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

Southwest Alaska Network (SWAN)

Natural Resource Report NPS/NRPC/ARD/NRR—2011/381

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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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.

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 953/107419, April 2011

Southwest Alaska Network (SWAN)

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, respectively, for the year 2002. Maps C and D show total S and N deposition, again for the year 2002. Regional deposition data are not available for Alaska, but deposition would be expected to be very low throughout most, but not necessarily all, of Alaska.

There are five parks in the Southwest Alaska Network. Four of them are larger than 100 square miles: Aniakchak (ANIA), Katmai (KATM), Kenai Fjords (KEFJ), and Lake Clark (LACL). The smaller park is Alagnak (ALAG).

Total annual S and N emissions, by county, are shown in Maps E and F, respectively, for lands in and surrounding the Southwest Alaska Network. County-level emissions of both S and N within the network were uniformly less than 1 ton per square mile. Maps G and H show point source emissions of SO_2 (Map G) and oxidized (nitrogen oxides, NO_x) and reduced (ammonia, NH_3) N (Map H). There were few point sources of emissions in this network, and those that do occur tend to be small.

Urban centers within the network and within a 300-mile buffer around the network are shown in Map I. There are no large population centers within the network and only one in proximity to the network.

Maps J and K showing total S and total N deposition in and around the network are not shown because there are no regional deposition data for Alaska. Given the small number of point sources and population centers, acidic deposition is expected to be low.

There are five active NADP/NTN wet deposition monitoring sites in Alaska: Poker Creek, Juneau, Denali National Park, Gates of the Arctic National Park, and KATM, with data collected since 1980 at Denali and since 1993 at Poker Creek**.** The other three monitoring sites have been added within the last decade. There are also Clean Air Status and Trends Network (CASTNET) dry deposition measurements at Denali and Poker Flats. At all monitored sites in Alaska, wet N deposition has consistently been less than 1 kg N/ha/yr, and it has been less than 0.5 kg N/ha/yr at all monitored sites except Juneau. Wet S deposition has been slightly higher than 1 kg S/ha/yr at Juneau, but less than that at the other monitoring sites. The dry deposition measurements by CASTNET have also been low. Thus, the sparse available atmospheric deposition data for Alaska are consistent with the general understanding that atmospheric deposition of both N and S tends to be very low at national park lands within Alaska. It can be assumed that both N and S deposition in each of the Alaskan networks would be lower than 1 to 2 kg/ha/yr, on average.

Land cover in and around the network is shown in Map L. The predominant cover types within this network are shrubland and perennial ice and snow.

Most of the land slope within the parks in this network is less than 20^o (Map M). There is some steeper land (between 20^o and 30^o) in LACL.

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 no Class I areas in this network, but there are a large number of wilderness areas. Three of the four large (larger than 100 square miles) parks in this network (all except ANIA) are mainly comprised of designated wilderness.

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 Southwest Alaska Network ranked in the lowest quintile among networks in Pollutant Exposure (Figure A). Emissions and expected S and N deposition within the network are very low. The network Ecosystem Sensitivity ranking was Moderate, within the middle quintile among networks (Figure B). There is no vegetation coverage in the I&M parks that occur in this network that includes red spruce or sugar maple, the primary tree species known to be sensitive to effects from acidic deposition, and there are no high-elevation lakes. Data are not available at this time for designating stream order in Alaska, so this variable was not included in the Ecosystem Sensitivity ranking. This network ranked in the top 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 yielded an overall Network Risk ranking that is in the middle of the distribution among networks (Figure D). The overall level of concern for acidification effects on I&M parks within this network is considered Moderate.

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 rankings, the park rankings 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 parks in the Southwest Alaska Network showed Pollutant Exposure ranking in the lowest quintile among parks (Figure E, Table A). Ecosystem Sensitivity ranking varied: one park (ALAG) was ranked Low, two parks were ranked High (ANAI and KEFJ), and two parks were ranked Very High (KATM and LACL; Figure F, Table A). Two parks (KATM, LACL) had Park Protection ranking in the highest quintile (Figure G). The three other parks had Park Protection ranking that was in the second highest (ALAG and KEFJ) or middle (ANIA) quintile among parks (Table A).

The park Summary Risk ranking was High for two of the large parks (KATM and LACL) and Moderate for the other two large parks (ANIA and KEFJ; Figure H, Table A). The one small park was ranked Low (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
Alagnak	Very Low	Low	High	Low
Aniakchak	Very Low	High	Moderate	Moderate
Katmai	Very Low	Very High	Very High	High
Kenai Fjords	Very Low	High	High	Moderate
Lake Clark	Very Low	Very High	Very High	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 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. Regional S deposition data are not available for Alaska. Total S deposition throughout most areas in Alaska is expected to be low, below about 1 to 2 kilograms of S per hectare per year. Total S deposition for the continental United States is presented for context here for the year 2002, expressed in units of kilograms of S deposited from the atmosphere to the earth surface per hectare per year. Wet and dry forms of deposition 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 D. Regional N deposition data are not available for Alaska. Total N deposition throughout most areas in Alaska is expected to be low, below about 1 to 2 kilograms of N per hectare per year. Total N deposition for the continental United States is presented for context here 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 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)

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.

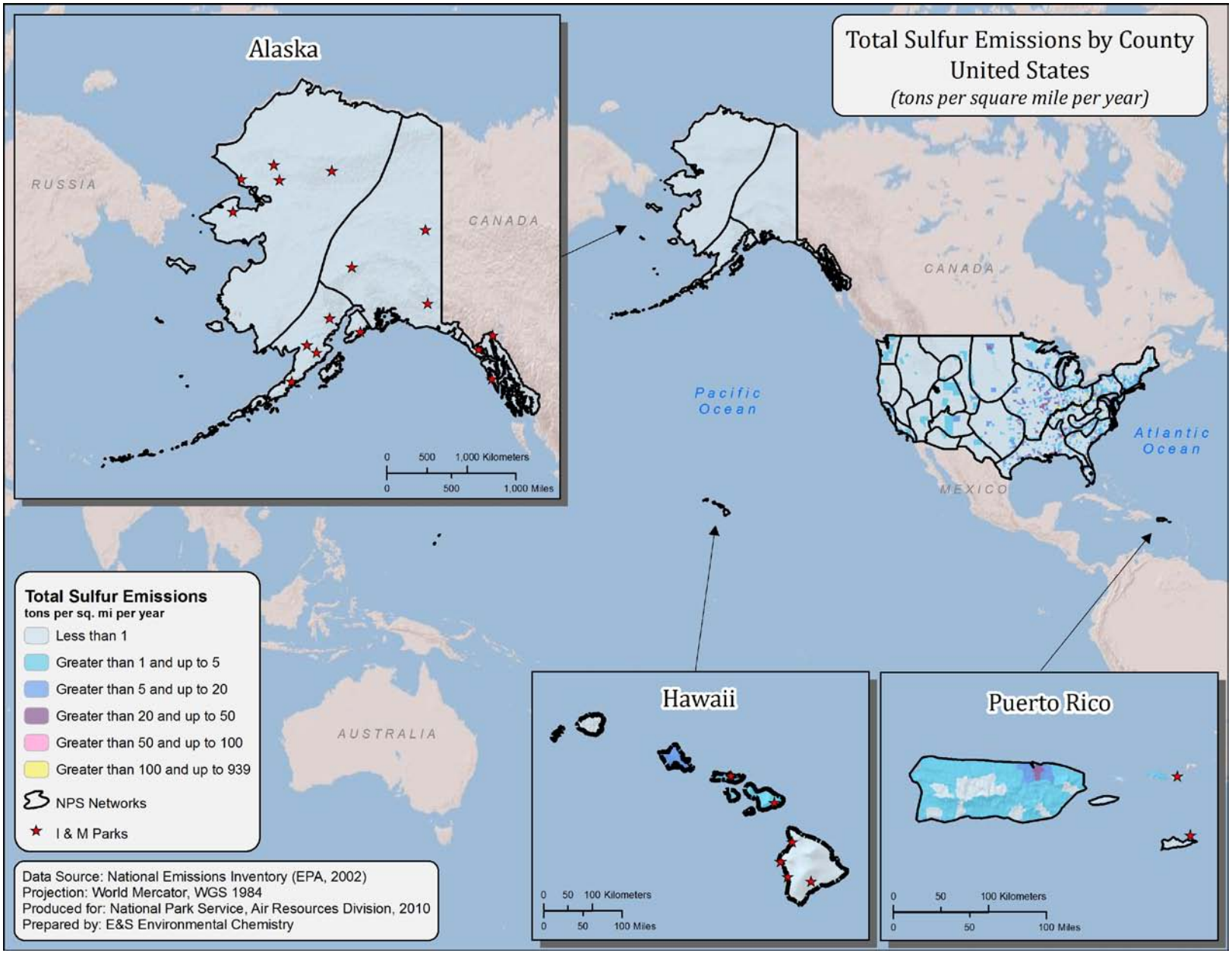
Figure D. Network Summary Risk rankings, calculated as the average of the quintile ranks for the Pollutant Exposure, Ecosystem Sensitivity, and Park Protection themes.

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.

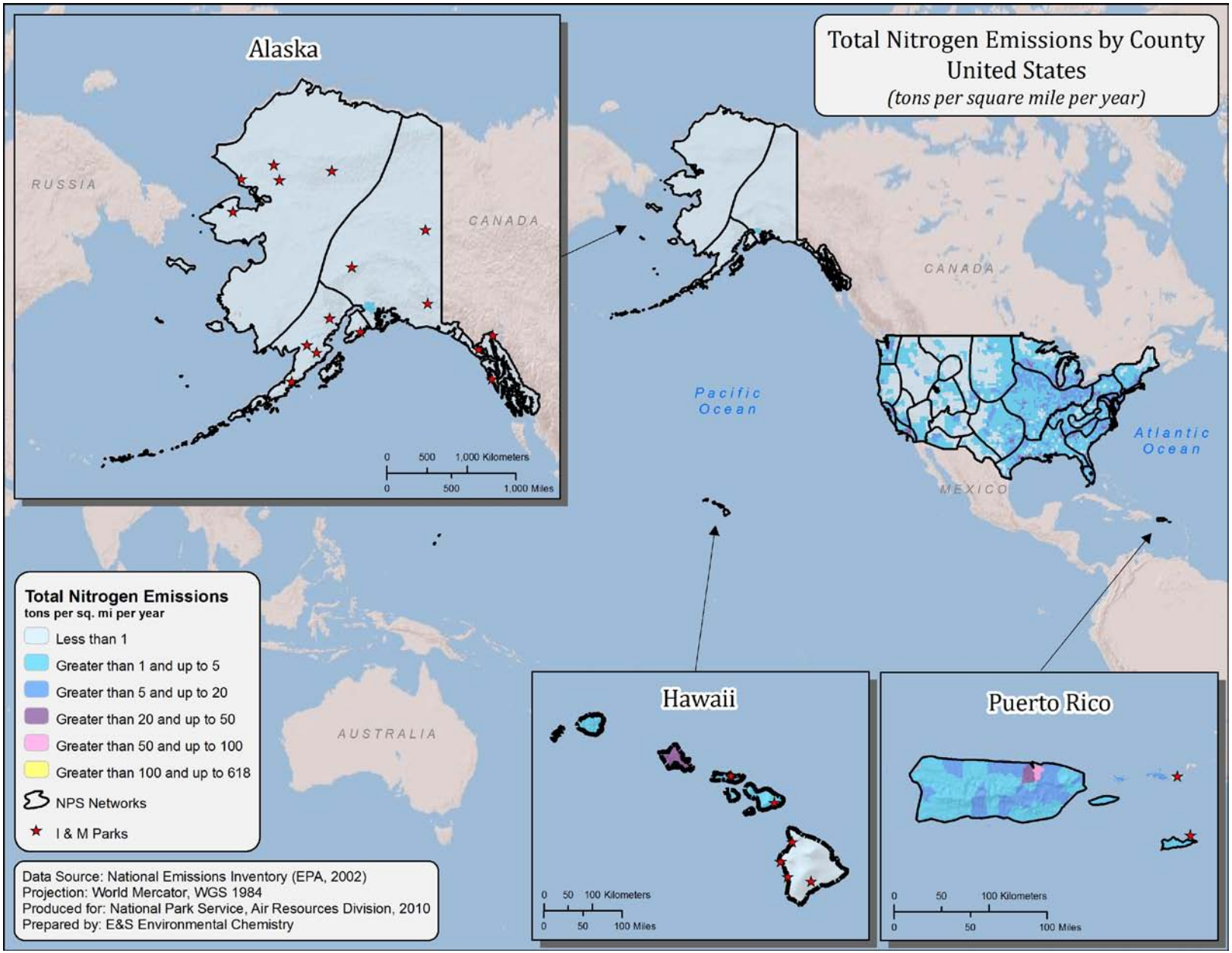
Figure F. Park rankings for Ecosystem Sensitivity for all parks larger than 100 square miles. Ranks for each park were calculated relative to all parks, regardless of size, as the average of scores for all Ecosystem Sensitivity variables.

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.

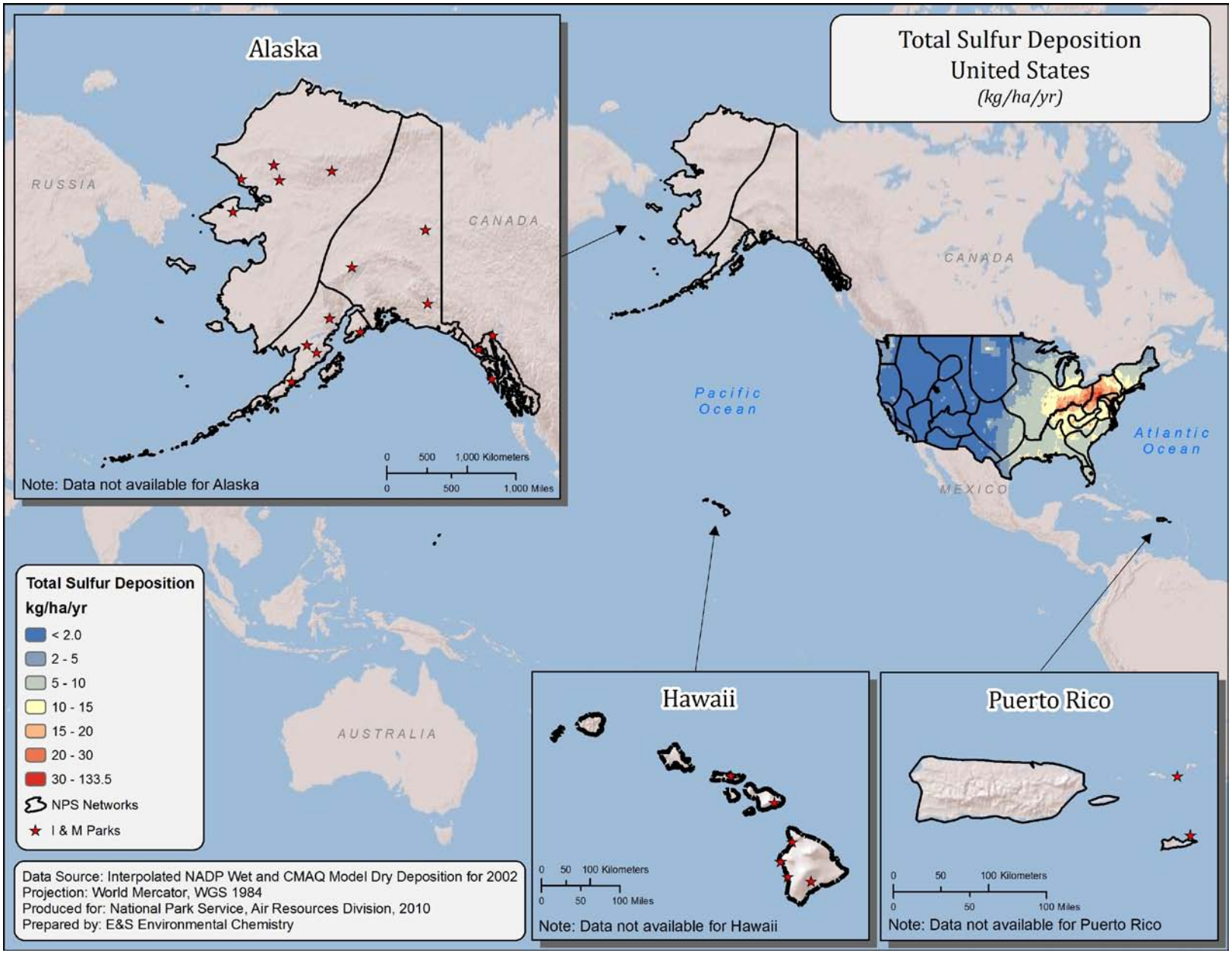
Figure H. Park rankings for Summary Risk for all parks larger than 100 square miles. Ranks for each park were calculated relative to all parks, regardless of size, as the average of the quintile ranks for the Pollutant Exposure, Ecosystem Sensitivity, and Park Protection themes.


Total Sulfur Emissions by County
United States
(tons per square mile per year)
Alaska
RUSSIA
CANADA
0 500 1,000 Kilometers
0 500 1,000 Miles
CANADA
Pacific Ocean
Atlantic Ocean
MEXICO
AUSTRALIA
Hawaii
0 50 100 Kilometers
0 50 100 Miles
Puerto Rico
0 50 100 Kilometers
0 50 100 Miles
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
NPS Networks
I & M Parks
Data Source: National Emissions Inventory (EPA, 2002)
Projection: World Mercator, WGS 1984
Produced for: National Park Service, Air Resources Division, 2010
Prepared by: E&S Environmental Chemistry

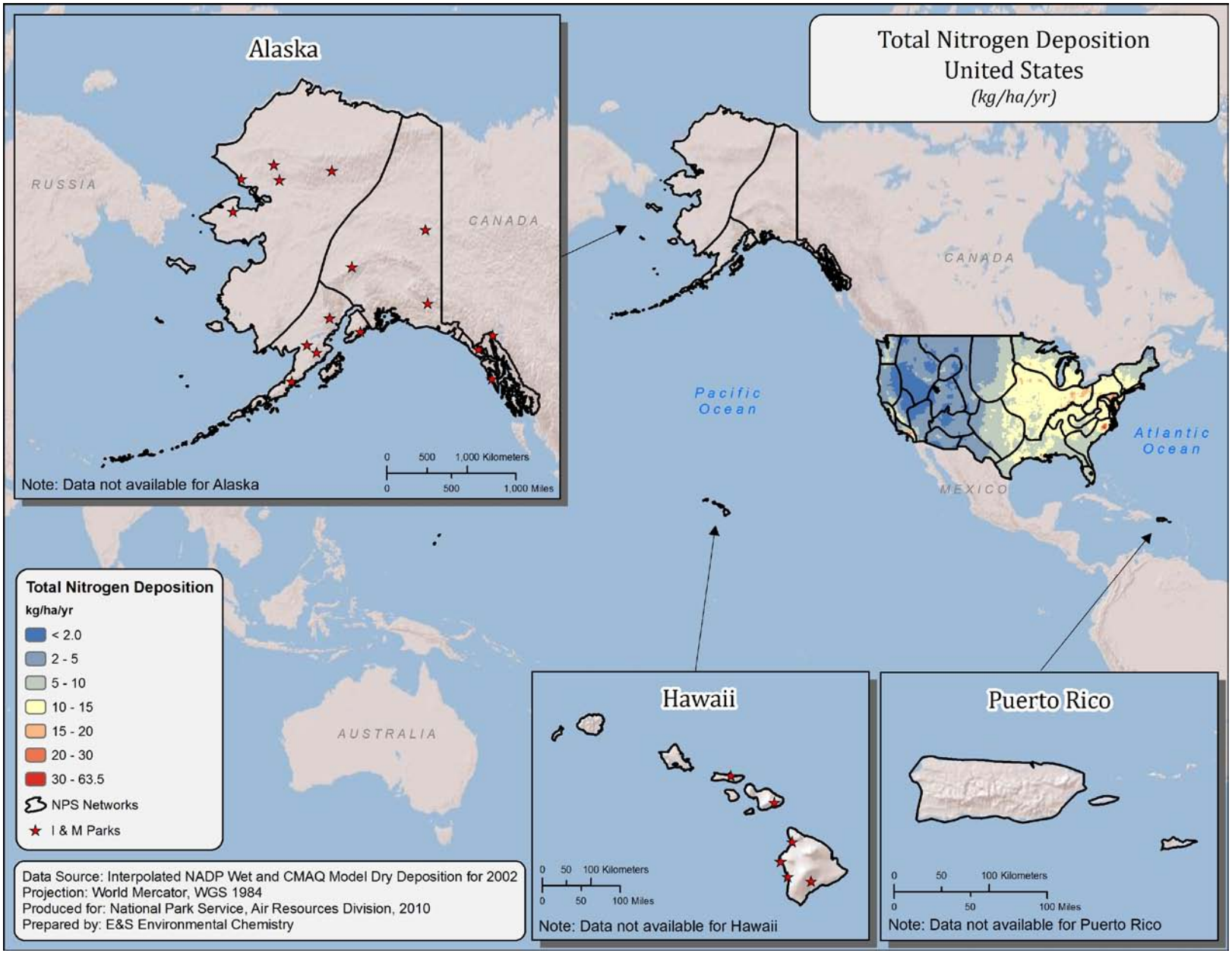
Map A


Total Nitrogen Emissions by County
United States
(tons per square mile per year)
Alaska
RUSSIA
CANADA
0 500 1,000 Kilometers
0 500 1,000 Miles
CANADA
Pacific Ocean
Atlantic Ocean
MEXICO
AUSTRALIA
Hawaii
0 50 100 Kilometers
0 50 100 Miles
Puerto Rico
0 50 100 Kilometers
0 50 100 Miles
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
NPS Networks
I & M Parks
Data Source: National Emissions Inventory (EPA, 2002)
Projection: World Mercator, WGS 1984
Produced for: National Park Service, Air Resources Division, 2010
Prepared by: E&S Environmental Chemistry

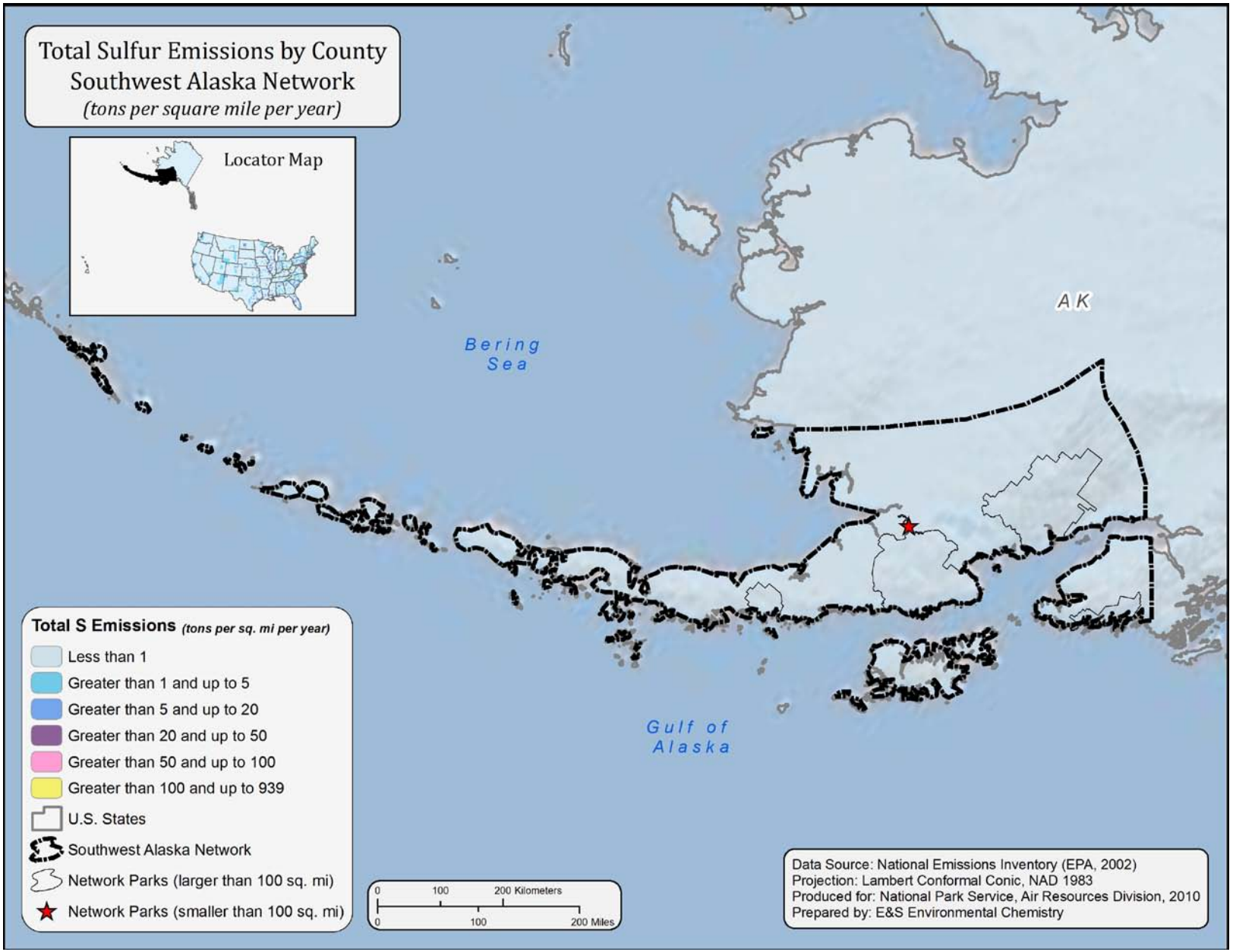
Map B


Alaska
Note: Data not available for Alaska
0 500 1,000 Kilometers
0 500 1,000 Miles
Total Sulfur Deposition
United States
(kg/ha/yr)
RUSSIA
CANADA
CANADA
MEXICO
Pacific Ocean
Atlantic Ocean
AUSTRALIA
Total Sulfur Deposition
kg/ha/yr
< 2.0
2 - 5
5 - 10
10 - 15
15 - 20
20 - 30
30 - 133.5
NPS Networks
I & M Parks
Hawaii
0 50 100 Kilometers
0 50 100 Miles
Note: Data not available for Hawaii
Puerto Rico
0 50 100 Kilometers
0 50 100 Miles
Note: Data not available for Puerto Rico
Data Source: Interpolated NADP Wet and CMAQ Model Dry Deposition for 2002
Projection: World Mercator, WGS 1984
Produced for: National Park Service, Air Resources Division, 2010
Prepared by: E&S Environmental Chemistry

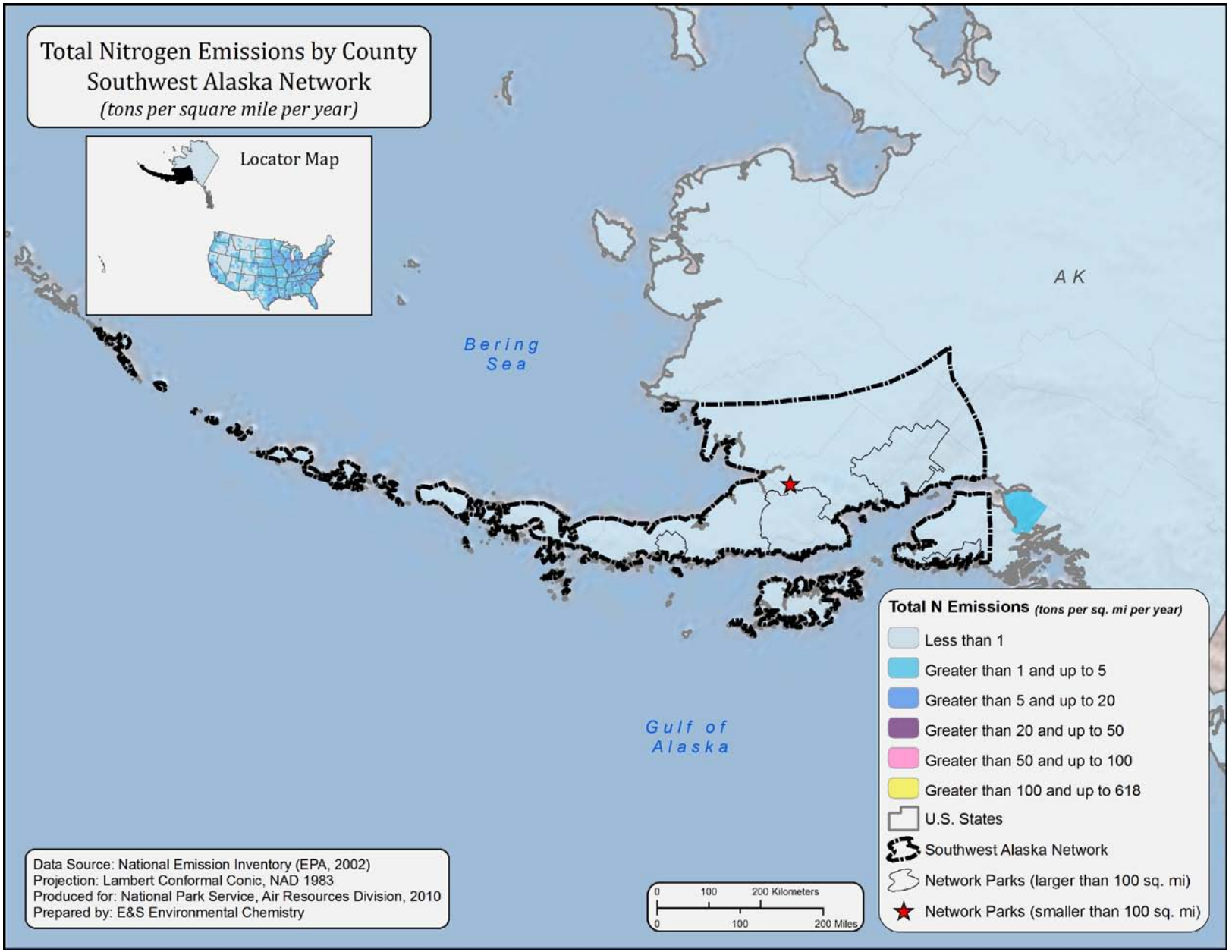
Map C


Alaska
Note: Data not available for Alaska
0 500 1,000 Kilometers
0 500 1,000 Miles
RUSSIA
CANADA
Total Nitrogen Deposition
United States
(kg/ha/yr)
Pacific Ocean
Atlantic Ocean
MEXICO
AUSTRALIA
Total Nitrogen Deposition
kg/ha/yr
< 2.0
2 - 5
5 - 10
10 - 15
15 - 20
20 - 30
30 - 63.5
NPS Networks
I & M Parks
Hawaii
0 50 100 Kilometers
0 50 100 Miles
Note: Data not available for Hawaii
Puerto Rico
0 50 100 Kilometers
0 50 100 Miles
Note: Data not available for Puerto Rico
Data Source: Interpolated NADP Wet and CMAQ Model Dry Deposition for 2002
Projection: World Mercator, WGS 1984
Produced for: National Park Service, Air Resources Division, 2010
Prepared by: E&S Environmental Chemistry

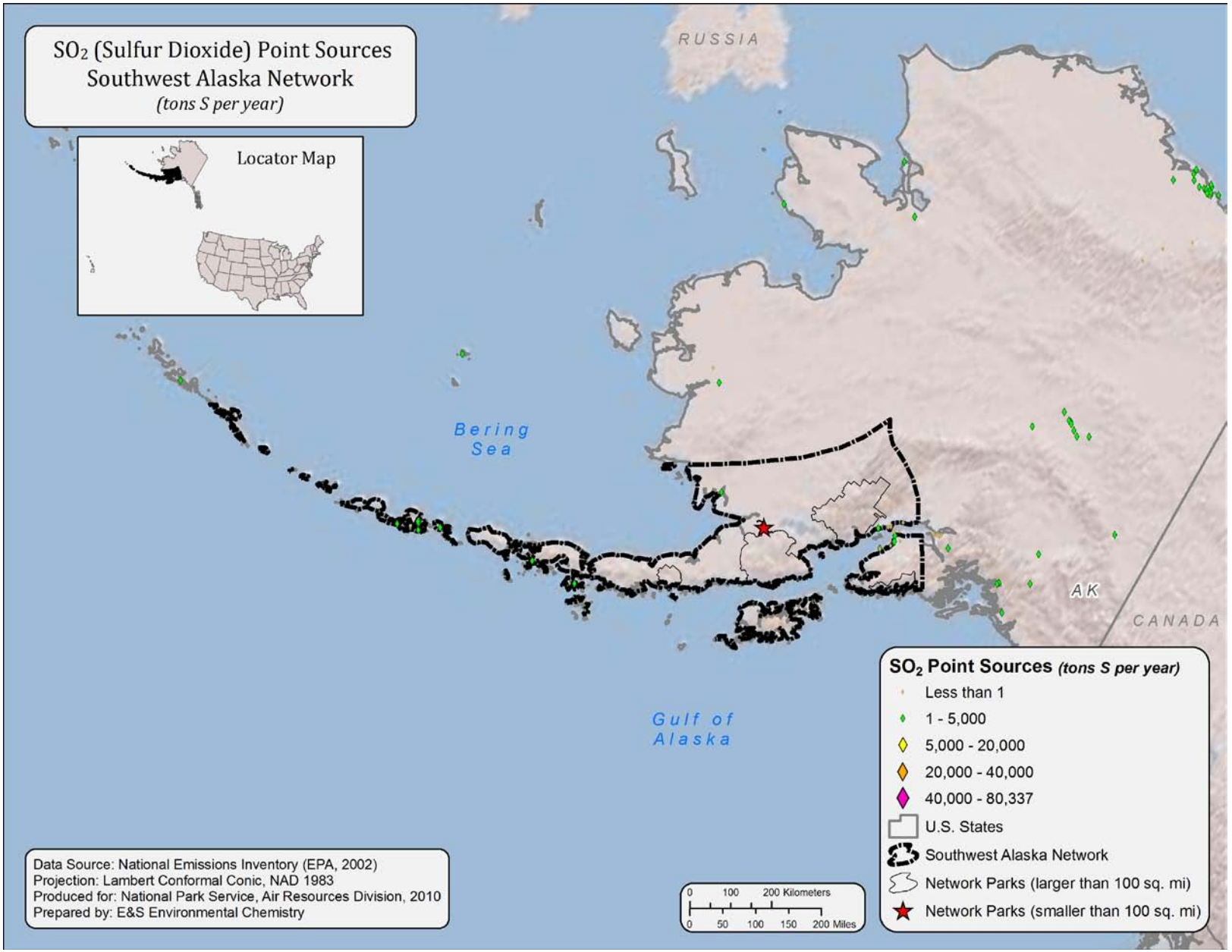
Map D


Total Sulfur Emissions by County
Southwest Alaska Network
(tons per square mile per year)
Locator Map
AK
Bering Sea
Gulf of Alaska
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
Southwest Alaska Network
Network Parks (larger than 100 sq. mi)
Network Parks (smaller than 100 sq. mi)
0 100 200 Kilometers
0 100 200 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

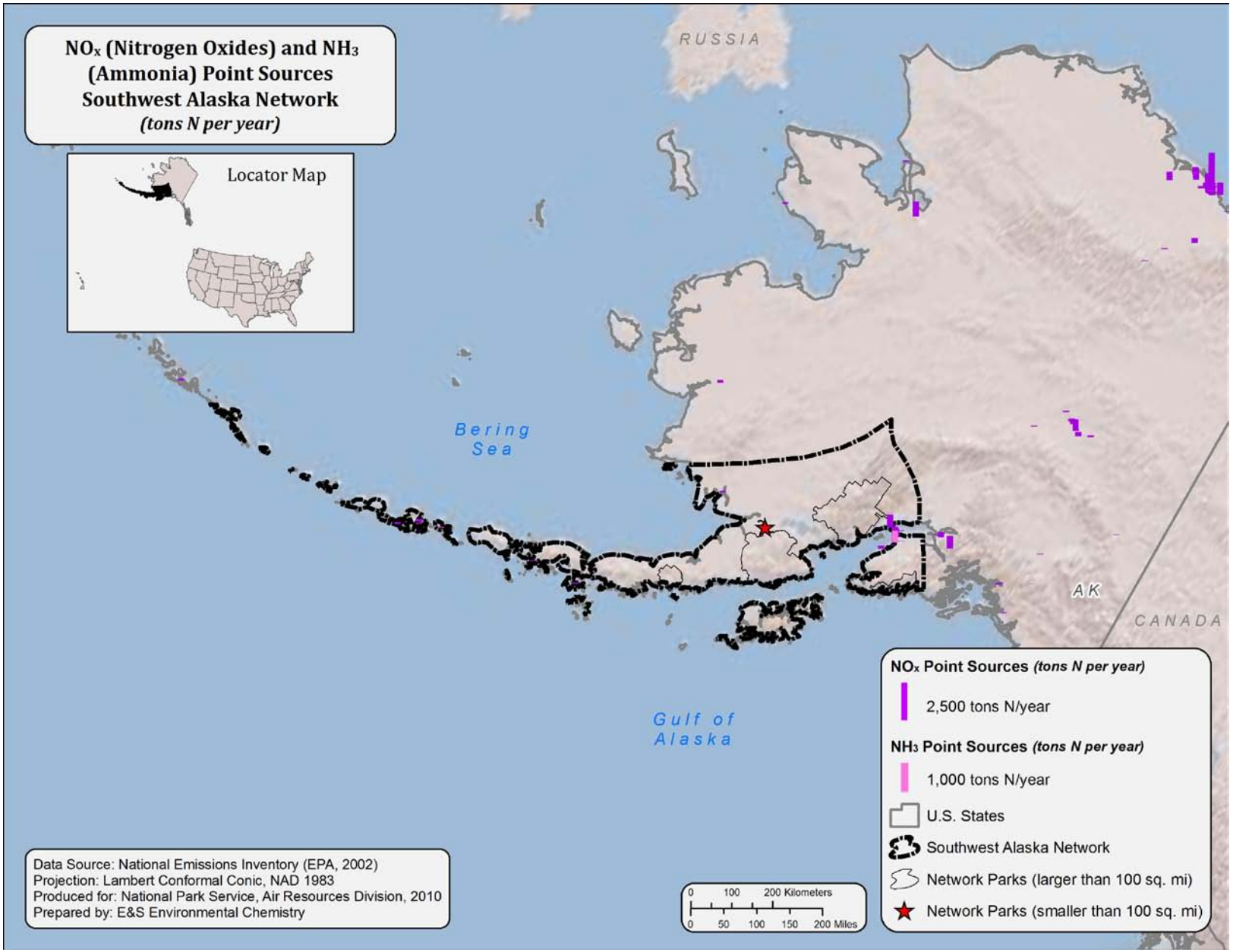
Map E


Total Nitrogen Emissions by County
Southwest Alaska Network
(tons per square mile per year)
Locator Map
AK
Bering Sea
Gulf of Alaska
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
Southwest Alaska Network
Network Parks (larger than 100 sq. mi)
Network Parks (smaller than 100 sq. mi)
Data Source: National Emission 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
0 100 200 Miles

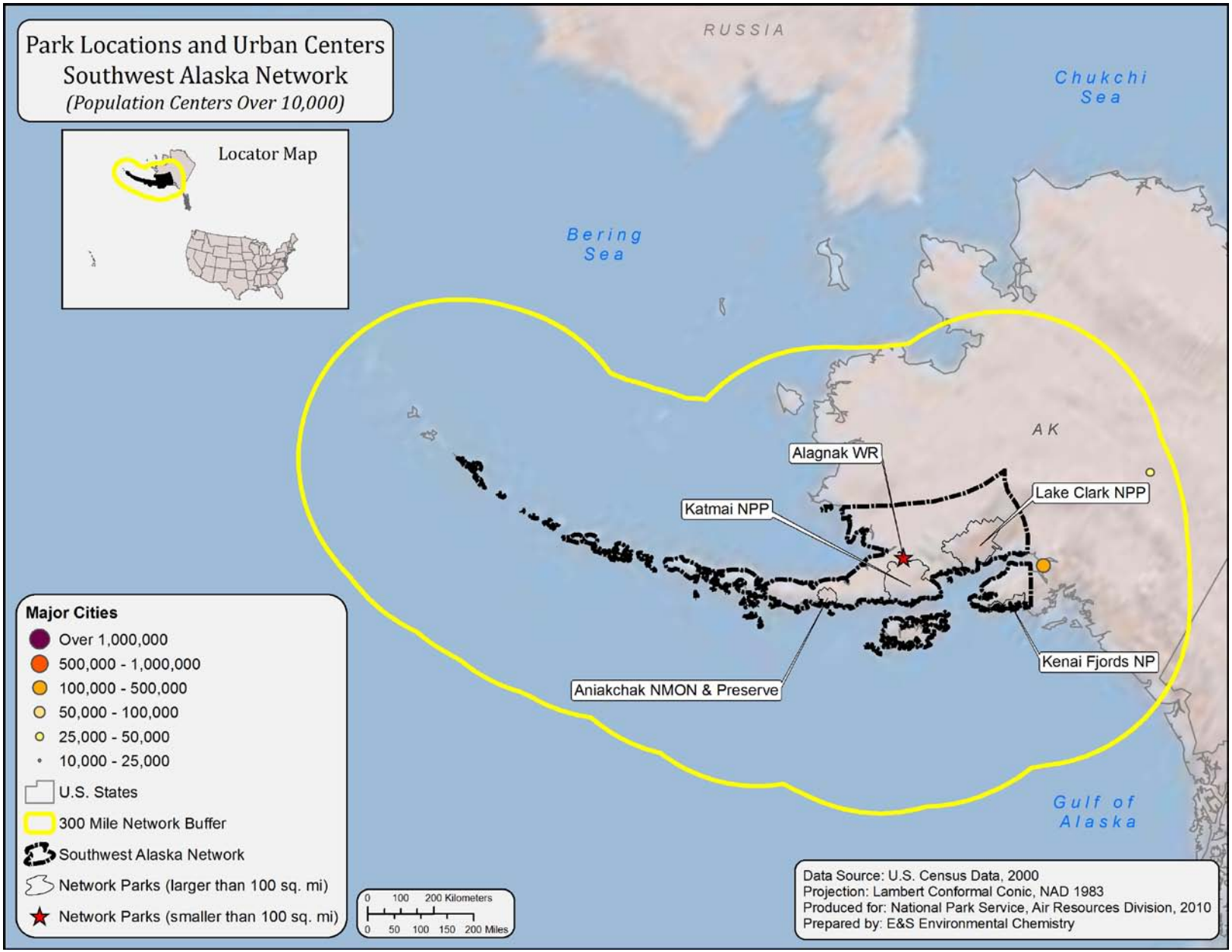
Map F


SO2 (Sulfur Dioxide) Point Sources
Southwest Alaska Network
(tons S per year)
Locator Map
RUSSIA
Bering Sea
Gulf of Alaska
AK
CANADA
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
Southwest Alaska 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

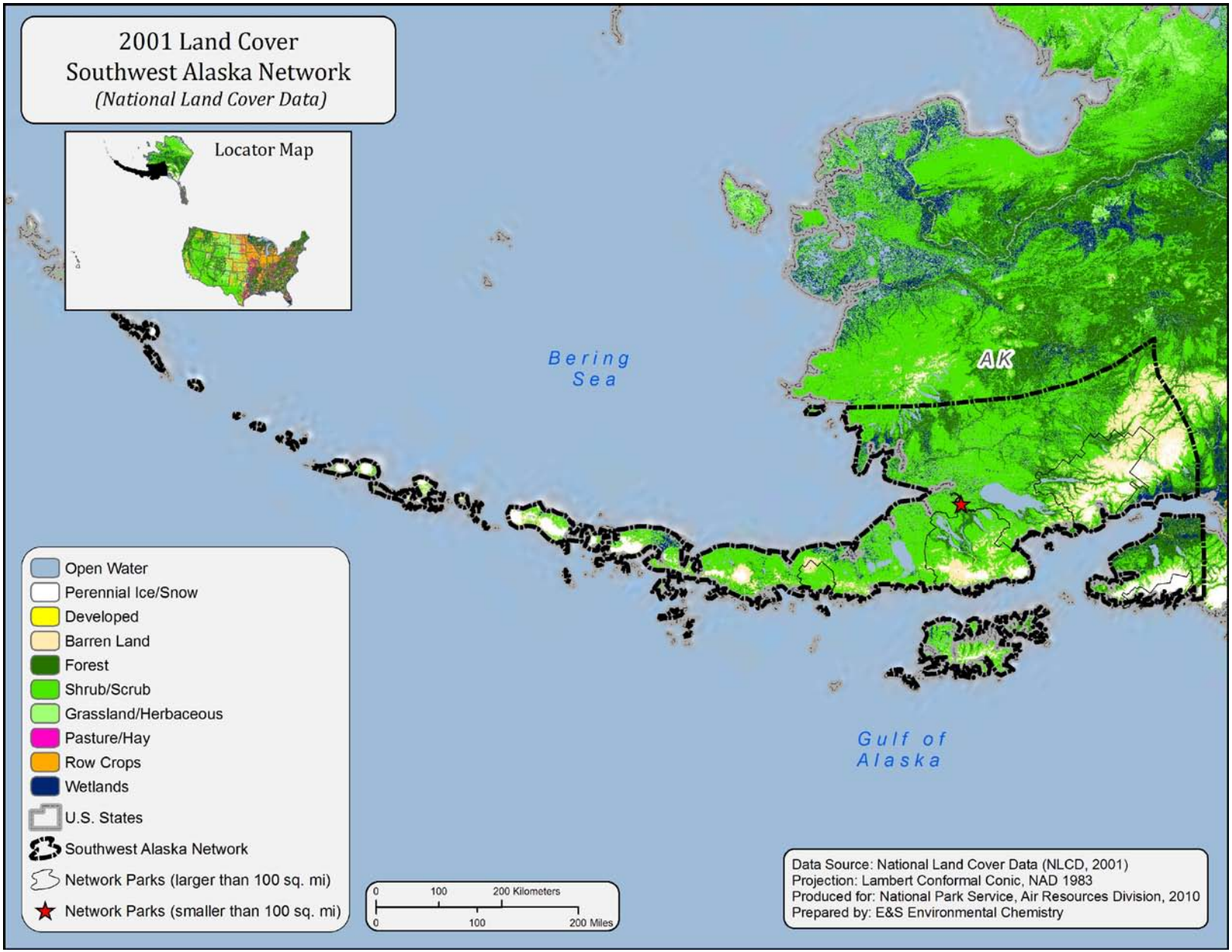
Map G


NOx (Nitrogen Oxides) and NH3 (Ammonia) Point Sources
Southwest Alaska Network
(tons N per year)
Locator Map
RUSSIA
Bering Sea
Gulf of Alaska
AK
CANADA
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
Southwest Alaska 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

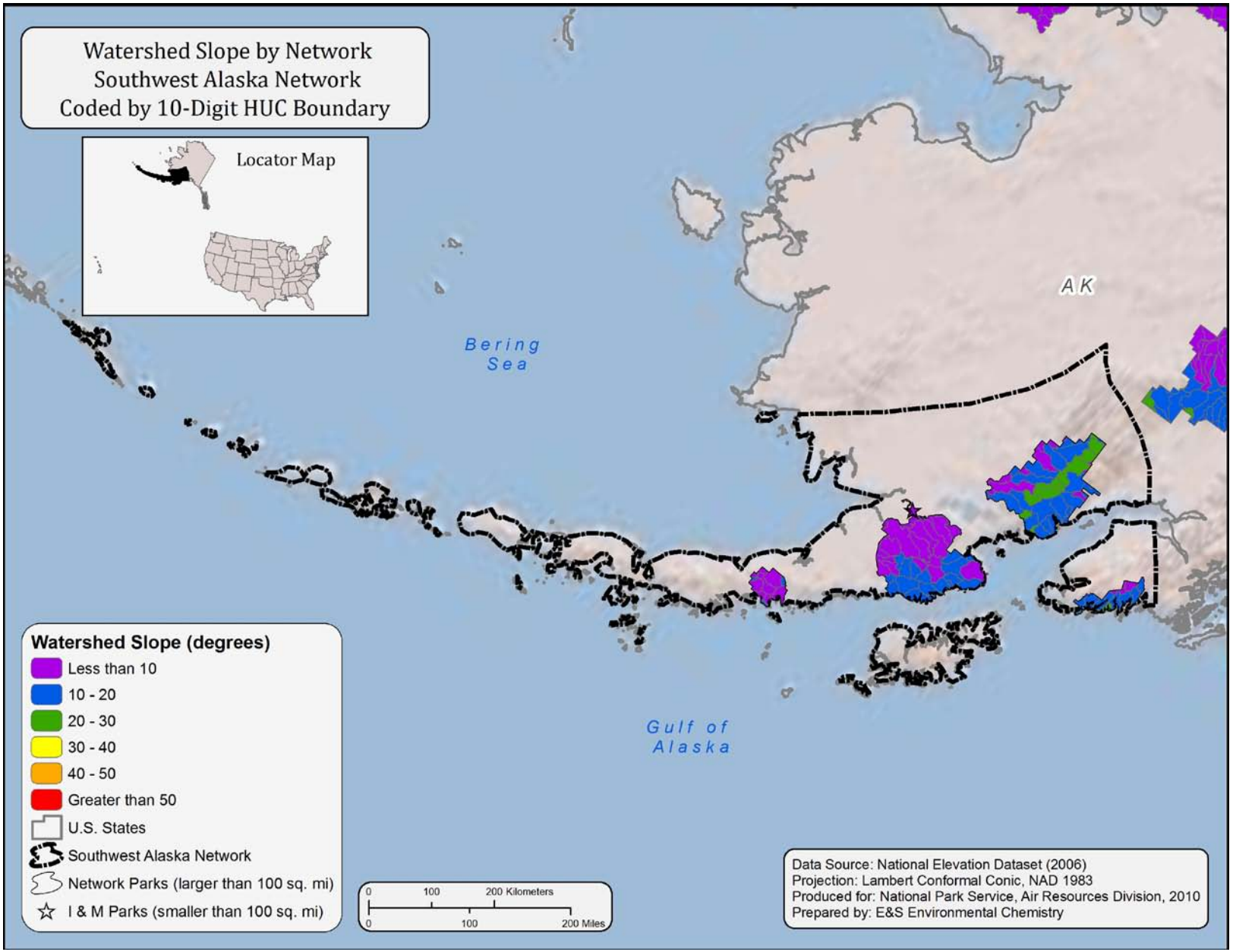
Map H


Park Locations and Urban Centers
Southwest Alaska Network
(Population Centers Over 10,000)
Locator Map
RUSSIA
Chukchi Sea
Bering Sea
AK
Alagnak WR
Lake Clark NPP
Katmai NPP
Kenai Fjords NP
Aniakchak NMON & Preserve
Gulf of Alaska
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
Southwest Alaska 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

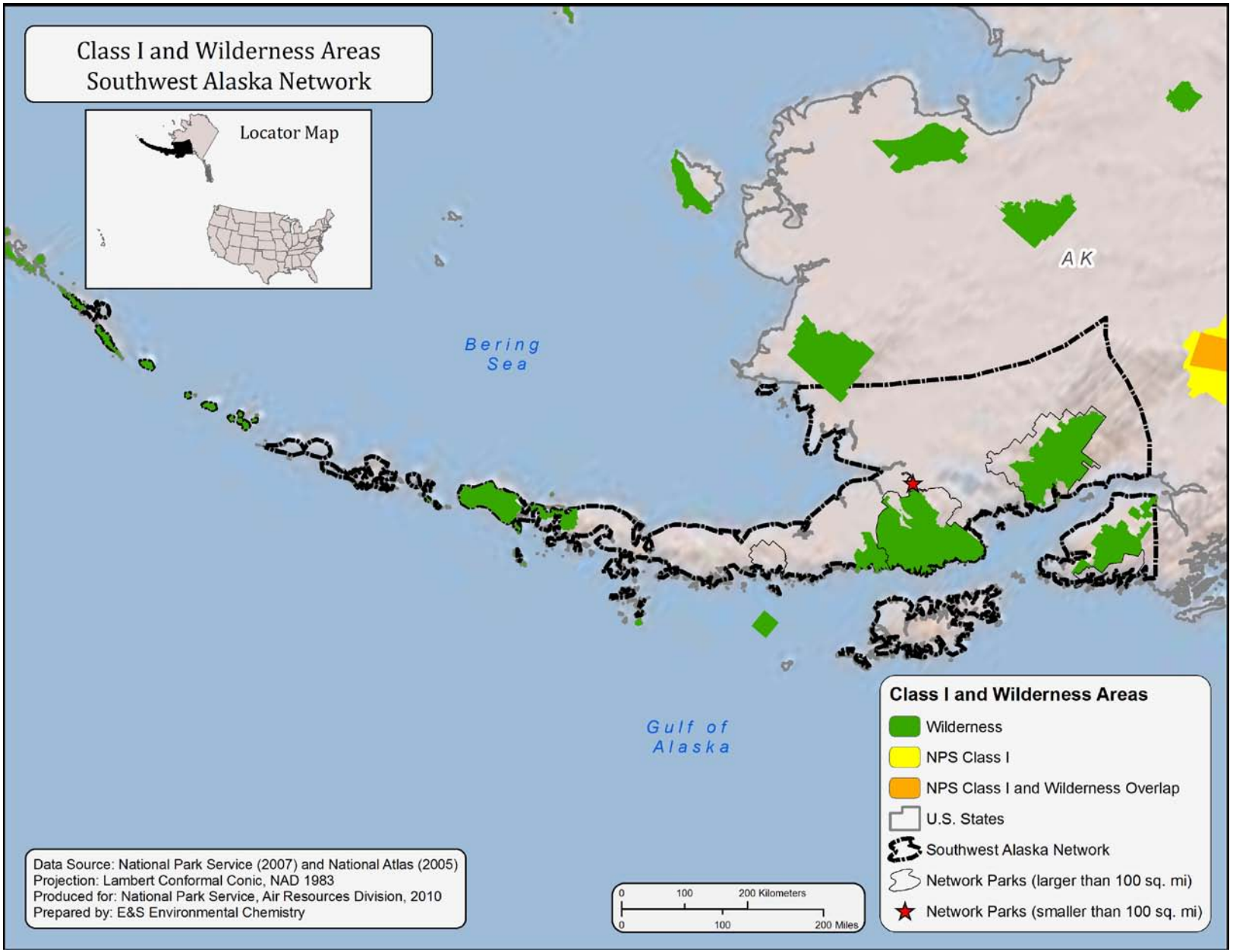
Map I


2001 Land Cover
Southwest Alaska Network
(National Land Cover Data)
Locator Map
Bering Sea
AK
Gulf of Alaska
Open Water
Perennial Ice/Snow
Developed
Barren Land
Forest
Shrub/Scrub
Grassland/Herbaceous
Pasture/Hay
Row Crops
Wetlands
U.S. States
Southwest Alaska Network
Network Parks (larger than 100 sq. mi)
Network Parks (smaller than 100 sq. mi)
0 100 200 Kilometers
0 100 200 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
Southwest Alaska Network
Coded by 10-Digit HUC Boundary
Locator Map
AK
Bering Sea
Gulf of Alaska
Watershed Slope (degrees)
Less than 10
10 - 20
20 - 30
30 - 40
40 - 50
Greater than 50
U.S. States
Southwest Alaska Network
Network Parks (larger than 100 sq. mi)
I & M Parks (smaller than 100 sq. mi)
0 100 200 Kilometers
0 100 200 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
Southwest Alaska Network
Locator Map
AK
Bering Sea
Gulf of Alaska
Class I and Wilderness Areas
Wilderness
NPS Class I
NPS Class I and Wilderness Overlap
U.S. States
Southwest Alaska Network
Network Parks (larger than 100 sq. mi)
Network Parks (smaller than 100 sq. mi)
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
0 100 200 Kilometers
0 100 200 Miles

Map N

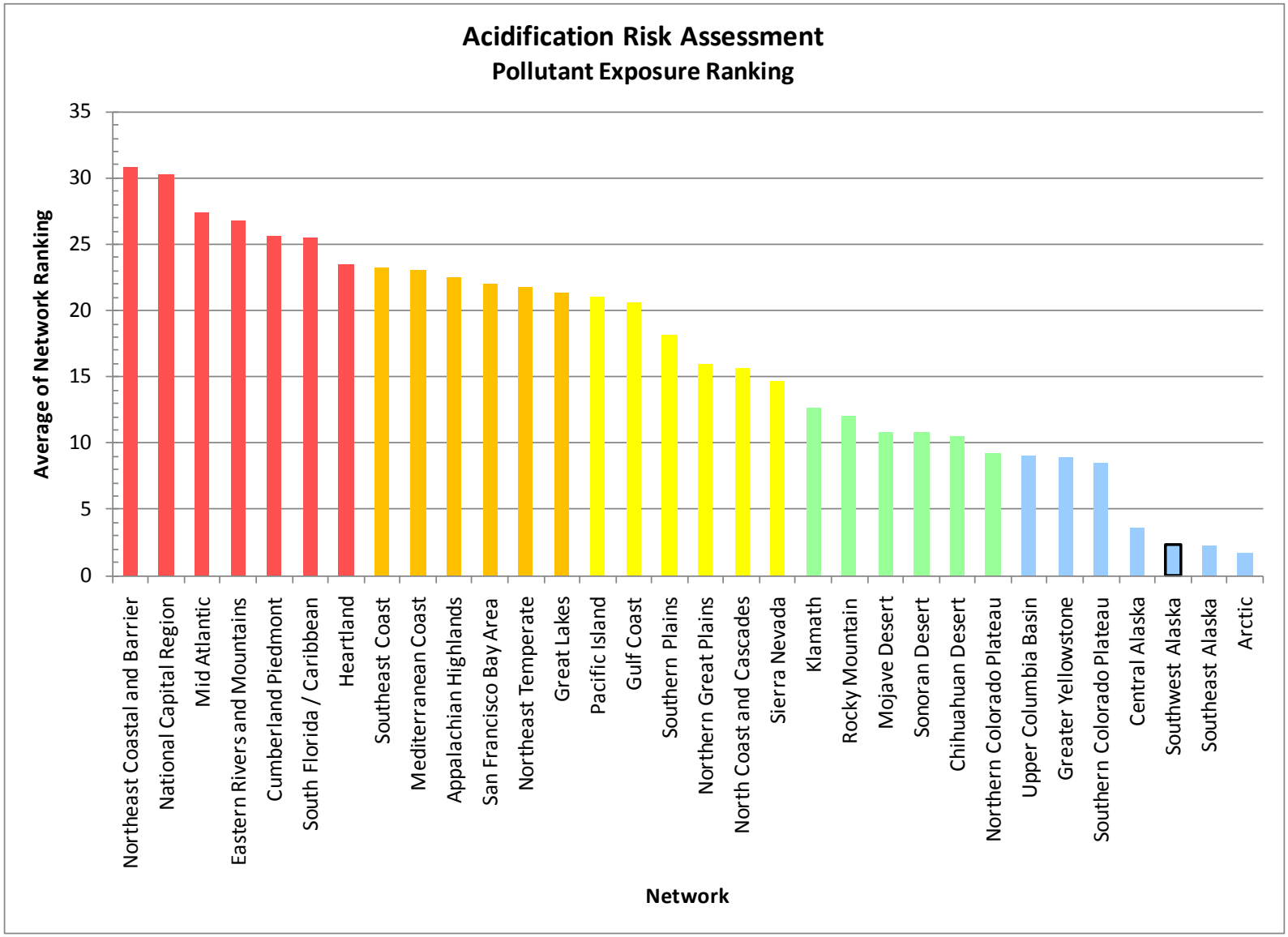

Acidification Risk Assessment
Pollutant Exposure Ranking
Average of Network Ranking
35
30
25
20
15
10
5
0
Northeast Coastal and Barrier
National Capital Region
Mid Atlantic
Eastern Rivers and Mountains
Cumberland Piedmont
South Florida / Caribbean
Heartland
Southeast Coast
Mediterranean Coast
Appalachian 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

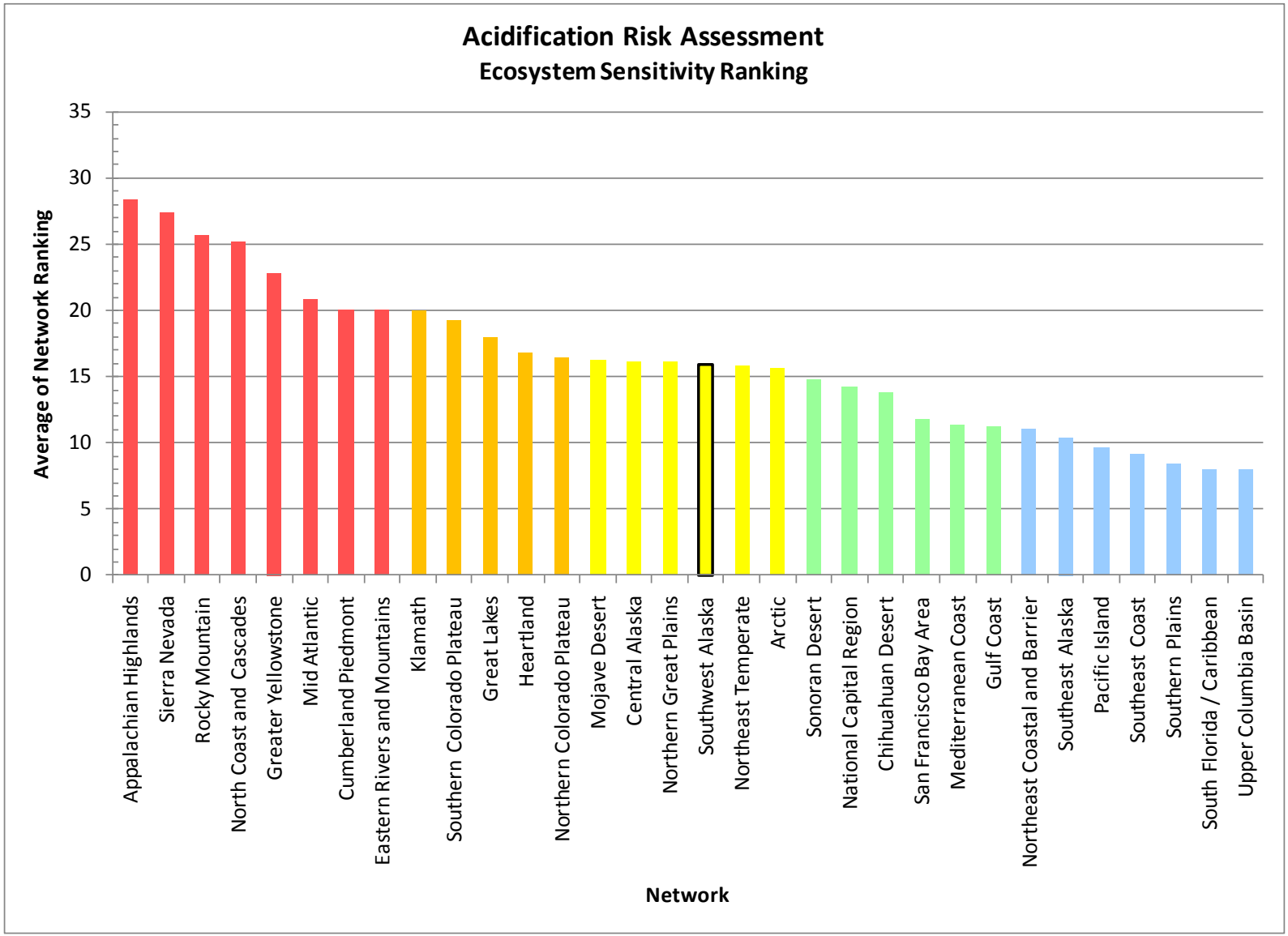

Acidification Risk Assessment
Ecosystem Sensitivity Ranking
Average of Network Ranking
35
30
25
20
15
10
5
0
Appalachian Highlands
Sierra Nevada
Rocky Mountain
North Coast and Cascades
Greater Yellowstone
Mid Atlantic
Cumberland Piedmont
Eastern Rivers and Mountains
Klamath
Southern Colorado Plateau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

Figure B

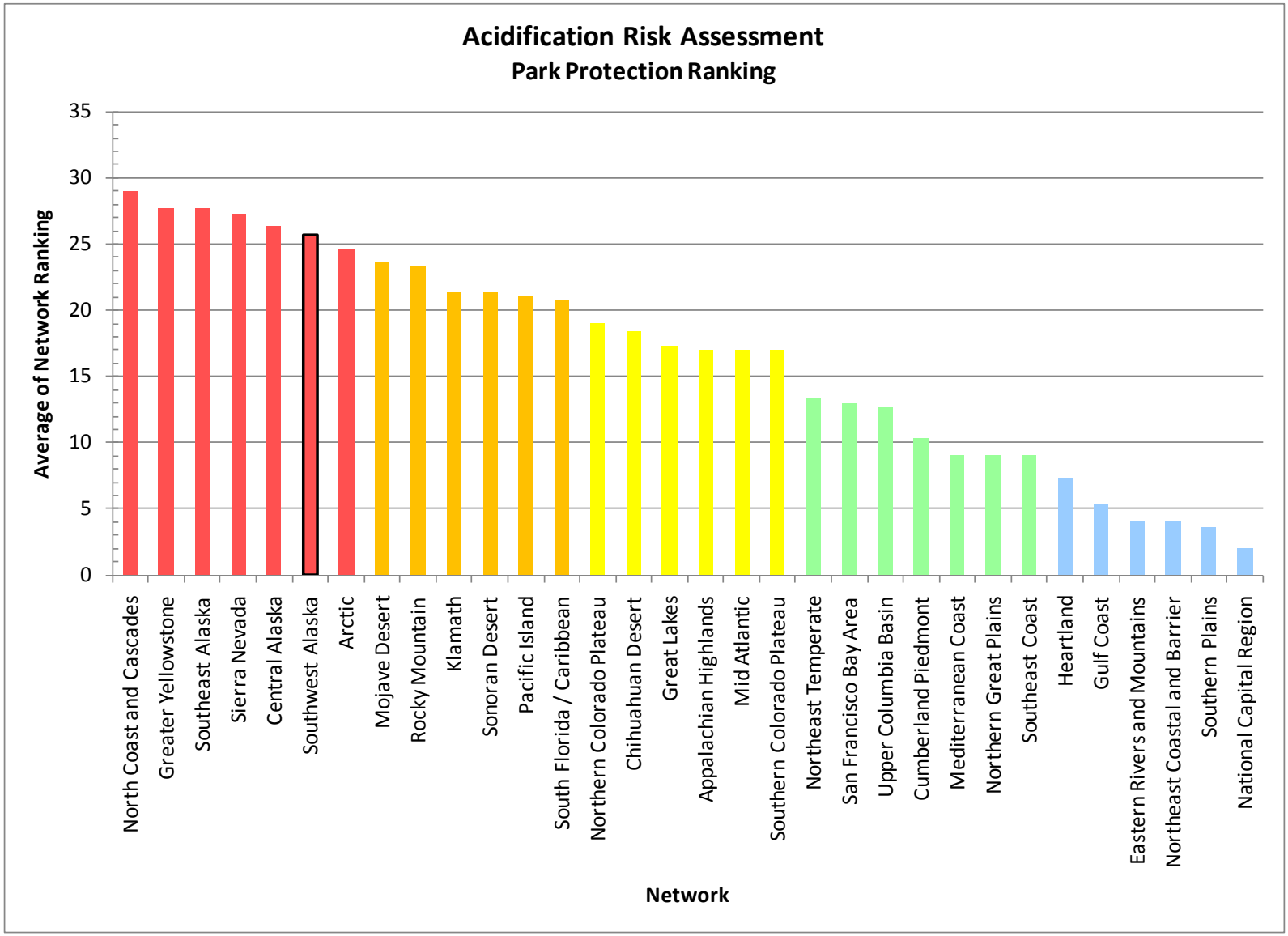

Acidification Risk Assessment
Park Protection Ranking
Average of Network Ranking
35
30
25
20
15
10
5
0
North Coast and Cascades
Greater Yellowstone
Southeast Alaska
Sierra Nevada
Central Alaska
Southwest Alaska
Arctic
Mojave Desert
Rocky Mountain
Klamath
Sonoran Desert
Pacific Island
South Florida /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

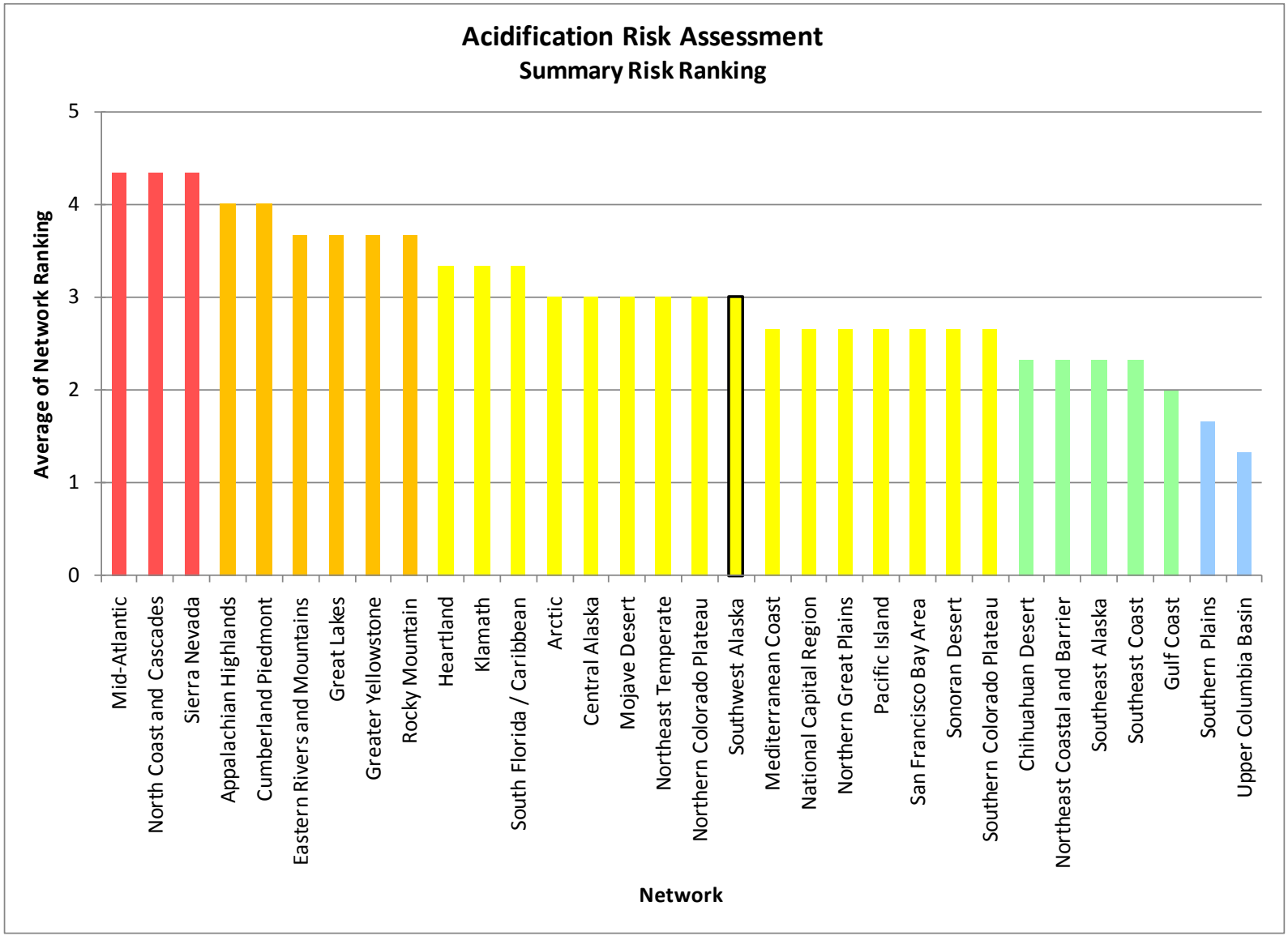

Acidification Risk Assessment
Summary Risk Ranking
Average of Network Ranking
0
1
2
3
4
5
Mid-Atlantic
North Coast and Cascades
Sierra Nevada
Appalachian Highlands
Cumberland Piedmont
Eastern Rivers and Mountains
Great Lakes
Greater Yellowstone
Rocky Mountain
Heartland
Klamath
South Florida / Caribbean
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
Network

Figure D

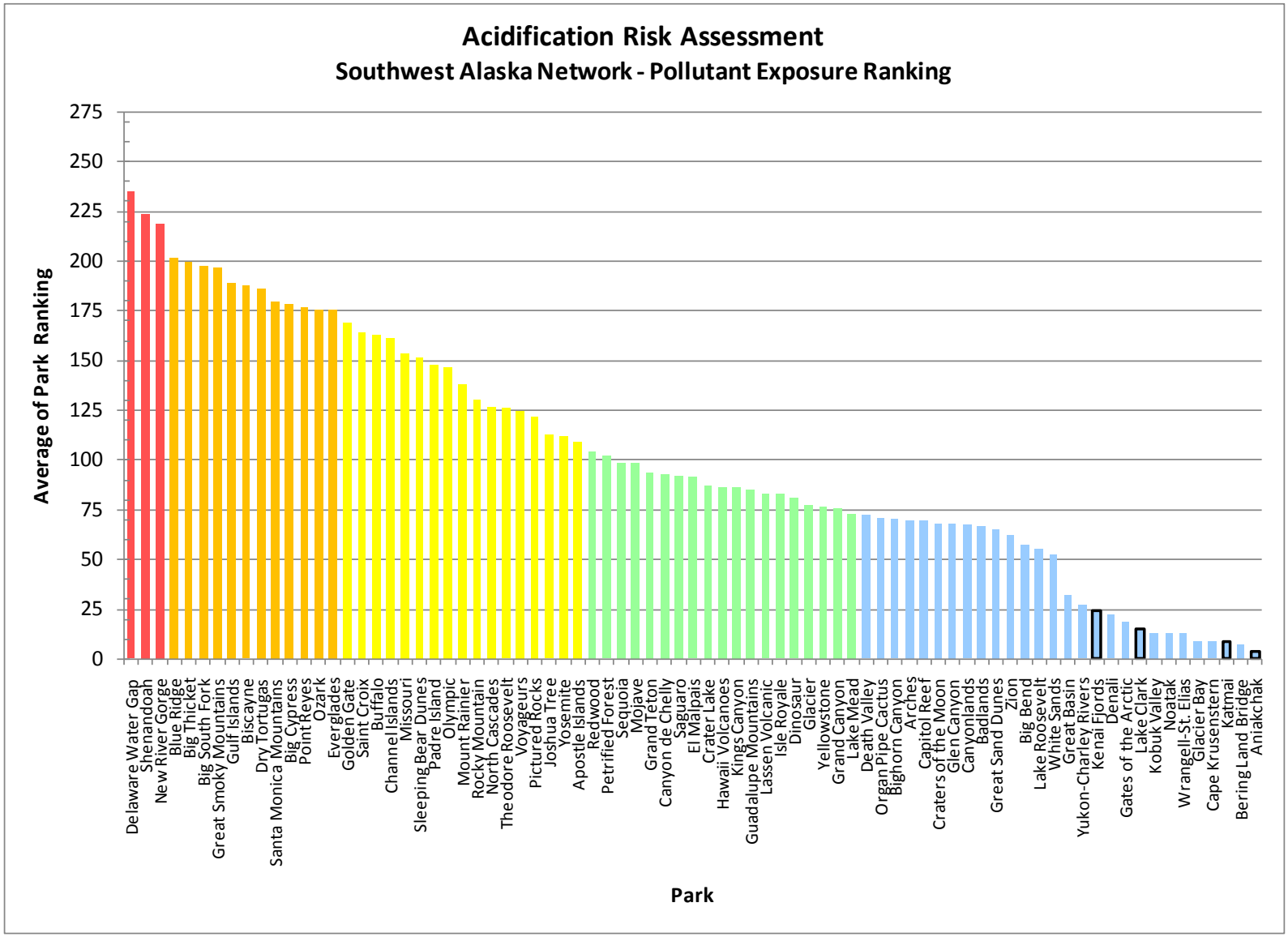

Acidification Risk Assessment
Southwest Alaska Network - Pollutant Exposure Ranking
Average of Park Ranking
275
250
225
200
175
150
125
100
75
50
25
0
Delaware Water Gap
Shenandoah
New River Gorge
Blue Ridge
Big Thicket
Big South Fork
Great Smoky Mountains
Gulf Islands
Biscayne
Dry Tortugas
Santa Monica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

Figure E

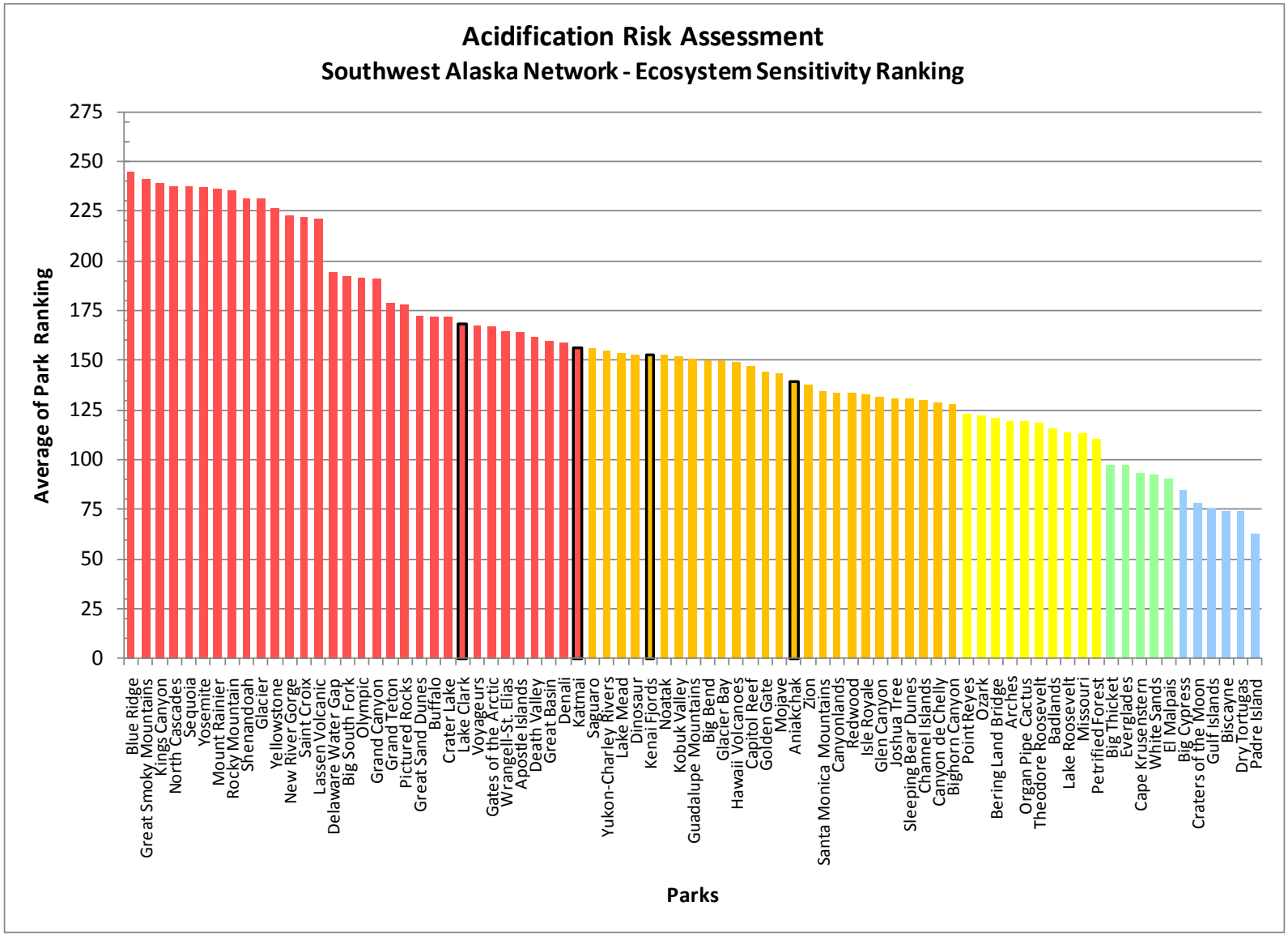

Acidification Risk Assessment
Southwest Alaska Network - Ecosystem Sensitivity Ranking
Average of Park Ranking
275
250
225
200
175
150
125
100
75
50
25
0
Blue Ridge
Great Smoky Mountains
Kings Canyon
North Cascades
Sequoia
Yosemite
Mount Rainier
Rocky Mountain
Shenandoah
Glacier
Yellowstone
New River 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

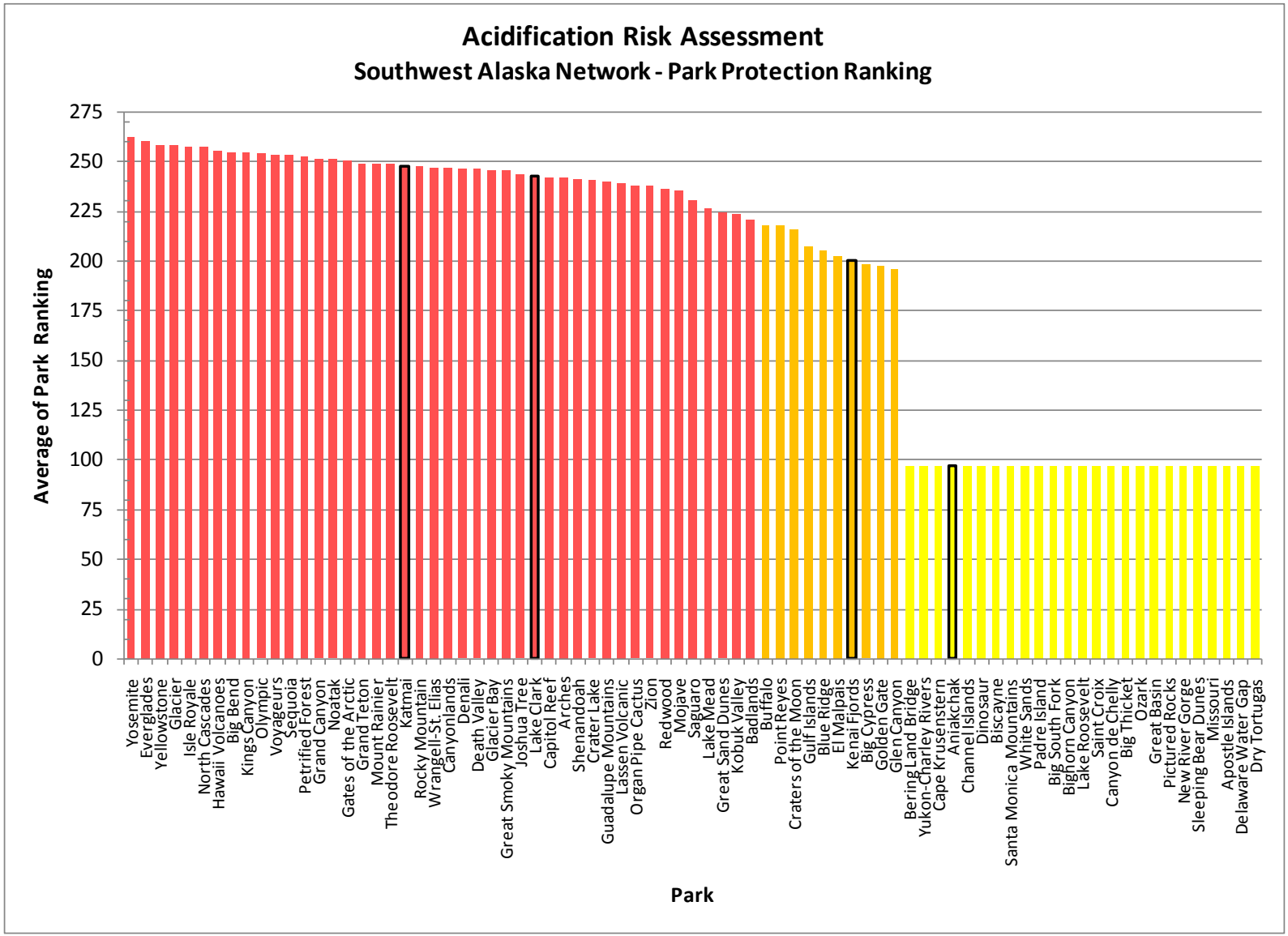

Acidification Risk Assessment
Southwest Alaska Network - Park Protection Ranking
Average of Park Ranking
275
250
225
200
175
150
125
100
75
50
25
0
Park
Yosemite
Everglades
Yellowstone
Glacier
Isle Royale
North Cascades
Hawaii Volcanoes
Big Bend
Kings Canyon
Olympic
Voyageurs
Sequoia
Petrified Forest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

Figure G

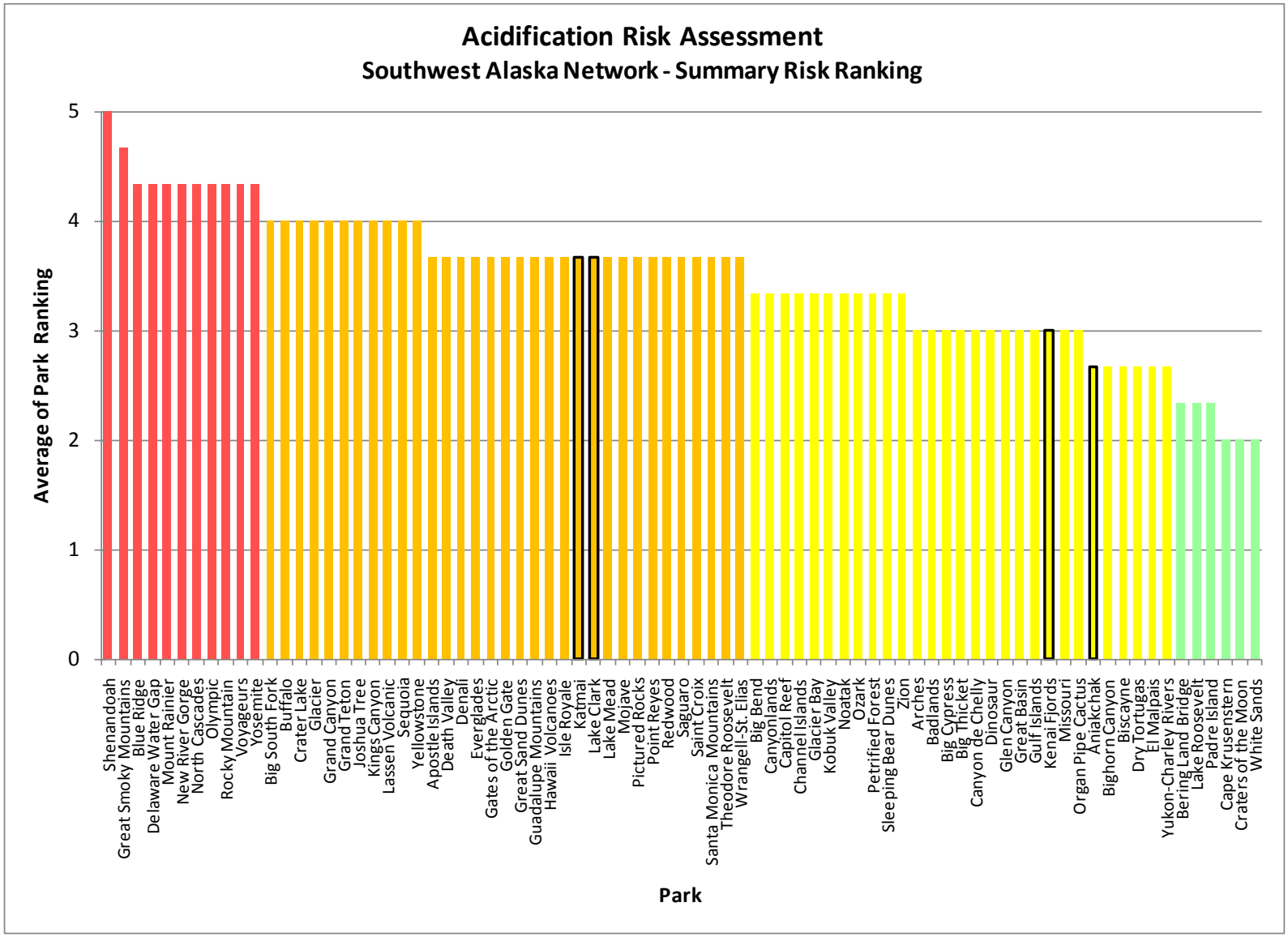

Acidification Risk Assessment
Southwest Alaska Network - Summary Risk Ranking
Average of Park Ranking
0
1
2
3
4
5
Park
Shenandoah
Great Smoky Mountains
Blue Ridge
Delaware Water Gap
Mount Rainier
New River Gorge
North Cascades
Olympic
Rocky Mountain
Voyageurs
Yosemite
Big South Fork
Buffalo
Crater Lake
Glacier
Grand Canyon
Grand Teton
Joshua Tree
Kings Canyon
Lassen Volcanic
Sequoia
Yellowstone
Apostle Islands
Death Valley
Denali
Everglades
Gates of the Arctic
Golden Gate
Great Sand Dunes
Guadalupe Mountains
Hawaii Volcanoes
Isle Royale
Katmai
Lake Clark
Lake Mead
Mojave
Pictured Rocks
Point Reyes
Redwood
Saguaro
Saint Croix
Santa Monica Mountains
Theodore Roosevelt
Wrangell-St. Elias
Big Bend
Canyonlands
Capitol Reef
Channel Islands
Glacier Bay
Kobuk Valley
Noatak
Ozark
Petrified Forest
Sleeping Bear Dunes
Zion
Arches
Badlands
Big Cypress
Big Thicket
Canyon de Chelly
Dinosaur
Glen Canyon
Great Basin
Gulf Islands
Kenai Fjords
Missouri
Organ Pipe Cactus
Aniakchak
Bighorn Canyon
Biscayne
Dry Tortugas
El Malpais
Yukon-Charley Rivers
Bering Land Bridge
Lake Roosevelt
Padre Island
Cape Krusenstern
Craters of the Moon
White Sands

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 953/107419, April 2011

National Park Service
U.S. Department of the Interior

Natural Resource Program Center
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PO Box 25287
Denver, CO 80225

www.nature.nps.gov/air