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

Southeast Coast Network (SECN)

Natural Resource Report NPS/NRPC/ARD/NRR—2011/329

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 Report NPS/NRPC/ARD/NRR—2011/329

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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U.S. Department of the Interior
National Park Service
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 910/106693, February 2011

Southeast Coast Network (SECN)

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. Total annual N emissions, by county, are shown in Map C for lands in and surrounding the Southeast Coast Network. County-level emissions within the network ranged from less than 1 ton per square mile to greater than 20 tons per square mile. In general, annual county N emissions were between 1 and 20 tons per square mile throughout most of the network, with scattered pockets of both lower and higher emissions. Point source emissions of oxidized (nitrogen oxides, NO_x) and reduced (ammonia, NH_3) N are shown in Map D. There are many relatively large (i.e., larger than about 2,000 tons per year) point sources of oxidized N scattered throughout the network. Point sources of reduced N tend to be smaller than 1,000 tons per year. Urban centers within the network and within a 300 mile buffer around the network are shown in Map E. The largest human population center with the network is Jacksonville (more than 500,000 people). There are also a number of moderately sized population centers in the range of 100,000 to 500,000 people, mainly to the north.

There are 17 parks in the Southeast Coast Network. None are larger than 100 square miles. The majority are located in close proximity to the Atlantic coastline.

Total N deposition in and around the network is shown in Map F. Included in this analysis are both wet and dry forms of N deposition and both the oxidized and reduced N species. Total N deposition within the network ranged from as low as 5 to 10 kg N/ha/yr to over 15 kg N/ha/yr. Estimated deposition throughout most of the network is between 5 and 15 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 highly mixed, with forest, shrubland, wetland, row crops, pasture/hay, and developed lands all being common.

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. There are many I&M parks in this network, but none are large. Sensitive vegetative types within the parks would not show up 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. There are no Class I areas in this network, and limited designated wilderness, all of it 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 Southeast Coast Network ranks in the second highest quintile, among networks, in N pollutant Exposure (Figure A). Nitrogen emissions and N deposition within the network are both fairly high. The network Ecosystem Sensitivity ranking is above the median, at the bottom of the second highest quintile, among networks (Figure B). This is mainly because there is a moderate amount of vegetation in the I&M parks that occur in this network that includes vegetation types 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 near the median among all networks (Figure D). The overall level of concern for nutrient N enrichment effects on I&M parks within this network is considered Moderate.

There are no I&M parks in this network that are larger than 100 square miles. Therefore, the figures to compare risks among the larger parks are not shown for parks in this network. Relative ranks for all parks, including the smaller parks, are given in Table A and Appendix B.

Most of the parks in this network are ranked in the second highest quintile in Pollutant Exposure. Three parks (Chattahoochee River, CHAT; Kennesaw Mountain, KEMO; and Moores Creek, MOCR) are ranked in the highest quintile for Pollutant Exposure, and two (Cumberland Island [CUIS] and Fort Pulaski [FOPU]) are ranked Moderate. Park rankings for Ecosystem Sensitivity are highly variable across the network, with rankings in the highest quintile for two of the parks (FOPU and Congaree, COSW). For other parks, Ecosystem Sensitivity ranges from the lowest quintile (three parks) to the second highest quintile (seven parks). Most (15) of the parks are ranked in the middle quintile in Park Protection; two (COSW and CUIS) are ranked in the second highest quintile.

The overall Summary Risk ranking places two of the parks (COSW and CUIS) in this network into the highest quintile and nine of the parks into the second highest quintile. Other parks in this network are ranked in the second lowest quintile (two parks) to the middle quintile (four 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
Canaveral	High	Moderate	Moderate	Moderate
Cape Hatteras	High	High	Moderate	High
Cape Lookout	High	High	Moderate	High
Castillo de San Marcos	High	Very Low	Moderate	Low
Chattahoochee River	Very High	Low	Moderate	Moderate
Congaree	High	Very High	High	Very High
Cumberland Island	Moderate	High	High	Very High
Fort Caroline	High	Moderate	Moderate	High
Fort Frederica	High	High	Moderate	High
Fort Matanzas	High	High	Moderate	High
Fort Pulaski	Moderate	Very High	Moderate	High
Fort Sumter	High	Very Low	Moderate	Low
Horseshoe Bend	High	Low	Moderate	Moderate
Kennesaw Mountain	Very High	Very Low	Moderate	Moderate
Moores Creek	Very High	Moderate	Moderate	High
Ocmulgee	High	High	Moderate	High
Timucaun Ecological and Historical Preserve	High	High	Moderate	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)

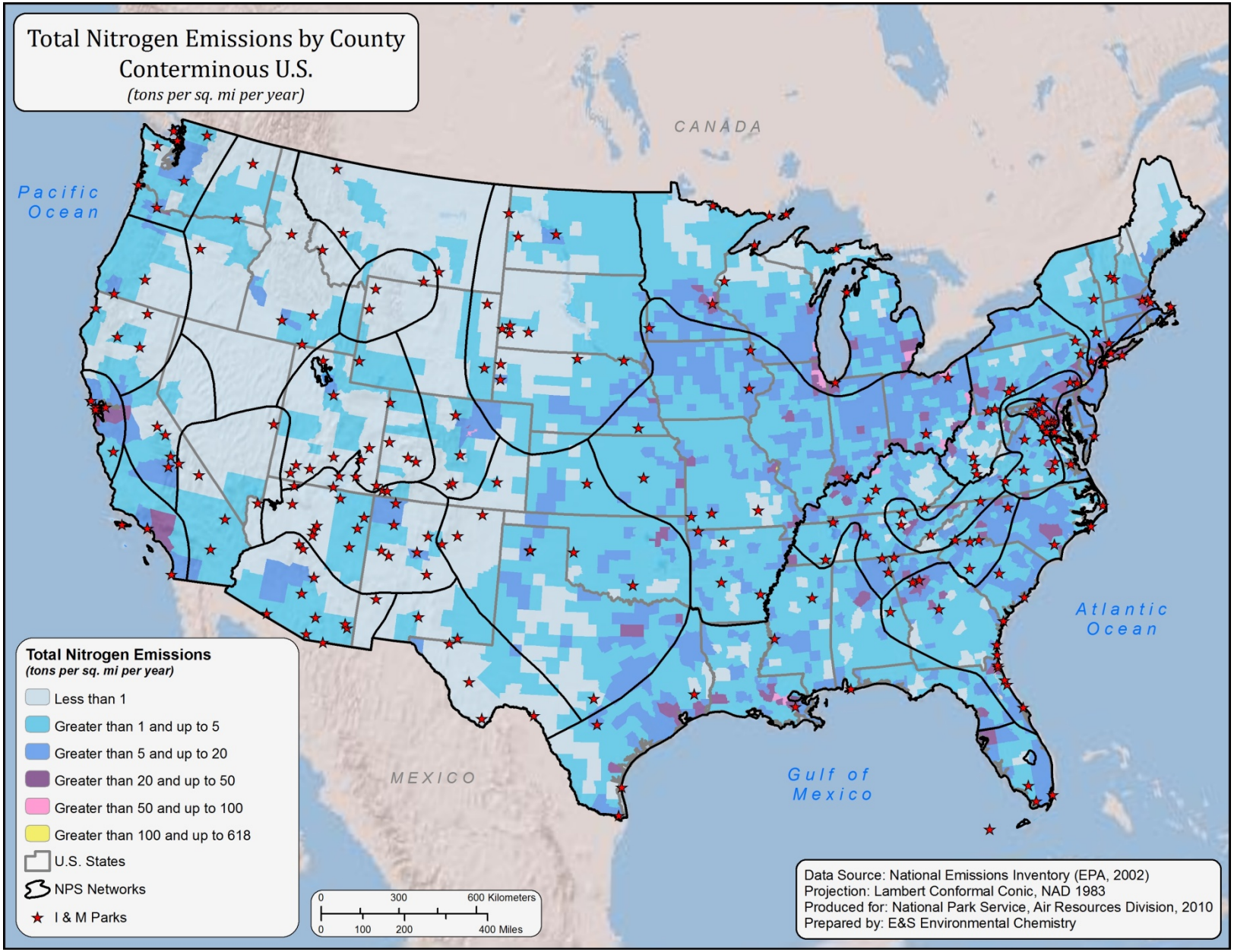
Map I. Lands within the network that are classified as Class I or wilderness area. (Source of data: USGS 2005 [National Atlas; http://nationalatlas.gov] and NPS)

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

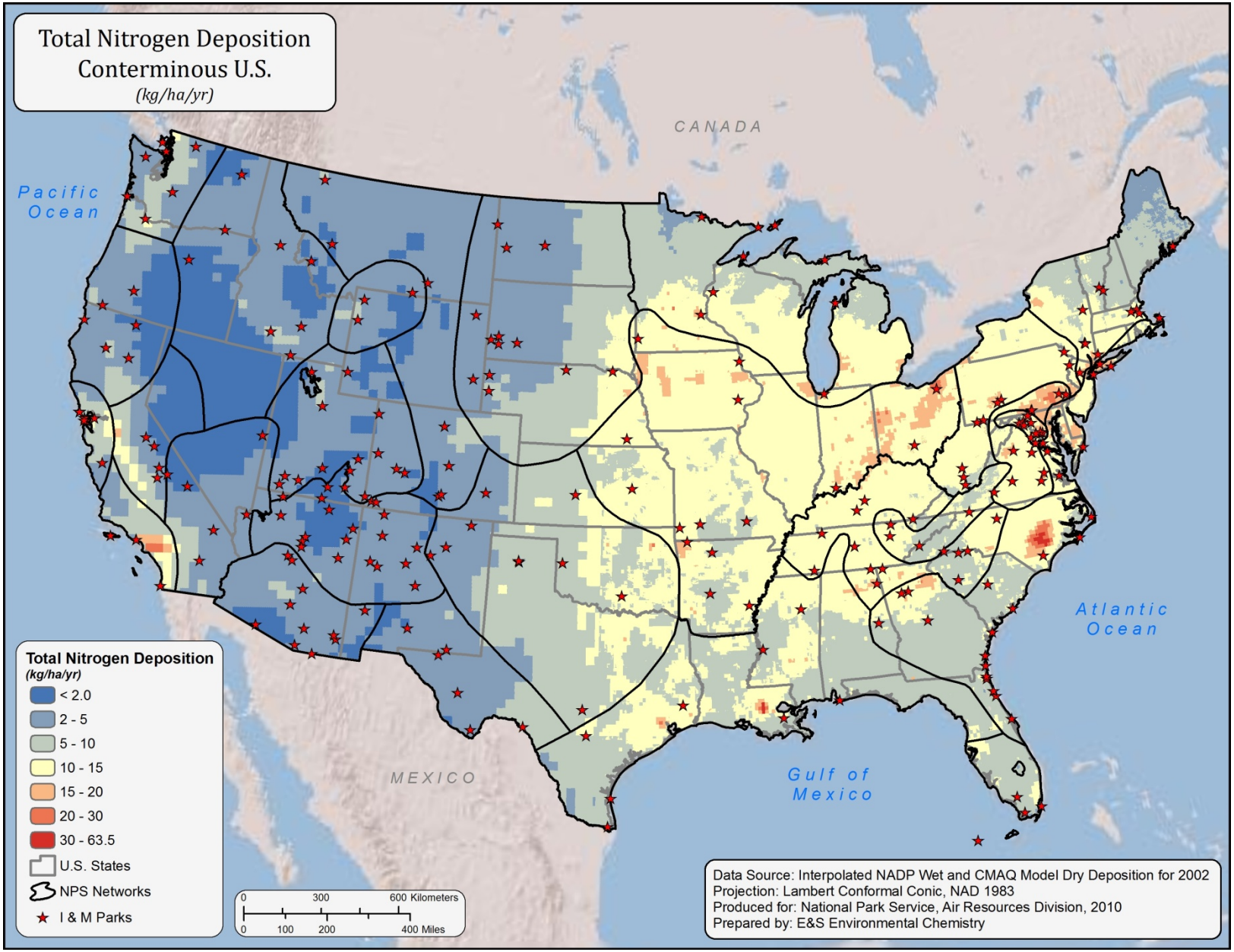
Figure B. Network rankings for Ecosystem Sensitivity, calculated as the average of scores for all Ecosystem Sensitivity variables.

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

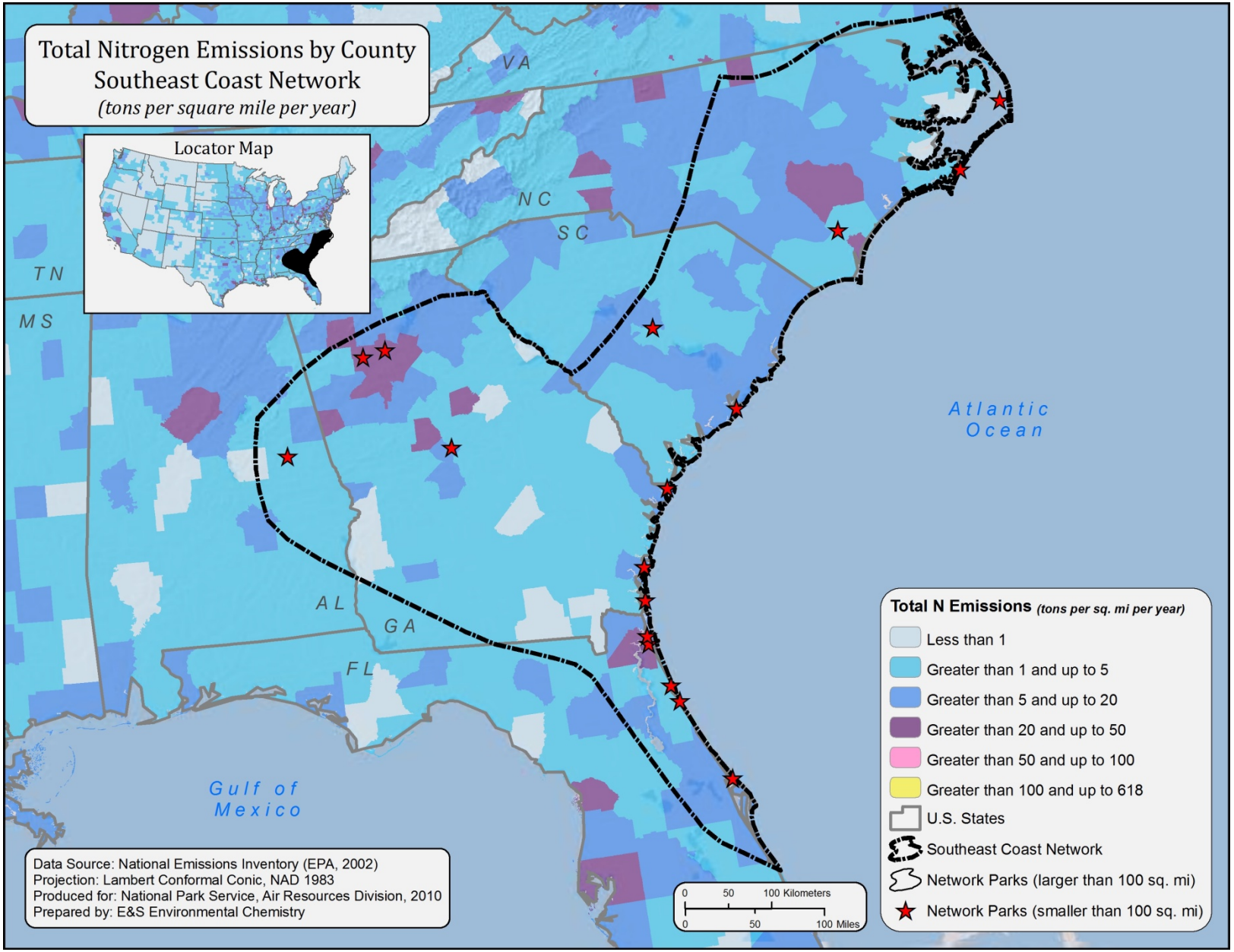
Figure D. Network Summary Risk ranking, calculated as the averages of the scores for Pollutant Exposure, Ecosystem Sensitivity, and Park Protection.


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

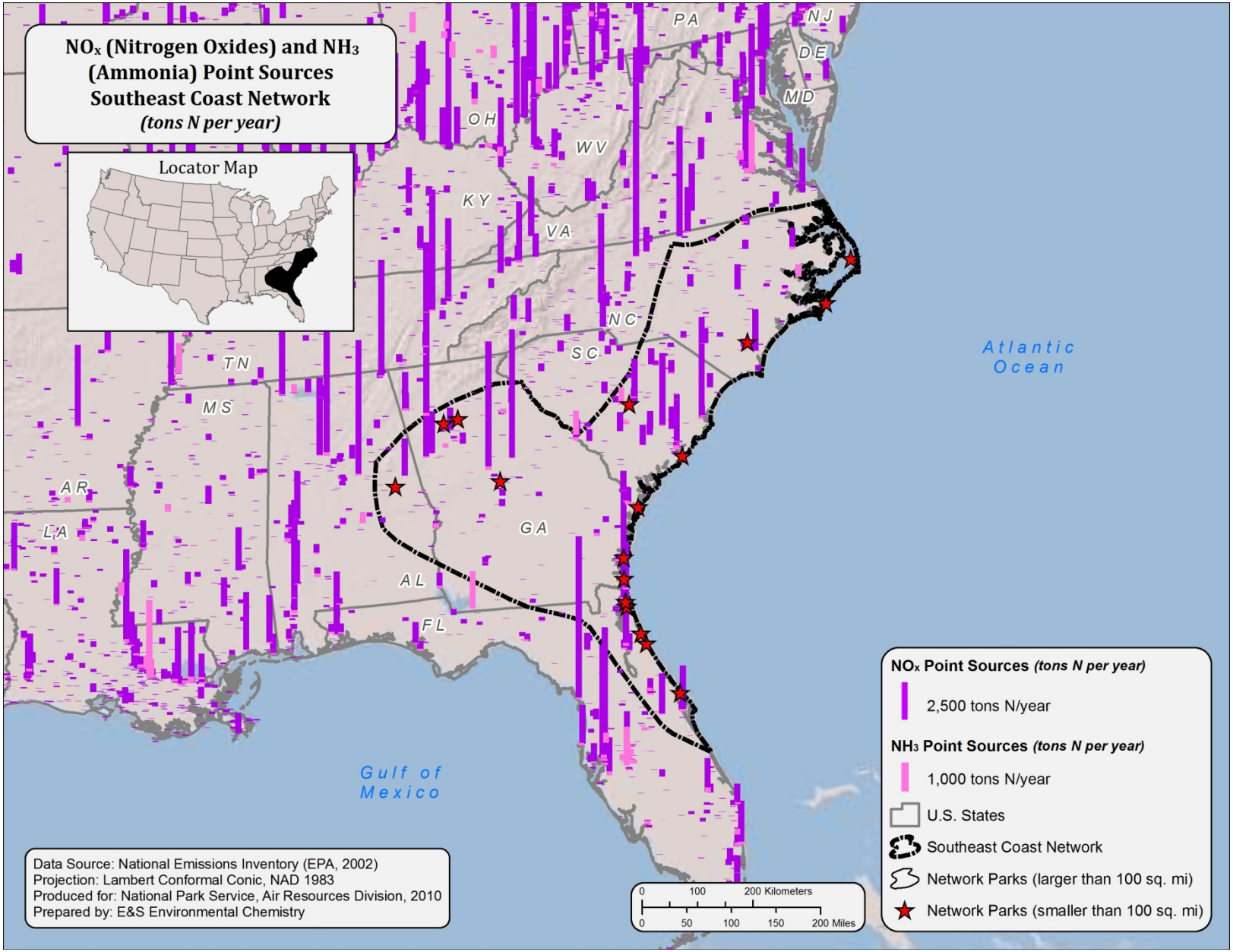
Map A


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

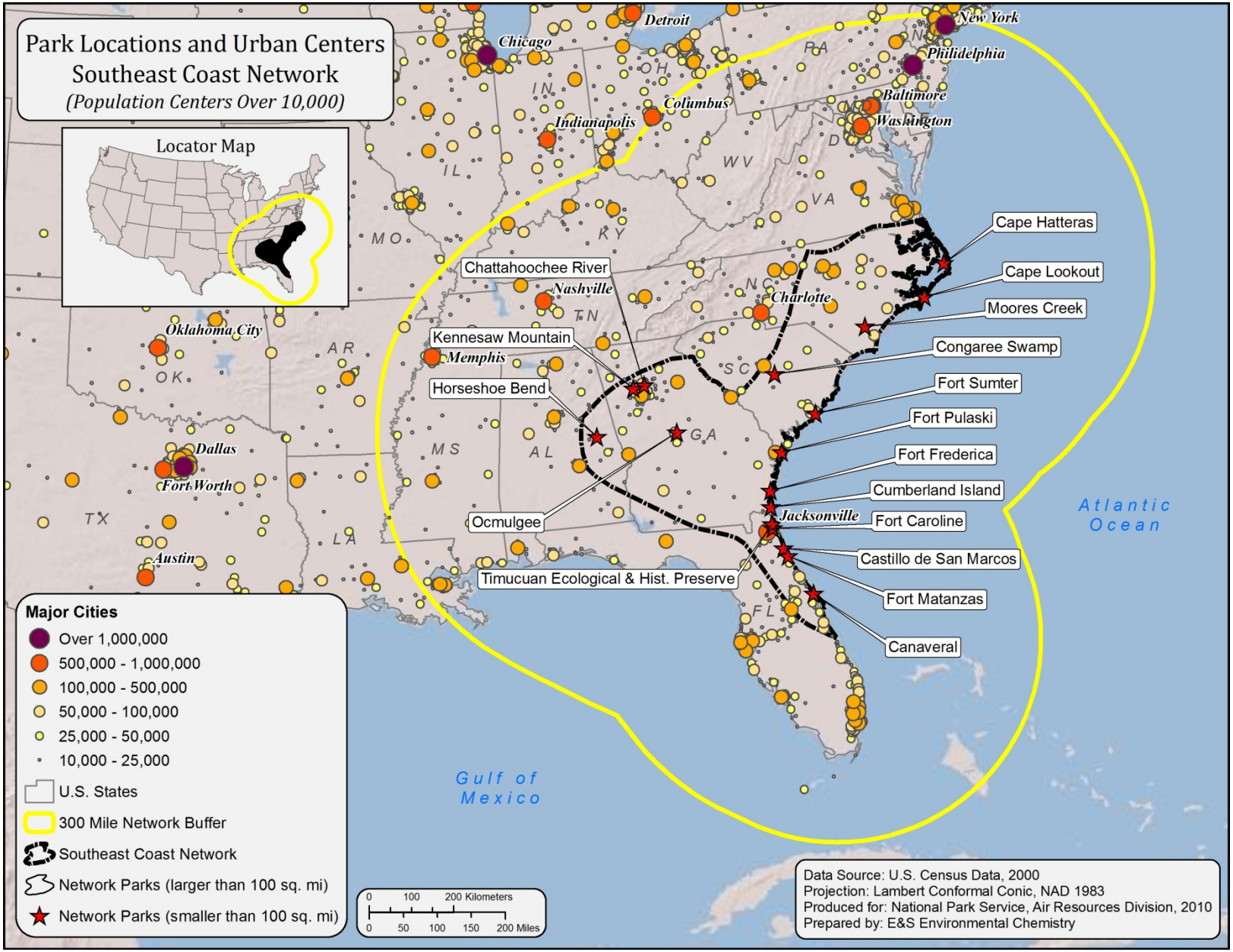
Map B


Total Nitrogen Emissions by County
Southeast Coast Network
(tons per square mile per year)
Locator Map
VA
NC
SC
TN
MS
AL
GA
FL
Atlantic Ocean
Gulf of Mexico
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
Southeast Coast 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

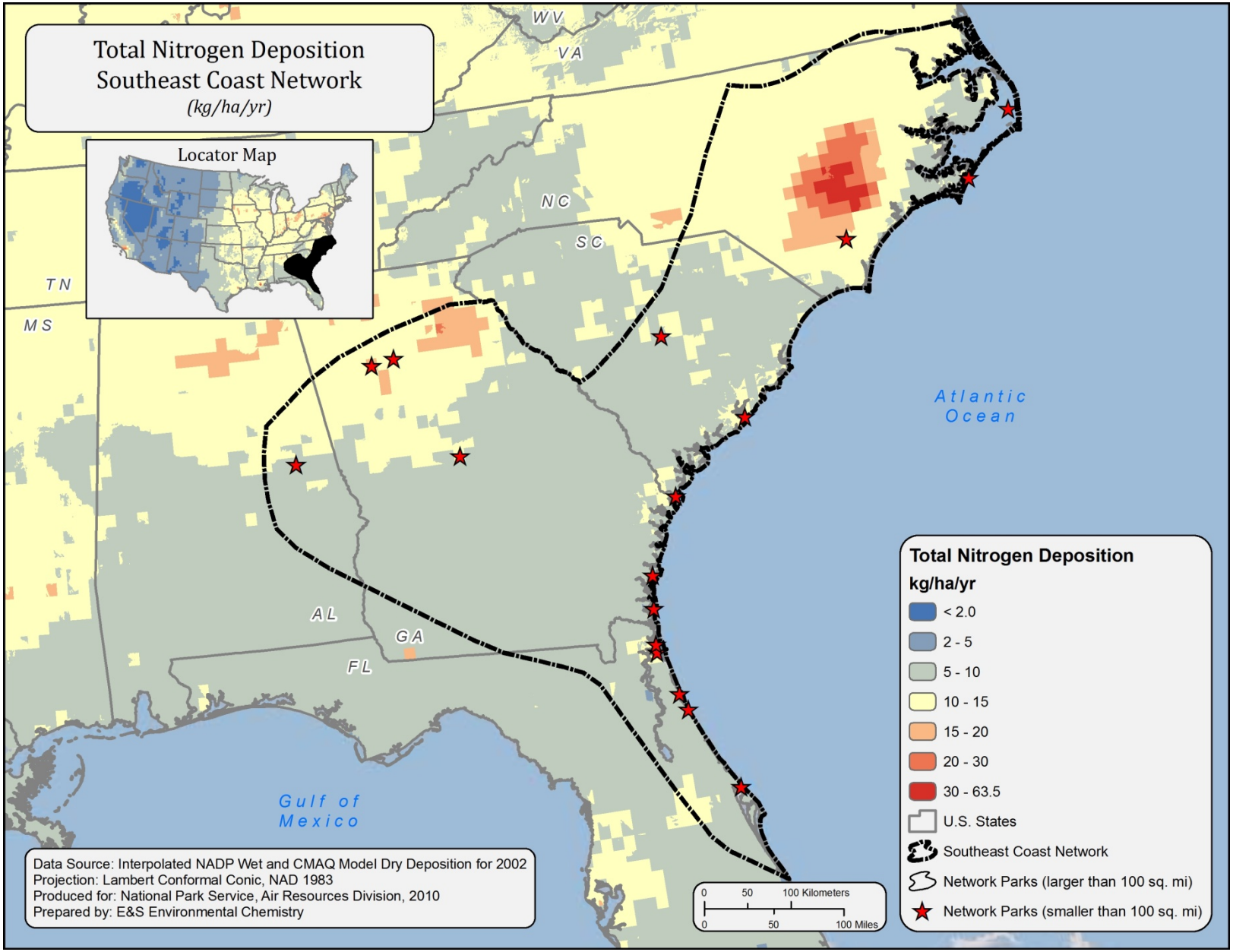
Map C


NOx (Nitrogen Oxides) and NH3 (Ammonia) Point Sources
Southeast Coast Network
(tons N per year)
Locator Map
PA
NJ
DE
MD
OH
WV
KY
VA
NC
SC
TN
MS
AR
LA
GA
AL
FL
Atlantic Ocean
Gulf of Mexico
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
Southeast Coast 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
0 100 200 Kilometers
0 50 100 150 200 Miles

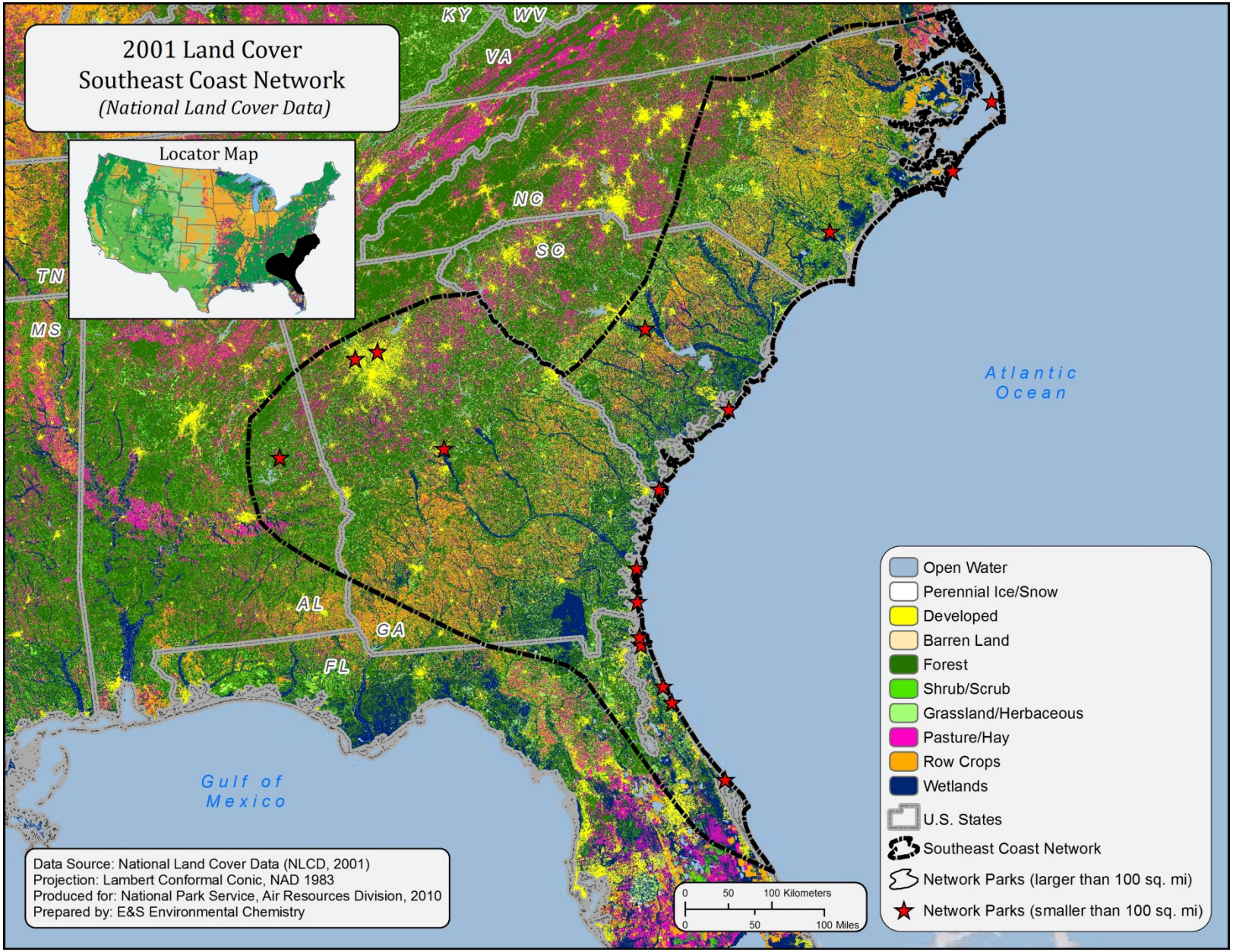
Map D


Park Locations and Urban Centers
Southeast Coast Network
(Population Centers Over 10,000)
Locator Map
Detroit
Chicago
New York
Philidelphia
Baltimore
Washington
Columbus
Indianapolis
Oklahoma City
Memphis
Nashville
Charlotte
Dallas
Fort Worth
Austin
Jacksonville
Cape Hatteras
Cape Lookout
Moores Creek
Congaree Swamp
Fort Sumter
Fort Pulaski
Fort Frederica
Cumberland Island
Fort Caroline
Castillo de San Marcos
Fort Matanzas
Canaveral
Chattahoochee River
Kennesaw Mountain
Horseshoe Bend
Ocmulgee
Timucuan Ecological & Hist. Preserve
Atlantic Ocean
Gulf of Mexico
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
Southeast Coast 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

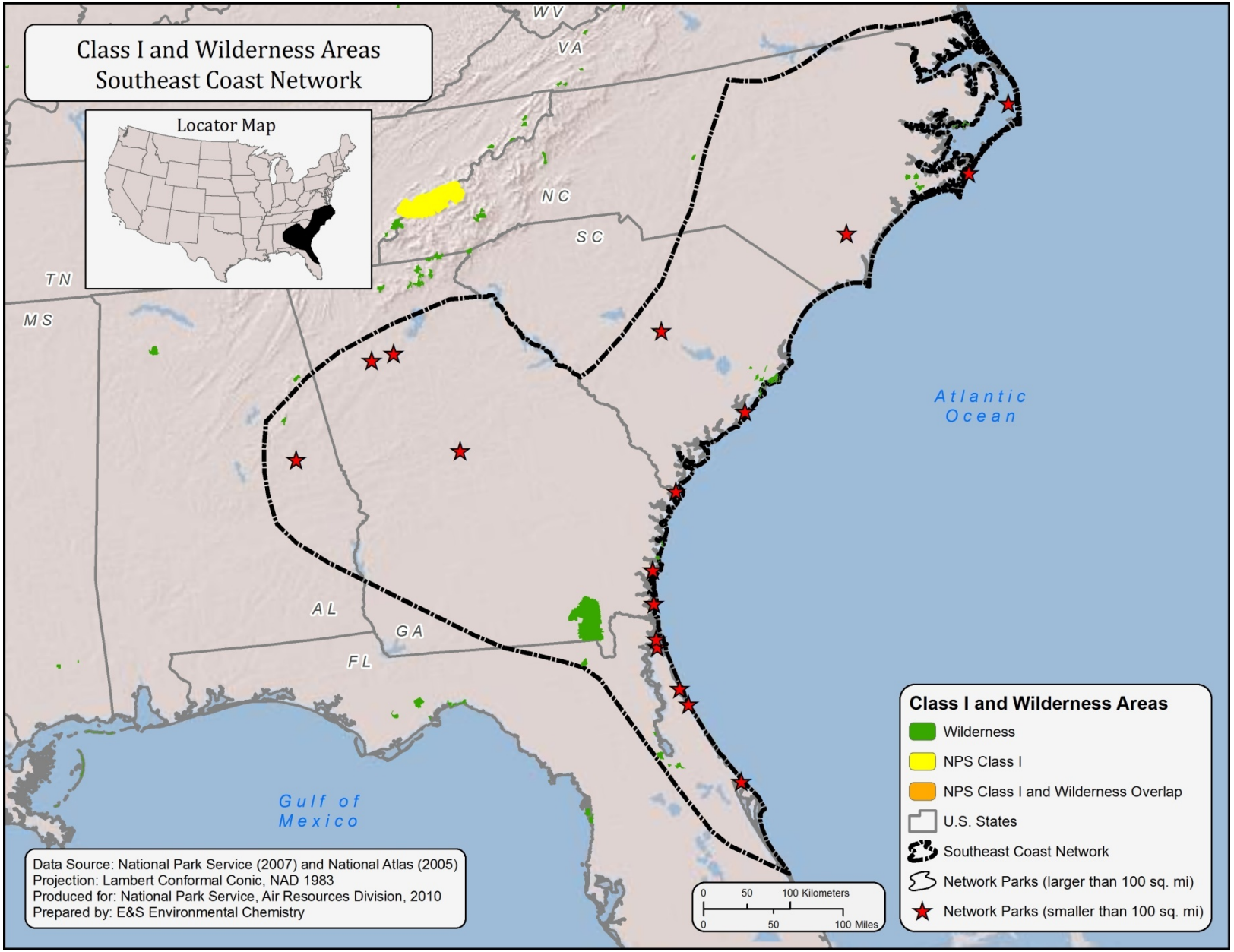
Map E


Total Nitrogen Deposition
Southeast Coast Network
(kg/ha/yr)
Locator Map
WV
VA
NC
SC
TN
MS
AL
GA
FL
Atlantic Ocean
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
Southeast Coast 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: 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
Southeast Coast Network
(National Land Cover Data)
Locator Map
KY
WV
VA
NC
SC
TN
MS
AL
GA
FL
Atlantic Ocean
Gulf of Mexico
Open Water
Perennial Ice/Snow
Developed
Barren Land
Forest
Shrub/Scrub
Grassland/Herbaceous
Pasture/Hay
Row Crops
Wetlands
U.S. States
Southeast Coast 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 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
Southeast Coast Network
Locator Map
WV
VA
NC
SC
TN
MS
AL
GA
FL
Atlantic Ocean
Gulf of Mexico
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 50 100 Kilometers
0 50 100 Miles
Class I and Wilderness Areas
Wilderness
NPS Class I
NPS Class I and Wilderness Overlap
U.S. States
Southeast Coast Network
Network Parks (larger than 100 sq. mi)
Network Parks (smaller than 100 sq. mi)

Map I

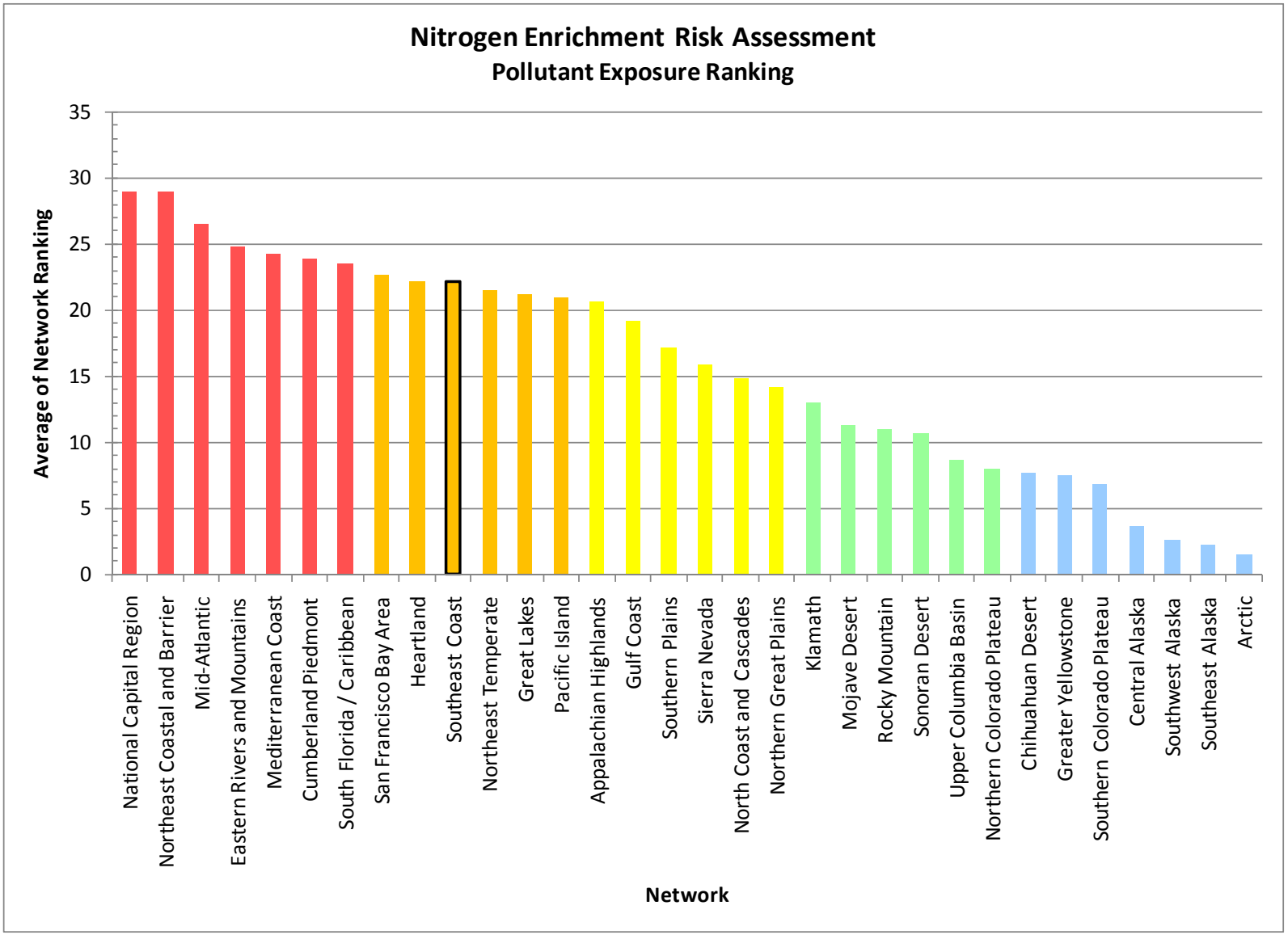

Nitrogen Enrichment Risk Assessment
Pollutant Exposure Ranking
Average of Network Ranking
35
30
25
20
15
10
5
0
National Capital Region
Northeast Coastal and Barrier
Mid-Atlantic
Eastern Rivers and Mountains
Mediterranean Coast
Cumberland Piedmont
South Florida / Caribbean
San Francisco Bay Area
Heartland
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

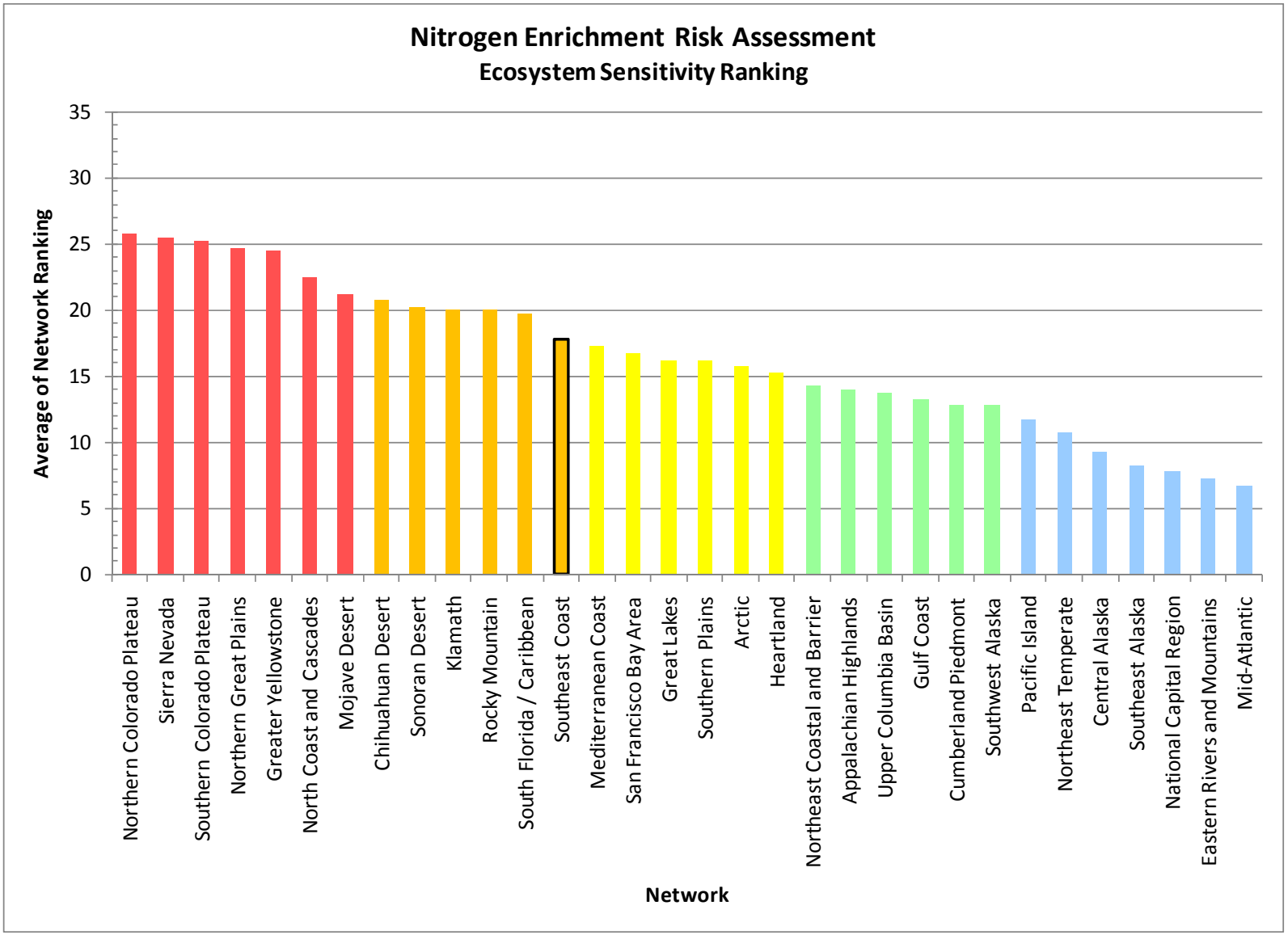

Nitrogen Enrichment Risk Assessment
Ecosystem Sensitivity Ranking
Average of Network Ranking
35
30
25
20
15
10
5
0
Northern Colorado Plateau
Sierra Nevada
Southern Colorado Plateau
Northern Great Plains
Greater Yellowstone
North Coast and Cascades
Mojave Desert
Chihuahuan Desert
Sonoran Desert
Klamath
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

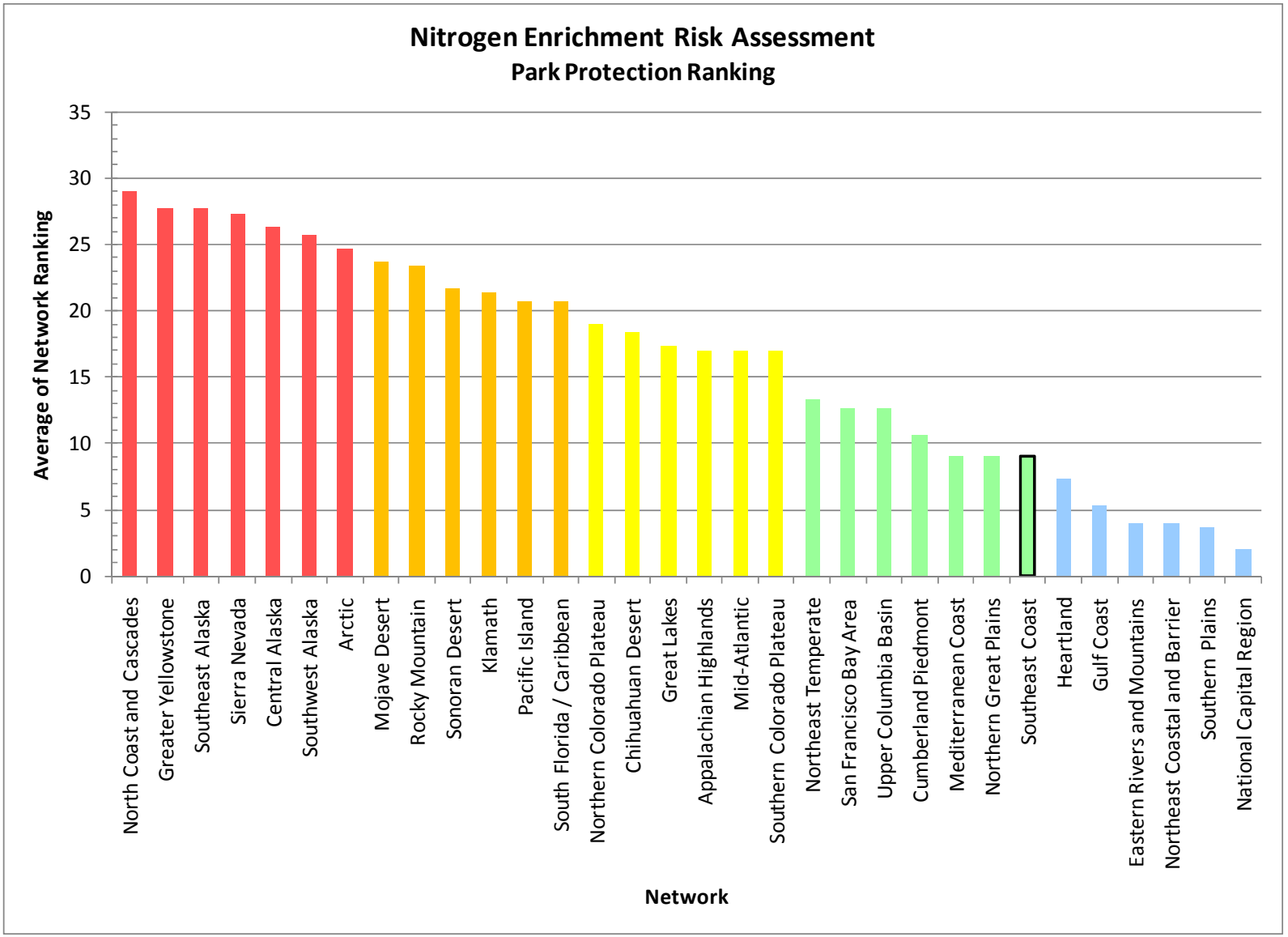

Nitrogen Enrichment Risk Assessment
Park Protection Ranking
Average of Network Ranking
35
30
25
20
15
10
5
0
North Coast and Cascades
Greater Yellowstone
Southeast Alaska
Sierra Nevada
Central Alaska
Southwest Alaska
Arctic
Mojave Desert
Rocky Mountain
Sonoran Desert
Klamath
Pacific Island
South Florida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

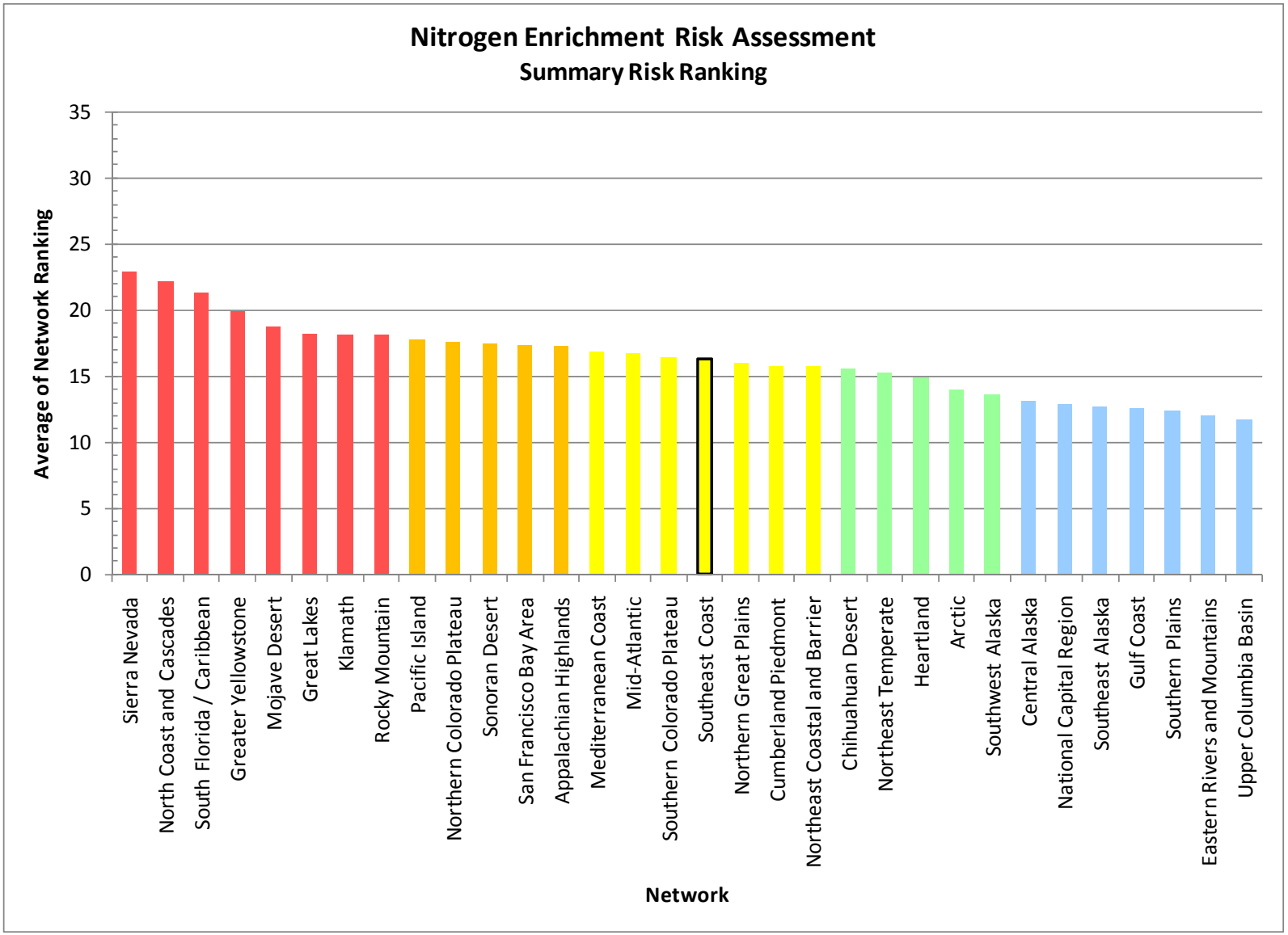

Nitrogen Enrichment Risk Assessment
Summary Risk Ranking
Average of Network Ranking
35
30
25
20
15
10
5
0
Sierra Nevada
North Coast and Cascades
South Florida / Caribbean
Greater Yellowstone
Mojave Desert
Great Lakes
Klamath
Rocky Mountain
Pacific Island
Northern Colorado Plateau
Sonoran Desert
San Francisco 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.

NPS 910/106693, February 2011

National Park Service
U.S. Department of the Interior

Natural Resource Program Center
Air Resources Division
PO Box 25287
Denver, CO 80225

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