NATIONAL ATMOSPHERIC DEPOSITION PROGRAM (NADP) CRITICAL LOADS OF ATMOSPHERIC DEPOSITION (CLAD) 2015-2016 ANNUAL REPORT

1.0 INTRODUCTION

Critical Loads of Atmospheric Deposition (CLAD) is a Science Committee of the National Atmospheric Deposition Program (NADP). The purpose of CLAD is to discuss current and emerging issues regarding the science and use of critical loads (CLs) for effects of atmospheric deposition on ecosystems in the United States (U.S.). This document serves as the 2015-2016 Annual Report of CLAD. The CLAD Annual Report contains sections that document the Fall 2015 and Spring 2016 meetings, the United Nations Economic Commission for Europe (UNECE) International Cooperative Programme (ICP) Modelling and Mapping (M&M) Working Group on Effects (WGE) Coordination Centre for Effects (CCE) annual meeting, CL definitions, development of the 2015 CLAD CL Map Summary, formation of new CLAD Working Groups, CLAD accomplishments, and CL-related publications that occurred during the year.

2.0 MEETINGS

The Fall NADP Meeting was conducted on October 19th during the Acid Rain conference from October 19th – 23rd in Rochester, New York. The Spring Meeting was conducted April 25th and 26th during the NADP meeting from April 25th - 28th in Madison, Wisconsin. The minutes from the Fall and Spring Meetings are presented in Sections 2.1 and 2.2, respectively.

2.1 FALL 2015 MEETING

Tuesday, October 19th

10:00 AM Welcome *(Jason Lynch and Claire O'Dea)*

The participants introduce themselves (in the order of introduction):

In person: Tim Sullivan (E&S Environmental Chemistry), Tamara Blett (NPS), Jeff Herrick (EPA), Hiroyuki Sase (Asia Center for Air Pollution Research (EANET Network Center)), Kevin Horn (Virginia Tech), Mark Fenn (USFS), Greg Lampman (NYSERDA), Rick Haeuber (EPA), Wayne Robarge (NCSU), Jill Webster (USFS), April Maxwell (EPA), Jalyn Cummings (NPS), Tonnie Cummings (NPS), Todd McDonnell (E&S Environmental Chemistry), Bill Jackson (USFS), Ginger Tennant (EPA), Randy Waite (EPA), Linda Pardo (USFS), Ivan Fernandez (U of Maine), Eladio Knipping (EPRI), Chuck Sams (USFS), John Buckley (RTI), Ralph Perron (USFS), Bennet Leon (VT DEC), Jason Williams (Washington State University), Linda Geiser (USFS), Doug Burns (USGS), Karen Roy (NYS DEC), Rich Scheffe (EPA), Jason Lynch (EPA), Claire O'Dea (USFS), and Jennifer Phelan (NADP/RTI). No participants joined remotely.

Accept Spring Meeting Minutes

Spring minutes were formally accepted.

10:10 – 10:30 am FOCUS update (*Jason Lynch*)

1. FOCUS Transition (Tamara Blett):

- History:
    - FOCUS Phase I
        - Unofficial FOCUS center in U.S. (small scale prototype of U.S. Focal Center for UNECE)
        - Develop national database of CL
    - FOCUS Phase II
        - Continue U.S. collaboration with other countries
        - Fill CL gaps
        - Provide resource for policy makers and land managers
- Transition:
    - Cindy retiring as FOCUS Project Manager
        - Served as Project Manager from 2011-2015
        - Accomplishments:
            - FOCUS Phase I report; FOCUS project teams, Workshops, Webinars, etc.
    - Jennifer stepping in as CLAD Program Manager October 2015
        - Starting at 25% time with additional funding through EPA (additional 25%)
    - FOCUS Steering Committee and CLAD Advisory Group:
        - FOCUS project is complete
        - FOCUS Project manager role can be replaced by CLAD Program Manager

- FOCUS Steering Committee oversight will be merged into CLAD Advisory Group
- CLAD Program Manager role to be more "science oriented"

Linda Geiser USFS) – How will relationship with UNECE continue?

Tamara Blett (NPS) – It will continue as CLAD Program Manager who will likely attend UNECE meetings

Jason Lynch (EPA) – Reporting to UNECE for CL update will also continue

1. National Critical Load Database and Call for data (*Jason Lynch*)

- NCLD v. 2.5 has been updated and will be loaded and posted to website after this fall meeting
- SW CL:
    - Expanded sites (3000 additional sites)
    - Dealt with duplicate sites (LOCID)
    - NHD Plus COMID update (has now been linked to water body and rivers)
    - New data are in the presses of being added: CA, VT, NY, NH, Alaska and EMDS (~140,000 points)
- SW CLs for Nutrient Enrichment
    - Jason Williams - funded by NPS to integrate SW CLs for western states
- Forest Soils CLs:
    - 2013 McNulty update from 2007
    - Phelan et al from PA
    - Sullivan and McDonald for VA and NY
- Empirical CL
    - Update to lichen for PNW
- New Projection for CL – TDep projection (working with Gary Lear to make conversion for consistency with CMAQ projection which assumes Lambert perfect sphere)
- Considering converting/providing CL as raster supported data
- Still accepting new data

10:30 – 10:45 am Critical Loads Projects (*Jason Lynch & Claire O'Dea*)

1. Critical Load Maps (*Jason Lynch*)

- Maps have finally been published as NADP document
- Jason has goal of updating database annually (available on the website); printed maps won't be updated annually
- Jason also hopes to be adding new maps to CL database (available on the website)

2. Critical Load Definitions (*Claire O'Dea*)

- 2 webinars to produce CLAD CL definitions
- Not finalized yet; will be formally accepted in Spring Meeting
- Still some definitions that need further work and input from CLAD
- Claire encouraged people to contact her with any suggested changes or additions

- Trying to build off European definitions but recognize evolution since original inception and for application in US and US condition WRT to deposition levels and policy
- CL definitions will be published on the website after they have been finalized and accepted by NADP Executive

10:45 – 11:45 pm General Discussion and CLAD Business (*Jason Lynch & Claire O'Dea*)

1. Annual Report (*Jennifer Phelan*)

- First CLAD Annual Report (2014/15)
- Way to summarize CL projects that are being conducted and CL publications
- Accepted as final report and will be posted to website

2. Open Discussion – new topics/issues for CLAD/Spring 2015 meeting (*Jason Lynch & Claire O'Dea*)

Randy Waite (EPA)/Linda Pardo USFS) – Invite Chris Clark, Linda Geiser and Kevin Horn to update on CL research for Spring Meeting

Linda Pardo (USFS) – How to synthesize/put CL on the same spatial scale and location

Jason Williams (Washington State University) – Uncertainty in deposition models

Linda Pardo (USFS) – How the uncertainty varies across the landscape should also be considered

Tim Sullivan (E&S Environmental Chemistry) – Has publications of recent work available for anyone who is interested

Cindy Huber (NADP) – FOCUS project is closing; FOCUS annual reports are not published on CLAD website; FOCUS project will be maintained on website

Jennifer Phelan (NADP/RTI) – Chris Clark present his ideas for CL on same location / RTI project of putting all CL on same 12km grid; possible for these topics to be inter-session webinars or presentations in spring meeting

Jason Lynch (EPA) – Perhaps good topic for a workshop

Ginger Tennant (EPA) – NOxSOx secondary standards review update – ISA is currently being completed; Tara is presenting on current state of ISA and Jeff Herrick and Meredith Lassiter will be presenting posters

3. Elect CLAD Co-Chair (*Jason Lynch & Claire O'Dea*)

- Nomination = Tonnie Cummings (NPS)
- Replace Jason Lynch for 2-year term
- Jason motioned to accept Tonnie as co-chair
- Accepted as co-chair

4. Announce CL papers and posters that will be presented at the Acid Rain 2015 (note that list of posters and presentations may not be complete; refer to 9th International Conference on Acid Deposition program for additional information)

Jason Lynch (EPA):

- Poster – SW CL exceedance poster
- Poster – Watershed S study (south of glaciation line) – focused on S budgets and adsorption. When will soils in the south reach their adsorption capacity and start releasing S?

Tim Sullivan (E&S Environmental Chemistry):

- Will be co-chairing dynamic modelling session

Tamara Blett (NPS):

- Chairing CL session
- Good international session/representation
- NPS booth that celebrates NPS centennial and "what's your park?"
- CLAD booth with mapping tool for CL mapping tool

Jeff Herrick (EPA):

- Poster – EPA NOxSOx secondary standard review Integrated Science Assessment (ISA)

Karen Roy (NYS DEC):

- Poster – Re-evaluating EPA long-term monitoring data (that support NOxSOx secondary standard review)
- Poster – Discussing NY state strategy to reduce gaps in knowledge introduced during 2008 ISA
- Poster – NY deposition

Jason Williams (Washington State University):

- Poster - Phytoplankton responses in high elevation lakes in SW

Bennet Leon (VT DEC):

- Poster - NADP deposition maps to determine CL exceedances

Ralph Perron (USFS):

- Poster - Legacy effects of pollution

Chuck Sams (USFS):

- USFS booth

Rich Scheffe (EPA):

- Presentation – N and S emissions; importance of natural and agriculture-based emissions
- N and S in Acadia National park

Linda Pardo (USFS):

- Presentation – USFS pilot geospatial tool that accounts for site conditions on forest response
- Poster – methods and results of USFS geospatial tool
- Poster – CLs for acidity and growth patterns in Red spruce
- Hosting Forestry session

Bill Jackson (USFS):

- Poster – EMDS framework and model ; how to use the information for management

Tonnie Cummings (NPS):

- Poster – demonstration of CL mapping tool

Jalyn Cummings (NPS):

- Presentation – 36-year water quality monitoring program; NPS perspective as land manager

Jill Webster (USFS):

- Poster – annual trends in deposition

Wayne Robarge (NCSU):

- Poster – NH4 exchange calculations for monitoring stations (interference of bicarbonate)

Rick Haeuber (EPA):

- Poster – examines different monitoring networks (emissions, deposition, etc) and success with emission reduction programs

Hiroyuki Sase (Asia Center for Air Pollution Research):

- Poster/presentation – CL exceedance in Japan

Mark Fenn (USFS):

- Presentation – 4 different ways to estimate total deposition
- Poster – use of isotope dilution as a method to estimate deposition

Kevin Horn (Virginia Tech):

- Presentation – Powell Center work that documents how trees responding to N deposition

Claire O'Dea (USFS):

- Poster – how CLs being used by USFS for land management
- CLAD and TDep booths

Cindy Huber:

- CLAD booth

11:45 – 1:00 pm Lunch

2.2 SPRING 2016 MEETING

Monday, April 25th

1:00 – 1:15 PM Welcome (*Claire O'Dea*)

The participants introduced themselves (in the order of introduction):

In person – Claire O'Dea (USFS), Tonnie Cummings (NPS), Jennifer Phelan (NADP), Doug Burns (USGS), Chuck Sams (USFS), Scott Weir, David Gay (NADP), Jason Williams (Washington State University), Rick Haeuber (EPA), Chris Clark (EPA), Linda Pardo (USFS), Donna Schwede (EPA), David Grande (Wisconsin), John Jensen (Southern Company), Mike Bell (NPS), Tamara Blett (NPS), Greg Wetherbee (USGS), and Jason Lynch (EPA). Phone/online – Bill Jackson (USFS), Kevin Horn (Virginia Tech), Ginger Tennant (EPA), Todd McDonnell (E&S Environmental Chemistry), Tim Sullivan (E&S Environmental Chemistry), Randy Waite (EPA), and Sam Simkin (University of Colorado)

1:15 – 1:55 PM CLAD Business

1. CLAD Program Management Update (*Jennifer Phelan*)

- Update on CLAD Working Groups (WG)
    - FOCUS Phase II project included 8 WG. FOCUS project was officially ended; WGs were closed. Jennifer provided a summary of the leads, objectives, final products and final status of each of the FOCUS WGs.
        1. WG A (Improve BCw and ANC for terrestrial acidification CL): Close; Completed objectives; EPA (Chris Clark) is currently conducting BCw project and will provide updates to CLAD on project
        2. WG B (Improve NO_3^- leaching, N immobilization and denitrification terms for terrestrial CL): close; objectives not accomplished; "N immobilization, NO_3^- leaching and denitrification" will remain on the list of CL research topics that require additional work to improve CL estimates for terrestrial ecosystems, some topics require additional work to refine CLs.

Linda Pardo (USFS) – Was there a decision also to prioritize these topics?

Jennifer Phelan (NADP) – Not aware of any prioritization of research topics at this point

3. WG C (Linking soil chemistry with vegetation response): close; "Linking soil chemistry with vegetation response" will remain on the list of CL research topics that require additional work to improve CL estimates for terrestrial ecosystems
4. WG D (Lichen CLs): maintain WG and CLAD support of WG on an "as needed basis"; components of this WG will be rolled into the new CL Topics WGs
5. WG E (Improve empirical CL of N (resolution, uncertainty)): maintain WG and CLAD support of WG on an "as needed basis"; components of this WG will be rolled into the new CL Topics WGs
6. WG F (Surface water CLs): close; continue as on-going effort of NCLD manager.
7. WG G (NCLD): close; continue as on-going effort of NCLD manager.
8. WG H (Biodiversity CLs): maintain WG and CLAD support of WG on an "as needed basis"; components of this WG will be rolled into maintain as needed. Components will be rolled into new WGs.

- Three new WGs
    1. WG1 (Add new data and CLs into NCLD): not yet started.
    2. WG2 (Characterization of uncertainty): will be accomplished in two phases; have had a couple of preparatory meetings; will “kick-off” during CLAD meeting Tuesday afternoon.
    3. WG3 (Synthesizing multiple CLs): will be described by during CLAD meeting on Monday afternoon; will have kick-off meeting Tuesday afternoon.

- Description and status of CLAD WG is summarized in two documents:
    - FOCUS WG Closure Final.xlsx
    - CLAD WG 2016.docx

2. Report on UNECE CCE Mapping and Modeling meeting (*Jennifer Phelan*)

- Jennifer attended UNECE ICP M&M WGE-CCE meeting in Dessau, Germany. She provided a description of the meeting and some of the research that was presented:
    - 63 participants; 20 countries
    - All presentations will be on ICP M&M/WGE-CCE website
    - 2017 Call for Data is currently due for January 2017. Does CLAD want to submit data in response to this call?
    - 2014 UNECE status report has proposed methods for biodiversity CL
    - Upcoming ozone CL meeting
    - Research findings
        - Importance of cumulative N in response to N relationships
        - Need to consider selection of biodiversity metrics; numerous studies have reported no net change in species richness when multiple studies/results (i.e., meta-analysis) are summarized

Chris Clark (EPA) – How receptive is the WGE-CCE to different biodiversity metrics?

Jennifer Phelan (NADP) – Quite flexible; is up to the individual country

- Potential methods (modified change-point analysis) for calculating CLs based on linear response
- Have been some updates to the ICP M&M Mapping Manual

Jason Lynch (EPA) – Did they talk about how to deal with DOC and surface water?

Jennifer Phelan (NADP) – Not mentioned, but will forward update documents

- Proposed revisions to N leaching term, to increase the number of ecosystem types and range of estimates
- Suggest using species-specific Bc/Al for terrestrial acidification CLs (from Sverdrup and Warfvinge, 1993 – posted on UNECE ICP M&M/WGE-CCE website)
- New base saturation threshold values (20-40%) based on research in Switzerland, but recommended that on some sites (where soils have naturally low base saturation, change in base saturation may be more relevant)
- Updated with more country-specific values for relationship between immobilization and temperature to estimate N immobilization

Chris Clark (EPA) – What was reaction to Jen's presentation?

Jennifer Phelan (NADP) – We were thanked for participating and received very positive feedback with respect to all the work that is being done in the U.S.

- The second half of the presentation provided an update on WGE-CCE funding and concerns regarding the continuation of WGE-CCE into the future:
    - 2016 budget reduced by 2/3
    - 2017 not yet secured (should know in October)
    - 2018 WGE-CCE will not be funded by The Netherlands; CCE is voluntarily funded, while EMEP within the CLRTAP has obligated funding.
    - Kimber Scavo (EPA) is the U.S. representative in the joint WGE-EMEP meetings; Bill Harnett is the chairperson of the Working Group on Strategies and Review
    - Jean-Paul strongly encouraged communicating with Bill and Kimber regarding CLAD products and efforts and participating at the non-official NFC to the ICP M&M

3. National Critical Load Database Update (*Jason Lynch*)

- NCLD v2.5 = posted on 2/23/16
- Surface Water CL
    - Expanded by 3,000 sites

    - NHDplus COMID added
- Forest acidity CL
    - Updated with new research
    - Updated with Tim Sullivan's new CLs
- Empirical CL of lichens
    - Updated for PNW
- Projects that have used NCLD:
    - More than 10 projects and review have used NCLD
- Plans for NCLD v.3 (NCLD v 2.5 = UNECE Data submission is not useful anymore)
    - Structure:
        - Break down into table structure for each of the CL types, but all linked by CLID
        - Projection change – work with common projection system that is used by other systems (Albers Equal Area Conic); even though not same projection as TDEP, it is easy to convert via datum
        - Grids:
            - As TDEP (as 4134 m) and CMAQ (12km)
        - GIS features:
            - Add additional features
    - Surface water CL:
        - "cleaning" datasets and representing standardized, single CL value for each water body
    - Add new CL data

1:55 – 3:00 PM Presentations

There were three presentations in this session.

1. Appalachian Trail deposition study (*Doug Burns*)

- Evaluated impacts of acidifying N and S deposition on AT corridor
    - Model N and S deposition
    - Measure soil and stream chemistry
    - Vegetation species composition and health
    - Estimate and map Cl, target loads and exceedances
- 3 levels of project field sampling design that governed what would be sampled (different intensities)
- Encountered problems with transferability of and relationships with geology
- Evaluated a large number of scenarios (out to three future years 2050, 2100 and 3000) using different criteria and thresholds for target load evaluations
- 60% of sites had BS less than 20%
- Found considerable variability in stream ANC and acidity along the corridor
- Main conclusions:
    - Variation in landscape acid buffering is more important than acid rain

- Soils were Ca depleted to point of Al mobilization at 60% of sites
- Deposition effects on plant communities were expressed through ecosystem relationships (not simple cause and effect)
- Variation on level of stream acidification (i.e., ANC levels)

2. Lake nutrient enrichment CLs/A database for western mountain lakes and N CLs (*Jason Williams*)

- Goal of research is to fill gap in CL (estimating nutrient enrichment CL for lakes)
- Mountain lakes are highly sensitive to N deposition
- Chemical response to N deposition is an increase in NO_3^-
- Biological response is changes in phytoplankton (species composition and biomass)
- P-limitation also influence phytoplankton response (species dependent)
- Can see a shift in nutrient limitation (e.g., shift from N to P limitation)
- No standardized method for calculating CL for these systems
- Responses that were characterized included:
  - Species
    - Abundance
    - Critical chemical limits (phytoplankton species)
  - Biomass
    - Chlorophyll a
    - Critical chemical limits (phytoplankton biomass)
- There are 2 phases to the project:
  - Build database for model
  - Calculate CL
- Currently in the stage of collecting data to build the database:
  - Chlorophyll a
  - Phytoplankton species
  - Shapefile with late watersheds boundaries
  - P deposition grids
  - Water chemistry

3. Air Quality and Ecosystem Services (*Tamara Blett and Mike Bell*)

- Need to be able to "translate" CLs into services that society/human values
- Conducted AQES workshop in February 2015 to discuss CL in the context of ecosystem services
- 28 ecologists, air quality and economist experts attended the workshop
- During the workshop, people were divided into 4 working groups focused on CL type: aquatic acidification, terrestrial acidification, aquatic eutrophication and terrestrial eutrophication
- Knowns:
  - Relationship between CL and biological indicators
  - Ecosystem service classification system
- Objective:
  - Need to connect CL "known" with Ecosystem service classification "known"

- Products of workshop was a final report; currently in the process of producing five journal articles for submission as a Special Issue in Ecosphere; will also be conducting a Special Session at Ecosystem Service conference in 2016
- The tool that was developed and applied at the workshop was the STEPS Framework which consists of:
    - 3 modules: Stressor, Ecological Production Function, and Final Ecosystem Goods and Services (FEGS) classification system
        - Stressor links environmental stressor to biological indicator
        - Ecological Production Function – step-wise series of cause and effect relationships that link change in biological indicator to ecological end point or FEG
        - FEGS-CS – classification system
- At the workshop, produced a total 1073 "chains" that linked CL to Ecological end point
- The next steps in this analysis is to explore the "demand-side" of the relationship and valuation of the ecosystem services

3:00 – 3:15 PM Break

3:15 – 3:55 PM New CL Presentations

There were two presentations in this session.

1. Tree Species CLs (*Kevin Horn*)

- The goal of this work was to evaluate how N deposition influences recruitment, growth (above-ground) of BAI or Jenkins C and mortality
- Can use these new data to further refine the forest ecosystem CLs from Pardo et al. (2011)
- Found that tree species exhibited different responses to N deposition: positive, negative, threshold or flat
- Response relationships are a function of: N deposition, canopy position, precipitation, temperature, and starting size
- Species-specific responses were found to vary by region and different levels of N deposition
- Found a big difference in growth responses between 1980-1990 data and 2000 data; much higher positive growth response in 1980-1990 vs. 2000, which showed decreases in growth (suggesting that cumulative N deposition may play a role)

2. Herbaceous Biodiversity CLs – herbs (*Chris Clark*)

- Responses of herbaceous vegetation to N deposition was evaluated through two levels of response:
    - Species richness responses - published in PNAS paper (based on 3800 species)
    - Individual species responses
- Species richness:
    - Based on temperature, precipitation, N deposition and soil pH as predictors
    - Models produced for open canopy and closed canopy systems

    - Models based on quantile regressions for 10th, 50th and 90th percentiles
    - Compared models using change in AIC
    - Analyses conducted at national level and by Vegetation Alliances (33 alliances)
    - CLs were based on response surface and partial derivative (with respect to N) equal to or less than 0 to isolate the values of N deposition associated with negative responses
    - Unimodal relationship found in response to N deposition in closed canopy and open canopy systems with pH interaction
    - Non-forested CL = 8.7 kg N/ha/yr
    - Forested = 13.4 kg N/ha/yr
    - Found lower CL in acidic soils for both systems
- Species-level analyses:
    - Based on presence/absence
    - Filters applied to data included:
        - Species were linked to Vegetation Alliances (with species presence in 5-90% of sites and with 5+ sites for each of the predictor variables)
        - Had to have a long deposition gradient (>7 kg N)
        - A total of 297 species had the necessary data
    - Of the 297 species, a total of 148 species showed a significant response to N
    - Based CL on response relationship and location/presence of hump
    - Next steps:
        - Publish results
        - Include CLs into NCLD

3:55 – 4:05 PM EPA CL Mapper Tool (*Chris Clark*)

- The goal of the CL Mapper Tool is to provide an interactive front end for the NCLD
- Access via EPA's Global Change Explorer
- Is a tool that provides a variety of layers and datasets to evaluate impacts of deposition in area of interest:
    - Deposition
    - CL
    - CL exceedance
- Eight CL included (in current and version 2)
- Deposition included:
    - TDEP
    - CMAQ
    - NADP
    - IPCC AR5 (historical (1860-2000) and future (2010-2100)
- Exceedance
- V1 out by the end of July; V2 out by end of December

4:05 – 4:40 PM CL Integration Maps Presentation & Discussion (*Chris Clark and Jennifer Phelan*)

- EPA ORD is conducting project that compares deposition (1800-2025) with CLs (6) from the NCLD to evaluate temporal and spatial patterns of CL exceedances; other objectives of the project include evaluating different levels of risk by aggregating CLs by 12km grid cells and how climate change and management scenarios impact estimates of future deposition
- Deposition is represented by Lamarque et al. (2010), in 10-year averages from 1850-2000; CMAQ (2002-2011), and CMAQ in 2025
- Deposition datasets were merged by pivoting from Lamarque et al. (2010) in 1850 to join with CMAQ in 2000 through a weighted average of the two datasets transitioning from 100% Lamarque et al. (2010) estimates in 1850 to 100% CMAQ estimates in 2000
- CLs include:
    - Terrestrial acidification
    - Aquatic acidification
    - Empirical CL of N for:
        - Herb/shrub composition
        - NO_3^- leaching
        - Lichens
        - Forest – tree health
- CLs were aggregated by 12 kg CMAQ grid cells and expressed, by CL type, as the minimum, 10^{th}, and/or 50^{th} percentile of the distribution of CL values in each cell
- Counts of the number of CL types in the grid cells ranged from 0-6 with 2-5 counts being the most common
- Lichens, in general, was the most sensitive CL type
- CL exceedances patterns differed by CL type and value (min, 10^{th} and 50^{th} percentiles), but were highest in the 1970's and 1980's; coverage of 10^{th} and 50^{th} percentile CLs and exceedances were reduced and less consistent then minimum CLs; CAA 2025 projections and additional reductions with agricultural maximum feasible reductions did not substantially reduce deposition relative to 2011 levels; despite the decreases in deposition since the 1970's (and CAA), additional reductions are still needed to reduce CL exceedance

4:40 – 5:00 PM CL Synthesis Presentation & Discussion (*Chris Clark*)

- CLAD is starting a WG focused on the evaluating methods for synthesizing/representing multiple CLs in the same unit area
- How do we combine multiple CL loads to assess the vulnerability of a given area?
- Two main options/approaches:
    i. Determine what to protect, or
    ii. Determine what is protected by different deposition levels (is protection adequate?)
- Goals of WG:
    - Develop method(s) for combining multiple CLs that differ in scale, quantity, and confidence

    - Apply method(s) to several case studies across the country.
    - Develop "best practices" for how future CLs should be reported (e.g. scale, which N dep data, quantification of uncertainty, etc.)
- Membership:
    - Core: Chris C., Linda P, Jason Lynch, Jennifer Phelan, Kevin Horn, Sam Simkin, Linda Geiser, Heather Root, Randy Waite, Chris Davis, Tara Greaver
- Frequency of meeting: Monthly

5:00 PM Adjourn for the day

Tuesday, April 26th

10:00 – 10:15 AM Day 2 Introductions & Agenda Review (*Claire O'Dea*)

10:15 AM – 12:00 PM Critical Loads Projects: Status and Results "Round Robin"

Jennifer Phelan (NADP) (RTI projects):

- EPA-ORD project that compares deposition (1800-2025) with CL (6) from NCLD to determine temporal and spatial patterns of CL exceedances
- EPA-ORD project that is evaluating the impacts of deposition (and climate) on future forest stand composition and associated ecosystem services
- EPA-ORD project that is using PROFILE model to estimate BCw rates to support terrestrial CL of acidity estimates in the continental U.S.
- EPA-ORD/OAQPS supporting development of the ISA for the NOxSOx secondary standards review

Chris Clark (EPA):

- CL Mapper Tool
- Translating tree responses of N into CL (working with Kevin Horn and Linda Pardo to develop the CLs)
- Publishing herb species responses to N deposition
- Using VSD-Props (compared with ForSAFE-Veg) to evaluate impacts of deposition and climate on understory species composition in two National Park sites and Hubbard Brook Research Forest

Mike Bell (NPS):

- Evaluating impact of oil and gas sector on deposition and associated impacts on National Parks; modelling/estimating what proportion of exceedances can be attributed to oil and gas sector
- TDEP and Parks (for CL exceedance estimates)
- Develop communication tools to communicate where deposition is exceeding CLs in National Parks

Tamara Blett (NPS):

- Continuing work on connecting CL with ecosystem services
- Using CL exceedance as a way to communicate with policy makers the impact of air quality on National Parks and also as a way to communicate with the public regarding which Parks are being impacted by deposition
- Currently communicating mainly through website
- Thinking about next phase of communication (to incorporate new science and tools)

Doug Burns (USGS):

- Work and publication of results to support/inform resource managers/policy makers regarding CLs and impacts of deposition in Adirondacks
- NYSERDA project (collaborating with Tim Sullivan, Greg Lawrence, Charlie Driscoll) to develop CL projections and target loads for Adirondack streams and rivers; trying to evaluate impact of seasonal flows and how this influences CL and CL exceedances; will include influences of both N and S deposition

Scott Weir:

- Working with Native Americans and tribes to evaluate impacts of deposition (and climate change) on ecosystems on tribal lands
- Need tools to communicate scientific findings to tribal nations

Chuck Sams:

- Facilitate use of CL tools and products (produced by CLAD community) by USFS land managers to assist with land restoration
- CL information has been/is being used for planning of forest/land management

Jason Williams:

- Publication in press that describes mountain lakes CL based on phytoplankton biomass and composition
- Joint session presentation of evaluation of CMAQ and TDEP performance in high elevation lakes and impacts on CL exceedance; performance of the models isn't (and should be!) included in CL exceedance determinations (bias in wet deposition can be 100%; CMAQ bias greater in high precipitation areas)
- P deposition may be an important driver of P, but don't have enough information regarding P deposition and influence of P on ecosystem dynamics and CLs

Tonnie Cummings:

- Writes air quality chapters for National Parks; challenge of writing these communication documents that translate the science into terms that can be understood by park managers and general public

Linda Pardo:

- Project to refine empirical CLs to address resource management and policy needs (GIS tool); trying to have finer resolution, address species responses, include impacts of climate and site conditions (products: tool, regional overview paper, users guide)

Jason Lynch:

- Working on and re-organizing NCLD
- Working on paper with Charlie Driscoll that examines temporal trends (long-term) in surface water chemistry
- Project using MAGIC to calculate surface water and soil CLs in Michigan
- Continuing to work on national assessment of CLs for the US

Claire O'Dea:

- Developing videos to connect CL types with ecosystem services to help public and USFS staff understand the relationships
- Working with Chris on CL Mapper Tool to provide CL exceedance metrics to assist USFS land managers with management decisions

Bill Jackson:

- Works with National Forest System; using CLs to assist with timber management
- In western NC, Nantahala and Pisgah are going through forest management review and revisions; attempting to use CLs and maps to identify areas of high risk (of impacts on deposition) and where/which sites should be reviewed further prior to forest management (and areas that require additional information and data); and identify potential sites for liming
- Working with Coweeta to identify areas for potential liming

Randy Waite:

- Moving forward on NOxSOx secondary standards review; ISA first draft should be completed in the fall; developing plan for Risk and Exposure Assessment (budget – conceptual approaches for national or local risk assessments for systems that haven't been well represented – riparian and estuaries) risk assessment for Hg methylation; eutrophication for streams and lakes; national mapping of BCw and CL of acidity

Todd McDonnell:

- MAGIC modelling of CL and target loads in 15 areas in the southeastern US
- Dynamic modelling projects: VSD-PROPS and ForSAFE-Veg to predict responses to future scenarios and target loads and to also compare results from the two model systems
- Developing PROPS database which consists of occurrence probability based on soil pH, CN ratio, N deposition, and precipitation (for 327 species)

Tim Sullivan:

- Working with RTI on NOxSOx secondary standards review (ISA)

- Doing work in southern Appalachian comparing tree species (red maple, sugar maple, yellow birch, and American Beech) and understory species relationships with soil base saturation
- Book relating air pollution and impacts in National Parks; 45 Parks are addressed; effects include N and S deposition, ozone, pesticides, and other pollutants

OTHER DISCUSSION TOPICS:

1. CLAD summary maps?

- Things to consider:
    - Single end points and which ones?
    - What resolution?
    - Do we try and further refine CL end points to be specific to land use types, aggregation, etc.; may also want to go back to the studies and ID locations of studies for the empirical CL of N (to help characterize uncertainty and geographical boundaries around the ecosystem type, etc. that the CL apply to); would also like to make more information regarding the study locations linked to the CL data
    - Need to document caveats, decisions being made, etc. with maps that are produced (significant documentation)
    - Are we comfortable with simply overlaying TDEP on CL maps given concerns regarding the accuracy?
    - Depending on timing, may be able to build in uncertainty information on which and how to present CLs
    - Concerns regarding accuracy of dry deposition because these are all modelled and not measured data (deposition velocity based on vegetation surface is a big factor)
- Considering including TDEP and CL exceedance in CLAD summary maps:
    - Tonnie and Claire will start working with NADP to include TDEP and CL exceedance in CLAD summary maps
- Timeframe – most likely that the maps and supporting documentation won't be completed until Fall 2017 (for presentation in following Spring meeting)

3:00 – 3:30 PM CL Uncertainty Discussion (*Linda Pardo*)

- CLAD is initiating WG focused on CL uncertainty
- Proposing 5-point scale rating scale to facilitate comparison of all CLs
- Two approaches for this 5-point scale:
    - Top down (theoretical) that uses pre-determined criteria:
        - Representativeness of the sample
        - Sample size
        - Range of deposition assessed
        - Correlation among predictors
        - Model strength (R2, AUC)
        - Model uniqueness (delta AIC)

        - CV of the CL
        - Accuracy of deposition measurement
    - Bottom up (data driven) that uses data from published CL studies to assess uncertainty:
        - Study/CL specific metrics
        - Should be identified/determined by experts and scientists who developed the CL
- For reported CL, envisage having a uncertainty rating (1-5)
- Still unsure how will combine the different criteria scores to produce a final uncertainty value
- Potential/series of metrics will be used to characterize the scores for each of the criteria
- Potential products: report detailing approach, website with updates, peer-reviewed journal article, updates to CL mapper, incorporate into Synthesis case studies, and incorporated when adding new data into NCLD
- Meet monthly
- In next meeting, suggest that start out with a list of requirements of what metrics will be needed/could be included

Jason Williams – What do we mean by uncertainty?

Chris Clark – Good question!

- Certainty with respect to the response being caused by deposition (i.e., is deposition just correlated with real predictor(s)/driver(s))
- Certainty of estimate of CL
- Both the CL value (and range) and uncertainty ranking will be provided to allow user to select with CL to use

3:30 – 4:30 PM Critical Load Definitions (*Claire O'Dea*)

Claire led review and discussion of CLAD CL terms and definitions. The intention of review was to produce an approved document (that can be updated as needed); CLAD sub-committee can continue to work on CL terms and definitions that need additional work/refinement

- Only changes to definitions are noted in these minutes
- Critical load - remove the red text in the critical load definition (as the same message is communicated by "based on current knowledge")
- Biological response – remove "response" from definition so it becomes "biological measure affected by atmospheric….."
- Will switch out "is the same as" with "is also referred to as" for all terms with this language
- Deposition Load – The amount of material deposited from the atmosphere to the earth's surface expressed as mass or charge per unit area per unit time. Examples of commonly used units of atmospheric deposition are kg N/ha/yr or eq/ha/yr
- Critical Load Exceedance – change "said to be" to "is" and "at" to "'for"
- Empirical Critical Load – change to "experimental manipulations of pollutants"

- Steady-State Critical Load – change to "Steady-State Mass-Balance Critical Load". Add "Steady state condition may be achieved far into the future."
- Target Critical Load – adopt the revised original definition that combines the management and modelled target loads; sub-committee/group can work on revisions to this term in the future, as needed
- Will construct/develop an annex/appendix that documents:
    b. Key decisions made in the process
    c. Additional details regarding the individual definitions that provide additional information or clarity

4:30 – 5:00 PM Wrap-Up

1. Fall Meeting Objectives
    - Could have a CL session
        - Perhaps biodiversity CL session
        - Jason and Chris will volunteer to co-chair the session
        - Could turn into 2 sessions if there are too many submissions
2. Critical Load Publications
    - Please send all CL publications to CLAD co-chairs
3. Update to CLAD Webpage
4. New CLAD Business General Discussion
4. CLAD positions:
    a. Claire O'Dea will be ending as co-chair
    b. Jennifer Phelan will be ending as secretary
    c. Please send nominations for these positions to Tonnie and Claire

5:00 PM Adjourns

3.0 UNECE ICP M&M WGE-CCE MEETING

The 26th CCE Workshop and 32nd Task Force Meeting of the ICP M&M was held in Dessau, Germany from April 19th – 22nd. The objective of this meeting was for representatives from each of the National Focal Centres (NFCs) of countries that are members and signatories of the Convention on Long-Range Transboundary Air Pollution (CLRTAP) to provide an interim update on their respective country's response to Call-for-Data for biodiversity CLs. Additional topics (as outlined on the WGE-CCE website - http://wge-cce.org/Activities/Workshops/Past_workshops/Germany_2016), that were addressed during the meeting included:

- Latest findings in field and laboratory experiments and through model assessments (of air pollution) impacts on plant species diversity

- Integrated assessment reports and studies on CL exceedances or effects on biodiversity in natural areas caused by changes in (agriculture) emission on specified spatial and temporal scales
- Review of the Mapping Manual, ICP M&M – work plan 2016-2017, and other Task Force issues including reporting requirements to the second joint session of EMEP and the WGE (September 2016)

A total of 63 participants from 20 countries were present at the meeting. Jennifer Phelan represented CLAD as the non-official NFC from the U.S., and gave a presentation on the variety of research being done in the U.S. to support the development of biodiversity CL for herbaceous species, tree, and lichens. All presentations from the meeting are available on the WGE-CCE website. It was noted that CL submissions for 2017 could consist of: biodiversity CLs and/or updates to conventional CLs (acidification, $CL_{emp}(N)$, and $CL_{nut}(N)$. Since the Meeting in Dessau, CLAD has decided not to submit data in response to the Call. Funding for the WGE-CCE into 2017 is uncertain.

4.0 CLAD CRITICAL LOAD DEFINITIONS

Last year, CLAD identified the need to define CL and CL-related terms. Two inter-meeting webinars were held in the 2014/2015 year followed by one additional webinar in the 2015/2016 year; discussions and revisions occurred during April of this year. Jennifer Phelan and Todd McDonnell presented and discussed the proposed CL terms and definitions with our European colleagues while in Dessau, Germany for the joint CCE Workshop and ICP M&M Task Force meeting. A final version of the definitions were presented and approved during the CLAD 2016 Spring meeting. These definitions are now available as a document titled, CLAD Critical Load Definitions, on the CLAD website (http://nadp.sws.uiuc.edu/lib/CLAD/NADP_CLADdefinitions.pdf).

5.0 CRITICAL LOAD MAP SUMMARY

Last year multiple meetings and webinars were conducted to discuss CLAD CL maps. During these meetings, CL maps for terrestrial acidification, aquatic acidification, and empirical CLs of nitrogen (N) for biological indicators including mycorrhizae, lichen, forest ecosystems, and herbaceous plants/shrubs were presented. The goals of the maps were to: 1. educate, 2. illustrate CLs in the NCLD, and 3. identify data gaps and additional needs. Responses and recommendations from last year's meetings and webinars were noted, and this year a set of maps were included in a document titled, "NCLD Critical Load Map Summary" (http://nadp.sws.uiuc.edu/committees/clad/db/NCLDMapSummary_2015.pdf). This document includes the first set of CL maps approved and published by NADP and associated documentation that describes the source, methods, and caveats of use of the maps. These maps will be updated with revisions to the source NCLD, as needed.

6.0 CLAD WORKING GROUPS

Scientific working groups (WGs) have been a component of CLAD since 2011. The objectives of WGs are to increase our understanding and ability to estimate and represent CLs of deposition in the U.S. This year, three WGs were initiated to advance the estimation and representation of CLs in the U.S. and improve the CLAD NCLD.

WG-1 ADDING NEW DATA AND CLS TO THE CLAD NCLD

Objective: The objective of this WG is to produce, adopt, and practice a standardized method for review and incorporation of new published data and CLs into the CLAD NCLD. New CL data associated with FOCUS project WGs D (Lichens), E (Empirical CL of N), and H (Biodiversity CL) will be included in CLAD WG-1 efforts.

WG-2 CHARACTERIZING UNCERTAINTY IN CL ESTIMATES

Objective: The objective of this WG is to provide estimates of uncertainty for CLs in a standardized way. This objective will be accomplished in two Phases: I. develop a common 5-point scale to quantify uncertainty that applies to all CLs, thereby allowing for a comparison between CLs, and II. improve the uncertainty characterization for individual CLs, with the intention of including estimates of uncertainty for the CLs that are and will be included in the CLAD NCLD. CL data associated with FOCUS project WGs D (Lichens), E (Empirical CL of N), and H (Biodiversity CL) will be included in CLAD WG-2 efforts.

WG-3 CL SYNTHESIS

Objective: The objective of this WG is to develop a methodology/process for combining multiple CLs in a rigorous and defensible manner. This objective will most likely progress through two complimentary efforts: I. development of "Best Research Practices" for CL estimates and reporting (including representation of uncertainty), and II. series of case studies representing/estimating CLs using different methodologies and sets of criteria applied in a series of locations. Development of "Best Research Practices" will involve reviewing CLs and developing the protocols for comparing and combining CLs within the same unit area. Case Studies representing/estimating CLs will involve combining CLs through a variety of different methods and criteria, and comparing the results to determine the preferred/recommended method(s) for representing multiple CLs within the same geographical area. It is anticipated that the different methods and criteria for representing multiple CLs will cover a range of different CLs and locations/systems (e.g. three case studies).

These WGs officially began during the Spring CLAD meeting and are expected to continue into next year.

7.0 CLAD SUMMARY OF ACCOMPLISHMENTS

The CLAD Summary of Accomplishments document was updated with CLAD accomplishments that occurred during this year. These accomplishments included:

1. Sponsored "Critical Loads: A Bridge between Science and Policy" scientific symposium at the Acid Rain conference in October 2015
2. Attendance at CLAD meetings during the Spring and Fall NADP meetings was between 25 and 32 participants
3. Represented CLAD as the U.S. non-official National Focal Centre (NFC) at the 26th CCE Workshop and 32nd Task Force Meeting of the ICP M&M was held in Dessau, Germany
4. Produced the CLAD NCLD Critical Load Map Summary (http://nadp.sws.uiuc.edu/committees/clad/db/NCLDMapSummary_2015.pdf)
5. Produced CLAD Critical Load Definitions document (http://nadp.sws.uiuc.edu/lib/CLAD/NADP_CLADdefinitions.pdf)
6. Initiated three scientific Working Groups (WGs) within CLAD to advance the estimation and representation of CLs in the U.S. and improve the CLAD NCLD

8.0 PUBLICATIONS

Critical load-related publications that were added to the CLAD website prior to the Fall 2016 meeting included the following.

2016

- Bingham, A.H. and M. F. Cotrufob. 2016. Organic nitrogen storage in mineral soil: Implications for policy and management. Science of The Total Environment 551–552: 116–126. doi:10.1016/j.scitotenv.2016.02.020
- Bytnerowicz, A., Fenn, M., Allen, E.B., and Cisneros, R. 2016. Atmospheric Chemistry, pp. 107-128, In H. Mooney and E. Zavaleta (Eds.), Ecosystems of California-A Sourcebook. University of California Press. Berkeley, California. (link)
- Caporn, S., Field, C., Payne, R., Dise, N., Britton, A., Emmett, B., Jones, L. Phoenix, G., Power, S., Sheppard, L., and Stevens, C. 2016. Assessing the effects of small increments of atmospheric nitrogen deposition (above the critical load) on seminatural habitats of conservation importance. Natural England Commissioned Reports, Number 210.(link)
- Phelan, J., S. Belyazid, P. Jones, J. Cajka, J. Buckley, and C. Clark. 2016. Assessing the Effects of Climate Change and Air Pollution on Soil Properties and Plant Diversity in Sugar Maple–Beech–Yellow Birch Hardwood Forests in the Northeastern United States: Model Simulations from 1900 to 2100. Water, Air, & Soil Pollution 227(3): 1-30. doi:10.1007/s11270-016-2762-x
- Simkin, S.M., E.B. Allen, W.D. Bowman, C.M. Clark, J. Belnap, M.L. Brooks, B.S. Cade, S.L. Collins, L.H. Geiser, F.S. Gilliam, S.E. Jovan, L.H. Pardo, B.K Schulz, C.J. Stevens, K.N. Suding, H.L. Throop, and D.M. Waller. 2016. Conditional vulnerability of plant diversity to atmospheric nitrogen deposition across the United States. Proceedings of the National Academy of Sciences of the United States of America, online in advance of print. doi:10.1073/pnas.1515241113

- Williams, J.J., M. Beutel, A. Nurse, B. Moore, S.E. Hampton, J.E. Saros. 2016. Phytoplankton responses to nitrogen enrichment in Pacific Northwest, USA Mountain Lakes. Hydrobiologia, pp. 1-16.
  DOI:10.1007/s10750-016-2758-y

2015

- Burns, D.A., and T.J. Sullivan, 2015, Critical Loads of Atmospheric Deposition to Adirondack Lake Watersheds: A Guide for Policymakers, NYSERDA Technical Report, Albany, NY, 16 p. (link)
- Bytnerowicz, A., Johnson, R.F., Zhang, L., Jenerette, G.D., Fenn, M.E., Schilling, S.L., and Gonzalez-Fernandez, I. 2015. An empirical inferential method of estimating nitrogen deposition to Mediterranean-type ecosystems: The San Bernardino mountains case study. Environ. Pollut. 203: 69-88.
  doi:10.1016/j.envpol.2015.03.028
- Cleavitt, N. L., Hinds, J. W., Poirot, R. L., Geiser, L. H., Dibble, A. C., Leon, B., Perron, R., Pardo, L. H. 2015. Epiphytic macrolichen communities correspond to patterns of sulfur and nitrogen deposition in the northeastern United States. The Bryologist 118(3), 304-324.
  doi:10.1639/0007-2745-118.3.304
- Lawrence, G.B., Sullivan, T.J., Burns, D.A., Bailey, S.A., Cosby, B.J., Dovciak, M., Ewing, H.A., McDonnell, T.C., Minocha, R., Quant, J., Rice, K.C., Siemion, J., and Weathers, K.C., 2015, Acidic deposition along the Appalachian Trail corridor and its effects on acid-sensitive terrestrial and aquatic resources: Results of the Appalachian Trail atmospheric deposition effects MEGA-transect study, Natural Resource Report NPS/NRSS/ARD/NRR—2015/996. National Park Service, Fort Collins, Colorado, 241 p. (link)
- Leavitt, S. D., & Clair, L. L. S. (2015). Bio-monitoring in Western North America: What Can Lichens Tell Us About Ecological Disturbances?. In Recent Advances in Lichenology (pp. 119-138). Springer India. (link)
- Fenn, M.E., J.S. Fried, H.K. Preisler, A. Bytnerowicz, S. Schilling, S. Jovan, and O. Kuegler. 2015. Remeasured FIA plots reveal tree-level diameter growth and tree mortality impacts of nitrogen deposition on California's forests. Proceedings of the 2015 FIA Symposium. Gen. Tech. Rep. PNW-GTR-931. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station.
  (link)
- McMurray, J. A., Roberts, D. W., & Geiser, L. H. (2015). Epiphytic lichen indication of nitrogen deposition and climate in the northern rocky mountains, USA. Ecological Indicators, 49, 154-161.
  doi:10.1016/j.ecolind.2014.10.015
- Pardo, L. H., Robin-Abbott, M. J., Fenn, M. E., Goodale, C. L., Geiser, L. H., Driscoll, C. T., ... & Dennis, R. L. (2015). Effects and Empirical Critical Loads of Nitrogen for Ecoregions of the United States. In Critical Loads and Dynamic Risk Assessments (pp. 129-169). Springer Netherlands.
  (link)

- Root, H. T., Geiser, L. H., Jovan, S., & Neitlich, P. (2015). Epiphytic macrolichen indication of air quality and climate in interior forested mountains of the Pacific Northwest, USA. Ecological Indicators, 53, 95-105. doi:10.1016/j.ecolind.2015.01.029
- Will-Wolf, S., Jovan, S., Neitlich, P., Peck, J. E., & Rosentreter, R. (2015). Lichen-based indices to quantify responses to climate and air pollution across northeastern USA. The Bryologist, 118(1), 59-82. doi:10.1639/0007-2745-118.1.059