National Park Service
U.S. Department of the Interior

Natural Resource Program Center

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

Northeast Temperate Network (NETN)

Natural Resource Report NPS/NRPC/ARD/NRR—2011/320

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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Natural Resource Program Center
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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NPS 962/106684, February 2011

Northeast Temperate Network (NETN)

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 11 parks in the Northeast Temperate Network. None are larger than 100 square miles. This network includes heavily urbanized areas around New York City and Boston, as well as relatively undeveloped areas in northern New York, New Hampshire, Vermont, and Maine.

Total annual N emissions, by county, are shown in Map C for lands in and surrounding the Northeast Temperate Network. County-level emissions within the network ranged from less than 1 ton per square mile to greater than 100 tons per square mile in some of the densely urbanized areas in and around Boston and near New York City. In general, annual county N emissions were less than 20 tons per square mile throughout all but the most heavily urbanized areas. Point source emissions of oxidized (nitrogen oxides, NO_x) and reduced (ammonia, NH_3) N are shown in Map D. There are few N point sources of any magnitude (i.e., larger than 500 to 1,000 tons per square mile) within this network. Urban centers within the network and within a 300 mile buffer around the network are shown in Map E. There is a large density of medium size to large urban population centers, especially along the coastal corridor between Boston and Washington, DC. Elsewhere within the network, there are fewer population centers larger than 50,000 people.

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 is highly variable from north to south, ranging from less than 2 kg N/ha/yr r in northern Maine to between 10 and 15 kg N/ha/yr in much of the south, and higher than that in some of the more heavily urbanized areas.

Land cover in and around the network is shown in Map G. The predominant cover types within this network are generally forest in the north, developed land and forest in the south, and a mix of forest, pasture/hay, row crops, and developed land in the west.

Map H, showing 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), is not shown. It would not be possible to discern the vegetation types in any of the parks at the scale of the network.

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 only Class I park is Acadia NP (ACAD). Only limited, relatively small, wilderness areas occur in this network, mostly in the mountains of New Hampshire and Vermont.

There are a number of I&M parks within this network, but most are small. The largest is ACAD. Park-specific maps are shown for ACAD in Maps J-1 and J-2. In general, the predominant

sensitive vegetation type is wetland (Map J-1). There are several lakes in ACAD, but none are located at high elevation (Map J-2). High-elevation lakes might be more prone than lakes at lower elevation to N-enrichment, and therefore potentially more susceptible to eutrophication in response to atmospheric N input. We have no evidence that lakes within ACAD are likely 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 Northeast Temperate Network ranks in the second highest quintile in N Pollutant Exposure (Figure A). Nitrogen emissions and N deposition within the network are both moderate. The network Ecosystem Sensitivity ranking is Very Low, within the lowest quintile among networks (Figure B). This is because there is limited vegetation coverage in the I&M parks in this network that includes vegetation types that are among those expected to be especially sensitive to nutrient enrichment effects from N deposition, and there are no high elevation lakes. This network ranks at the top of 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 lowest 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 Low. Because there are no parks in this network that are larger than 100 square miles, the figures used to compare rankings among the larger parks are not shown for this network. Relative rankings for all parks, including the smaller parks, are given in Table A and Appendix B. Pollutant Exposure rankings for the individual parks in this network were variable, from Moderate (middle quintile) for four of the parks to Very High (top quintile) for five parks. In contrast, the Ecosystem Sensitivity rankings were lower (Low to Very Low) for all parks except Boston Harbor Islands (BOHA), Saugus Iron Works (SAIR), and Weir Farm (WEFA), which were ranked in the middle quintile for this theme. Park Protection rankings were all Moderate, with the exception of ACAD, which was ranked Very High in Park Protection.

Park Summary rankings were highly variable, from Very Low for two of the parks to Very High for WEFA. Summary rankings were High, in the second highest quintile, for ACAD, BOHA, Home of Franklin D. Roosevelt (HOFR), Morristown (MORR), and SAIR.

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
Acadia	Moderate	Low	Very High	High
Boston Harbor Islands	Very High	Moderate	Moderate	High
Home of Franklin D. Roosevelt	Very High	Low	Moderate	High
Marsh-Billings-Rockefeller	Moderate	Very Low	Moderate	Very Low
Minute Man	High	Low	Moderate	Moderate
Morristown	Very High	Very Low	Moderate	High
Saint-Gaudens	Moderate	Very Low	Moderate	Very Low
Saratoga	Moderate	Low	Moderate	Low
Saugus Iron Works	High	Moderate	Moderate	High
Vanderbilt Mansion	Very High	Very Low	Moderate	Moderate
Weir Farm	Very High	Moderate	Moderate	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, 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 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, 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 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, NH_3) 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, 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 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, NH_3) 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)

Map J-1. Park-specific map: sensitive vegetation types in ACAD. (Source of data: See Appendix A)

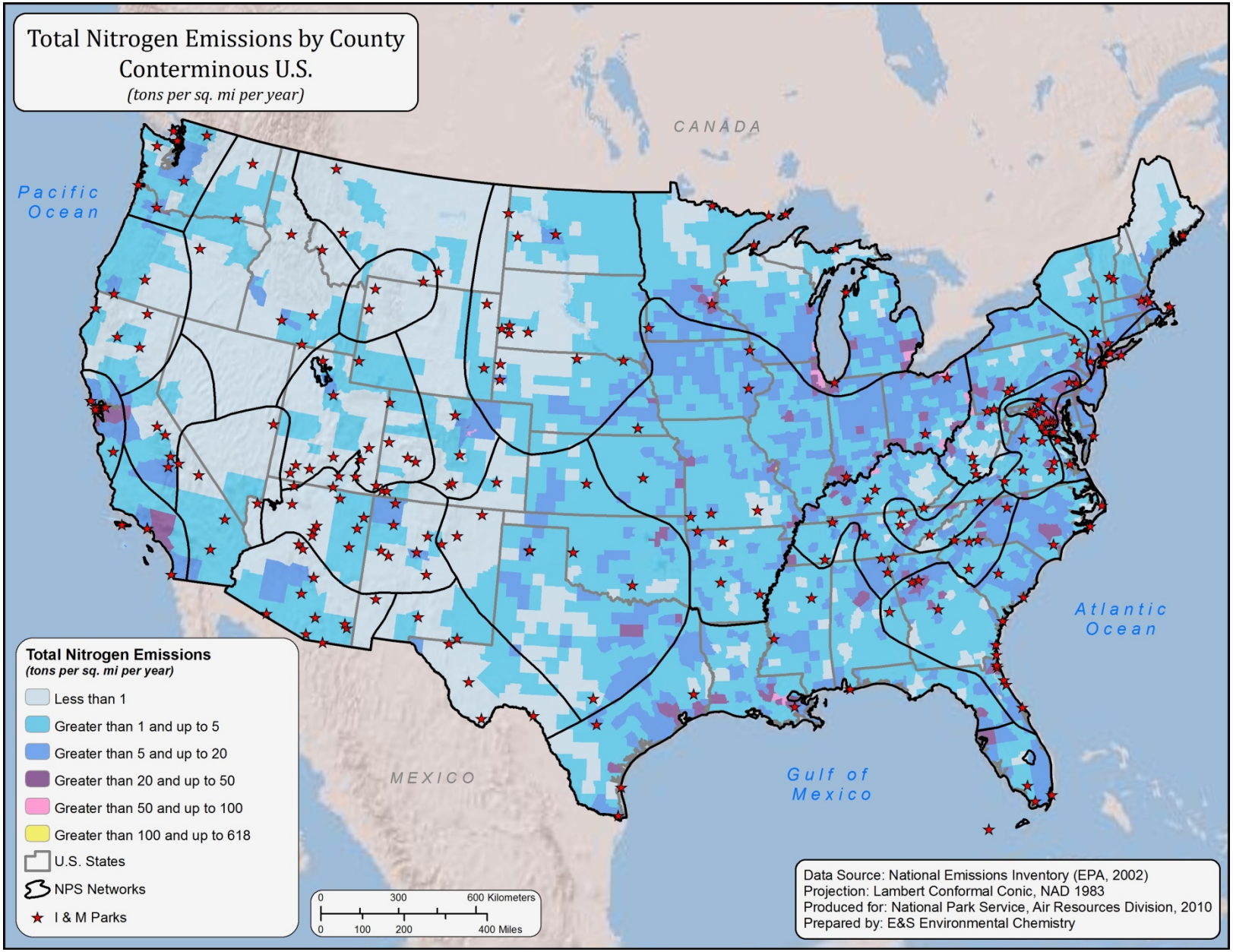
Map J-2. Park-specific map: high-elevation lakes in ACAD. (Source of data: U.S. EPA National Elevation Dataset and U.S. EPA/USGS National Hydrography Dataset Plus [http://www.horizon-systems.com/nhdplus/])

Figure A. Network rankings for Pollutant Exposure, calculated as the average of scores for all Pollutant Exposure variables.

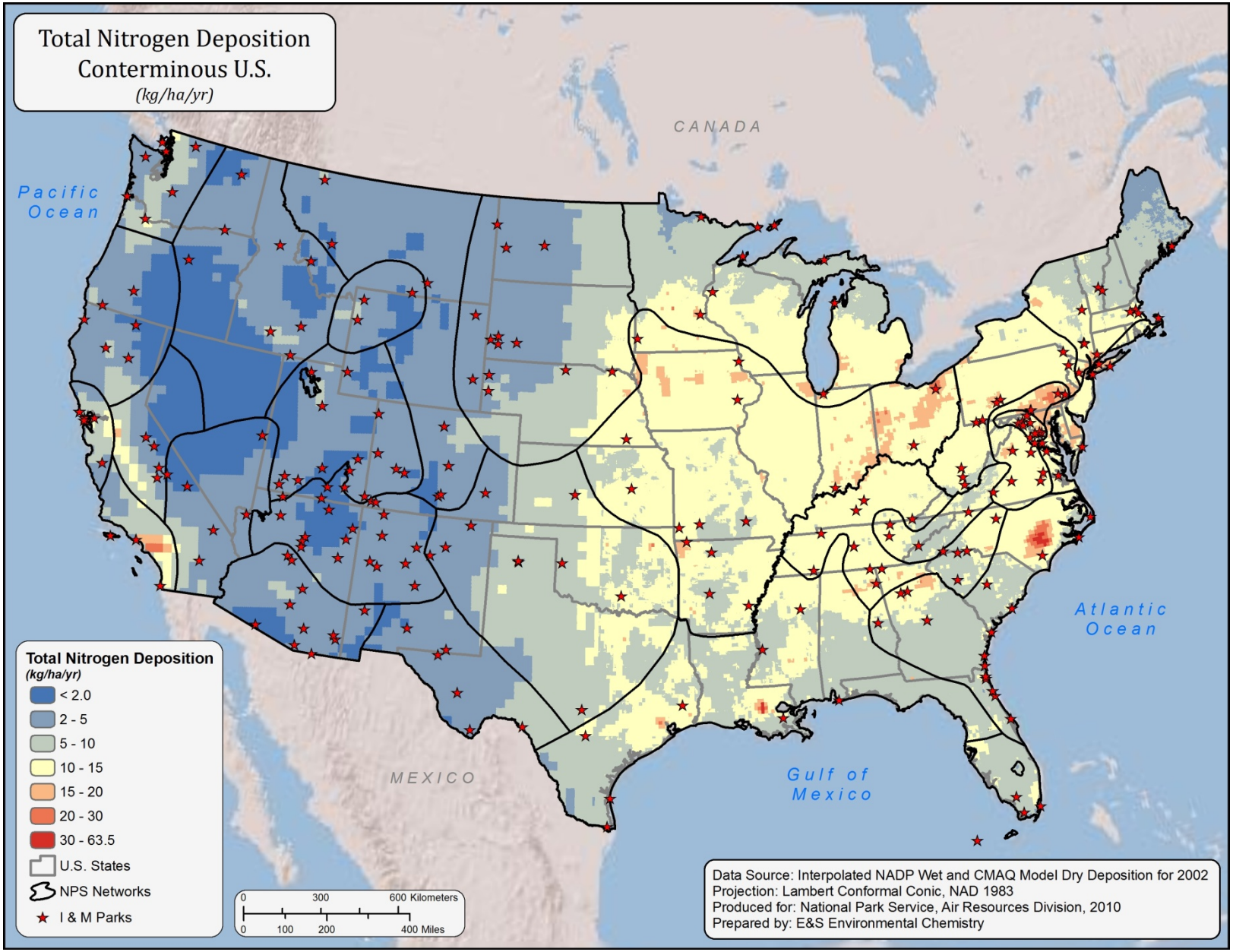
Figure B. Network rankings for Ecosystem Sensitivity, calculated as the average of scores for all Ecosystem Sensitivity variables.

Figure C. Network rankings for Park Protection, calculated as the average of scores for all Park Protection variables.

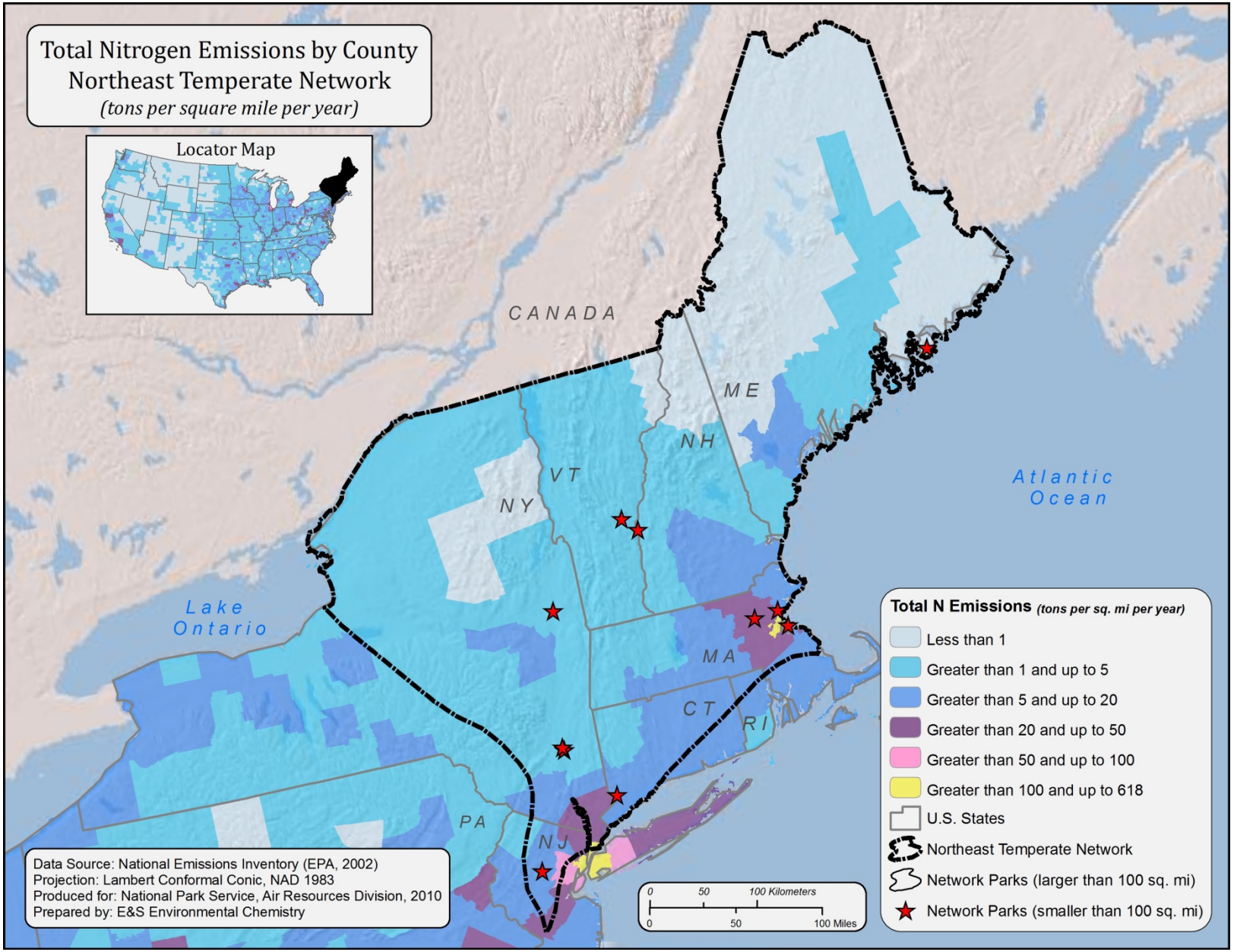
Figure D. Network Summary Risk ranking, calculated as the sum of the averages of the scores for Pollutant Exposure, Ecosystem Sensitivity, and Park Protection.


Total Nitrogen Emissions by County
Conterminous U.S.
(tons per sq. mi per year)
CANADA
Pacific Ocean
Atlantic Ocean
MEXICO
Gulf of 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

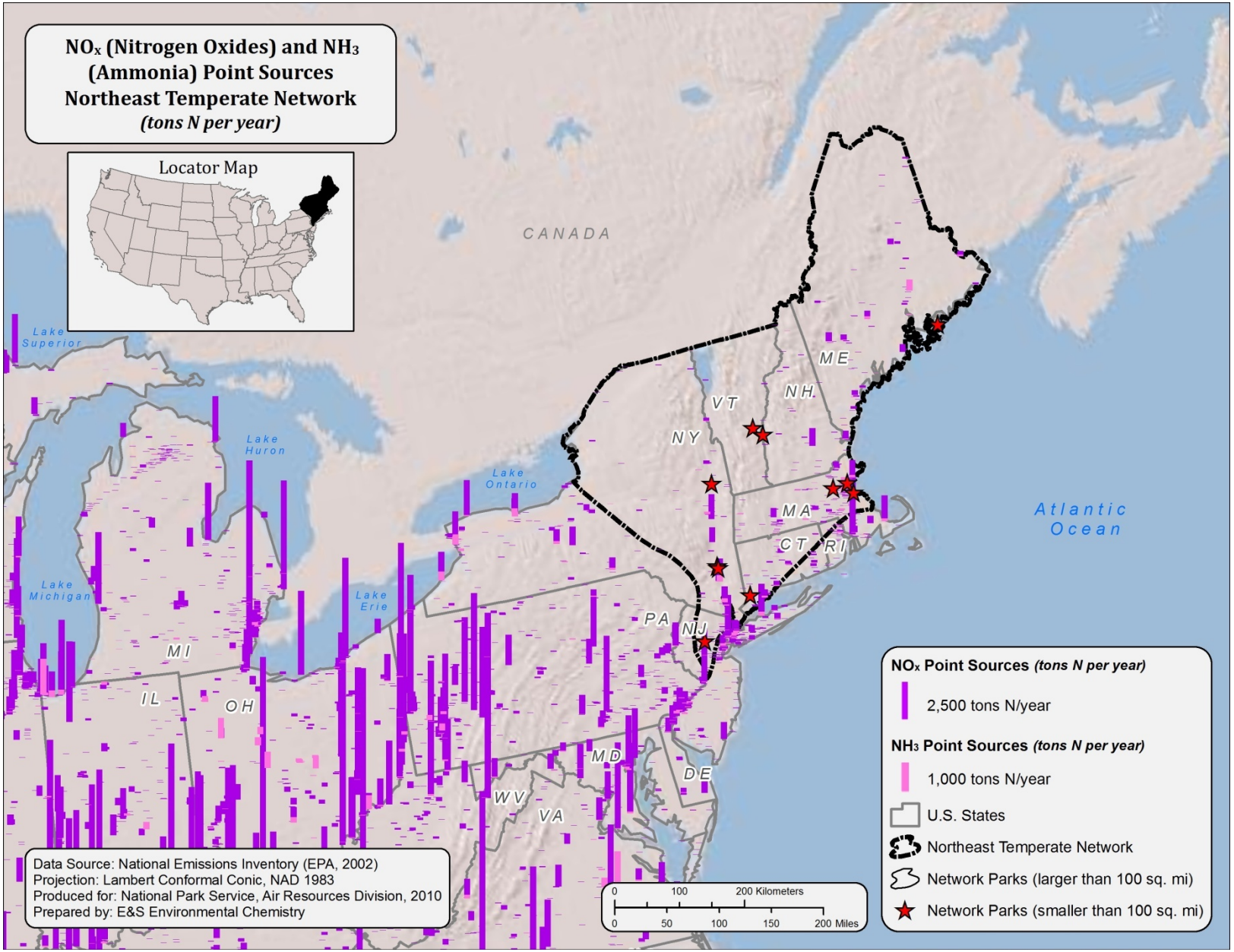
Map A


Total Nitrogen Deposition
Conterminous U.S.
(kg/ha/yr)
CANADA
Pacific Ocean
Atlantic Ocean
MEXICO
Gulf of 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

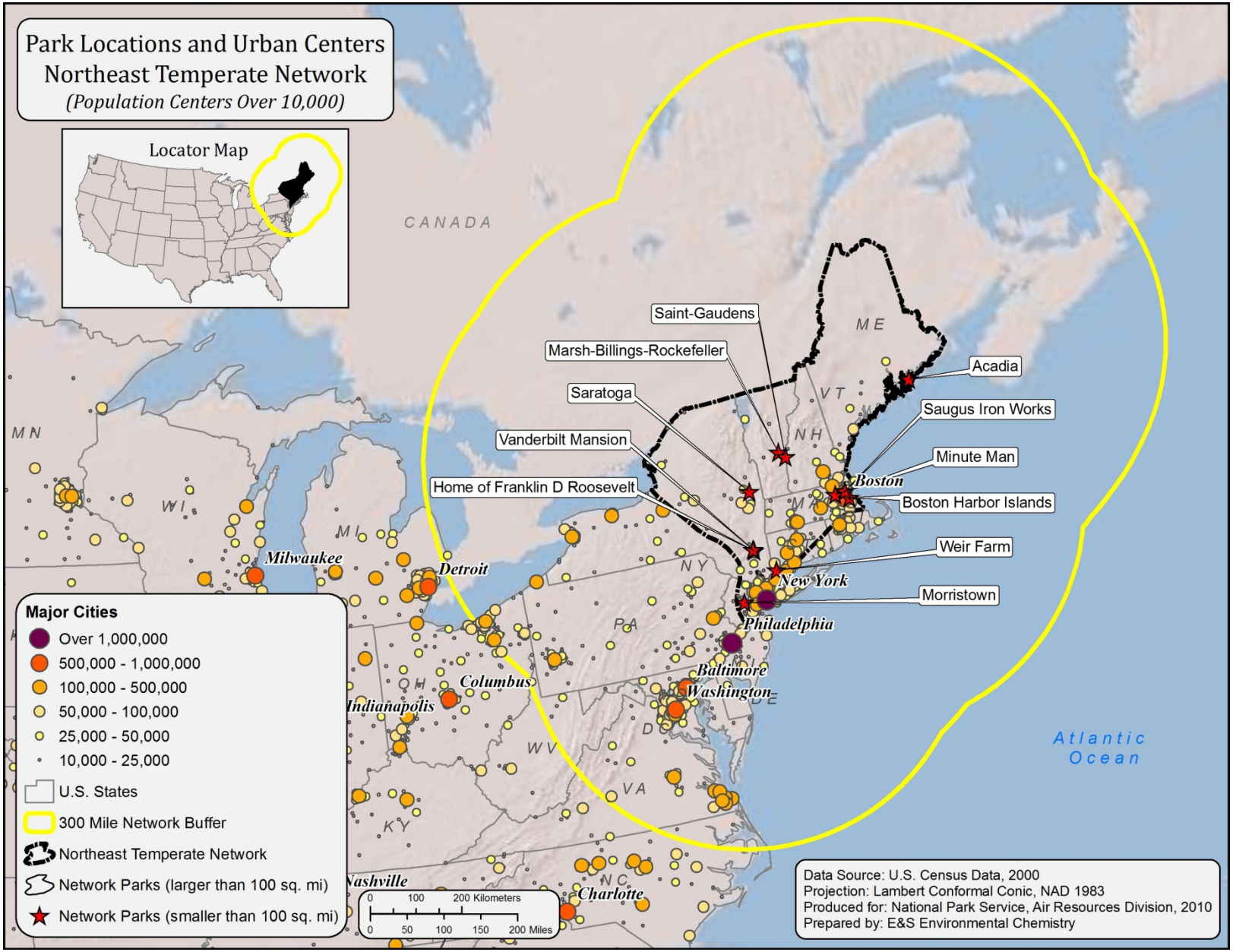
Map B


Total Nitrogen Emissions by County
Northeast Temperate Network
(tons per square mile per year)
Locator Map
CANADA
ME
NH
VT
NY
MA
CT
RI
PA
NJ
Lake Ontario
Atlantic Ocean
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
Northeast Temperate Network
Network Parks (larger than 100 sq. mi)
Network Parks (smaller than 100 sq. mi)
0 50 100 Kilometers
0 50 100 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

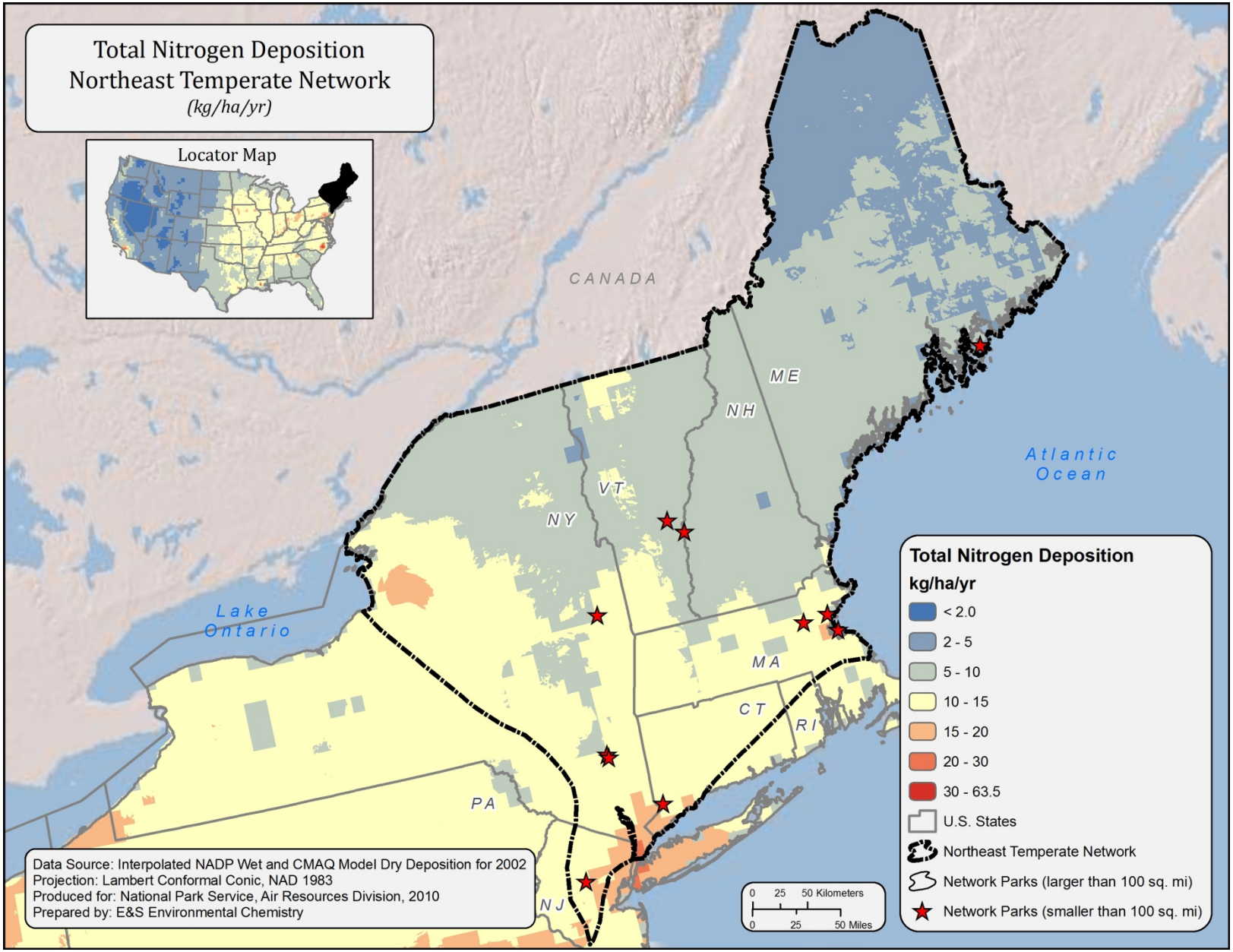
Map C


NOx (Nitrogen Oxides) and NH3 (Ammonia) Point Sources
Northeast Temperate Network
(tons N per year)
Locator Map
CANADA
Lake Superior
Lake Huron
Lake Michigan
Lake Erie
Lake Ontario
Atlantic Ocean
ME
NH
VT
NY
MA
CT
RI
PA
NJ
MI
IL
OH
WV
VA
MD
DE
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
0 100 200 Kilometers
0 50 100 150 200 Miles
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
Northeast Temperate Network
Network Parks (larger than 100 sq. mi)
Network Parks (smaller than 100 sq. mi)

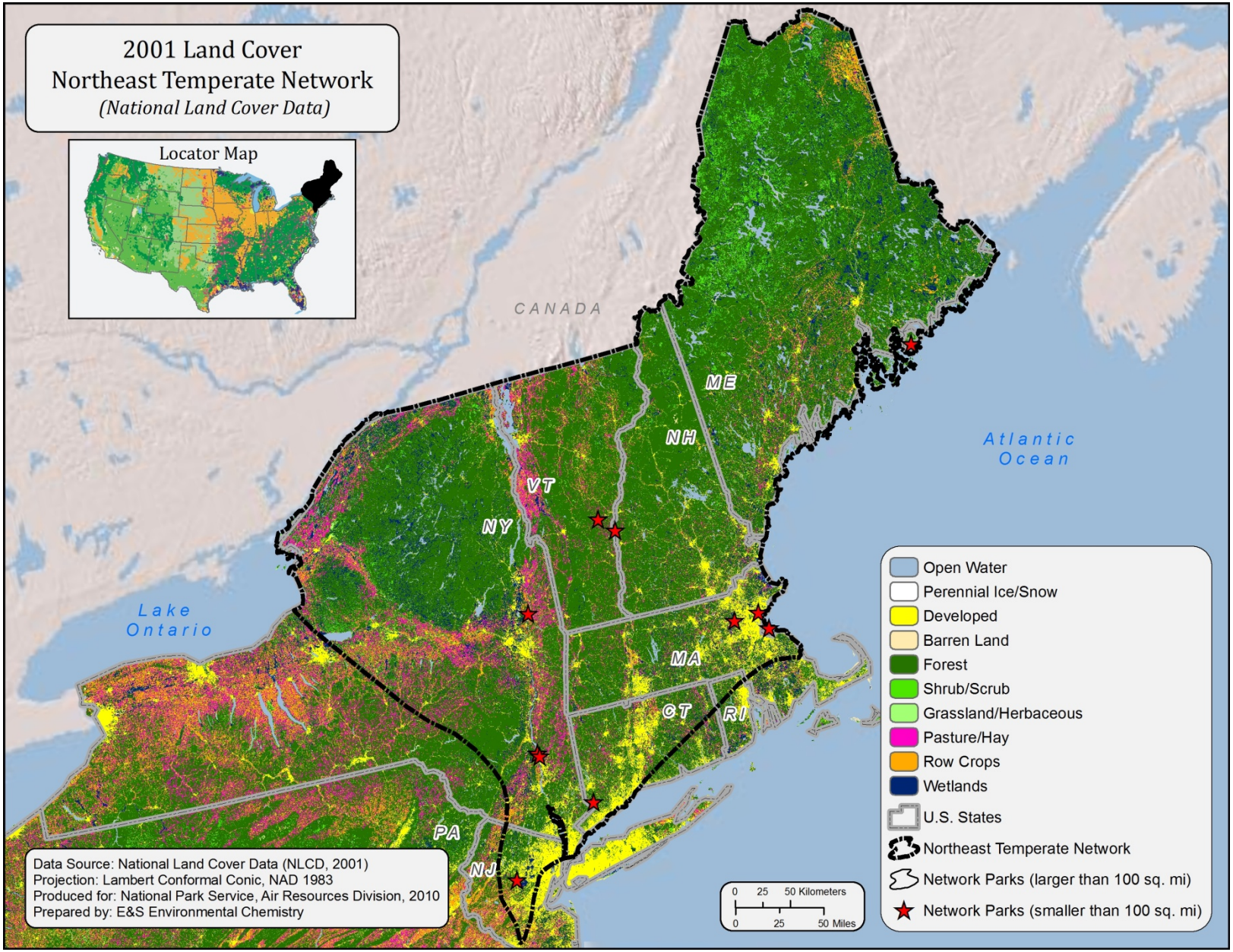
Map D


Park Locations and Urban Centers
Northeast Temperate Network
(Population Centers Over 10,000)
Locator Map
CANADA
Saint-Gaudens
Marsh-Billings-Rockefeller
Saratoga
Vanderbilt Mansion
Home of Franklin D Roosevelt
Acadia
Saugus Iron Works
Minute Man
Boston
Boston Harbor Islands
Weir Farm
New York
Morristown
Philadelphia
Baltimore
Washington
Milwaukee
Detroit
Columbus
Indianapolis
Charlotte
Atlantic Ocean
ME
VT
NH
MA
NY
PA
MI
WI
MN
OH
WV
VA
KY
NC
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
Northeast Temperate 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

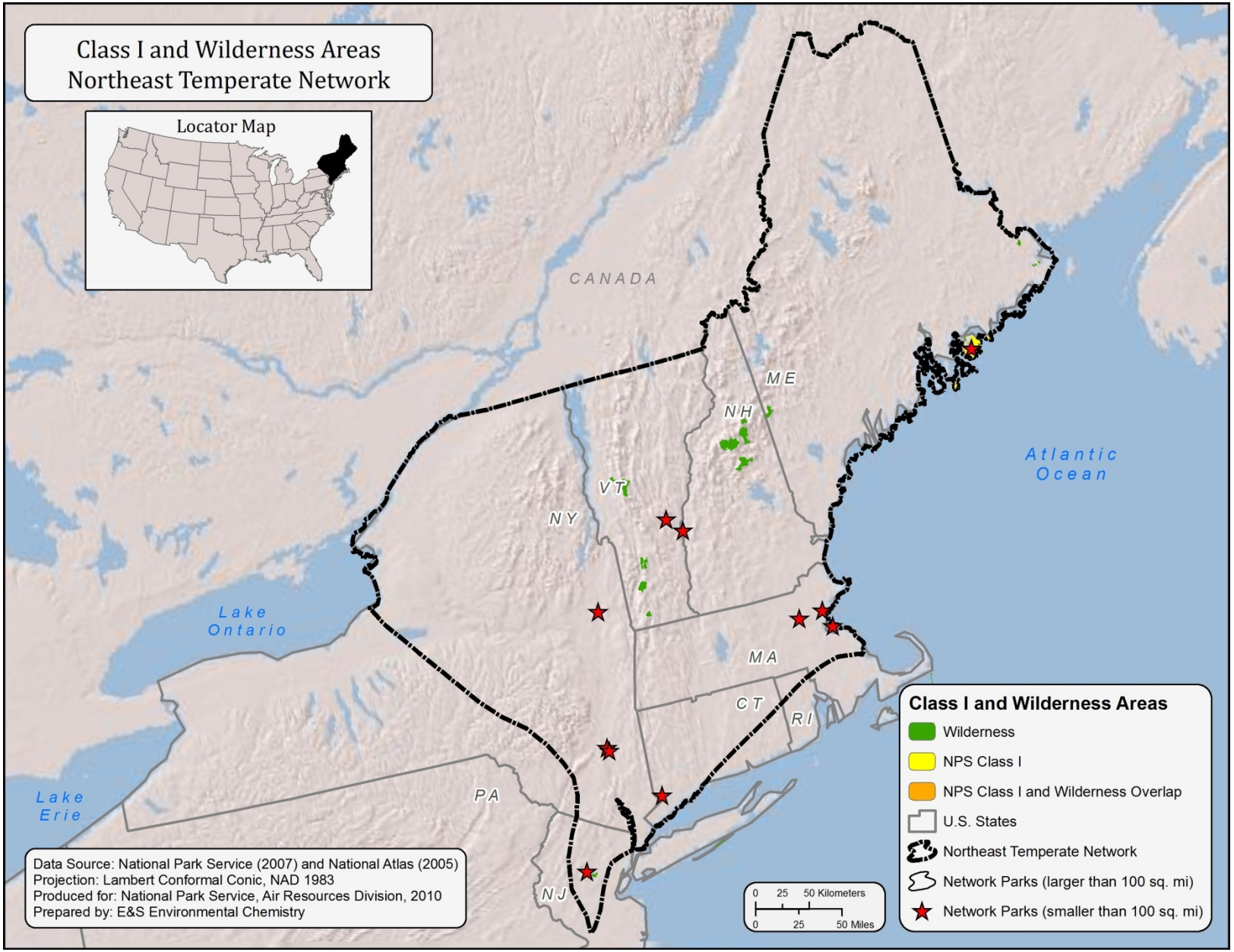
Map E


Total Nitrogen Deposition
Northeast Temperate Network
(kg/ha/yr)
Locator Map
CANADA
ME
NH
VT
NY
MA
CT
RI
PA
NJ
Lake Ontario
Atlantic Ocean
Total Nitrogen Deposition
kg/ha/yr
< 2.0
2 - 5
5 - 10
10 - 15
15 - 20
20 - 30
30 - 63.5
U.S. States
Northeast Temperate 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: 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

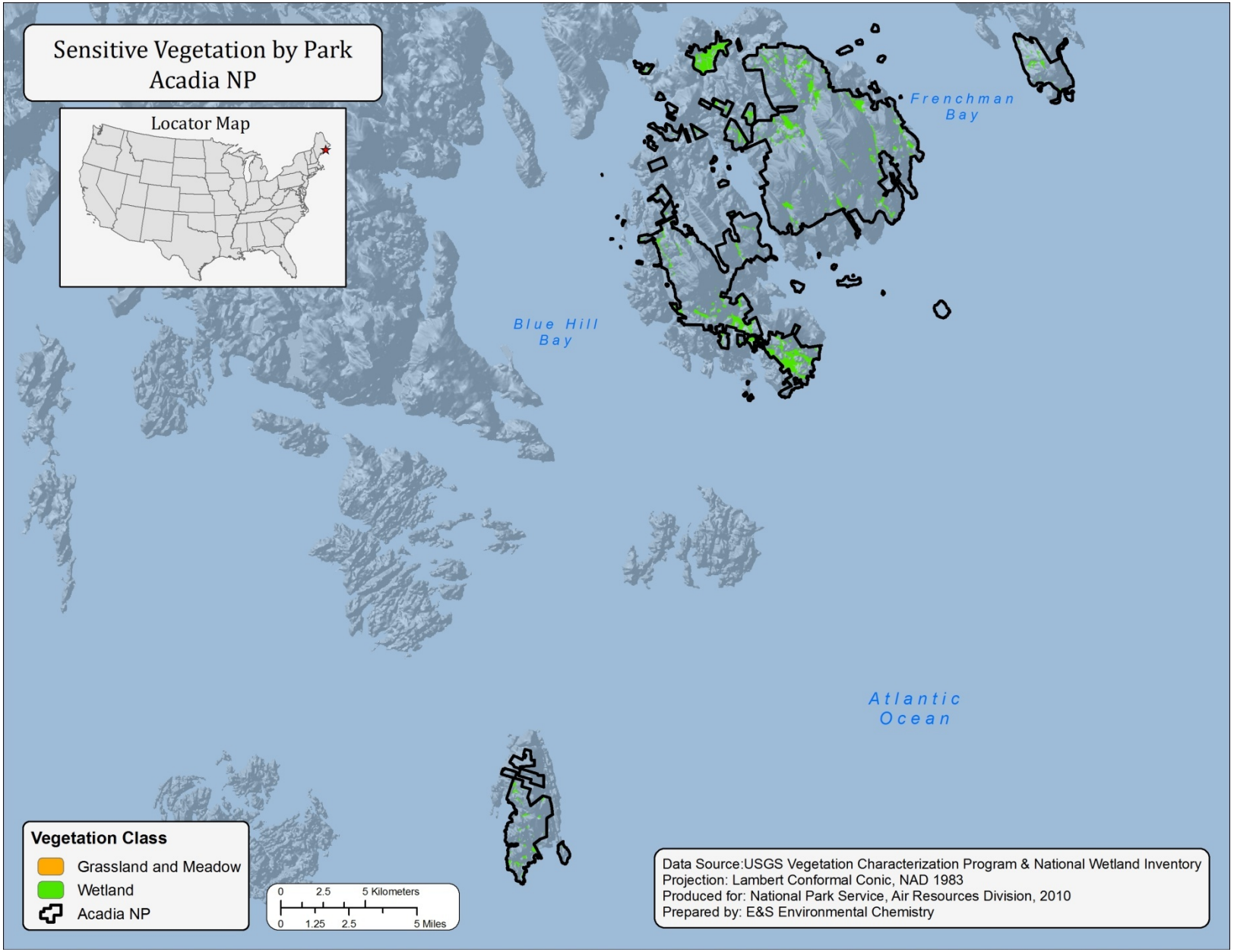
Map F


2001 Land Cover
Northeast Temperate Network
(National Land Cover Data)
Locator Map
CANADA
ME
NH
VT
NY
MA
CT
RI
PA
NJ
Lake Ontario
Atlantic Ocean
Open Water
Perennial Ice/Snow
Developed
Barren Land
Forest
Shrub/Scrub
Grassland/Herbaceous
Pasture/Hay
Row Crops
Wetlands
U.S. States
Northeast Temperate 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

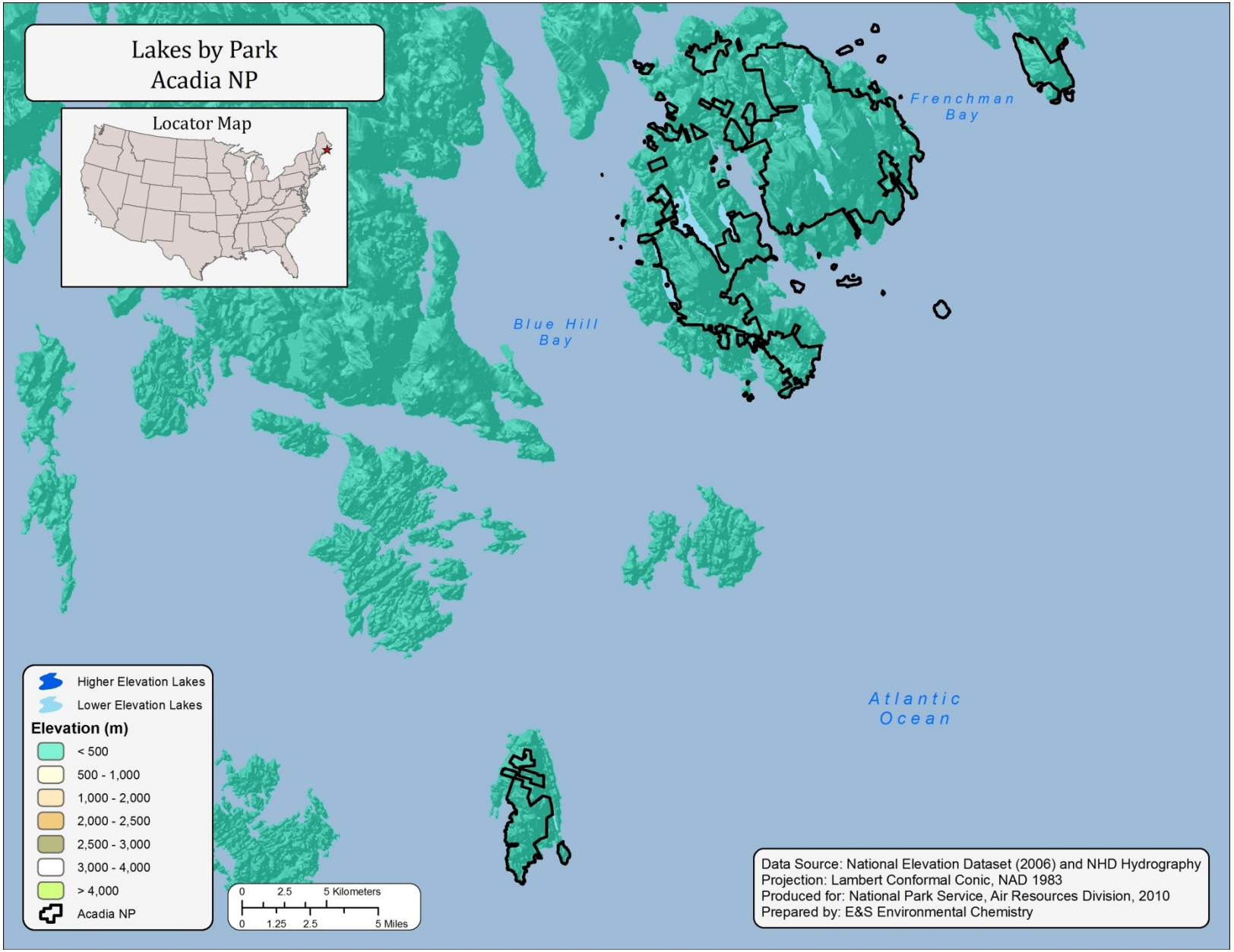
Map G


Class I and Wilderness Areas
Northeast Temperate Network
Locator Map
CANADA
ME
NH
VT
NY
Atlantic Ocean
Lake Ontario
MA
CT
RI
PA
Lake Erie
NJ
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
0 25 50 Kilometers
0 25 50 Miles
Class I and Wilderness Areas
Wilderness
NPS Class I
NPS Class I and Wilderness Overlap
U.S. States
Northeast Temperate Network
Network Parks (larger than 100 sq. mi)
Network Parks (smaller than 100 sq. mi)

Map I


Sensitive Vegetation by Park
Acadia NP
Locator Map
Frenchman Bay
Blue Hill Bay
Atlantic Ocean
Vegetation Class
Grassland and Meadow
Wetland
Acadia NP
0 2.5 5 Kilometers
0 1.25 2.5 5 Miles
Data Source:USGS Vegetation Characterization Program & National Wetland Inventory
Projection: Lambert Conformal Conic, NAD 1983
Produced for: National Park Service, Air Resources Division, 2010
Prepared by: E&S Environmental Chemistry

Map J-1


Lakes by Park
Acadia NP
Locator Map
Frenchman Bay
Blue Hill Bay
Atlantic Ocean
Higher Elevation Lakes
Lower 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
Acadia NP
0 2.5 5 Kilometers
0 1.25 2.5 5 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 J-2

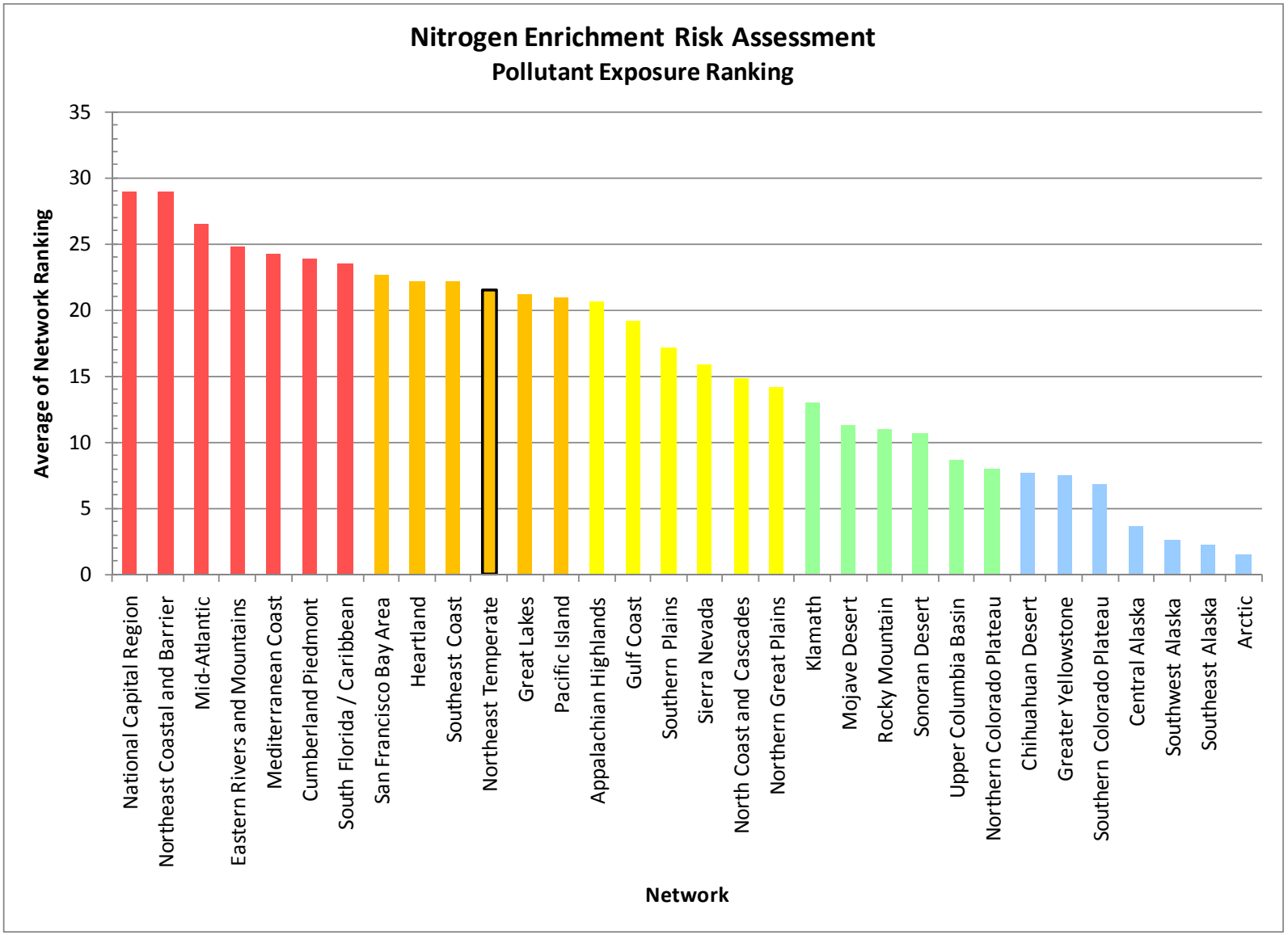

Nitrogen Enrichment Risk Assessment
Pollutant Exposure Ranking
Average of Network Ranking
35
30
25
20
15
10
5
0
National Capital Region
Northeast Coastal and Barrier
Mid-Atlantic
Eastern Rivers and Mountains
Mediterranean Coast
Cumberland Piedmont
South Florida / Caribbean
San Francisco Bay Area
Heartland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

Figure A

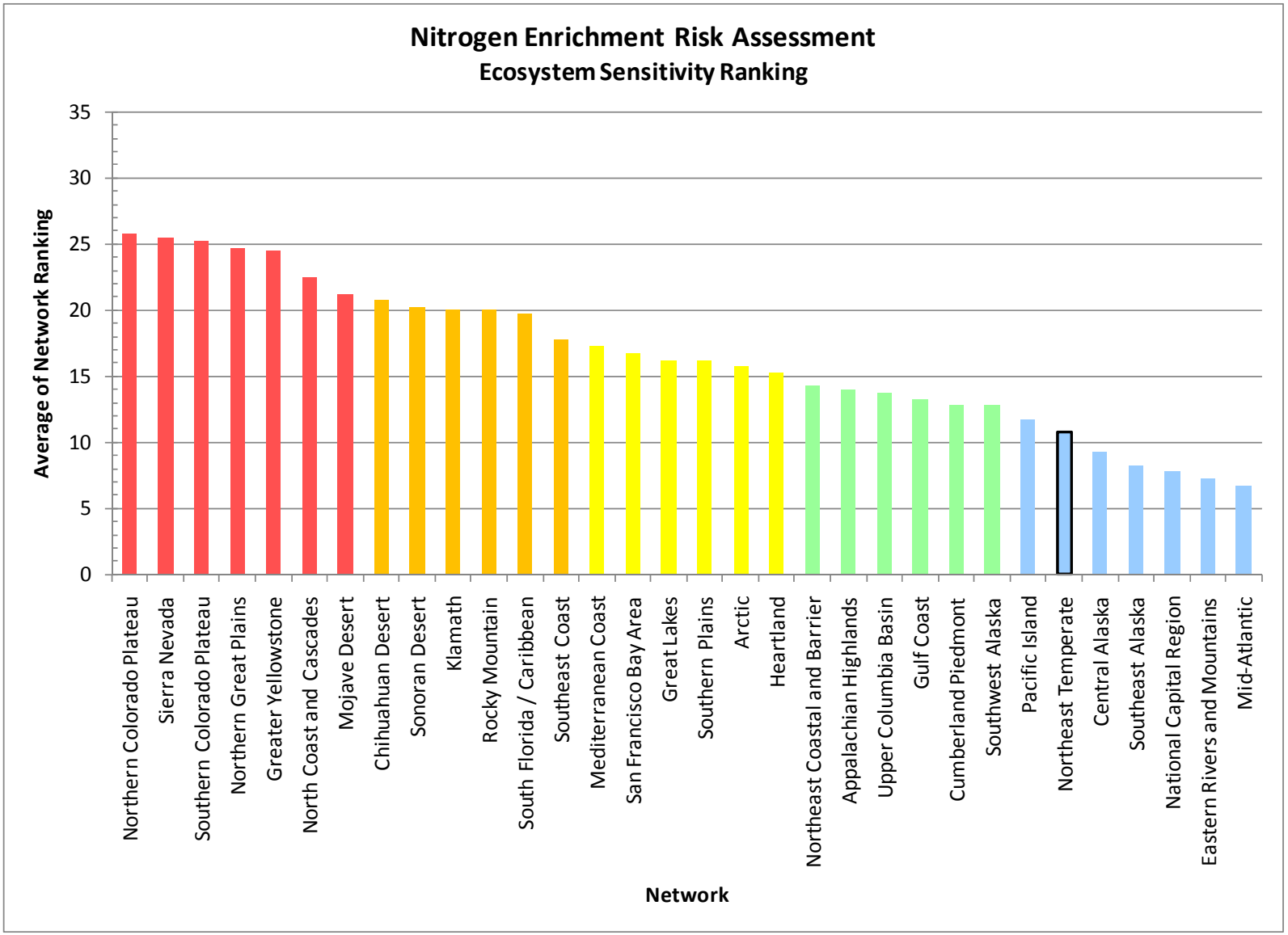

Nitrogen Enrichment Risk Assessment
Ecosystem Sensitivity Ranking
Average of Network Ranking
35
30
25
20
15
10
5
0
Northern Colorado Plateau
Sierra Nevada
Southern Colorado Plateau
Northern Great Plains
Greater Yellowstone
North Coast and Cascades
Mojave Desert
Chihuahuan Desert
Sonoran Desert
Klamath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

Figure B

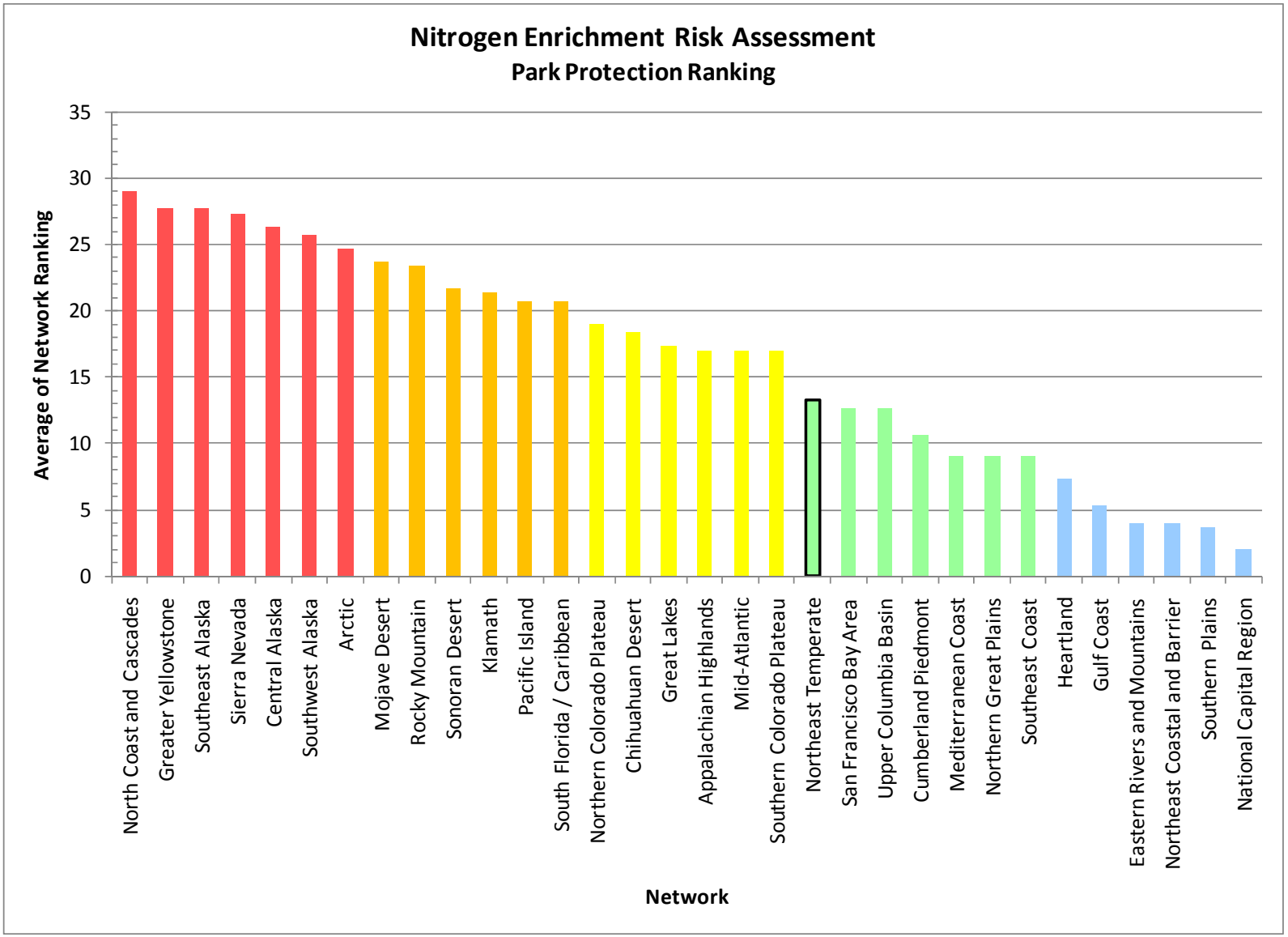

Nitrogen Enrichment Risk Assessment
Park Protection Ranking
Average of Network Ranking
35
30
25
20
15
10
5
0
North Coast and Cascades
Greater Yellowstone
Southeast Alaska
Sierra Nevada
Central Alaska
Southwest Alaska
Arctic
Mojave Desert
Rocky Mountain
Sonoran Desert
Klamath
Pacific Island
South Florida / 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

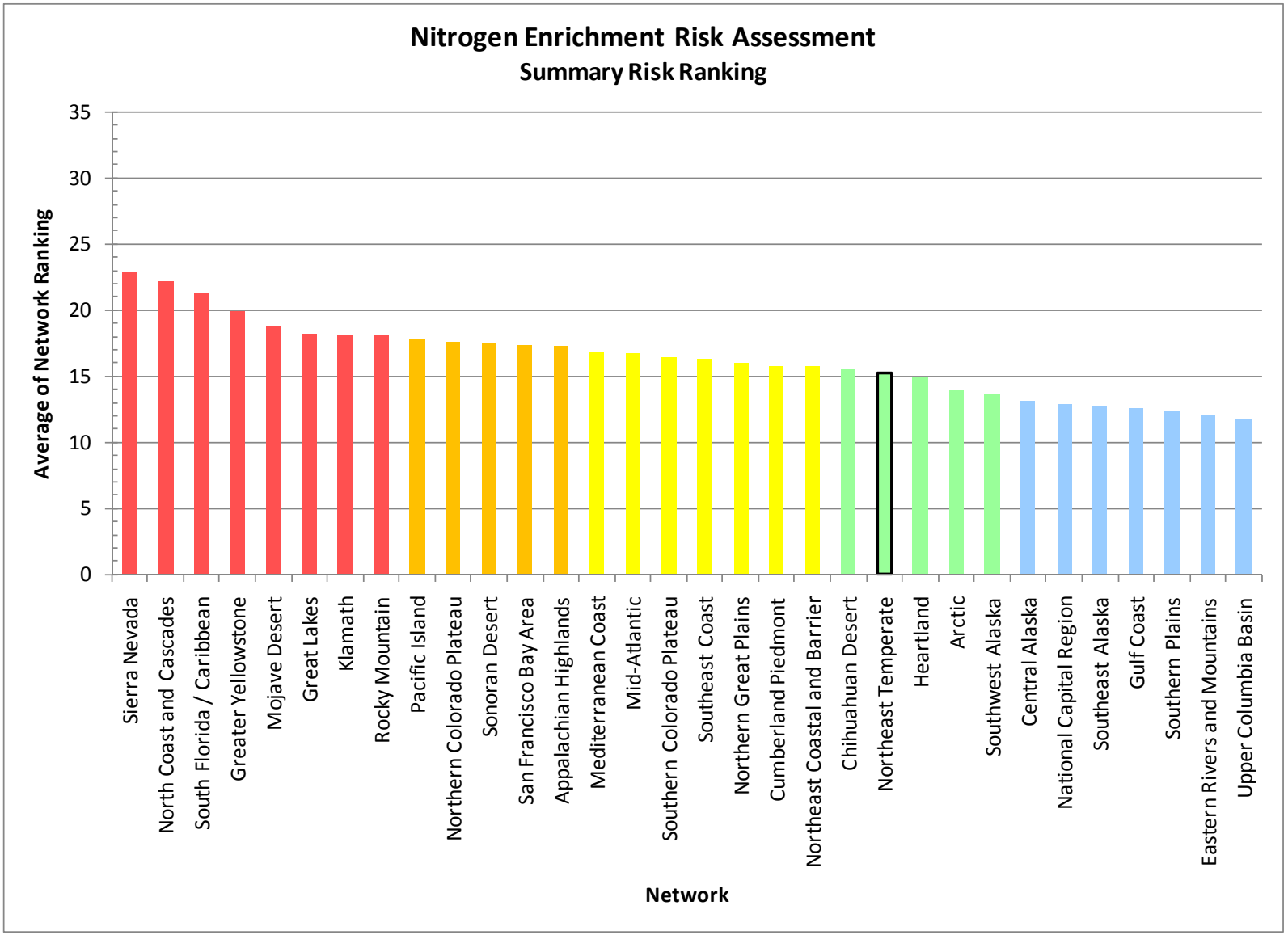

Nitrogen Enrichment Risk Assessment
Summary Risk Ranking
Average of Network Ranking
35
30
25
20
15
10
5
0
Sierra Nevada
North Coast and Cascades
South Florida / Caribbean
Greater Yellowstone
Mojave Desert
Great Lakes
Klamath
Rocky Mountain
Pacific Island
Northern Colorado Plateau
Sonoran Desert
San Francisco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

Figure D

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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U.S. Department of the Interior

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