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

Central Alaska Network (CAKN)

Natural Resource Report NPS/NRPC/ARD/NRR—2011/304
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
Evaluation of the Sensitivity of Inventory and Monitoring National Parks to Nutrient Enrichment Effects from Atmospheric Nitrogen Deposition

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February 2011

U.S. Department of the Interior  
National Park Service  
Natural Resource Program Center  
Denver, Colorado
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Please cite this publication as:

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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. Regional deposition data are not available for Alaska, but N deposition would be expected to be very low throughout most, but not necessarily all, of Alaska. There are five active NADP/NTN wet deposition monitoring sites in Alaska: Poker Creek, Juneau, Denali National Park (DENA), Gates of the Arctic National Park, and Katmai National Park, with data collected since 1980 at DENA and since 1993 at Poker Creek. The other three monitoring sites have been added within the last decade. There are also CASTNET dry deposition measurements at DENA 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. The dry N deposition measurements by CASTNET have also been low, below about 0.25 kg N/ha/yr for each site and year measured. Thus, the sparse available atmospheric N deposition data for Alaska are consistent with the general understanding that atmospheric deposition tends to be very low at national park lands within Alaska. It can be assumed that N deposition in each of the Alaskan networks would be lower than 1 to 2 kg/ha/yr, on average, across each of those networks.

The Central Alaska Network contains three park units: DENA, Wrangell-St. Elias (WRST), and Yukon-Charley Rivers (YUCH). All are larger than 100 square miles.

Total N emissions, by county, are shown in Map C for lands in and surrounding the Central Alaska Network. County-level emissions within most of the network were less than 1 ton per square mile. Only one county showed higher emissions, in the range of 1 to 5 tons per square mile per year. Point source emissions of oxidized (nitrogen oxides, NOx) and reduced (ammonia, NH3) N are shown in Map D. No point sources emitted more than 1,000 tons of N per year, and there were very few point sources of any magnitude within the network. Point sources that did occur within the network were mainly sources of oxidized, rather than reduced, N. Only two urban centers occur within the network and only one additional urban center occurs within a 300-mile buffer around the network (Map E).

Map F is not shown for this network because regional atmospheric deposition data are not available for networks in Alaska. Total N deposition within this network is expected to be quite low (less than 1 kg N/ha/yr) due to the scarcity of point sources and urban areas and the low calculated emissions levels from the various counties that comprise the network. Atmospheric N deposition in this network is assumed to be in the first quintile of deposition values among the various networks for the purpose of ranking networks according to N Pollutant Exposure.

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

Map H shows the distribution within the major parks that occur in this network of the five vegetation types thought to be most responsive to nutrient N enrichment effects (arctic herbaceous, alpine, grassland and meadow, wetland, and arid and semi-arid). In general, the predominant sensitive vegetation types within the parks found in this network are wetland and arctic herbaceous vegetation.
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 large areas designated as wilderness and as NPS class I within the network.

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 Central Alaska Network ranks in the lowest quintile, among networks, in N Pollutant Exposure (Figure A). Nitrogen emissions within the network and expected N deposition within the network are both very low. The network Ecosystem Sensitivity ranking is also very low (Figure B). This network ranks in the top quintile in Park Protection (Figure C), having substantial amounts of protected lands. In combination, the network rankings for Pollutant Exposure, Ecosystem Sensitivity, and Park Protection yield an overall Network Risk ranking that is very low compared with all networks (Figure D).

Similarly, park rankings are given in Figures E through H for the same metrics. In the case of the park rankings, we only show in the figures the parks that are larger than 100 square miles. Relative ranks for all parks, including the smaller parks, are given in Table A and Appendix B. As for the network ranking figures, the park ranking figures highlight those parks that occur in this network to show their relative position compared with parks in the other 31 networks. Note that the rankings shown in Figures E through H reflect the rank of a given park compared with all other parks, irrespective of size.

<table>
<thead>
<tr>
<th>Relative Ranking of Individual Parks¹</th>
<th>Pollutant Exposure</th>
<th>Ecosystem Sensitivity</th>
<th>Park Protection</th>
<th>Summary Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Denali</td>
<td>Very Low</td>
<td>Low</td>
<td>Very High</td>
<td>Low</td>
</tr>
<tr>
<td>Wrangell-St. Elias</td>
<td>Very Low</td>
<td>Low</td>
<td>Very High</td>
<td>Low</td>
</tr>
<tr>
<td>Yukon-Charley Rivers</td>
<td>Very Low</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Very Low</td>
</tr>
</tbody>
</table>

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.
All three I&M parks in this network are ranked in the lowest quintile for Pollutant Exposure (Figure E). Each is ranked in the middle (YUCH) or second lowest (DENA, WRST) quintile in Ecosystem Sensitivity (Figure F). DENA and WRST are ranked Very High for Park Protection, whereas YUCH only ranked Moderate in Park Protection (Figure G). The combined Summary Risk ranking is in the lowest quintile for YUCH, and in the second lowest quintile for DENA and WRST (Figure H). Based on this classification and ranking scheme, the overall level of concern for nutrient N enrichment in the parks in this network is considered Low to Very Low. It is possible, however, that the ecosystem sensitivity of parks in this network is underestimated by the methodology and data used for this analysis. Shrub and forest vegetation communities in high-latitude locations may indeed be highly sensitive to relatively low levels of N addition. Unfortunately, experimental data are generally lacking. We assume that both arctic and alpine plant communities dominated by graminoids and herbaceous plants are likely to be especially sensitive, but we do not have adequate basis for evaluating the relative sensitivity of woody plants at high-latitude locations. In addition, much of the land coverage in some of these parks is snow and ice or barren land, generally lacking vascular plants. Lichens and mosses in barren areas may be highly sensitive to N addition, but cannot be used for inter-park and inter-network comparisons because data on distribution and abundance of these species are not available for enough locations.

If the arctic climate continues to warm, widespread melting of permafrost may contribute N to surface waters. This conversion of stored N to a more highly available form may augment atmospherically deposited N, leading to greater eutrophication effects in the future under a warming climate.

Map A. National map of total N emissions by county for the year 2002. Both oxidized (nitrogen oxides, NOₓ) and reduced (ammonia, NH₃) forms of N are included. The total is expressed in tons per square mile per year. (Source of data: EPA National Emissions Inventory, [http://www.epa.gov/ttn/chief/net/2002inventory.html](http://www.epa.gov/ttn/chief/net/2002inventory.html))

Map B. Regional deposition data are not available for Alaska. Total N deposition throughout most areas in Alaska is expected to be low, below about 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, NOₓ) and reduced (ammonia, NH₃) N are included. For the eastern half of the country, wet deposition values were derived from interpolated measured values from NADP (three-year average centered on 2002) and dry deposition values were derived from 12-km CMAQ model projections for 2002. For the western half of the country, both wet and dry deposition values were derived from 36-km CMAQ model projections for 2002. NADP interpolations were performed using the approach of Grimm and Lynch (1997). CMAQ model projections were provided by Robin Dennis, U.S. EPA.
Map C. Total N emissions by county for lands surrounding the network, expressed as tons of N emitted into the atmosphere per square mile per year. The total includes both oxidized (nitrogen oxides, NOx) and reduced (ammonia, NH3) N. (Source of data: EPA National Emissions Inventory, http://www.epa.gov/ttn/chieft/net/2002inventory.html)

Map D. Major point source emissions of oxidized (nitrogen oxides, NOx) and reduced (ammonia, NH3) N in and around the network. The base of each vertical bar is positioned in the map at the approximate location of the source. The height of the bar is proportional to the magnitude of the source. (Source of data: EPA National Emissions Inventory, http://www.epa.gov/ttn/chieft/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 G. Land cover types in and around the network, based on the National Land Cover dataset. (Source of data: National Land Cover Dataset, http://www.mrlc.gov/nlcd_multizone_map.php)

Map H. Distribution within the larger (larger than 100 square miles) parks that occur in this network of the five terrestrial vegetation types thought to be most sensitive to N-nutrient enrichment effects: arctic, alpine, grassland and meadow, wetland, and arid and semi-arid. (Source of data: See Appendix A)

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

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

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

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

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

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

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

Figure H. Park rankings for Summary Risk for all parks larger than 100 square miles. Ranks for each park were calculated relative to all parks, regardless of size, as the average of scores for all Summary Risk variables.
Map A

Total Nitrogen Emissions by County
United States
(tons per square mile per year)

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
Total Nitrogen Deposition
United States
(kg/ha/yr)

Note: Data not available for Alaska

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

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

Note: Data not available for Hawaii

Note: Data not available for Puerto Rico
Map E
Map H
Figure A
Figure B
Nitrogen Enrichment Risk Assessment
Park Protection Ranking

Figure C
Nitrogen Enrichment Risk Assessment
Summary Risk Ranking

Figure D
Figure E
Nitrogen Enrichment Risk Assessment
Central Alaska Network - Ecosystem Sensitivity Ranking

Figure F
Nitrogen Enrichment Risk Assessment
Central Alaska Network - Park Protection Ranking

Figure G
Figure H

Central Alaska Network - Summary Risk Ranking

Nitrogen Enrichment Risk Assessment

Average of Park Ranking

Park

Everglades
Sequoia
North Cascades
Yosemite
Joshua Tree
Kings Canyon
Mount Rainier
Olympic
Point Reyes
Big Cypress
Rocky Mountain
Grand Canyon
Grand Teton
Mojave
Yellowstone
Blue Ridge
Shenandoah
Petrified Forest
Buffalo
Golden Gate
Death Valley
Guadalupe Mountains
Theodore Roosevelt
Saguaro
Organ Pipe Cactus
Great Sand Dunes
Glacier
Lassen Volcanic
Big Bend
Great Smoky Mountains
Crater Lake
Gulf Islands
Lake Mead
Arches
Canyonlands
Voyagers
Santa Monica Mountains
Capitol Reef
Zion
Badlands
Saint Croix
Big Thicket
Delaware Water Gap
Isle Royale
Hawaii Volcanoes
Redwood
Gates of the Arctic
Craters of the Moon
Channel Islands
Noatak
Glen Canyon
Katmai
Missouri
Biscayne
Padre Island
Lake Clark
El Malpais
Denali
Kobuk Valley
Sleeping Bear Dunes
Wrangell-St. Elias
Glacier Bay
New River Gorge
Ozark
Pictured Rocks
Dinosaur
Big South Fork
Renai Fiords
Bighorn Canyon
Canyon de Chelly
Cape Krusenstern
Apostle Islands
White Sands
Dry Tortugas
Lake Roosevelt
Bering Land Bridge
Yukon-Charley Rivers
Aniakchak
Great Basin
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 953/106644, February 2011