

Critical Loads, Deposition, and Exceedances in the United States – *Transitions*

Jennifer Phelan, Michael Bell, Jeff Herrick, Linda Geiser, and Jason Lynch



National Atmospheric Deposition Program

Critical Loads of Atmospheric Deposition Science Committee

Critical Load (CL) “Transitions” in the U.S.

1. NADP-CLAD CL Database →
Management and Policy in U.S.
2. Transitions within NADP-CLAD



CL Database → Management and Policy in U.S.

NADP-CLAD National Critical Load Database (NCLD) v3.0:

- CLs in NCLD:
 - Forest soil acidification
 - Surface water acidification
 - 5 Empirical CLs of N
- 2,989,920 geographically-referenced CLs
- Used by U.S. Federal Agencies to support policy development/review and natural resource management

NADP-CLAD National Critical Load Database (NCLD), version 3.0

This database is a compilation of empirical and calculated critical loads data and information from many regional and national scale projects. The focus is on critical loads of sulfur and nitrogen deposition and the effects on terrestrial and aquatic environments. A report is included in the download file with details on calculations and references for all critical loads.

CLAD members submitted data to this cooperative effort as a productive and meaningful way to share information to improve methods for estimating, calculating, mapping, interpreting and refining critical loads.

We invite you to use these data and to share your findings and reactions with CLAD. Updates to the database are anticipated through periodic "calls for data" and corrections. Those who are interested in participating and contributing data are encouraged to join CLAD to ensure the timeliest notification on future activities. Contact the CLAD secretary to be added to the mailing list.

CLAD Database Access Registration

After submitting the following form, you will receive a link to the CLAD database by email

Personal Information

Name: (optional)

Affiliation:

Email:

Planned Use of Data

☐ Education

☐ Research

☐ Environmental Assessment

☐ Policy Development

☐ Other

© 2019 National Atmospheric Deposition Program | [Data Use Conditions](#) | [Comments?](#) | [Contacts](#) | [Home](#) | Follow us: [f](#) [t](#) [in](#)

<http://nadp.slh.wisc.edu/committees/clad/db/>



National Atmospheric Deposition Program

Critical Loads of Atmospheric Deposition Science Committee

CL Database → Management and Policy in U.S.

NADP-CLAD National Critical Load Database (NCLD) v3.0:

- **CLs in NCLD:**
 - **Forest soil acidification**
 - **Surface water acidification**
 - **5 Empirical CLs of N**
- **2,989,920 geographically-referenced CLs**
- **Used by U.S. Federal Agencies to support policy development/review and natural resource management**

NADP Committees >
EROS >
NOS >
CLAD >
About CLAD
- Meetings
- Annual Reports
- Critical Load Maps
- Scientific Working Groups
- National Critical Loads Database (NCLD)
Critical Load Web Resources
Critical Load References
Critical Load Videos
Contacts
TDEP >
AMSC >

CLAD National Critical Load Database (NCLD), version 3.0

This database is a compilation of empirical and calculated critical loads data and information from many regional and national scale projects. The focus is on critical loads of sulfur and nitrogen deposition and the effects on terrestrial and aquatic environments. A report is included in the download file with details on calculations and references for all critical loads.

CLAD members submitted data to this cooperative effort as a productive and meaningful way to share information to improve methods for estimating, calculating, mapping, interpreting and refining critical loads.

We invite you to use these data and to share your findings and reactions with CLAD. Updates to the database are anticipated through periodic "calls for data" and corrections. Those who are interested in participating and contributing data are encouraged to join CLAD to ensure the timeliest notification on future activities. Contact the CLAD secretary to be added to the mailing list.

CLAD Database Access Registration

After submitting the following form, you will receive a link to the CLAD database by email

Personal Information

Name: (optional)
Affiliation:
Email:

Planned Use of Data

☐ Education
☐ Research
☐ Environmental Assessment
☐ Policy Development
☐ Other

© 2019 National Atmospheric Deposition Program | [Data Use Conditions](#) | [Comments?](#) | [Contacts](#) | [Home](#) | Follow us: [f](#) [t](#) [in](#)

<http://nadp.slh.wisc.edu/committees/clad/db/>



National Atmospheric Deposition Program

Critical Loads of Atmospheric Deposition Science Committee

New studies for the NADP-CLAD NCLD

- **Herbaceous species richness (ecoregion-level):**

- Simkin, S. M., et al. 2016. Conditional vulnerability of plant diversity to atmospheric nitrogen deposition across the United States. *Proceedings of the National Academy of Sciences USA* 113:4086–4091.

- **Surface Water Acidification:**

- Four studies in eastern U.S.

- **Herbs species:**

- Christopher M. Clark, Samuel M. Simkin, Edith B. Allen, William D. Bowman, Jayne Belnap, Matthew L. Brooks, Scott L. Collins, Linda H. Geiser, Frank S. Gilliam, Sarah E. Jovan, Linda H. Pardo, Bethany K. Schulz, Carly J. Stevens, Katharine N. Suding, Heather L. Throop, and Donald M. Waller. Potential vulnerability of 348 herbaceous species to atmospheric deposition of nitrogen and sulfur in the U.S. In review, *Nature Plants*.

- **Trees species:**

- Horn KJ, Thomas RQ, Clark CM, Pardo LH, Fenn ME, Lawrence GB, et al. (2018) Growth and survival relationships of 71 tree species with nitrogen and sulfur deposition across the conterminous U.S. *PLoS ONE* 13(10): e0205296.

- **Lichens community:**

- Geiser, LH; Heather Root, HT; Jovan, SE; St. Clair, L; Dillman, K.L.; Schwede, D. In prep. Lichen community responses to atmospheric deposition and climate indicate protective air pollution thresholds for US Forests.
- Geiser, LH; Nelson, PR; Jovan, SE; Root, HT; Clark, CM. (In review) Assessing ecological risks from atmospheric deposition of nitrogen and sulfur using epiphytic macrolichens. *Biodiversity (Special Issue on Lichen Diversity and Biomonitoring)* https://www.mdpi.com/journal/diversity/special_issues/lichen_diversity_biomonitoring



CL Database → Management and Policy in U.S.

NADP-CLAD National Critical Load Database (NCLD) v3.0:

- CLs in NCLD:
 - Forest soil acidification
 - Surface water acidification
 - 5 Empirical CLs of N
- 2,989,920 geographically-referenced CLs
- Used by U.S. Federal Agencies to support policy development/review and natural resource management

NADP-CLAD National Critical Load Database (NCLD), version 3.0

This database is a compilation of empirical and calculated critical loads data and information from many regional and national scale projects. The focus is on critical loads of sulfur and nitrogen deposition and the effects on terrestrial and aquatic environments. A report is included in the download file with details on calculations and references for all critical loads.

CLAD members submitted data to this cooperative effort as a productive and meaningful way to share information to improve methods for estimating, calculating, mapping, interpreting and refining critical loads.

We invite you to use these data and to share your findings and reactions with CLAD. Updates to the database are anticipated through periodic "calls for data" and corrections. Those who are interested in participating and contributing data are encouraged to join CLAD to ensure the timeliest notification on future activities. Contact the CLAD secretary to be added to the mailing list.

CLAD Database Access Registration

After submitting the following form, you will receive a link to the CLAD database by email

Personal Information

Name: (optional)

Affiliation:

Email:

Planned Use of Data

☐ Education

☐ Research

☐ Environmental Assessment

☐ Policy Development

☐ Other

© 2019 National Atmospheric Deposition Program | [Data Use Conditions](#) | [Comments?](#) | [Contacts](#) | [Home](#) | Follow us: [f](#) [t](#) [in](#)

<http://nadp.slh.wisc.edu/committees/clad/db/>



National Atmospheric Deposition Program

Critical Loads of Atmospheric Deposition Science Committee

CL Database → Management and Policy in U.S.

NADP-CLAD National Critical Load Database (NCLD) v3.0:

- CLs in NCLD:
 - Forest soil acidification
 - Surface water acidification
 - 5 Empirical CLs of N
- 2,989,920 geographically-referenced CLs
- **Used by U.S. Federal Agencies to support policy development/review and natural resource management**

NADP-CLAD National Critical Load Database (NCLD), version 3.0

This database is a compilation of empirical and calculated critical loads data and information from many regional and national scale projects. The focus is on critical loads of sulfur and nitrogen deposition and the effects on terrestrial and aquatic environments. A report is included in the download file with details on calculations and references for all critical loads.

CLAD members submitted data to this cooperative effort as a productive and meaningful way to share information to improve methods for estimating, calculating, mapping, interpreting and refining critical loads.

We invite you to use these data and to share your findings and reactions with CLAD. Updates to the database are anticipated through periodic "calls for data" and corrections. Those who are interested in participating and contributing data are encouraged to join CLAD to ensure the timeliest notification on future activities. Contact the CLAD secretary to be added to the mailing list.

CLAD Database Access Registration

After submitting the following form, you will receive a link to the CLAD database by email

Personal Information

Name: (optional)

Affiliation:

Email:

Planned Use of Data

☐ Education

☐ Research

☐ Environmental Assessment

☐ Policy Development

☐ Other

© 2019 National Atmospheric Deposition Program | [Data Use Conditions](#) | [Comments?](#) | [Contacts](#) | [Home](#) | Follow us: [f](#) [t](#) [in](#)

<http://nadp.slh.wisc.edu/committees/clad/db/>



National Atmospheric Deposition Program

Critical Loads of Atmospheric Deposition Science Committee

U.S. Federal Agencies that use CLs

- Environmental Protection Agency (EPA) – to support review of NOx and SOx National Ambient Air Quality Standards
- National Park Service (NPS) – to assess current risk to resources and support review new point sources of pollution
- Forest Service (USFS) – to support development of management plans and status and trends reports for national forests
- Bureau of Land Management (BLM) – to support review of new sources of pollution in protected areas



CLAD Scientific Working Groups

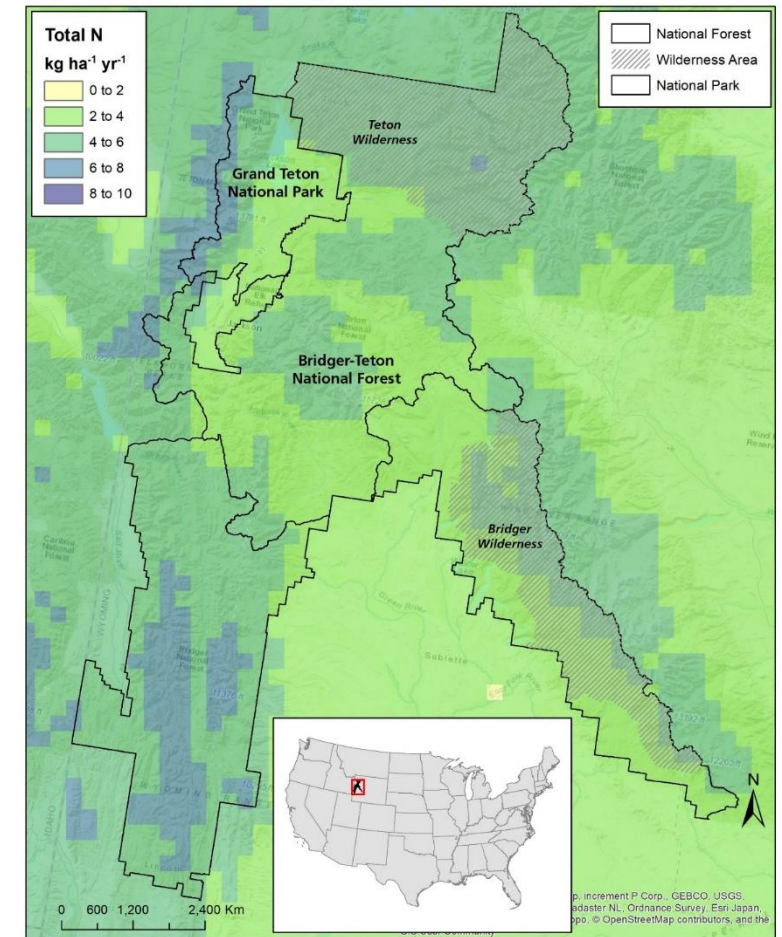
- **WG-1:** National Critical Load Database (NCLD)
- **WG-2:** Critical Load Uncertainty
- **WG-3:** Critical Load Synthesis
- **WG-4:** Uncertainty in Deposition Estimates
- **WG-5:** Critical Loads Communication and Outreach



CLAD Scientific Working Groups

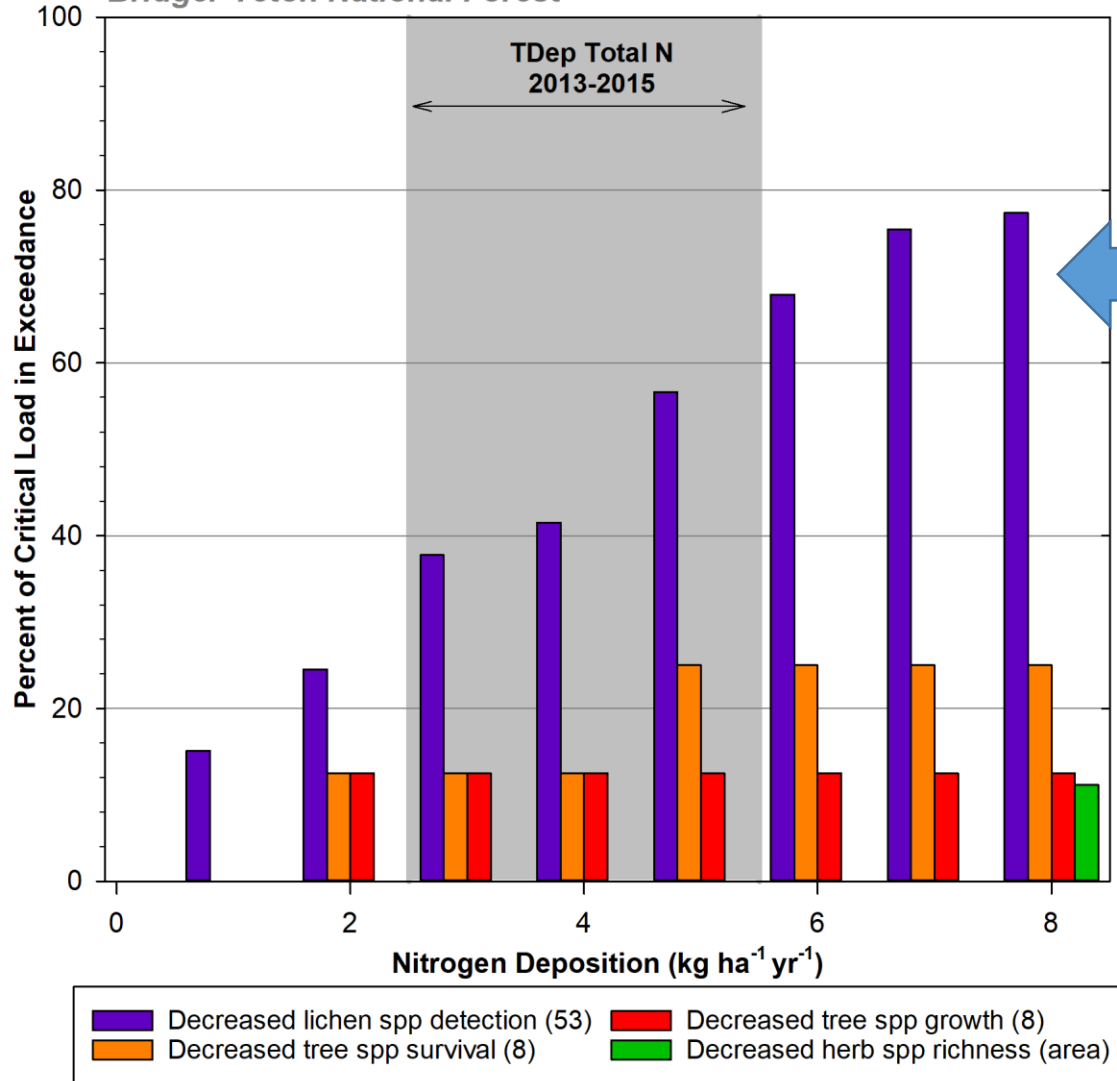
- **WG-3: Critical Load Synthesis:**
 - Objective: Develop standardized methods to represent individual and multiple critical load types in same geographic area.
 - Goal: Determine which CL to use in a given location.
 - Lead by: Linda Pardo (USFS), Chris Clark (EPA), and Mike Bell (NPS)

Example: Bridger Teton National Forest



Critical Load of N

Bridger-Teton National Forest



Bridger-Teton National Forest

- Critical Loads (N) available:
 - Terrestrial - N
 - Lichen species detectability (53 spp)
 - Tree species survival (8 spp)
 - Tree species growth (8 spp)
 - Herbaceous species richness (open and closed canopy)
- Critical Loads range from:
 - 1 – 8 kg N/ha/yr
- Exceedances range from:
 - 0 – 80% of spp
 - 2 biological receptors / 3 CL types

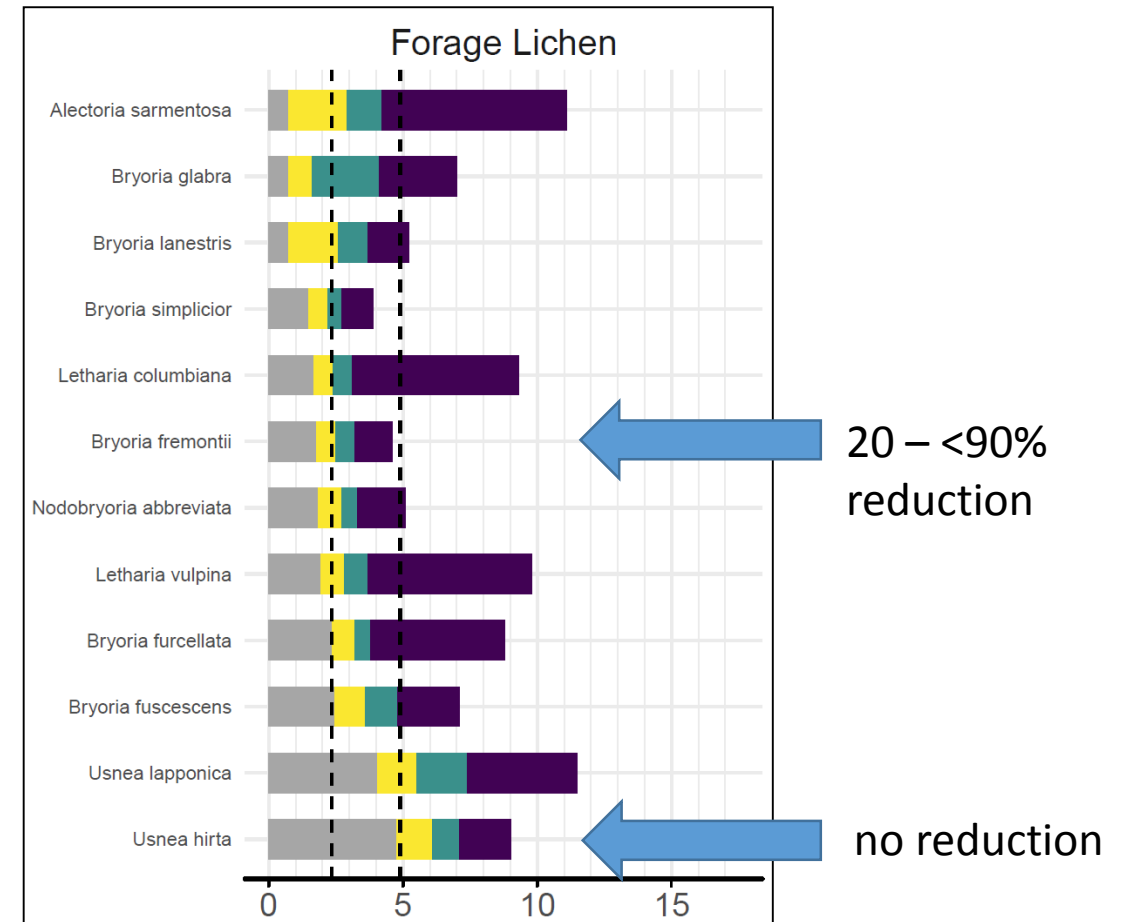
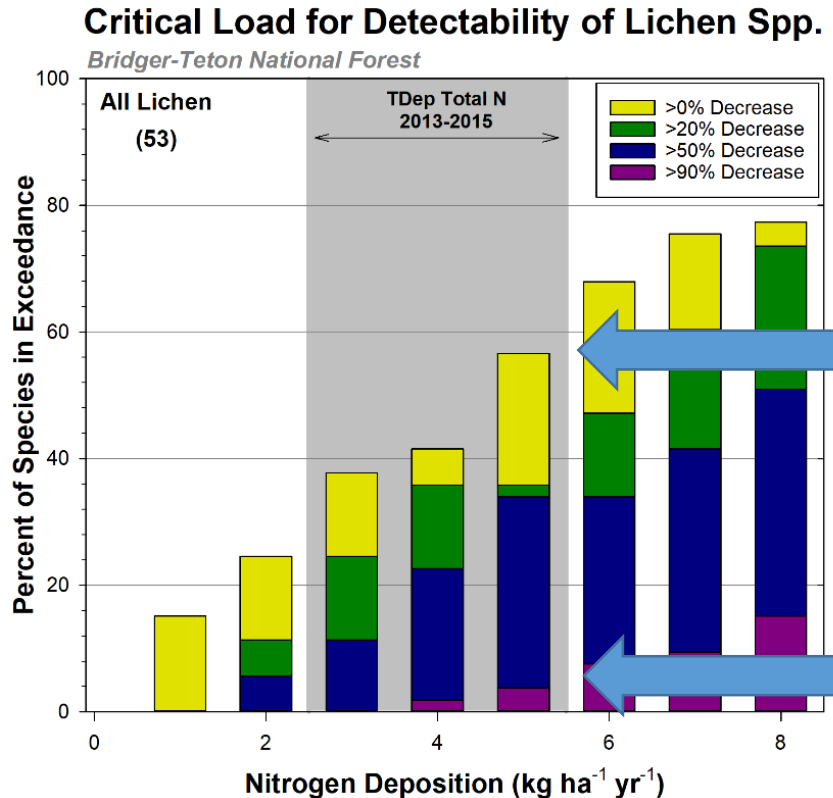


National Atmospheric Deposition Program

Critical Loads of Atmospheric Deposition Science Committee

Different levels of acceptable change

Different sensitivities by species

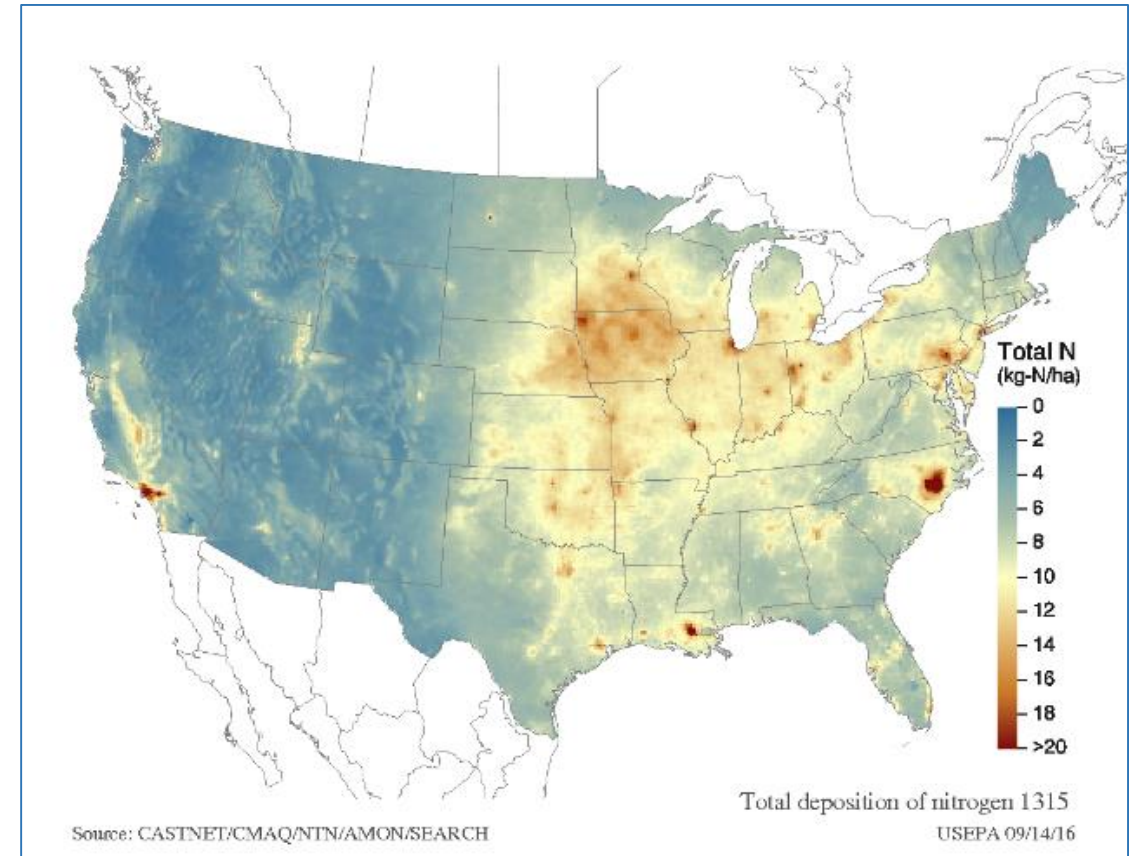


National Atmospheric Deposition Program

Critical Loads of Atmospheric Deposition Science Committee

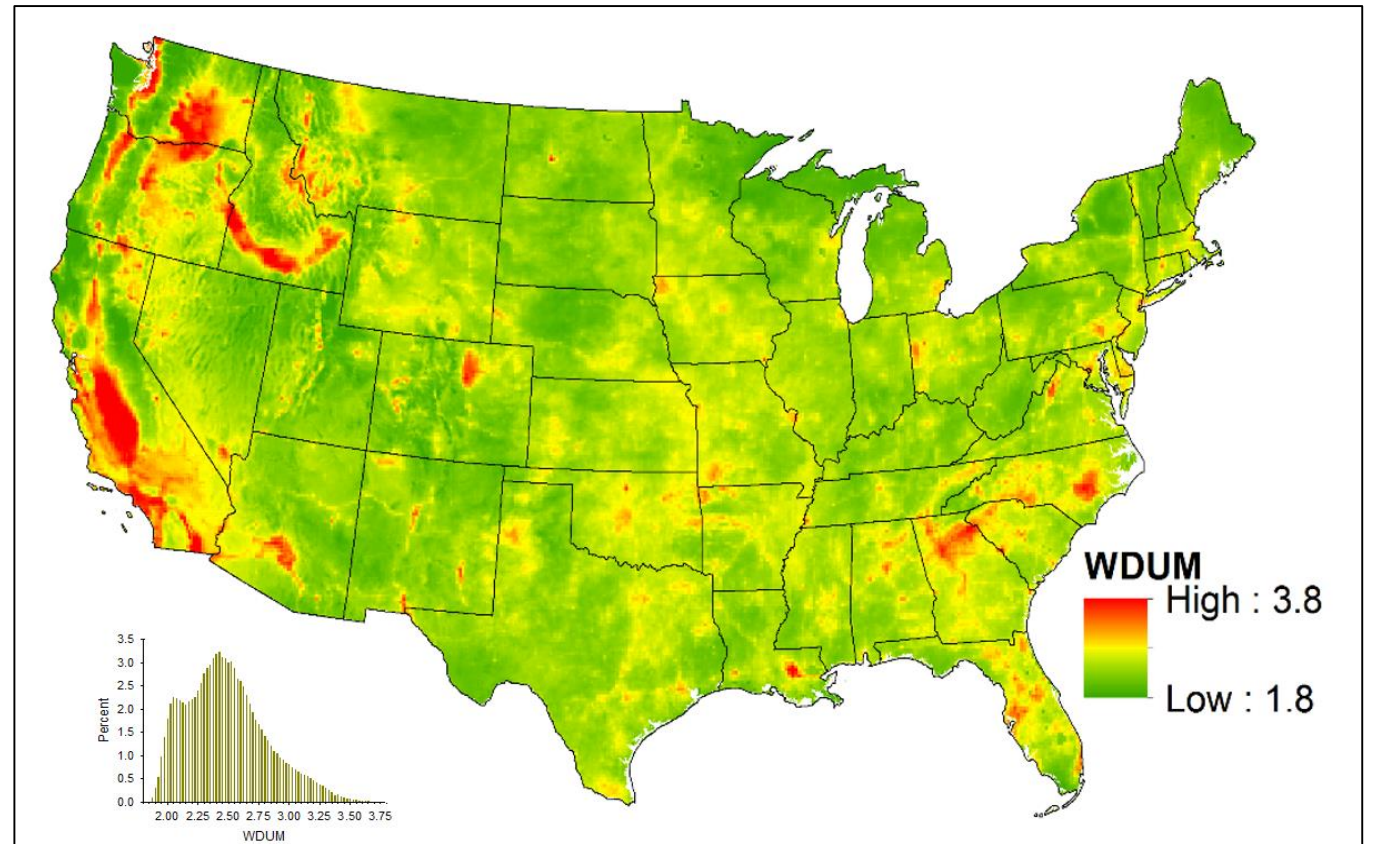
CLAD Scientific Working Groups

- **WG-4:** Uncertainty in Deposition Estimates
 - Objective: Characterize the uncertainty of deposition estimates through measurement–model and model–model comparisons.
 - Goal: Understand the degree to which variation and uncertainty in deposition estimates influence CL exceedances.
 - Lead by: Mike Bell (NPS) and John Walker (EPA)



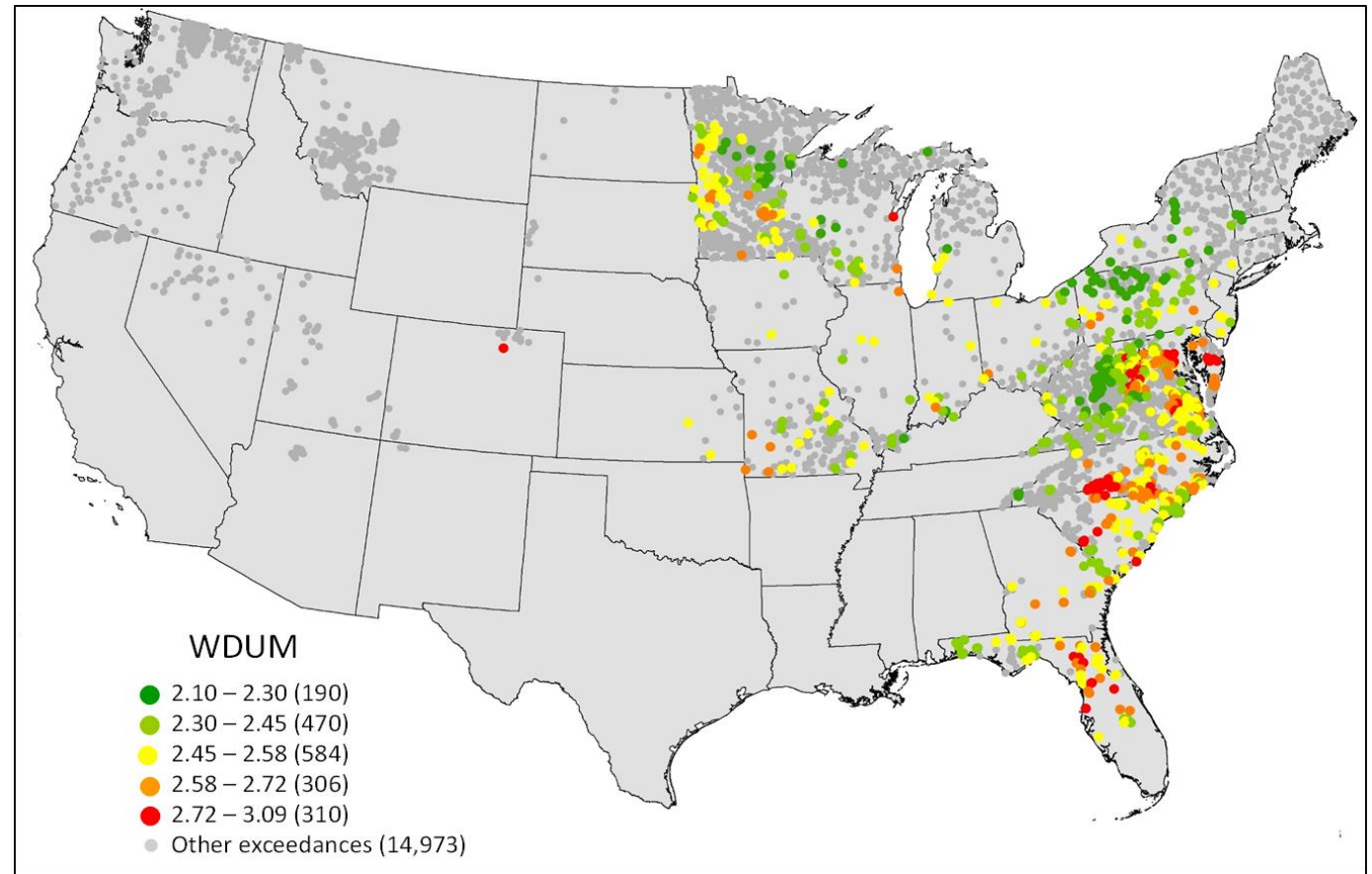
Uncertainty in total N deposition

- WDUM = Weighted Deposition Uncertainty Metric
- 8 categories of uncertainty
 - Wet/**Dry ammonia**
 - Wet/Dry nitrate
 - **Wet/Dry non-measured nitrogen**
 - Dry nitric acid and ammonium



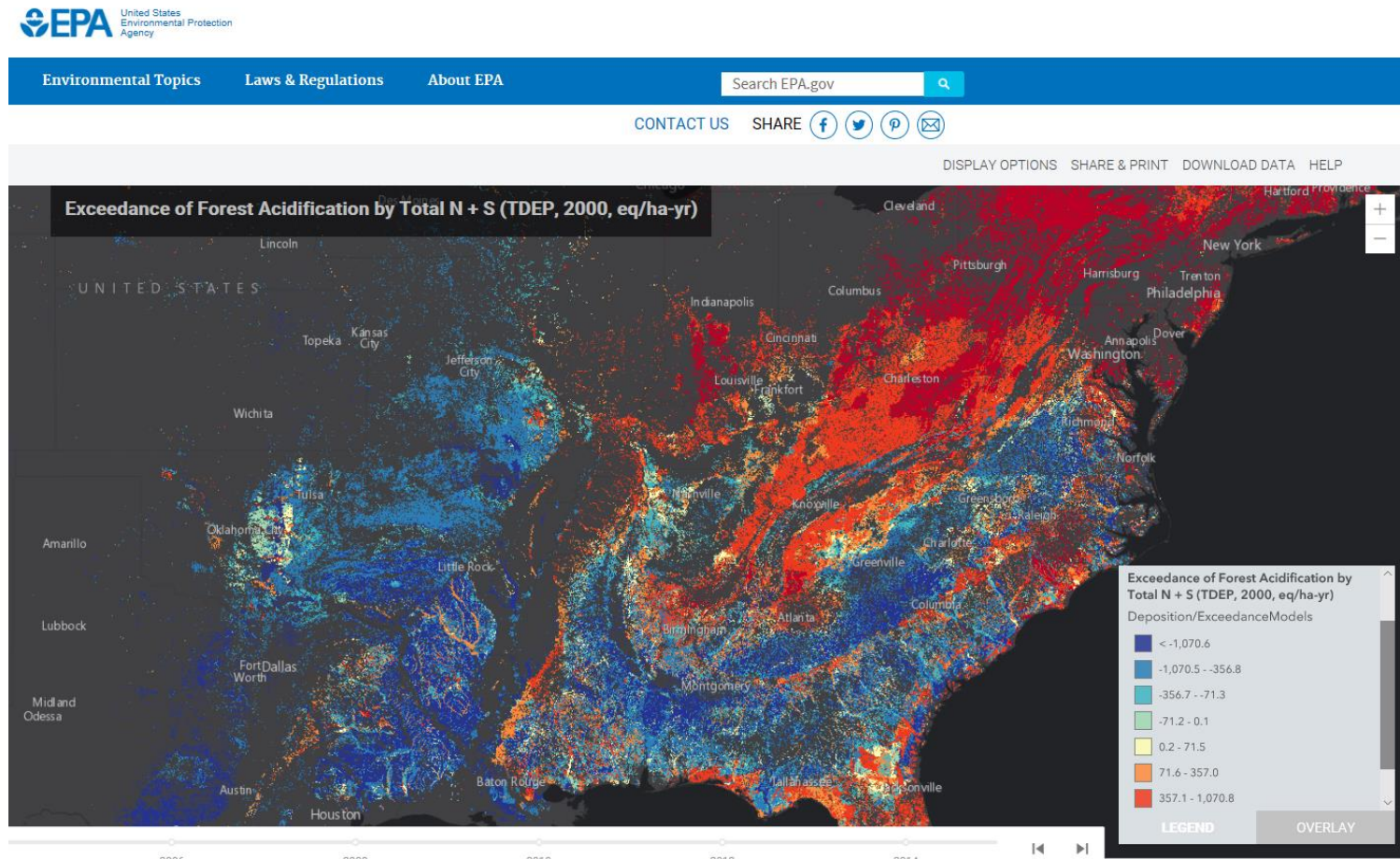
Uncertainty in CL Exceedance by total N deposition

- Herbaceous species richness CLs
- Points with color = near exceedance in 2013-2015 (± 2 kg/ha/yr)



CL Mapper Tool

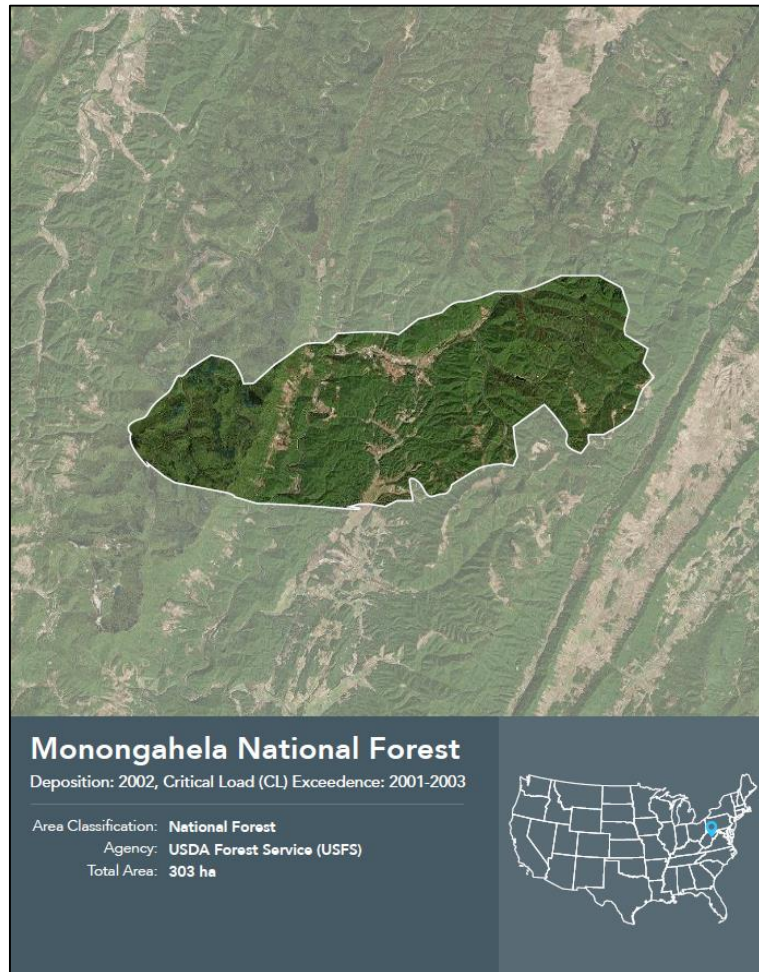
- V2.0 available online
(<https://clmapper.epa.gov/>)



National Atmospheric Deposition Program

Critical Loads of Atmospheric Deposition Science Committee

CL Mapper Tool – Report

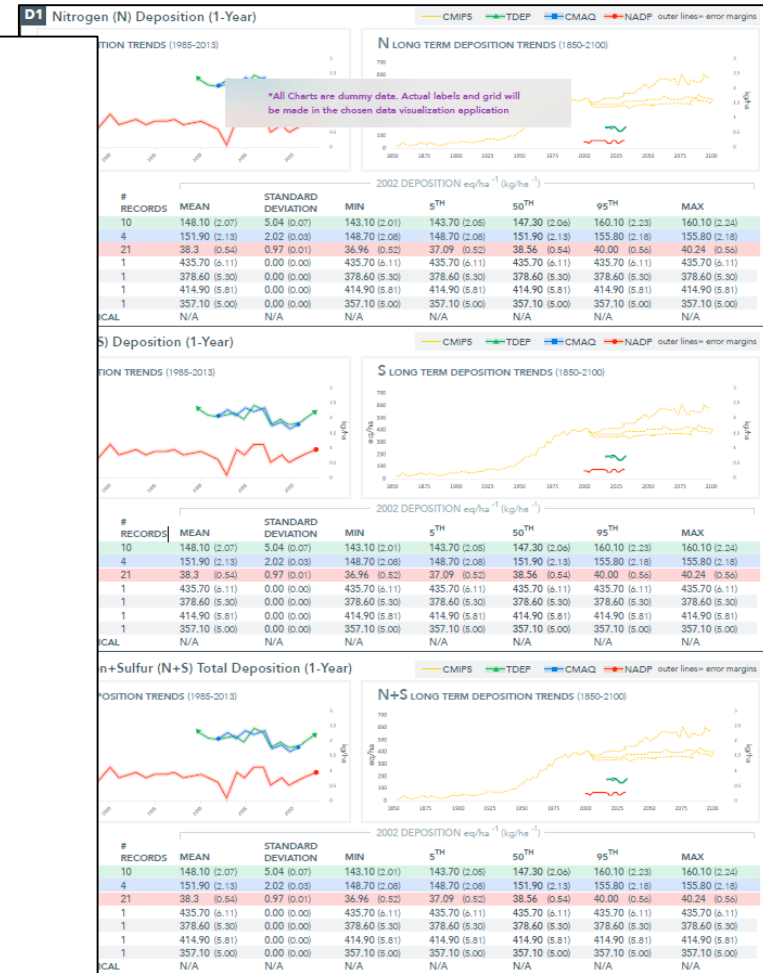


Contents

D	Deposition	Page 3
D1 - Nitrogen (N), Deposition (3-Year Average)		
D2 - Sulfur (S), Deposition (3-Year Average)		
D3 - Nitrogen and Sulfur (N+S), Deposition (3-Year Average)		
CL	Critical Load	Page 4
CL - Critical Loads (CLs)		
E	CL Exceedance	Page 4-6
E2 - Terrestrial Acidification (N+S, 3-Year Average)		
E3 - Aquatic Acidification (N+S, 3-Year Average)		
E4 - Empirical Forest Min (N, 3-Year Average)		
E5 - Empirical Forest Mid (N, 3-Year Average)		
E6 - Empirical Herb/Shrub Min (N, 3-Year Average)		
E7 - Empirical Herb/Shrub Mid (N, 3-Year Average)		
E8 - Empirical Mycorrhizae Min (N, 3-Year Average)		
E9 - Empirical Mycorrhizae Mid (N, 3-Year Average)		
E1 - CL Exceedance (1-Year) Trends		
EE	CL Exceedance Extent	Page 7-9
EE1 - CL Exceedance Extent		
EE2 - Terrestrial Acidification (N+S, 3-Year Average)		
EE3 - Aquatic Acidification (N+S, 3-Year Average)		
EE4 - Empirical Forest Min (N, 3-Year Average)		
EE5 - Empirical Forest Mid (N, 3-Year Average)		
EE6 - Empirical Herb/Shrub Min (N, 3-Year Average)		
EE7 - Empirical Herb/Shrub Mid (N, 3-Year Average)		
EE8 - Empirical Mycorrhizae Min (N, 3-Year Average)		
EE9 - Empirical Mycorrhizae Mid (N, 3-Year Average)		
ES	CL Exceedance Severity	Page 10
ES1 - CL Exceedance Severity		

Final Report

The final report lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit enim id est laborum.



National Atmospheric Deposition Program

Critical Loads of Atmospheric Deposition Science Committee

Transitions with NADP-CLAD

- NADP-CLAD objectives:
 - discuss, support, and advance current and emerging issues regarding the science and use of critical loads for effects of atmospheric deposition on ecosystems in the U.S.
 - Developed and “houses” NCLD
 - Serve as “non-official” U.S. National Focal Centre (NFC) to WGE-CCE
- NADP-CLAD Program Manager:
 - New manager in Fall 2019
 - Committed to continued participation with ICP M&M WGE-CCE



Transitions with NADP-CLAD

- Interim contact until position filled:

Michael Bell (CLAD Co-Chair)

National Park Service

michael_d_bell@nps.gov



Thanks and Questions?



National Atmospheric Deposition Program

Critical Loads of Atmospheric Deposition Science Committee
