Assessing Effects of N Deposition on Terrestrial and Aquatic Ecosystems in the U.S.

Linda Pardo
US Forest Service
Burlington, VT
1. Workshop: Empirical CL for N (EPA sponsored)

1. Database

2. Additional CL $N_{\text{nut}}$ Projects in US
N Deposition Effects on Ecosystems Expert Workshop

February 2008, Washington, DC

- synthesize current state of knowledge on effects of atmospheric N inputs on terrestrial and aquatic ecosystems in the U.S.
- emphasis on identifying potential critical loads for nitrogen deposition
Workshop Products

- Database of N inputs and effects
- Synthesis report (Fall 2008)
  - Similar to Bobbink et al. 2003
- Summary table of Empirical CL for N
- Synthesis paper (Winter 2008)
Workshop Attendees

Edie Allen
Jill Baron
Roland Bobbink
Bill Bowman
Charlie Driscoll
Bridget Emmett
Mark Fenn
Linda Geiser
Frank Gilliam
Christy Goodale
Erik Lilleskov
Knute Nadelhoffer
Steve Perakis
John Stoddard
Kathie Weathers
Rick Haeuber
Tara Greaver
Jason Lynch
Ellen Porter
Rich Pouyat
ECOLOGICAL REGIONS OF NORTH AMERICA

Toward a Common Perspective
Report Format

- Deposition
- Tundra
- Taiga
- Northern Forests
- Northwest Forested Mountains
- Marine West Coast Forest
- Eastern Forests
- Great Plains
- North American Deserts
- Mediterranean California
- Southern Semi-Arid Highlands
- Temperate Sierra
- Tropical Wet Forest
- Wetlands
- Aquatic
Biodiversity/changes in species composition

- Lichens
- Mycorrhizal fungi
- Species composition:
  - Over story
  - Understory
Issues

- What receptors do we care about?
- Defining response criteria
- What level of change is significant?
  - Range between known effects and no effects
  - Short-term fertilizations
- Comparing CL based on different criteria
- Deposition
Inorganic nitrogen wet deposition from nitrate and ammonium, 2003

National Atmospheric Deposition Program/National Trends Network
http://nadp.sws.uiuc.edu
ClimCalc Deposition Model  Ollinger et al., 1993
Comparison of Deposition Models

Kathie Weathers

- NADP (wet only)
- NADP + CASTNET (wet + dry)
- CMAQ (36 km grid)
Deposition Source affects Empirical CL $N_{\text{nutrient}}$ for lichens

CL N (kg N/ha/y)

<table>
<thead>
<tr>
<th>Region</th>
<th>NADP</th>
<th>IMPROVE</th>
<th>CMAQ</th>
<th>RESIN TUBE</th>
</tr>
</thead>
<tbody>
<tr>
<td>NW FOREST MTNS</td>
<td>1.2-2.1 (0-8.1)</td>
<td>0.26-0.33 (1.16-0.43)</td>
<td>3.7-5.0 (0-13.5)</td>
<td>4.0-5.2 (0.9-8.2)</td>
</tr>
<tr>
<td>MARINE W. COAST MTNS</td>
<td>3.1 (0.7-5.1)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Empirical $\text{CL N}_{\text{nutrient}}$ for various ecosystems, receptors

<table>
<thead>
<tr>
<th>Ecoregion</th>
<th>Compart ment</th>
<th>CL N kg N/ha/y</th>
<th>Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>TUNDRA</td>
<td>Lichens</td>
<td>5-10</td>
<td>#</td>
</tr>
<tr>
<td>TAIGA</td>
<td>Lichens</td>
<td>5-10</td>
<td>?</td>
</tr>
<tr>
<td>NORTHERN FOREST</td>
<td>Forest</td>
<td>9-13</td>
<td>##</td>
</tr>
<tr>
<td></td>
<td>Ectomycor-</td>
<td>5-10</td>
<td>?</td>
</tr>
<tr>
<td></td>
<td>rhizal Fungi</td>
<td></td>
<td></td>
</tr>
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Empirical CL $N_{\text{nutrient}}$ for various ecosystems, receptors

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<tr>
<th>Ecoregion</th>
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<th>CL N $\text{kg N/ha/y}$</th>
<th>Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>NORTHWEST FORESTED MOUNTAINS</td>
<td>Forest</td>
<td>4-10</td>
<td>#</td>
</tr>
<tr>
<td></td>
<td>Lichens</td>
<td>3-5</td>
<td>?</td>
</tr>
<tr>
<td></td>
<td>Alpine</td>
<td>3-10</td>
<td>#</td>
</tr>
</tbody>
</table>
### Empirical CL $N_{\text{nutrient}}$

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<th>CL N</th>
<th>Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>MARINE WEST COAST FOREST</td>
<td>Forest</td>
<td>?</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lichens</td>
<td>3-5</td>
<td>##</td>
</tr>
<tr>
<td></td>
<td>ECM Fungi</td>
<td>5</td>
<td>?</td>
</tr>
<tr>
<td>EASTERN TEMPERATE FOREST</td>
<td>Forest</td>
<td>9-13</td>
<td>##</td>
</tr>
<tr>
<td></td>
<td>SE COASTAL PLAIN: ECM Fungi</td>
<td>&gt;4 and &lt;8</td>
<td>?</td>
</tr>
</tbody>
</table>
Lichen Sensitivity in the Pacific Northwest

Air Score
- **Best**—All Sensitive Species Present; 75% Quantile for All Sensitive Species (-1.4 - 0.11)
- **Good**—All Sensitive Species Present; 90% Quantile for All Sensitive Species (-0.11 - 0.02)
- **Fair**—Some of the Sensitive Species Absent; 97.5% Quantile for All Sensitive Species (0.02 - 0.21)
- **Degraded**—Most of the Sensitive Species Absent (0.21 - 0.35)
- **Poor**—Weedy Nitrophilous Species Enhanced (0.35 - 0.49)
- **Worst**—All Sensitive Species Absent (0.49 - 2)

- Study Area
- Urban Areas

### NA Deserts: Empirical CL $N_{nutrient}$

5-40 kg N/ha/y

<table>
<thead>
<tr>
<th>Ecosystem</th>
<th>CL N kg N/ha/y</th>
<th>Ecosystem response</th>
<th>Study location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Piñon-Juniper and Creosote Scrub</td>
<td>5</td>
<td>invasive grasses</td>
<td>Joshua Tree NP; Allen et al. 2008</td>
</tr>
<tr>
<td>Desert grasslands</td>
<td>&gt;6-20</td>
<td>Changes in species composition</td>
<td>Baez et al. 2007, Sevillet LTER</td>
</tr>
<tr>
<td>Desert grassland</td>
<td>40</td>
<td>Invasive species</td>
<td>Schwinning et al. 2005, CO Plateau</td>
</tr>
<tr>
<td>Desert scrub</td>
<td>32</td>
<td>Increase exotic grasses</td>
<td>Brooks et al. 2003; Mohave Desert</td>
</tr>
</tbody>
</table>
### Empirical CL $N_{\text{nutrient}}$ for various ecosystems, receptors

<table>
<thead>
<tr>
<th>Ecoregion</th>
<th>Compartment</th>
<th>CL N $^*$</th>
<th>Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>MEDITERRANEAN CALIFORNIA</td>
<td>Coastal Sage Scrub</td>
<td>10-11 kg N/ha/y</td>
<td>#</td>
</tr>
<tr>
<td></td>
<td>Chaparral</td>
<td>13-18</td>
<td>#</td>
</tr>
<tr>
<td></td>
<td>Mixed Conifer Forest</td>
<td>3-26</td>
<td>#</td>
</tr>
</tbody>
</table>

$^*$ Note: CL N values are given in kg N/ha/y.
Empirical CL $N_{\text{nutrient}}$ for various ecosystems, receptors

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<th>Compartmennt</th>
<th>CL N kg N/ha/y</th>
<th>Reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>AQUATIC</td>
<td>Biotic</td>
<td>1.5-2.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Abiotic: West</td>
<td>2</td>
<td>#</td>
</tr>
<tr>
<td></td>
<td>Abiotic: East</td>
<td>6</td>
<td>##</td>
</tr>
<tr>
<td>WETLANDS</td>
<td>Freshwater Inland</td>
<td>10-14</td>
<td>?</td>
</tr>
</tbody>
</table>
Empirical CL $N_{\text{nutrient}}$ for Forests (conifer/deciduous)

<table>
<thead>
<tr>
<th>Ecosystem</th>
<th>Location</th>
<th>CL N (kg N/ha/y)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FOREST</td>
<td>East</td>
<td>5-13</td>
</tr>
<tr>
<td></td>
<td>West</td>
<td>3-10</td>
</tr>
</tbody>
</table>
No CL for Other Ecoregions

**Data not available**
- Southern Semi-Arid Highlands
- Temperate Sierra

**Synthesis not completed**
- Great Plains
- Tropical Wet Forest
Database Development

- Resource for policy and research
- Searchable (relational) Database
- Updated periodically
Database Structure

- Citation Table
- Study Site Table
  - Site Description, Actual deposition, Duration,
- CL Table
  - Input, Responses, Current Status, Reliability, etc.
  - CL Method
<p>| Sheibley, Rich; Paulson, Tony (US Geological Survey and National Park Service) | Developing Critical Loads for Atmospheric Deposition of Inorganic Nitrogen to North Coast and Cascades Network Lakes |</p>
<table>
<thead>
<tr>
<th>Authors</th>
<th>Title</th>
</tr>
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<tbody>
<tr>
<td>Clow, David; Campbell, Don; Jasmine Saros, Leora Nanus, Jim Sickman,</td>
<td></td>
</tr>
<tr>
<td>Mark Fenn, Jill Baron, Mark Williams</td>
<td>Mapping Critical Loads of Atmospheric N and S in the Rocky Mountains</td>
</tr>
<tr>
<td>Dave Clow, Don Campbell and Jim Sickman</td>
<td>Critical Loads for Nitrogen Excess in High Elevation Catchments in the Colorado Front Range</td>
</tr>
<tr>
<td>Dave Clow and Mark Fenn</td>
<td>Critical Loads for Nitrogen Deposition in Yosemite National Park</td>
</tr>
<tr>
<td>Dave Clow, Allan Gallegos, Jim Sickman and Neil Berg</td>
<td>Critical Loads for Nitrogen Deposition Impacts to High Elevation Lakes in the Sierra Nevada</td>
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</table>
Critical Loads for Nitrogen as a Nutrient in Sierran Mixed Conifer Forests; using multiple approaches: SSMB; empirical methods; Daycent and NuCM models

Critical Loads for Nitrogen Deposition Effects on Lichen Communities and Chemistry in the Pacific Northwest

Critical Loads for Nitrogen Deposition Effects on Lichen Communities and Chemistry in the Sierra Nevada

N deposition effects on aquatic and terrestrial ecosystems Synthesis

Critical Loads for Nitrogen Deposition in High Elevation Lakes of the Sierra Nevada as Indicated by Diatom Communities
Summary

- Next year—CL N document (final!)
- Future directions:
  - Western US work
  - Use of CL in emissions policy?!
Site Distribution

n=23 states
Surface water [NO₃⁻] concentrations increase with N deposition (Aber et al., 2003 BioScience 53(4): 375-389)
Map of the western US showing areas where N deposition effects have been reported (Fenn et al., 2003 BioScience 53(4): 404-420)