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

*Northeast Temperate Network (NETN)*

Natural Resource Report NPS/NRPC/ARD/NRR—2011/320
ON THE COVER
Some ecosystems, such as arid shrublands, subalpine meadows, remote high elevation lakes, and wetlands, are sensitive to the effects of nutrient enrichment from atmospheric nitrogen deposition.
Photograph by: National Park Service
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Northeast Temperate Network (NETN)

National maps of atmospheric N emissions and deposition are provided in Maps A and B as context for subsequent network data presentations. Map A shows county level emissions of total N for the year 2002. Map B shows total N deposition, again for the year 2002.

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

Total annual N emissions, by county, are shown in Map C for lands in and surrounding the Northeast Temperate Network. County-level emissions within the network ranged from less than 1 ton per square mile to greater than 100 tons per square mile in some of the densely urbanized areas in and around Boston and near New York City. In general, annual county N emissions were less than 20 tons per square mile throughout all but the most heavily urbanized areas. Point source emissions of oxidized (nitrogen oxides, NOx) and reduced (ammonia, NH3) N are shown in Map D. There are few N point sources of any magnitude (i.e., larger than 500 to 1,000 tons per square mile) within this network. Urban centers within the network and within a 300 mile buffer around the network are shown in Map E. There is a large density of medium size to large urban population centers, especially along the coastal corridor between Boston and Washington, DC. Elsewhere within the network, there are fewer population centers larger than 50,000 people.

Total N deposition in and around the network is shown in Map F. Included in this analysis are both wet and dry forms of N deposition and both the oxidized and reduced N species. Total N deposition within the network is highly variable from north to south, ranging from less than 2 kg N/ha/yr r in northern Maine to between 10 and 15 kg N/ha/yr in much of the south, and higher than that in some of the more heavily urbanized areas.

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

Map H, showing the distribution within the parks that occur in this network of the five vegetation types thought to be most responsive to nutrient N enrichment effects (arctic, alpine, grassland and meadow, wetland, and arid and semi-arid), is not shown. It would not be possible to discern the vegetation types in any of the parks at the scale of the network.

Park lands requiring special protection against potential adverse impacts associated with nutrient N enrichment from atmospheric N deposition are shown in Map I. Also shown on Map I are all federal lands designated as wilderness, both lands managed by NPS and also lands managed by other federal agencies. The land designations used to identify this heightened protection included Class I designation under the CAAA and wilderness designation. The only Class I park is Acadia NP (ACAD). Only limited, relatively small, wilderness areas occur in this network, mostly in the mountains of New Hampshire and Vermont.

There are a number of I&M parks within this network, but most are small. The largest is ACAD. Park-specific maps are shown for ACAD in Maps J-1 and J-2. In general, the predominant
sensitive vegetation type is wetland (Map J-1). There are several lakes in ACAD, but none are located at high elevation (Map J-2). High-elevation lakes might be more prone than lakes at lower elevation to N-enrichment, and therefore potentially more susceptible to eutrophication in response to atmospheric N input. We have no evidence that lakes within ACAD are likely to be N-limited.

Network rankings are given in Figures A through C as the average ranking of the Pollutant Exposure, Ecosystem Sensitivity, and Park Protection metrics, respectively. Figure D shows the overall network Summary Risk ranking. In each figure, the rank for this particular network is highlighted to show its relative position compared with the ranks of the other 31 networks.

The Northeast Temperate Network ranks in the second highest quintile in N Pollutant Exposure (Figure A). Nitrogen emissions and N deposition within the network are both moderate. The network Ecosystem Sensitivity ranking is Very Low, within the lowest quintile among networks (Figure B). This is because there is limited vegetation coverage in the I&M parks in this network that includes vegetation types that are among those expected to be especially sensitive to nutrient enrichment effects from N deposition, and there are no high elevation lakes. This network ranks at the top of the second lowest quintile in Park Protection, having limited amounts of protected lands (Figure C).

In combination, the network rankings for Pollutant Exposure, Ecosystem Sensitivity, and Park Protection yield an overall Network Risk ranking that is in the second lowest quintile among all networks (Figure D). The overall level of concern for nutrient N enrichment effects on I&M parks within this network is considered Low. Because there are no parks in this network that are larger than 100 square miles, the figures used to compare rankings among the larger parks are not shown for this network. Relative rankings for all parks, including the smaller parks, are given in Table A and Appendix B. Pollutant Exposure rankings for the individual parks in this network were variable, from Moderate (middle quintile) for four of the parks to Very High (top quintile) for five parks. In contrast, the Ecosystem Sensitivity rankings were lower (Low to Very Low) for all parks except Boston Harbor Islands (BOHA), Saugus Iron Works (SAIR), and Weir Farm (WEFA), which were ranked in the middle quintile for this theme. Park Protection rankings were all Moderate, with the exception of ACAD, which was ranked Very High in Park Protection.

Park Summary rankings were highly variable, from Very Low for two of the parks to Very High for WEFA. Summary rankings were High, in the second highest quintile, for ACAD, BOHA, Home of Franklin D. Roosevelt (HOFR), Morristown (MORR), and SAIR.
### Table A. Relative rankings of individual I&M parks within the network for Pollutant Exposure, Ecosystem Sensitivity, Park Protection, and Summary Risk from atmospheric nutrient N enrichment.

<table>
<thead>
<tr>
<th>I&amp;M Parks² in Network</th>
<th>Relative Ranking of Individual Parks¹</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Pollutant Exposure</td>
</tr>
<tr>
<td>Acadia</td>
<td>Moderate</td>
</tr>
<tr>
<td>Boston Harbor Islands</td>
<td>Very High</td>
</tr>
<tr>
<td>Home of Franklin D. Roosevelt</td>
<td>Very High</td>
</tr>
<tr>
<td>Marsh-Billings-Rockefeller</td>
<td>Moderate</td>
</tr>
<tr>
<td>Minute Man</td>
<td>High</td>
</tr>
<tr>
<td>Morristown</td>
<td>Very High</td>
</tr>
<tr>
<td>Saint-Gaudens</td>
<td>Moderate</td>
</tr>
<tr>
<td>Saratoga</td>
<td>Moderate</td>
</tr>
<tr>
<td>Saugus Iron Works</td>
<td>High</td>
</tr>
<tr>
<td>Vanderbilt Mansion</td>
<td>Very High</td>
</tr>
<tr>
<td>Weir Farm</td>
<td>Very High</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.

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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. 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, 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](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. (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, NOₓ) and reduced (ammonia, NH₃) N. Values are expressed as kilograms of N deposited per hectare per year. (Source of data: Interpolated NADP wet and CMAQ Model dry deposition data for 2002; see information for Map B above for details)

Map G. Land cover types in and around the network, based on the National Land Cover dataset. (Source of data: National Land Cover Dataset, http://www.mrlc.gov/nlcd_multizone_map.php)

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

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


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 A
Figure B
Figure D
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