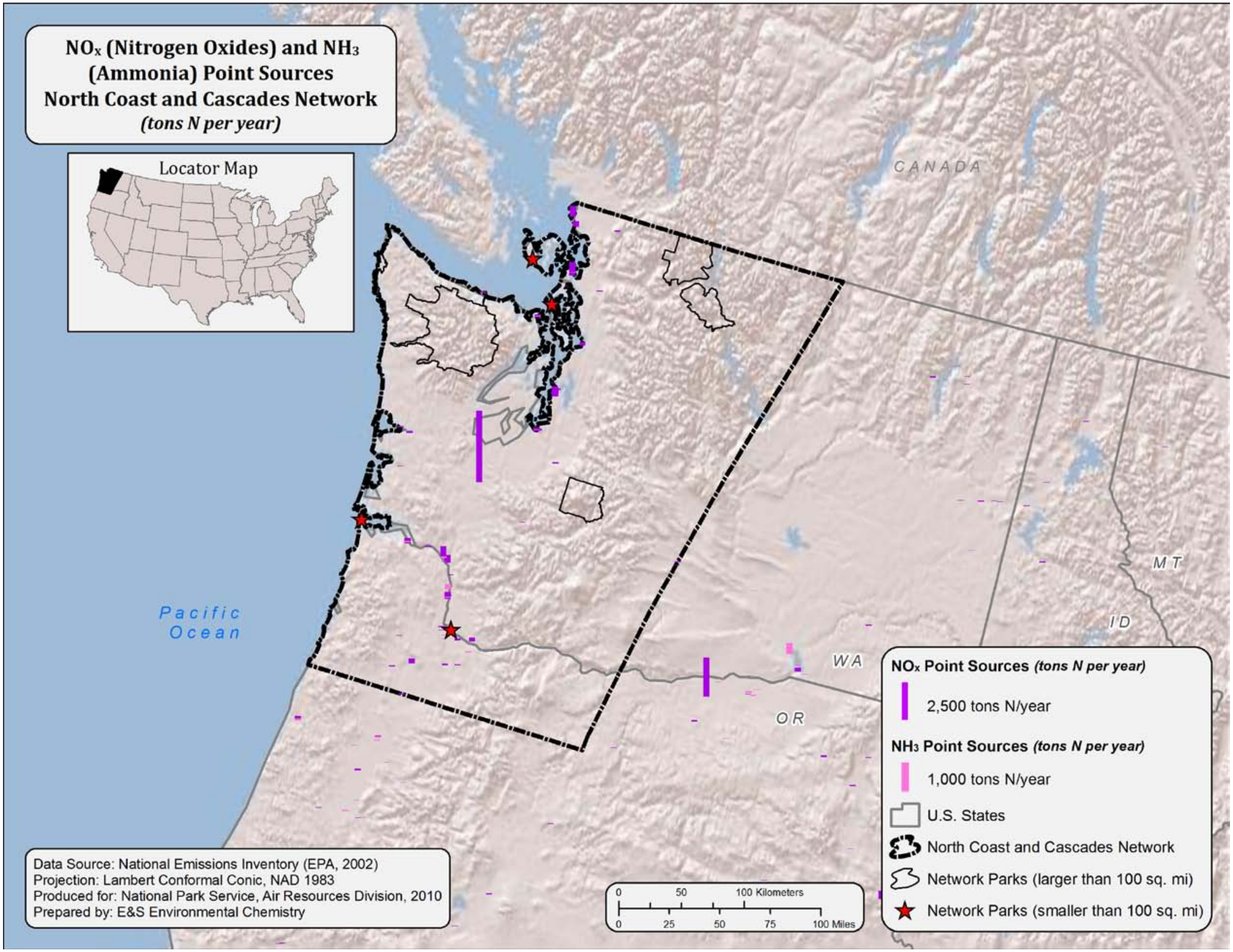
Map E


Total Nitrogen Emissions by County
North Coast and Cascades Network
(tons per square mile per year)
Locator Map
CANADA
Pacific Ocean
WA
OR
Total N Emissions (tons per sq. mi per year)
Less than 1
Greater than 1 and up to 5
Greater than 5 and up to 20
Greater than 20 and up to 50
Greater than 50 and up to 100
Greater than 100 and up to 618
U.S. States
North Coast and Cascades Network
Network Parks (larger than 100 sq. mi)
Network Parks (smaller than 100 sq. mi)
0 25 50 Kilometers
0 25 50 Miles
Data Source: National Emissions Inventory (EPA, 2002)
Projection: Lambert Conformal Conic, NAD 1983
Produced for: National Park Service, Air Resources Division, 2010
Prepared by: E&S Environmental Chemistry

Map F

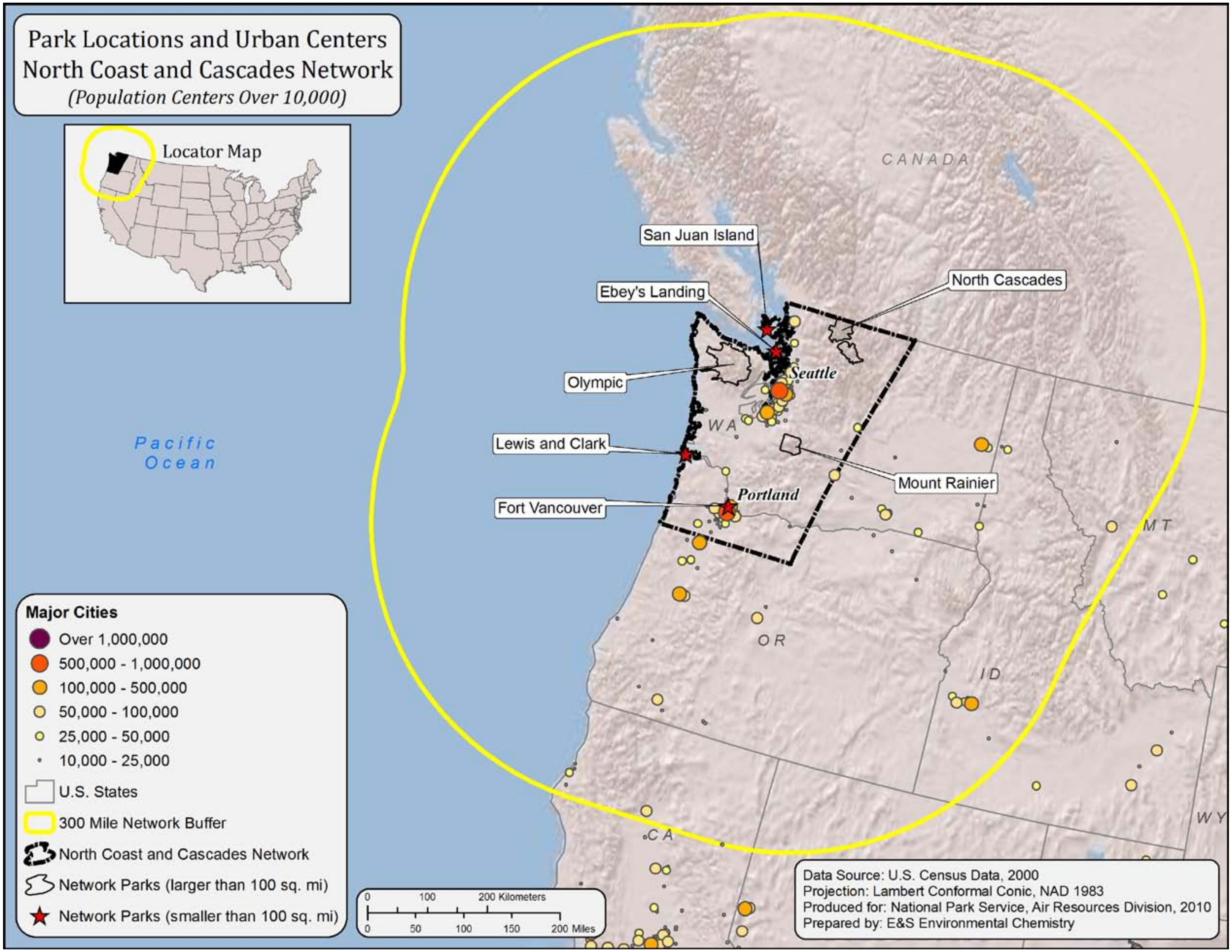

SO2 (Sulfur Dioxide) Point Sources
North Coast and Cascades Network
(tons S per year)
Locator Map
CANADA
Pacific Ocean
WA
OR
ID
MT
SO2 Point Sources (tons S per year)
Less than 1
1 - 5,000
5,000 - 20,000
20,000 - 40,000
40,000 - 80,337
U.S. States
North Coast and Cascades Network
Network Parks (larger than 100 sq. mi)
Network Parks (smaller than 100 sq. mi)
0 50 100 Kilometers
0 25 50 75 100 Miles
Data Source: National Emissions Inventory (EPA, 2002)
Projection: Lambert Conformal Conic, NAD 1983
Produced for: National Park Service, Air Resources Division, 2010
Prepared by: E&S Environmental Chemistry

Map G



NOx (Nitrogen Oxides) and NH3 (Ammonia) Point Sources
North Coast and Cascades Network
(tons N per year)
Locator Map
CANADA
Pacific Ocean
WA
OR
ID
MT
NOx Point Sources (tons N per year)
2,500 tons N/year
NH3 Point Sources (tons N per year)
1,000 tons N/year
U.S. States
North Coast and Cascades Network
Network Parks (larger than 100 sq. mi)
Network Parks (smaller than 100 sq. mi)
Data Source: National Emissions Inventory (EPA, 2002)
Projection: Lambert Conformal Conic, NAD 1983
Produced for: National Park Service, Air Resources Division, 2010
Prepared by: E&S Environmental Chemistry
0 50 100 Kilometers
0 25 50 75 100 Miles

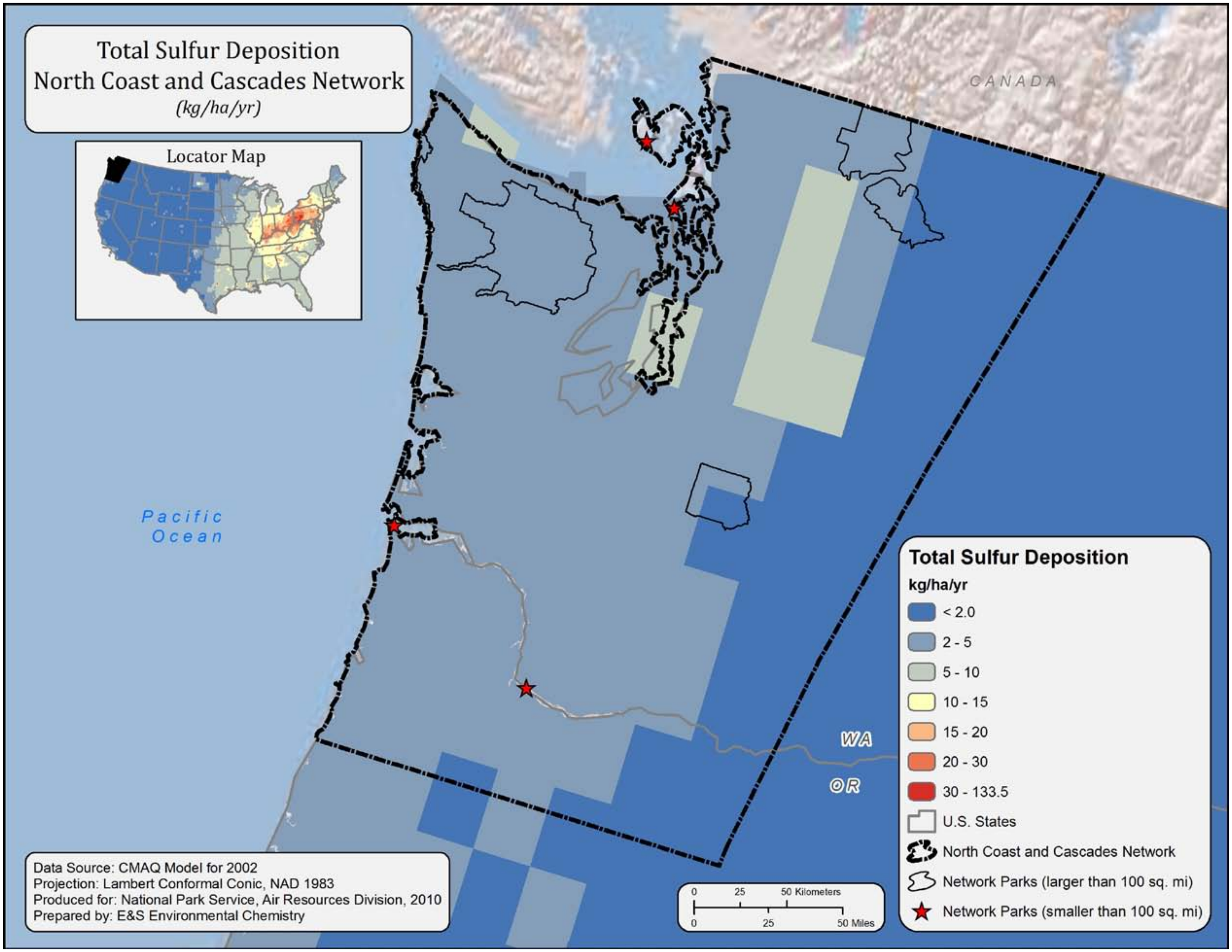
Map H



Park Locations and Urban Centers
North Coast and Cascades Network
(Population Centers Over 10,000)
Locator Map
CANADA
San Juan Island
Ebey's Landing
North Cascades
Olympic
Seattle
WA
Lewis and Clark
Mount Rainier
Portland
Fort Vancouver
Pacific Ocean
MT
OR
ID
CA
WY
Major Cities
Over 1,000,000
500,000 - 1,000,000
100,000 - 500,000
50,000 - 100,000
25,000 - 50,000
10,000 - 25,000
U.S. States
300 Mile Network Buffer
North Coast and Cascades Network
Network Parks (larger than 100 sq. mi)
Network Parks (smaller than 100 sq. mi)
0 100 200 Kilometers
0 50 100 150 200 Miles
Data Source: U.S. Census Data, 2000
Projection: Lambert Conformal Conic, NAD 1983
Produced for: National Park Service, Air Resources Division, 2010
Prepared by: E&S Environmental Chemistry

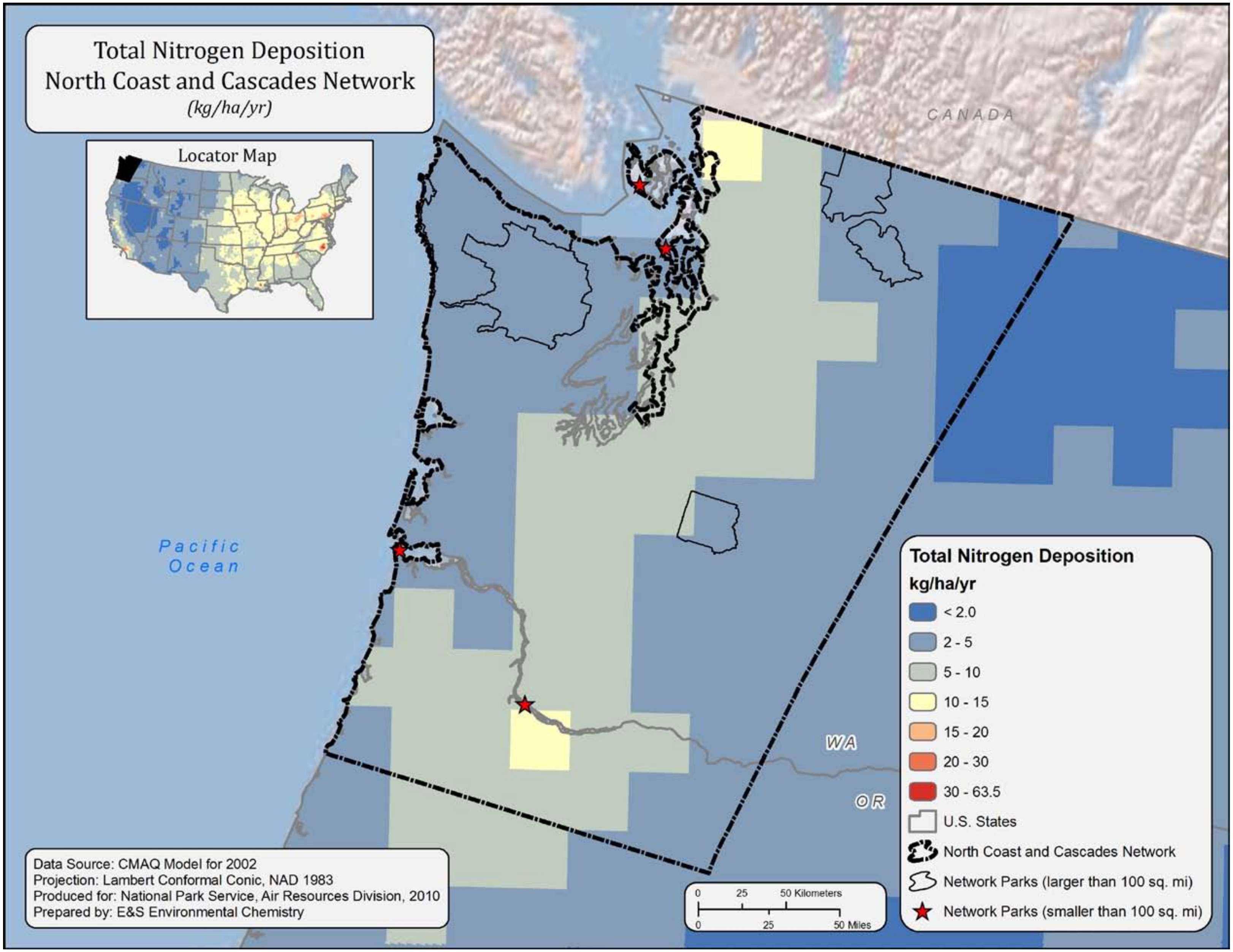
Map I

NCCN-16

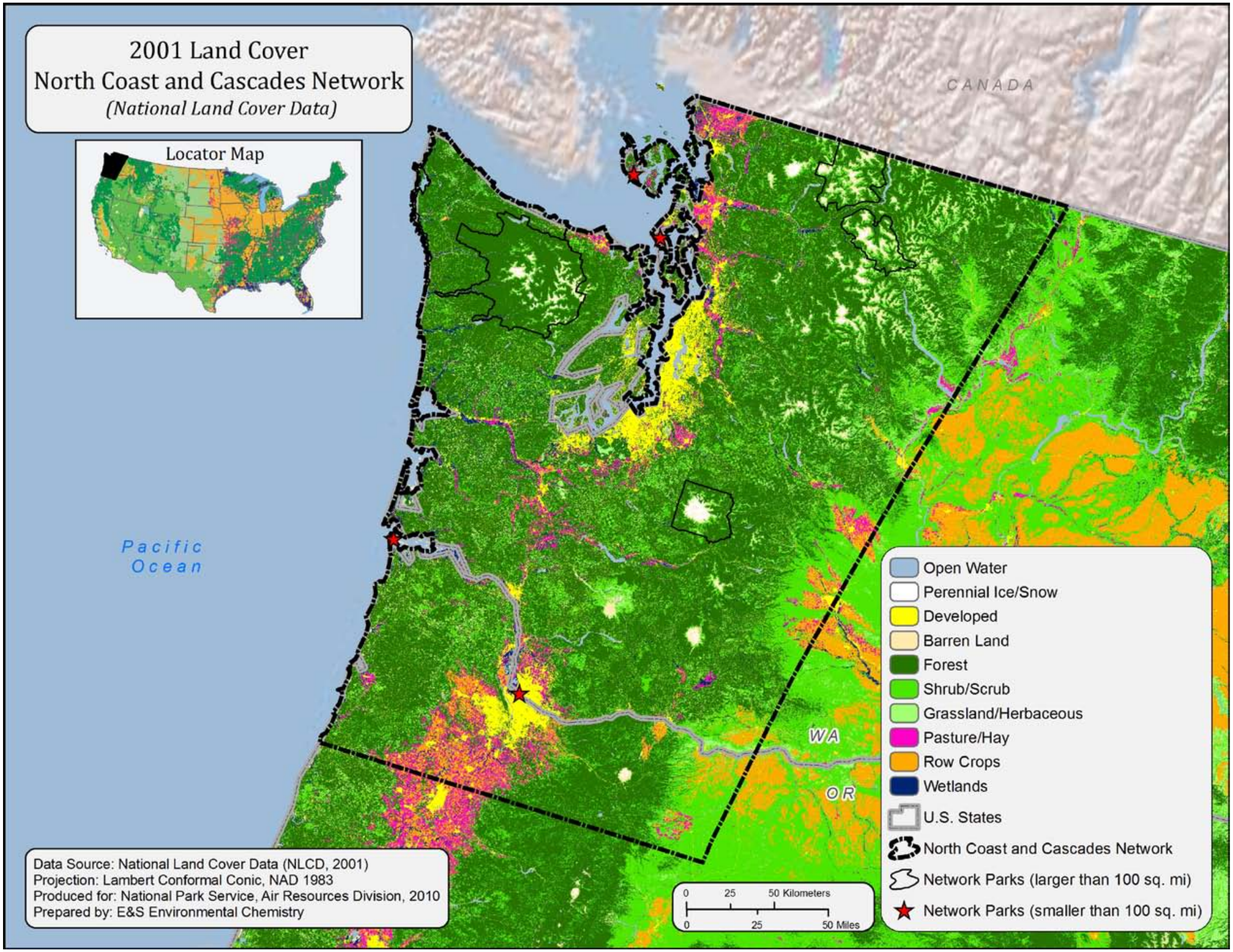


Total Sulfur Deposition
North Coast and Cascades Network
(kg/ha/yr)
Locator Map
CANADA
Pacific Ocean
WA
OR
Total Sulfur Deposition
kg/ha/yr
< 2.0
2 - 5
5 - 10
10 - 15
15 - 20
20 - 30
30 - 133.5
U.S. States
North Coast and Cascades Network
Network Parks (larger than 100 sq. mi)
Network Parks (smaller than 100 sq. mi)
0 25 50 Kilometers
0 25 50 Miles
Data Source: CMAQ Model for 2002
Projection: Lambert Conformal Conic, NAD 1983
Produced for: National Park Service, Air Resources Division, 2010
Prepared by: E&S Environmental Chemistry

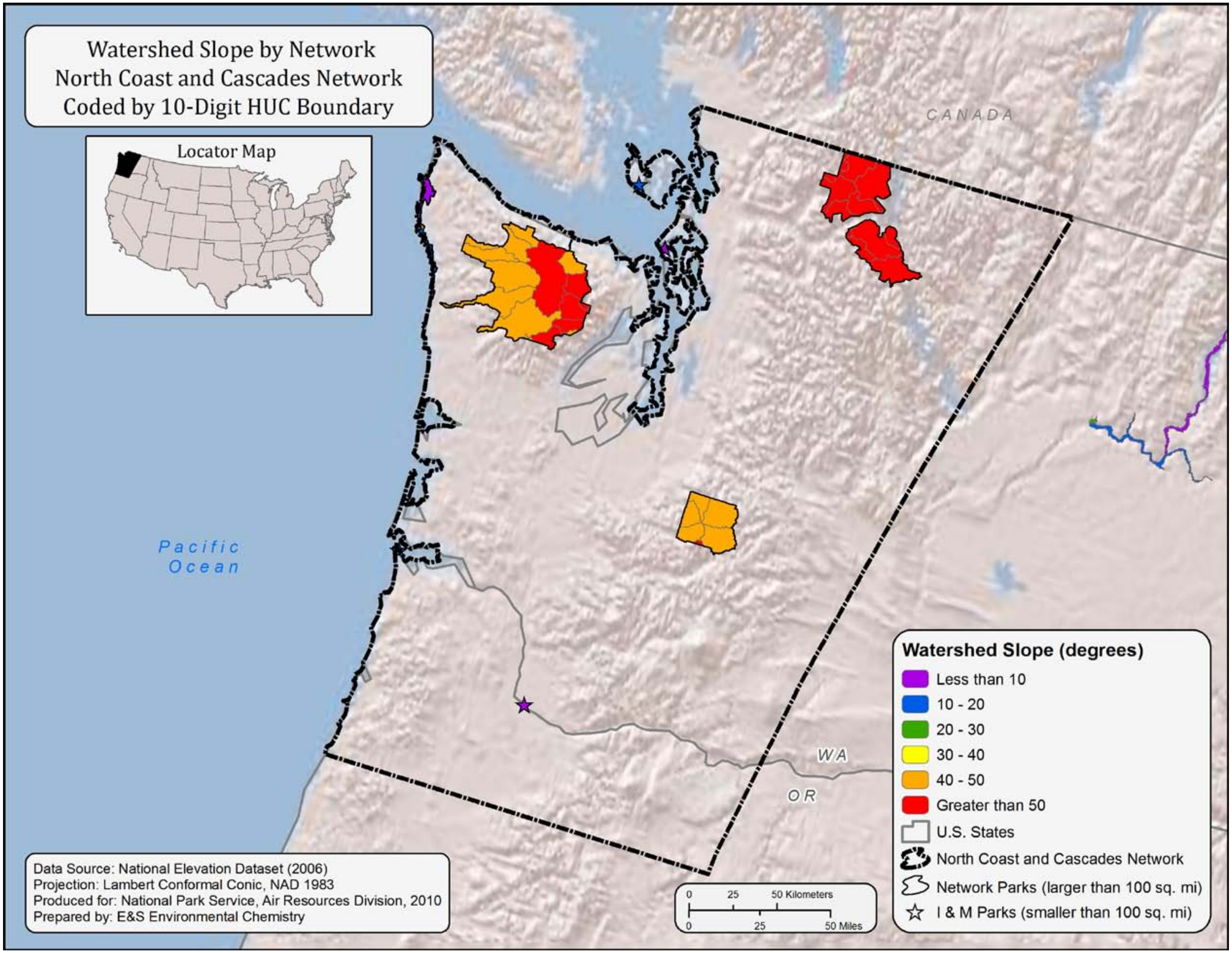
Map J


Total Nitrogen Deposition
North Coast and Cascades Network
(kg/ha/yr)
Locator Map
CANADA
Pacific Ocean
WA
OR
Total Nitrogen Deposition
kg/ha/yr
< 2.0
2 - 5
5 - 10
10 - 15
15 - 20
20 - 30
30 - 63.5
U.S. States
North Coast and Cascades Network
Network Parks (larger than 100 sq. mi)
Network Parks (smaller than 100 sq. mi)
0 25 50 Kilometers
0 25 50 Miles
Data Source: CMAQ Model for 2002
Projection: Lambert Conformal Conic, NAD 1983
Produced for: National Park Service, Air Resources Division, 2010
Prepared by: E&S Environmental Chemistry

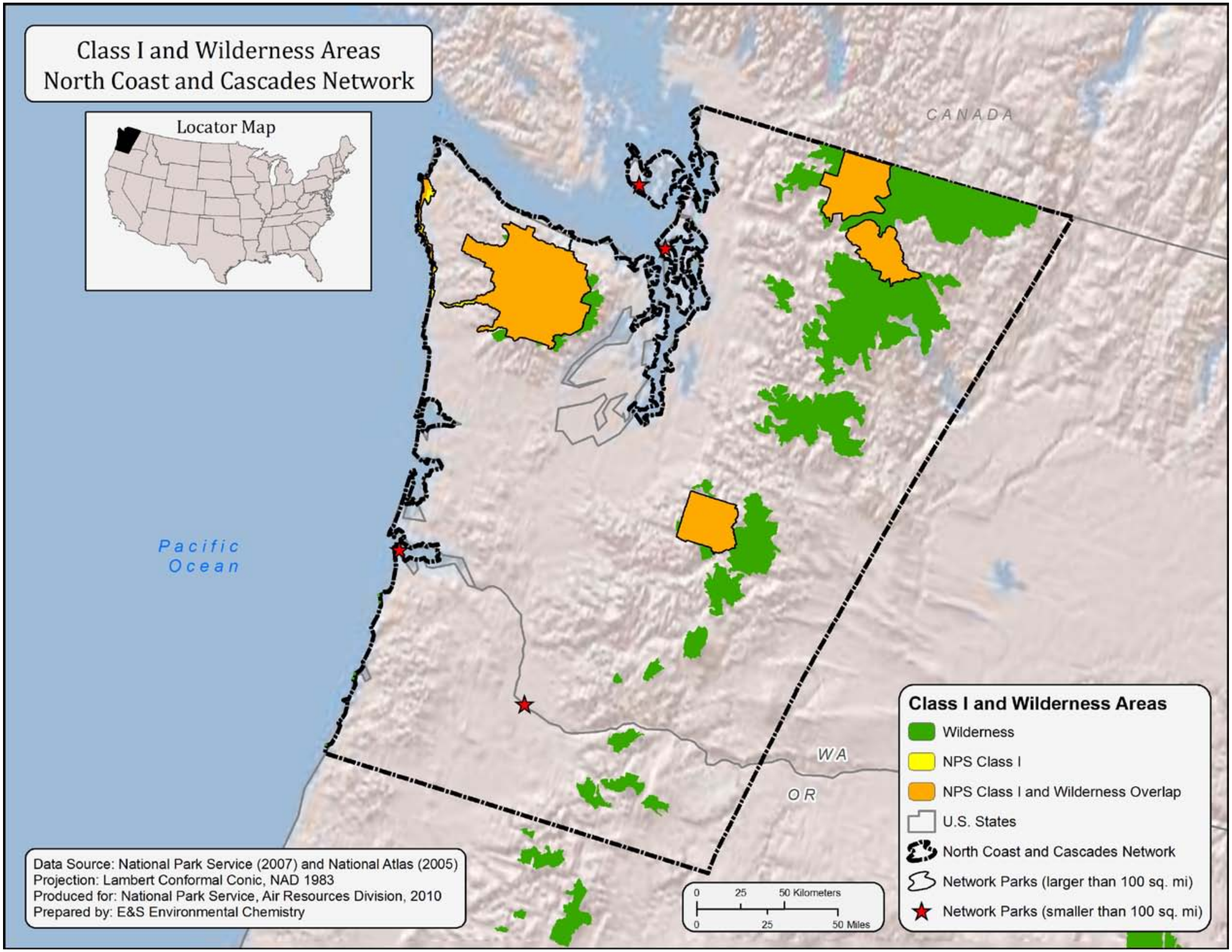
Map K


2001 Land Cover
North Coast and Cascades Network
(National Land Cover Data)
Locator Map
CANADA
Pacific Ocean
WA
OR
Open Water
Perennial Ice/Snow
Developed
Barren Land
Forest
Shrub/Scrub
Grassland/Herbaceous
Pasture/Hay
Row Crops
Wetlands
U.S. States
North Coast and Cascades Network
Network Parks (larger than 100 sq. mi)
Network Parks (smaller than 100 sq. mi)
0 25 50 Kilometers
0 25 50 Miles
Data Source: National Land Cover Data (NLCD, 2001)
Projection: Lambert Conformal Conic, NAD 1983
Produced for: National Park Service, Air Resources Division, 2010
Prepared by: E&S Environmental Chemistry

Map L

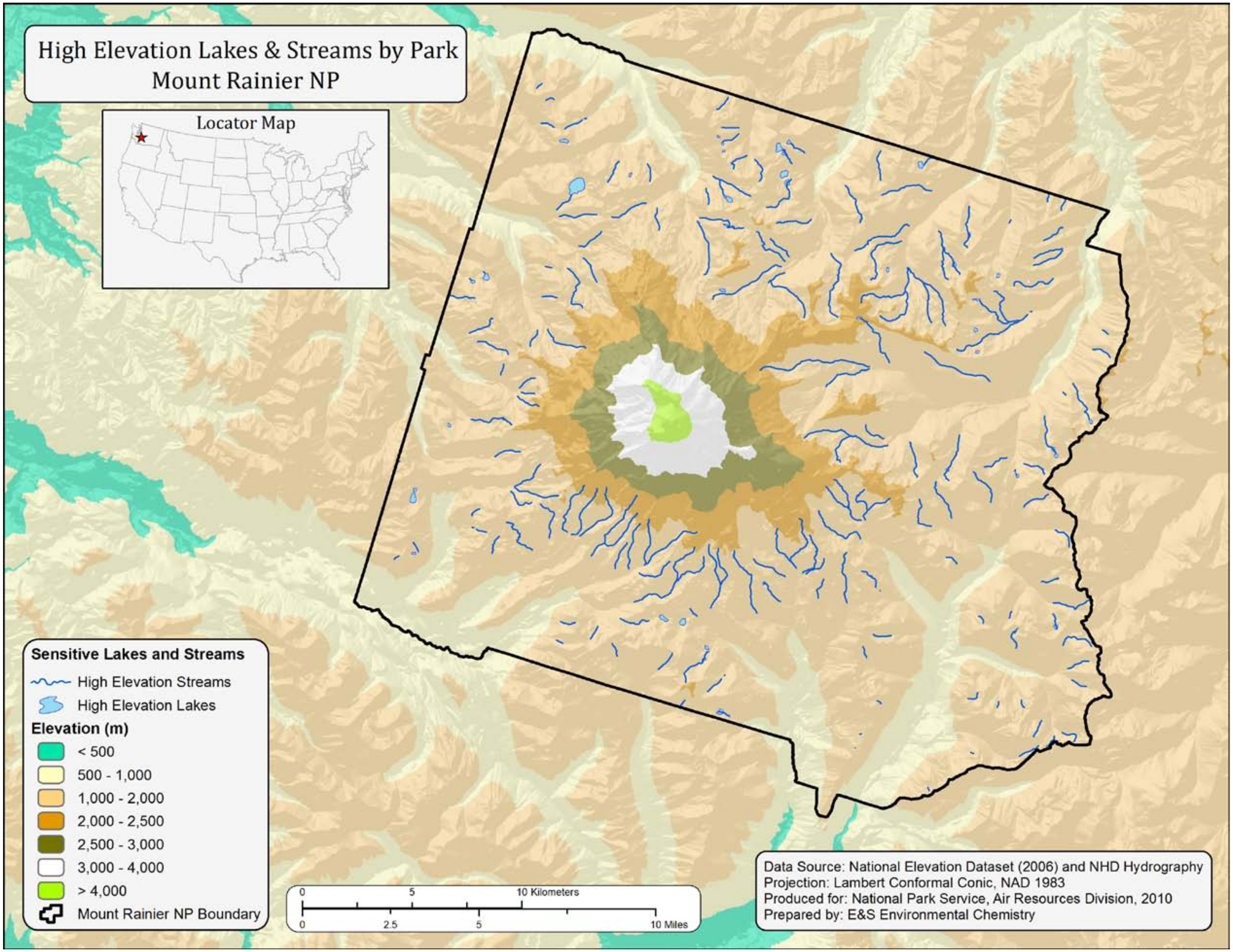

Watershed Slope by Network
North Coast and Cascades Network
Coded by 10-Digit HUC Boundary
Locator Map
CANADA
Pacific Ocean
WA
OR
Watershed Slope (degrees)
Less than 10
10 - 20
20 - 30
30 - 40
40 - 50
Greater than 50
U.S. States
North Coast and Cascades Network
Network Parks (larger than 100 sq. mi)
I & M Parks (smaller than 100 sq. mi)
0 25 50 Kilometers
0 25 50 Miles
Data Source: National Elevation Dataset (2006)
Projection: Lambert Conformal Conic, NAD 1983
Produced for: National Park Service, Air Resources Division, 2010
Prepared by: E&S Environmental Chemistry

Map M

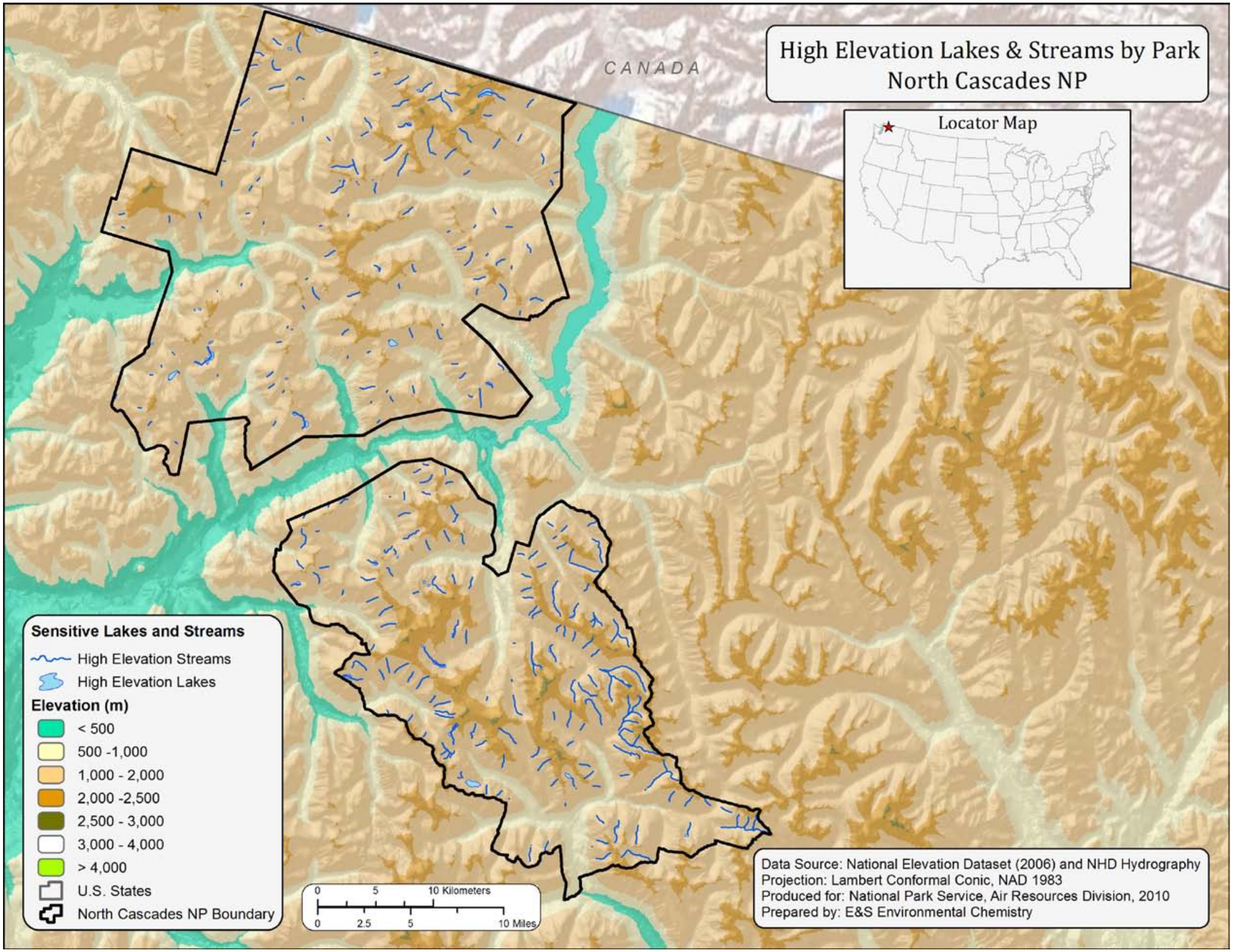


Class I and Wilderness Areas
North Coast and Cascades Network
Locator Map
CANADA
Pacific
Ocean
WA
OR
Class I and Wilderness Areas
Wilderness
NPS Class I
NPS Class I and Wilderness Overlap
U.S. States
North Coast and Cascades Network
Network Parks (larger than 100 sq. mi)
Network Parks (smaller than 100 sq. mi)
0 25 50 Kilometers
0 25 50 Miles
Data Source: National Park Service (2007) and National Atlas (2005)
Projection: Lambert Conformal Conic, NAD 1983
Produced for: National Park Service, Air Resources Division, 2010
Prepared by: E&S Environmental Chemistry

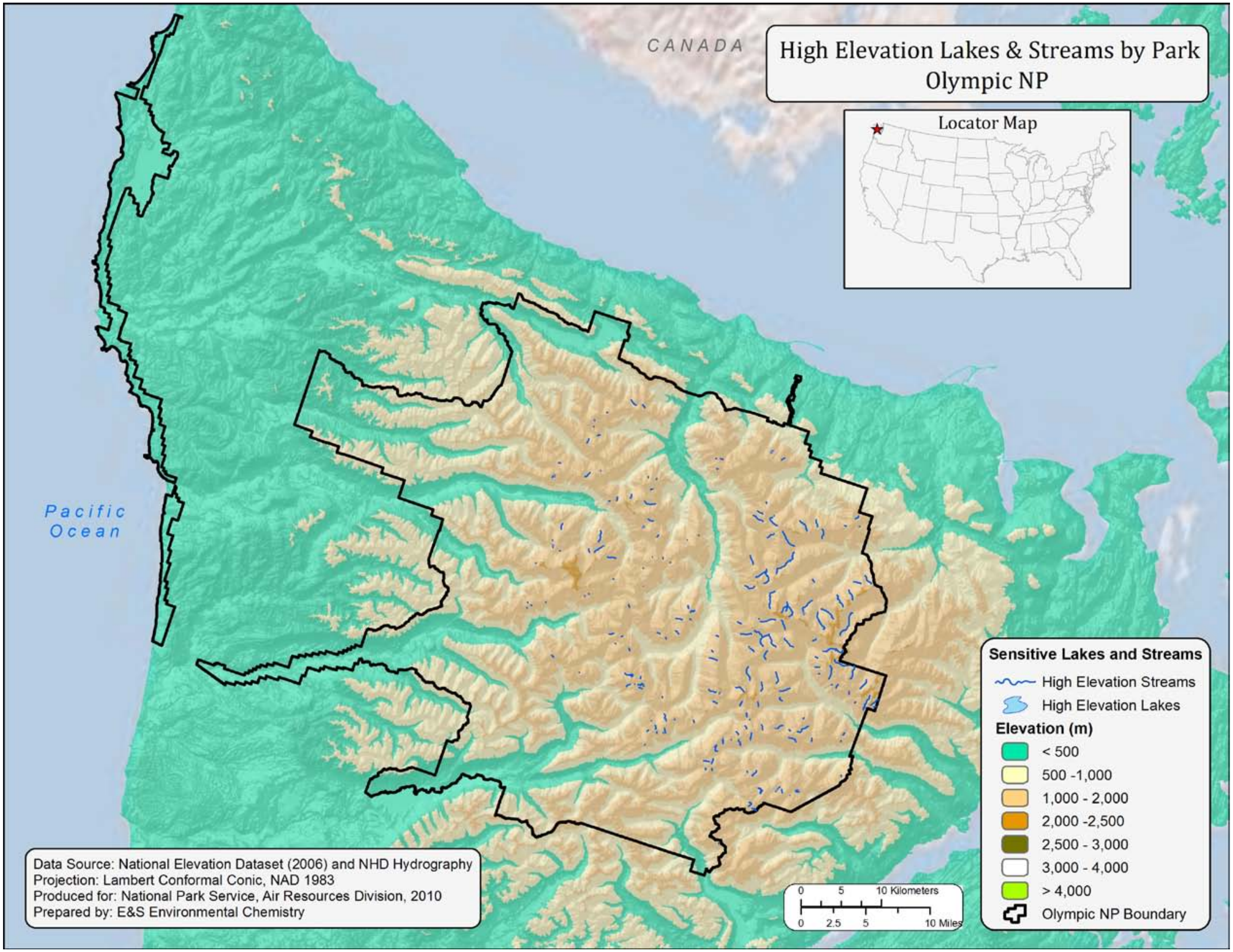
Map N


High Elevation Lakes & Streams by Park
Mount Rainier NP
Locator Map
Sensitive Lakes and Streams
High Elevation Streams
High Elevation Lakes
Elevation (m)
< 500
500 - 1,000
1,000 - 2,000
2,000 - 2,500
2,500 - 3,000
3,000 - 4,000
> 4,000
Mount Rainier NP Boundary
0
5
10 Kilometers
0
2.5
5
10 Miles
Data Source: National Elevation Dataset (2006) and NHD Hydrography
Projection: Lambert Conformal Conic, NAD 1983
Produced for: National Park Service, Air Resources Division, 2010
Prepared by: E&S Environmental Chemistry

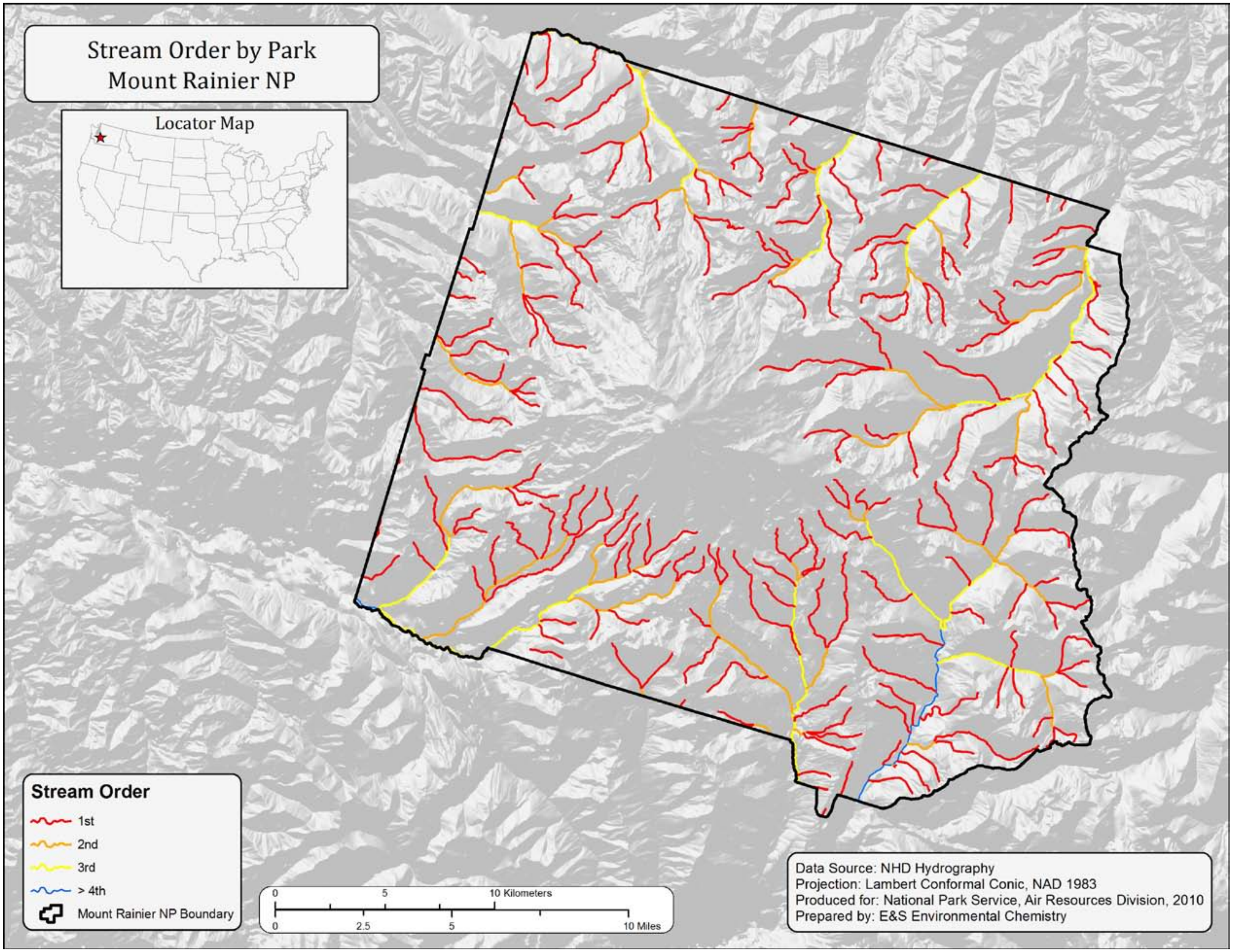
Map P-1


High Elevation Lakes & Streams by Park
North Cascades NP
CANADA
Locator Map
Sensitive Lakes and Streams
High Elevation Streams
High Elevation Lakes
Elevation (m)
< 500
500 -1,000
1,000 - 2,000
2,000 -2,500
2,500 - 3,000
3,000 - 4,000
> 4,000
U.S. States
North Cascades NP Boundary
0 5 10 Kilometers
0 2.5 5 10 Miles
Data Source: National Elevation Dataset (2006) and NHD Hydrography
Projection: Lambert Conformal Conic, NAD 1983
Produced for: National Park Service, Air Resources Division, 2010
Prepared by: E&S Environmental Chemistry

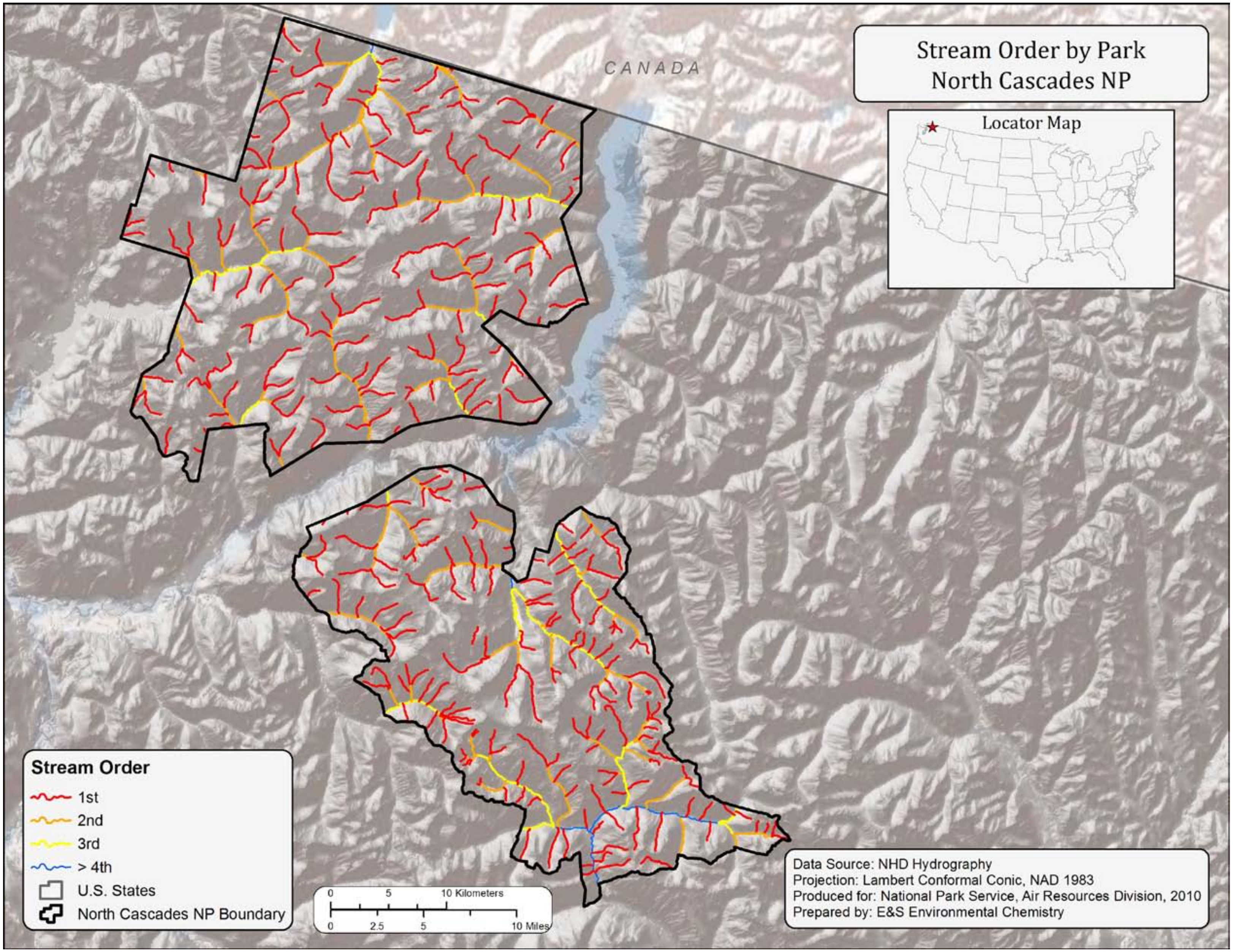
Map P-2


High Elevation Lakes & Streams by Park
Olympic NP
Locator Map
CANADA
Pacific Ocean
Sensitive Lakes and Streams
High Elevation Streams
High Elevation Lakes
Elevation (m)
< 500
500 -1,000
1,000 - 2,000
2,000 -2,500
2,500 - 3,000
3,000 - 4,000
> 4,000
Olympic NP Boundary
0 5 10 Kilometers
0 2.5 5 10 Miles
Data Source: National Elevation Dataset (2006) and NHD Hydrography
Projection: Lambert Conformal Conic, NAD 1983
Produced for: National Park Service, Air Resources Division, 2010
Prepared by: E&S Environmental Chemistry

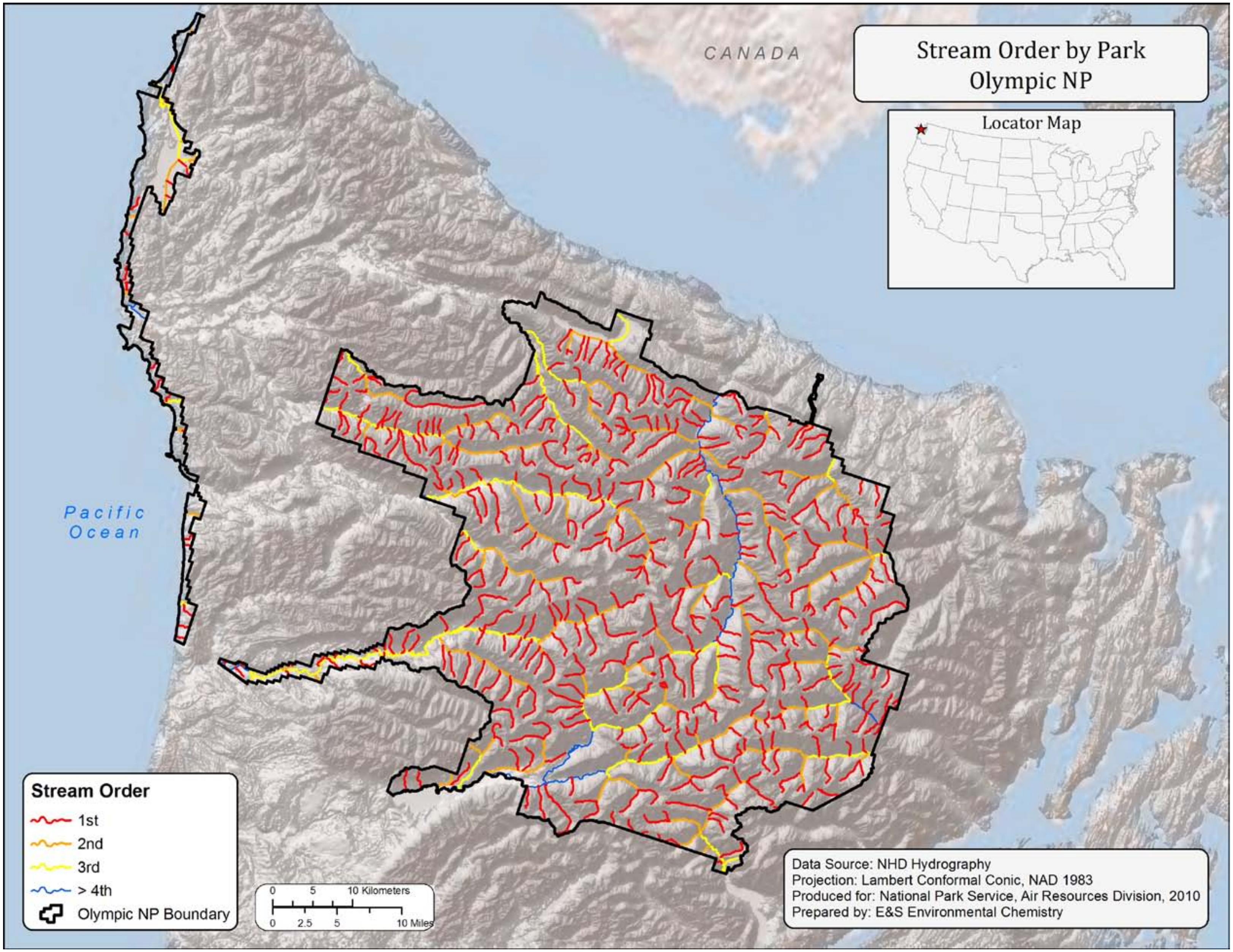
Map P-3


Stream Order by Park
Mount Rainier NP
Locator Map
Stream Order
1st
2nd
3rd
> 4th
Mount Rainier NP Boundary
0
5
10 Kilometers
0
2.5
5
10 Miles
Data Source: NHD Hydrography
Projection: Lambert Conformal Conic, NAD 1983
Produced for: National Park Service, Air Resources Division, 2010
Prepared by: E&S Environmental Chemistry

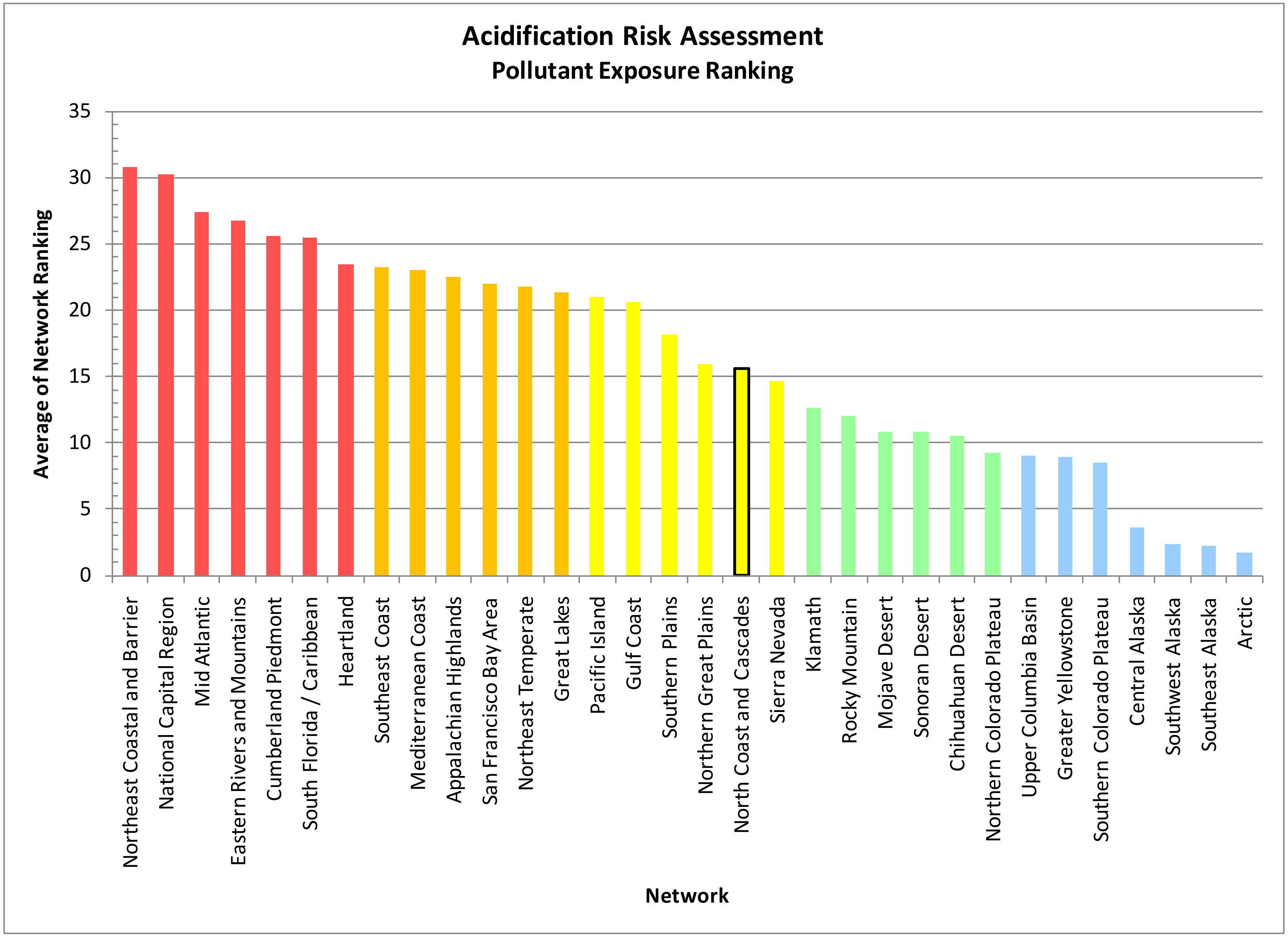
Map P-4


Stream Order by Park
North Cascades NP
CANADA
Locator Map
Stream Order
1st
2nd
3rd
> 4th
U.S. States
North Cascades NP Boundary
0 5 10 Kilometers
0 2.5 5 10 Miles
Data Source: NHD Hydrography
Projection: Lambert Conformal Conic, NAD 1983
Produced for: National Park Service, Air Resources Division, 2010
Prepared by: E&S Environmental Chemistry

Map P-5


Stream Order by Park
Olympic NP
Locator Map
CANADA
Pacific Ocean
Stream Order
1st
2nd
3rd
> 4th
Olympic NP Boundary
0 5 10 Kilometers
0 2.5 5 10 Miles
Data Source: NHD Hydrography
Projection: Lambert Conformal Conic, NAD 1983
Produced for: National Park Service, Air Resources Division, 2010
Prepared by: E&S Environmental Chemistry

Map P-6



Acidification Risk Assessment
Pollutant Exposure Ranking
Average of Network Ranking
35
30
25
20
15
10
5
0
Northeast Coastal and Barrier
National Capital Region
Mid Atlantic
Eastern Rivers and Mountains
Cumberland Piedmont
South Florida / Caribbean
Heartland
Southeast Coast
Mediterranean Coast
Appalachian Highlands
San Francisco Bay Area
Northeast Temperate
Great Lakes
Pacific Island
Gulf Coast
Southern Plains
Northern Great Plains
North Coast and Cascades
Sierra Nevada
Klamath
Rocky Mountain
Mojave Desert
Sonoran Desert
Chihuahuan Desert
Northern Colorado Plateau
Upper Columbia Basin
Greater Yellowstone
Southern Colorado Plateau
Central Alaska
Southwest Alaska
Southeast Alaska
Arctic
Network

Figure A

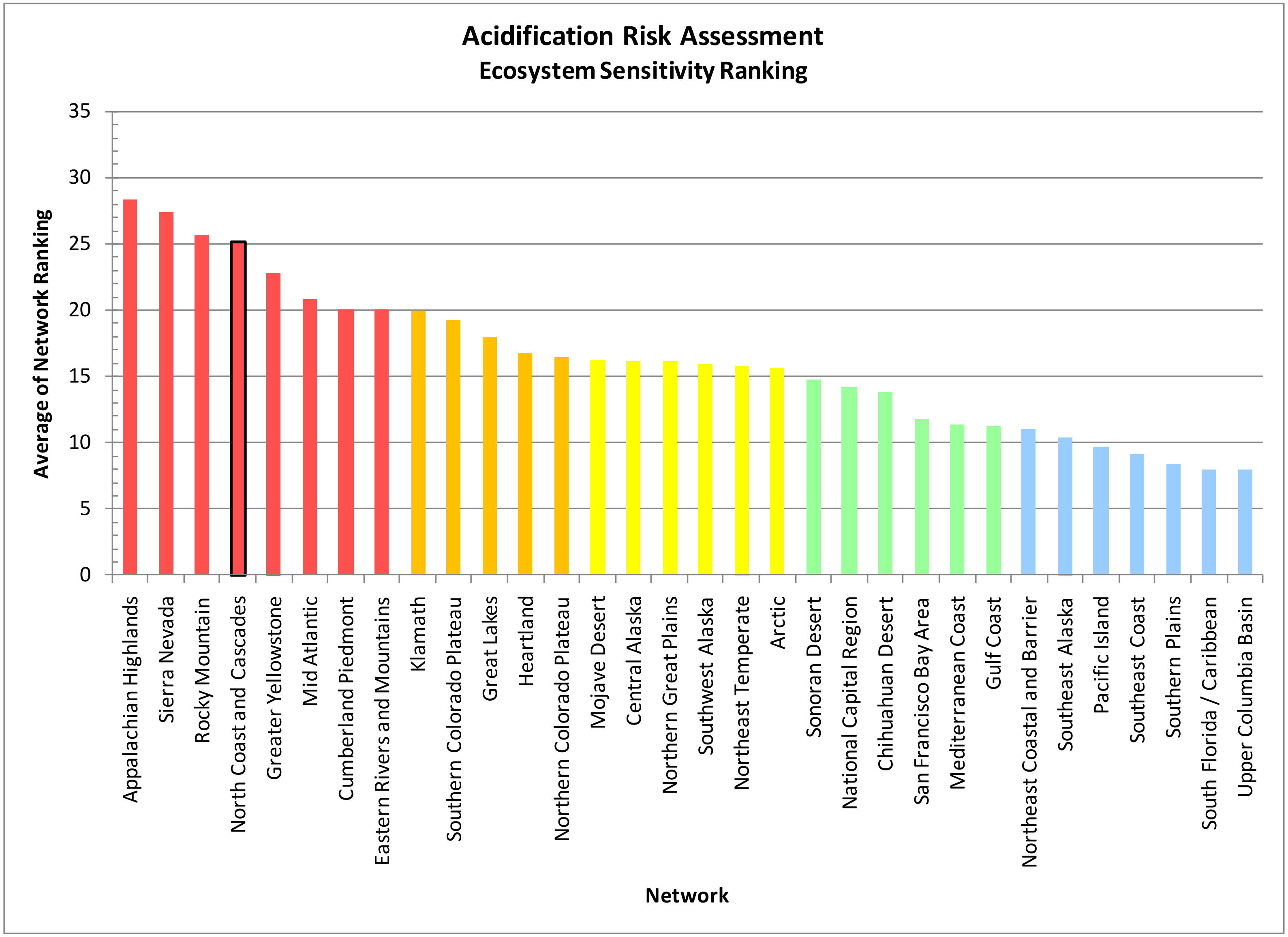
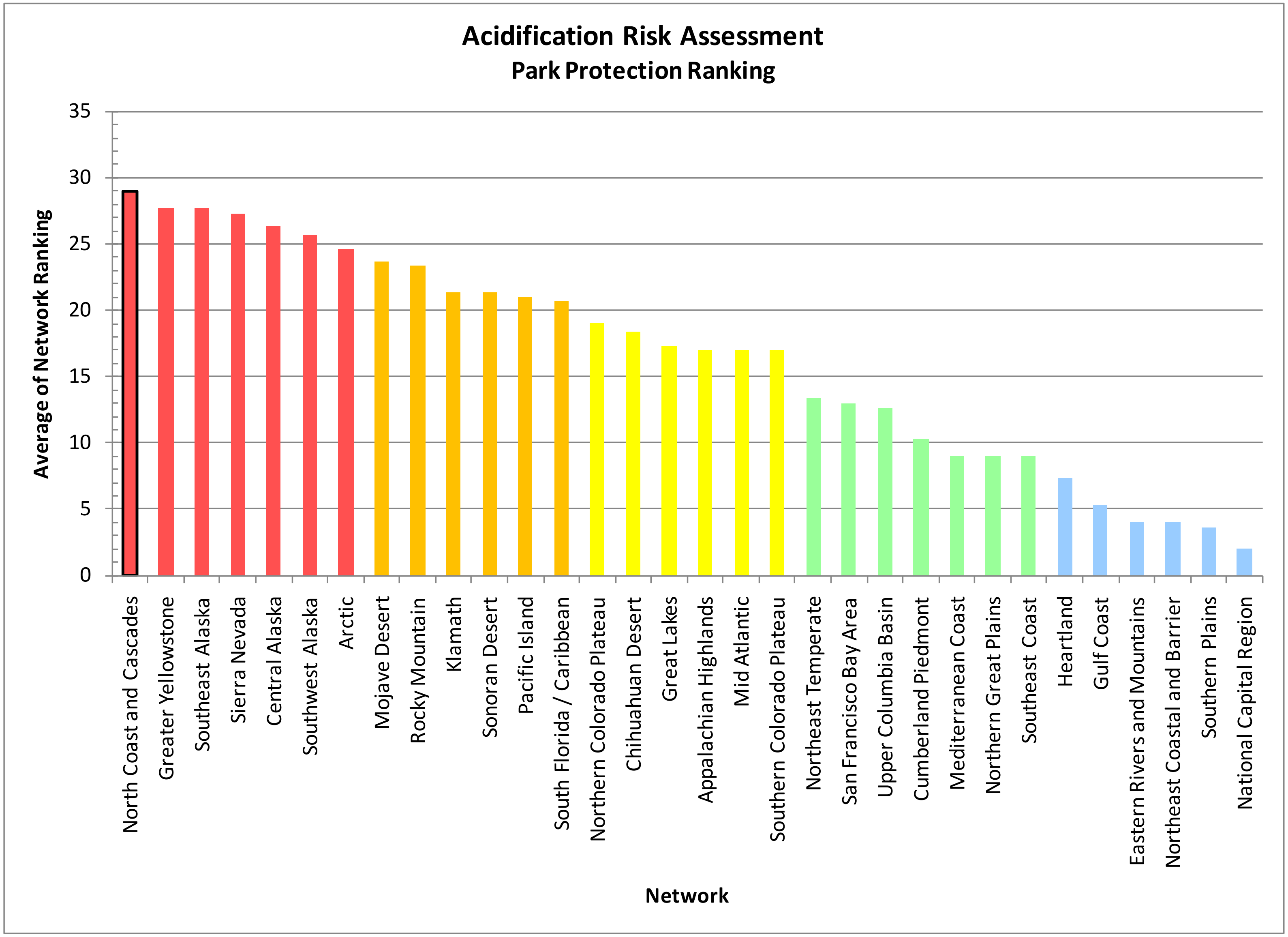


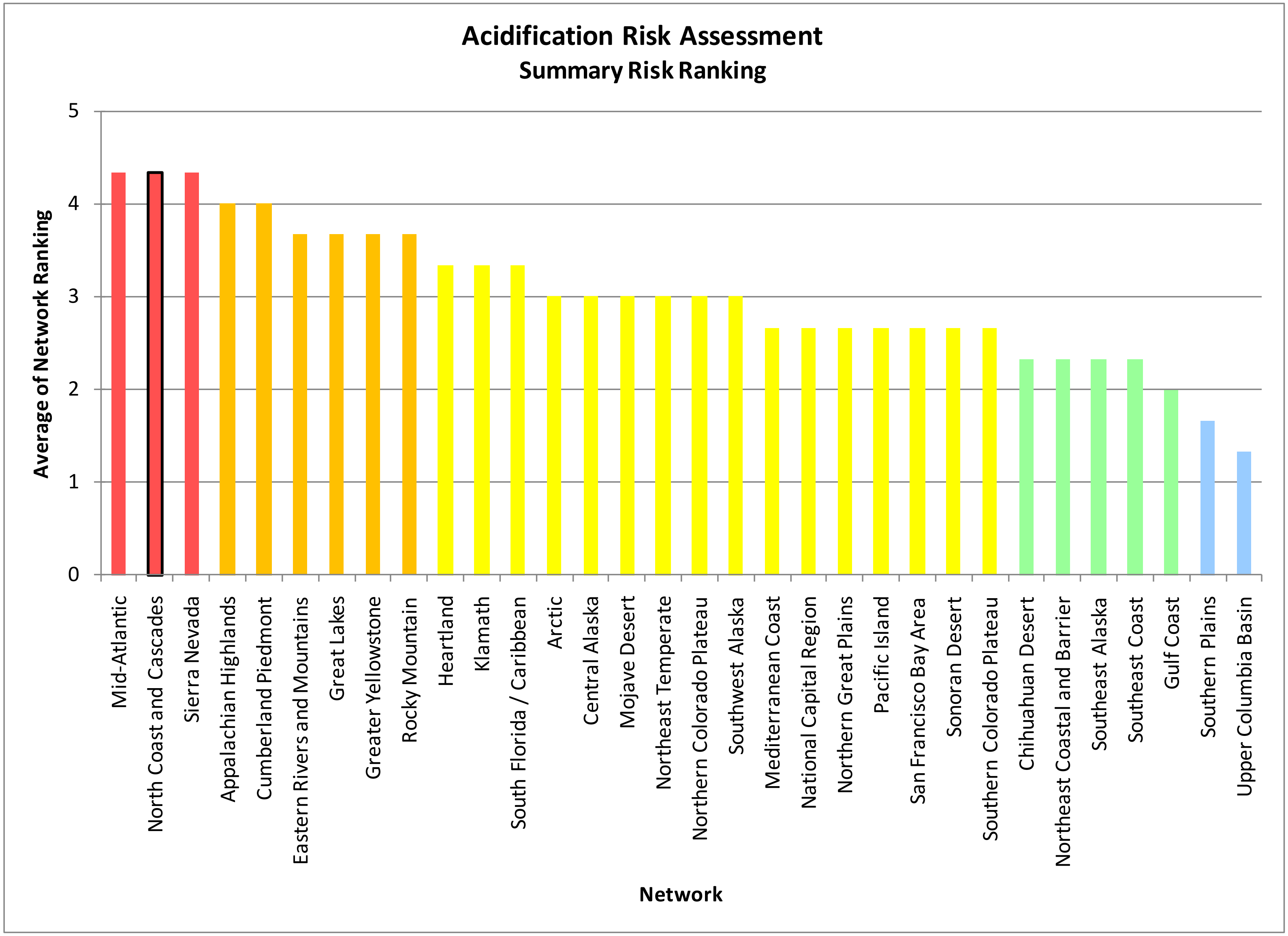
Figure B

NCCN-28



Acidification Risk Assessment
Park Protection Ranking
Average of Network Ranking
35
30
25
20
15
10
5
0
North Coast and Cascades
Greater Yellowstone
Southeast Alaska
Sierra Nevada
Central Alaska
Southwest Alaska
Arctic
Mojave Desert
Rocky Mountain
Klamath
Sonoran Desert
Pacific Island
South Florida / Caribbean
Northern Colorado Plateau
Chihuahuan Desert
Great Lakes
Appalachian Highlands
Mid Atlantic
Southern Colorado Plateau
Northeast Temperate
San Francisco Bay Area
Upper Columbia Basin
Cumberland Piedmont
Mediterranean Coast
Northern Great Plains
Southeast Coast
Heartland
Gulf Coast
Eastern Rivers and Mountains
Northeast Coastal and Barrier
Southern Plains
National Capital Region
Network

Figure C



Acidification Risk Assessment
Summary Risk Ranking
Average of Network Ranking
Network
0
1
2
3
4
5
Mid-Atlantic
North Coast and Cascades
Sierra Nevada
Appalachian Highlands
Cumberland Piedmont
Eastern Rivers and Mountains
Great Lakes
Greater Yellowstone
Rocky Mountain
Heartland
Klamath
South Florida / Caribbean
Arctic
Central Alaska
Mojave Desert
Northeast Temperate
Northern Colorado Plateau
Southwest Alaska
Mediterranean Coast
National Capital Region
Northern Great Plains
Pacific Island
San Francisco Bay Area
Sonoran Desert
Southern Colorado Plateau
Chihuahuan Desert
Northeast Coastal and Barrier
Southeast Alaska
Southeast Coast
Gulf Coast
Southern Plains
Upper Columbia Basin

Figure D

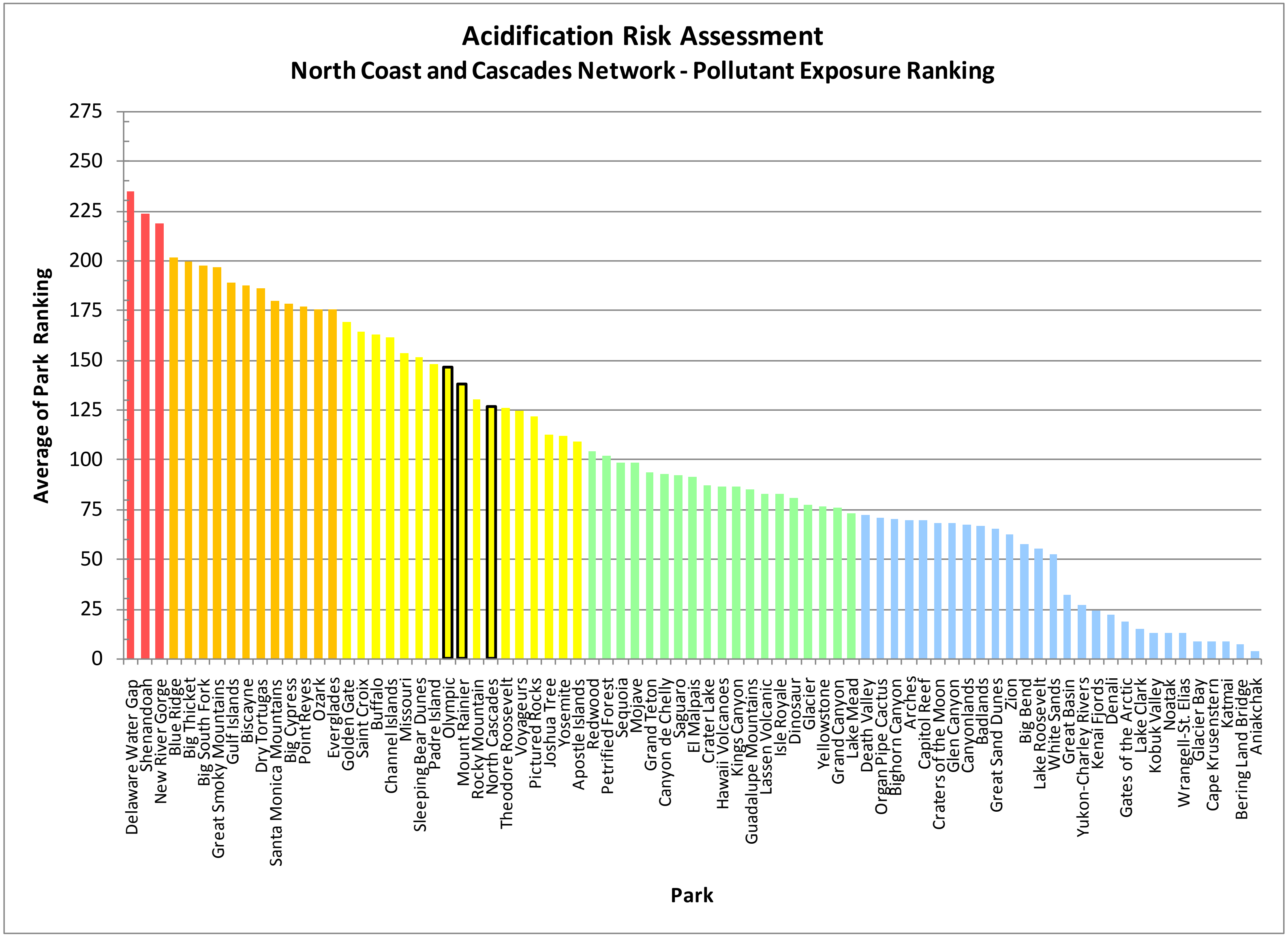
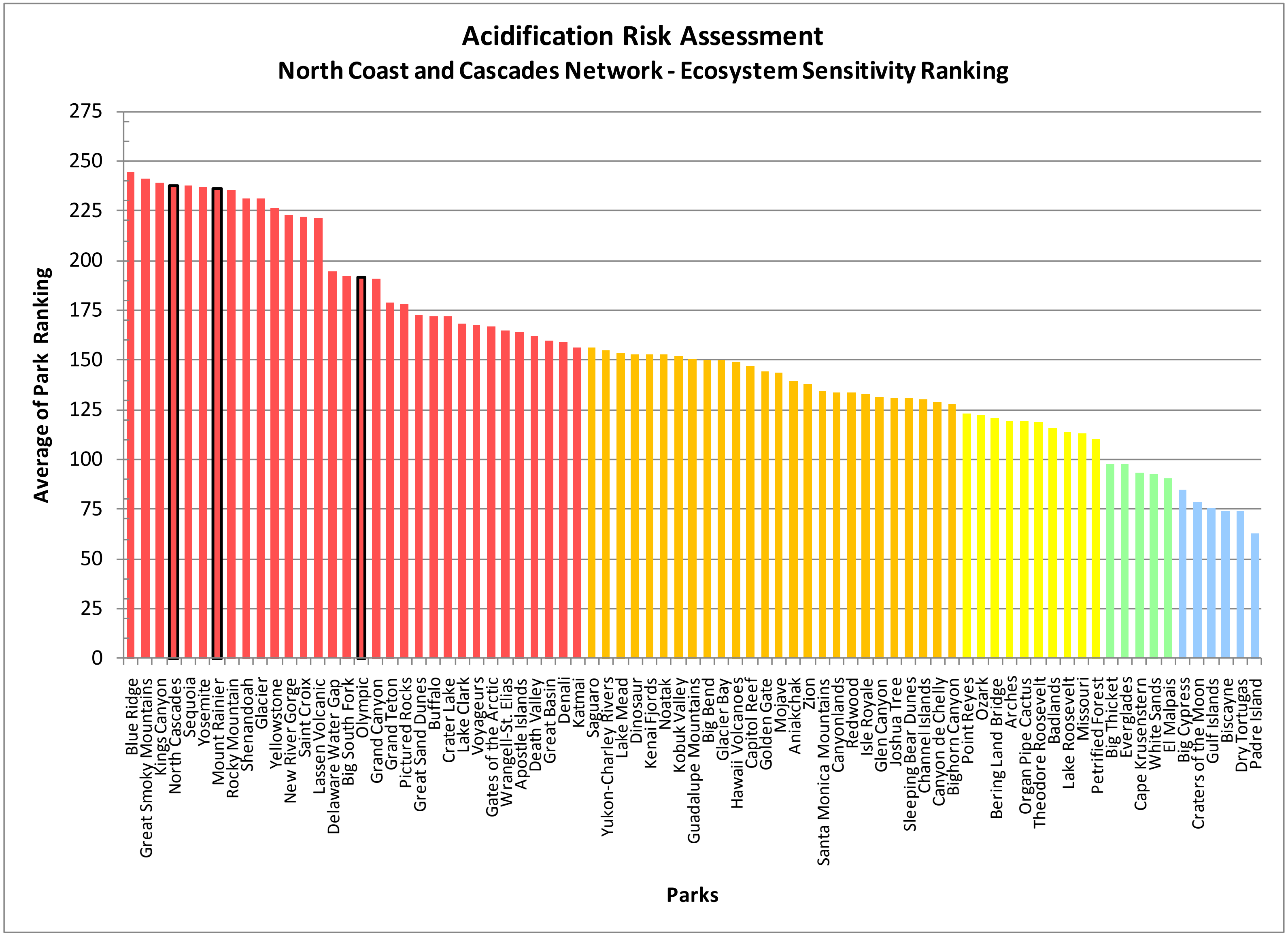


Figure E

NCCN-31



Acidification Risk Assessment
North Coast and Cascades Network - Ecosystem Sensitivity Ranking
Average of Park Ranking
275
250
225
200
175
150
125
100
75
50
25
0
Blue Ridge
Great Smoky Mountains
Kings Canyon
North Cascades
Sequoia
Yosemite
Mount Rainier
Rocky Mountain
Shenandoah
Glacier
Yellowstone
New River Gorge
Saint Croix
Lassen Volcanic
Delaware Water Gap
Big South Fork
Olympic
Grand Canyon
Grand Teton
Pictured Rocks
Great Sand Dunes
Buffalo
Crater Lake
Lake Clark
Voyageurs
Gates of the Arctic
Wrangell-St. Elias
Apostle Islands
Death Valley
Great Basin
Denali
Katmai
Saguaro
Yukon-Charley Rivers
Lake Mead
Dinosaur
Kenai Fjords
Noatak
Kobuk Valley
Guadalupe Mountains
Big Bend
Glacier Bay
Hawaii Volcanoes
Capitol Reef
Golden Gate
Mojave
Aniakchak
Zion
Santa Monica Mountains
Canyonlands
Redwood
Isle Royale
Glen Canyon
Joshua Tree
Sleeping Bear Dunes
Channel Islands
Canyon de Chelly
Bighorn Canyon
Point Reyes
Ozark
Bering Land Bridge
Arches
Organ Pipe Cactus
Theodore Roosevelt
Badlands
Lake Roosevelt
Missouri
Petrified Forest
Big Thicket
Everglades
Cape Krusenstern
White Sands
El Malpais
Big Cypress
Craters of the Moon
Gulf Islands
Biscayne
Dry Tortugas
Padre Island
Parks

Figure F

NCCN-33

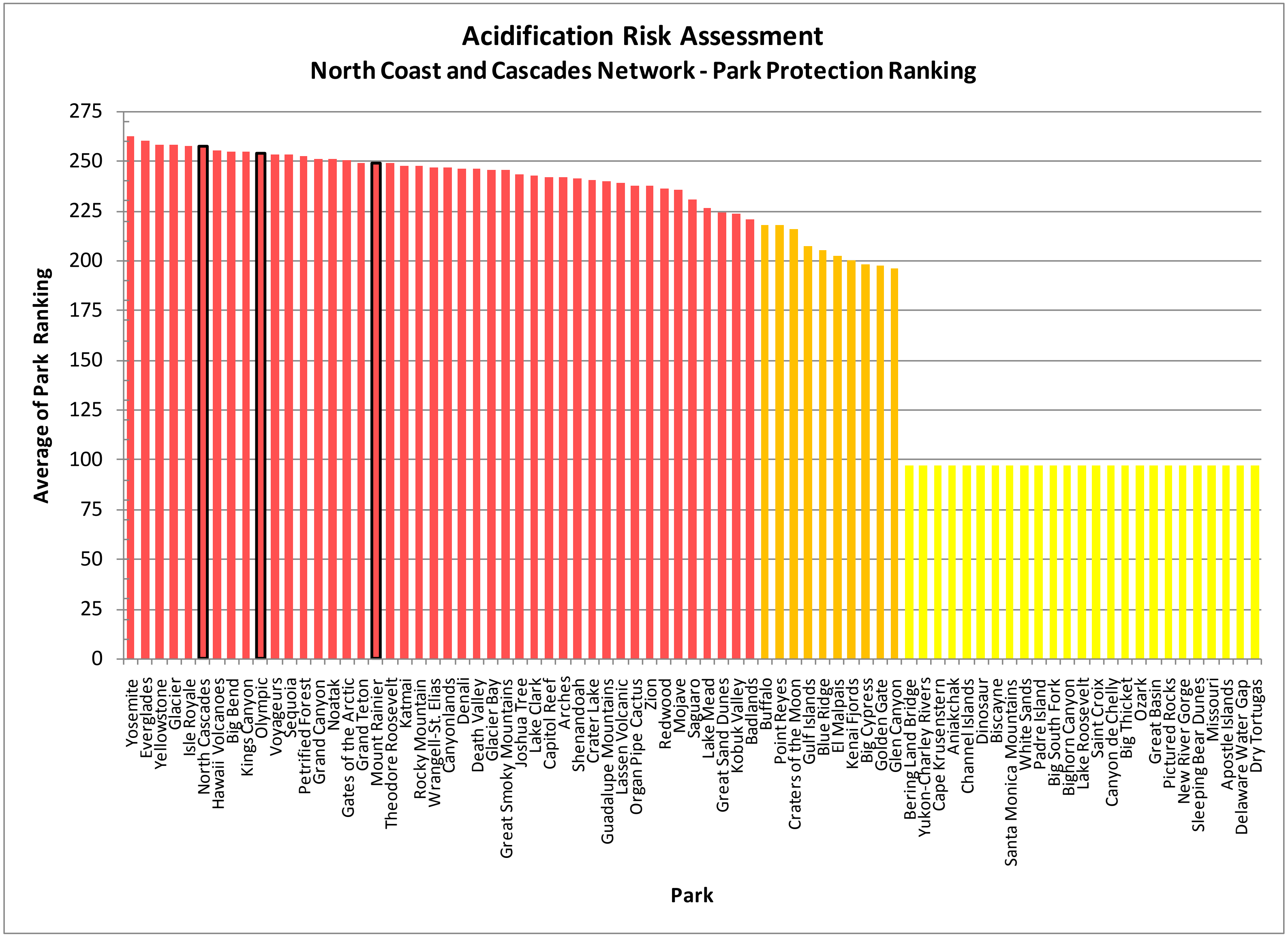


Figure G

NCCN-34

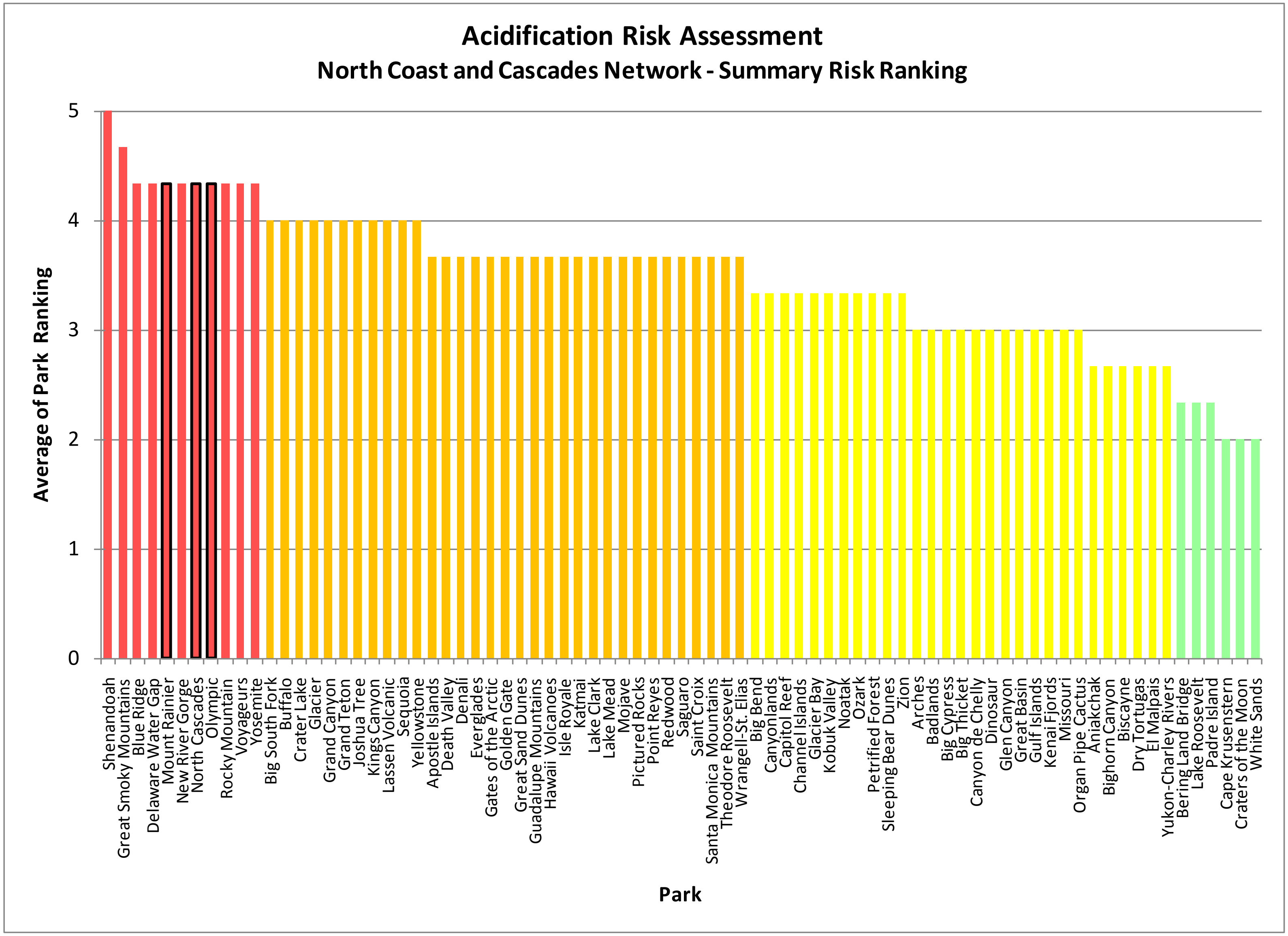


Figure H

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 963/107401, April 2011

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