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

Pacific Island Network (PACN)

Natural Resource Report NPS/NRPC/ARD/NRR—2011/323
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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Pacific Island Network (PACN)

The Pacific Island Network includes islands at diverse locations in the Pacific Ocean (Map PACN-1). It includes the Hawaiian Islands, northern Mariana Islands, Guam, and American Samoa. There are nine parks in the Pacific Island Network. Only one is larger than 100 square miles: Hawaii Volcanoes (HAVO), which is located on the island of Hawaii.

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. Deposition data are not available for the Pacific Islands Network, but deposition would be expected to be relatively high on some of the Hawaiian Islands, especially Oahu, and lower elsewhere.

Total annual N emissions, by county, are shown in Map C for lands in and surrounding the Pacific Island Network. County-level emissions within the network ranged from less than 1 ton per square mile on the big island of Hawaii to between 20 and 50 tons per square mile on Oahu. Annual emissions of N from the other Hawaiian Islands were intermediate, between 1 and 5 tons per square mile. Point source emissions of oxidized (nitrogen oxides, NOx) and reduced (ammonia, NH3) N are shown in Map D. There are relatively few N point sources in Hawaii. Most are located on Oahu and emit oxidized N. Urban centers within the network and within a 300 mile buffer around the network are shown in Map E-1. The only population center of any magnitude (more than 100,000 people) is Honolulu on Oahu. There are no large population centers in the American Affiliated Islands (Map E-2).

Map F of total N deposition in the Pacific Island network is not shown. There are no available data for atmospheric N deposition in the Pacific Islands Network. Deposition of N is expected to be low on the American Affiliated Islands, but not necessarily on all of the Hawaiian islands, especially Oahu.

Land cover in and around the network is shown in Maps G-1 and G-2. The predominant cover types within this network are mixed and include substantial forest, row crop, shrubland, and grassland/herbaceous cover types.

Map H shows 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). The only park large enough to see the vegetation pattern at the scale of the network is HAVO. The predominant sensitive vegetation type in this park is grassland and meadow.

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 some wilderness and Class I areas in the Hawaiian Islands, mostly limited to HAVO in the southern portion of the island of Hawaii.
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 Pacific Island Network ranks at the bottom of the second highest quintile, among networks in N Pollutant Exposure (Figure A). However, the network Ecosystem Sensitivity ranking is relatively 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 in the second highest quintile in Park Protection, having moderately high 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 at the top of the second highest 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 High.

Similarly, park rankings are given in Figures E through H for the same metrics. In the case of the park rankings, we only show in the figures the parks that are larger than 100 square miles. Relative ranks for all parks, including the smaller parks, are given in Table A and Appendix 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.

The one I&M park (HAVO) in the Pacific Island Network that is larger than 100 square miles ranks in the second lowest quintile in Pollutant Exposure (Figure E). This may be because HAVO is located on the southern side of the Island of Hawaii, some distance from the areas of concentrated N pollution emissions sources on the islands of Oahu and Maui. The smaller parks in the network also rank Low, in the second lowest quintile, in Pollutant Exposure, except for Kalaupapa (KALA), which ranks Very High. HAVO is in the second lowest quintile in Ecosystem Sensitivity (Figure F) and in the highest quintile in Park Protection (Figure G). Most of the smaller parks in the network are ranked in the lowest or second lowest quintile for Ecosystem Sensitivity. The exceptions are American Memorial Park (AMME) and Haleakala (HALE), which are ranked in the middle quintile for this theme and Kaloko-Honokohau (KAHO) which is ranked High. Like HAVO, HALE is ranked in the highest quintile in Park Protection, whereas other parks in the network are ranked in the middle quintile.

HAVO scores in the second highest quintile in the Summary Park Risk ranking (Figure H). Its overall risk of damage from nutrient N enrichment is considered High. HALE and KALA are also ranked in the second highest quintile for Summary Risk, whereas other small parks in the network are ranked in the lowest or second lowest quintile. Thus, the overall risk from nutrient N deposition to parks in this network is High for HALE, HAVO, and KALA, but Low to Very Low for the other parks in the Pacific Island Network.
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.

<table>
<thead>
<tr>
<th>I&amp;M Parks² in Network</th>
<th>Relative Ranking of Individual Parks¹</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pollutant Exposure</td>
</tr>
<tr>
<td>American Memorial Park</td>
<td>ND³</td>
</tr>
<tr>
<td>Haleakala</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Hawaii Volcanoes</strong></td>
<td>Low</td>
</tr>
<tr>
<td>Kalaupapa</td>
<td>Very High</td>
</tr>
<tr>
<td>Kaloko-Honokohau</td>
<td>Low</td>
</tr>
<tr>
<td>National Park of American Samoa</td>
<td>ND³</td>
</tr>
<tr>
<td>Pu'uhonua o Honaunau</td>
<td>Low</td>
</tr>
<tr>
<td>Puukohola Heiau</td>
<td>Low</td>
</tr>
<tr>
<td>War in the Pacific</td>
<td>ND³</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.

³ ND indicates no data.

Map PACN-1. Location of the islands that comprise the Pacific Island Network.

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. Deposition data are not available for the Pacific Island Network. Total N deposition throughout most areas 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/chief/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.

Map E-1. Urban centers having more than 10,000 people within the Hawaiian portion of the network and within a 300-mile buffer around the perimeter of the network. (Source of data: U.S. Census 2000)

Map E-2. Urban centers having more than 10,000 people within the American Affiliated Islands portion of the network and within a 300-mile buffer around the perimeter of the network. (Source of data: U.S. Census 2000)

Map G-1. Land cover types in and around the Hawaiian portion of 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 in the Hawaiian portion of the 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.
Total Nitrogen Deposition
United States
(kg/ha/yr)

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 Alaska

Note: Data not available for Hawaii

Note: Data not available for Puerto Rico
Total Nitrogen Emissions by County
Pacific Island Network - Hawaii
(tons per square mile per year)

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

Network Parks (larger than 100 sq. mi)
Network Parks (smaller than 100 sq. mi)
Map G-2
Class I and Wilderness Areas
Pacific Island Network - Hawaii

Projection: Lambert Conformal Conic, NAD 1983
Produced for: National Park Service, Air Resources Division, 2010
Prepared by: E&S Environmental Chemistry

Map H
Nitrogen Enrichment Risk Assessment
Pollutant Exposure Ranking

Figure A
Figure B

Nitrogen Enrichment Risk Assessment
Ecosystem Sensitivity Ranking

Network

Average of Network Ranking

Northeast Colorado Plateau
Sierra Nevada
Northern Great Plains
Greater Yellowstone
North Coast and Cascades
Mojave Desert
Sonoran Desert
Klamath
Rocky Mountain
South Coast
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
National Capital Region
Eastern Rivers and Mountains
Mid-Atlantic

Figure B
Nitrogen Enrichment Risk Assessment
Summary Risk Ranking

Average of Network Ranking

Network

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
Caspian Desert
Chihuahuan Desert
Northeastern Upland
Heartland
Arctic
Southwest Alaska
Central Alaska
National Capital Region
Southeast Alaska
Gulf Coast
Southern Plains
Eastern Rivers and Mountains
Upper Columbia Basin

Figure D
Nitrogen Enrichment Risk Assessment
Pacific Island Network - Pollutant Exposure Ranking

Figure E
Nitrogen Enrichment Risk Assessment
Pacific Island Network - Ecosystem Sensitivity Ranking

Figure F
Figure H

Nitrogen Enrichment Risk Assessment
Pacific Island Network - Summary Risk Ranking
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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