NATIONAL ATMOSPHERIC DEPOSITION PROGRAM (NADP) CRITICAL LOADS OF ATMOSPHERIC DEPOSITION (CLAD) 2014-2015 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 for effects of atmospheric deposition on ecosystems in the United States (U.S.). This document serves as the 2014-2015 Annual Report of CLAD. The CLAD Annual Report contains documentation from the Fall 2014 and Spring 2015 meetings, inter-meeting webinars, CLAD re-certification and critical load-related publications that occurred during the year.

2.0 MEETINGS

The Fall NADP Meeting was conducted from October 21st-24th with the CLAD meeting on October 21 in Indianapolis, Indiana. The Spring Meeting was conducted from April 13th-14th in Pacific Grove, California. The minutes from the Fall and Spring Meetings are presented in Sections 2.1 and 2.2, respectively.

2.1 FALL 2014 MEETING

Tuesday, October 21st

10:00 AM Welcome and CLAD Business *(Jason Lynch & Jennifer Phelan)*

The participants introduce themselves:

In person: Jason Lynch (USEPA), Jennifer Phelan (RTI), Cindy Huber (NADP), Rich Haeuber (USEPA), Tim Sullivan (E&S), Tamara Blett (NPS), Rich Pouyat (USFS), Claire O'Dea (USFS), Linda Pardo (USFS), Chuck Sams (USFS), Robin Dennis (USEPA), Doug Burns (USGS), Eladio Knipping (EPRI), Wayne Robarge (NCState), John Jansen (Southern Co.), Ginger Tennant (USEPA), Jill Webster (US FWS), Tonnie Cummings (NPS), Julian Aherne (Trent U.) Phone/ Online: Clara Funk (EPA), Bill Jackson (USFS), Jason Williams (WSU), John Buckley (RTI), Randy Waite (USEPA), Shaun Watmough (Trent U.), Jeff Herrick (USEPA), and Chris Clark (USEPA).

10:05 AM FOCUS Update

FOCUS (Focal Center Utility Study) is a project of CLAD that was initiated in the fall of 2010 following the guidance of UNECE to assemble a national critical loads database. Phase I was to put together a national database of CLs.

1. FOCUS Phase II (*C. Huber*)
    a. Recent accomplishments
        i. Call for Data (Jason, new additions to database)
        ii. Powell Center Proposal "Forecasting Forest Response to Nitrogen Deposition" was selected for funding (Aug. 2013)
        iii. New initiative under RCN (Reactive Nitrogen Cooperative) Tamara will discuss
        iv. Mark Fenn leading working group on Nitrogen input parameters in CL- now working with Cindy Prescott, hope to be moving forward again soon
2. US Call for Critical Load data for NCLD (*J. Lynch*)
    a. Update and add to current data
    b. Especially interested in Surface waters CLs for nutrient enrichment
    c. Nutrient CL for Forest Ecosystems
    d. Update on database:
        i. Forest soil CLs: resolve data at modeled 1 km resolution but lots of data is unwieldy. Switching from Access to Oracle Database and csv files
        ii. Have been correcting mistakes in Supporting Information files
        iii. Surface Waters, added about 3,000+ new sites. Currently resolving duplicate site issues for lakes and stream reaches (LOCID).

iv. NHDplus - ComID to be added

v. Index for place for towns and cities boundaries (Census data)

3. Ecosystem Services (ES)/ CL Workshop (*T. Blett*)

a. Feb 2015 in Santa Monica, 27 invited subject matter experts, February 2015

b. Sponsorship – Woods Hole

c. CLAD interests: ES is a tool for linking natural areas to things people care about, using established approaches and terms, addresses the "so what" question of change or damage

d. Create specific linkages from CL endpoints to benefits and human health and beneficiaries. Hopefully will help distill CLAD's message about why CLs are important and help defend NOx/Sox 2nd standards.

e. Follow-up of workshop will be on demand side

i. NESCS (follow-up valuations – demand side)

4. Forest Response to Nitrogen – Powell Center update (*C. Clark, L. Pardo*)

Objectives:

a. Review exposure and growth response of quaking aspen to N Dep. Using this as central example/pillar

b. Build in other drivers of growth and mortality responses (soils)

c. Determine if there is regional responses for species that are nationwide

10:30 AM CL Projects: Status and Results

- Announce CL papers and posters that will be presented at the NADP science symposium

- Inter-meeting project update webinar(s) (*J. Lynch*)

- Round robin of current and new critical loads projects being conducted by CLAD participants – maximum of 5 minutes per person (*J. Phelan*)

Contributors are welcomed to add to their sections as they see fit.

Chris Clark (USEPA):

- Powell Center (N Meta-analysis of impacts of N deposition on understory species composition)
- ForSAFE-Veg project
- Impacts of N Deposition and Climate Change on Forest Composition

Tim Sullivan (E&S) - (contact Tim with additional questions and copies of manuscripts/also listed on CLAD website):

- Book published
- Manuscripts/Reports:
    - Rocky Mountain ForSAFE-Veg
    - Science and Policy of Critical Loads
    - Southern Appalachains and BCw extrapolation
    - Habitat Squeeze paper is currently in review (CL and water warming impacts on fish habitat)
    - AQRV for NPS (hope to have this completed this year):
        - Summary of air pollution issues in Park Service (1500-2000 page report)
    - AT Report
    - Report for USFS evaluating impacts of different sources of deposition estimates on CL exceedance

Tamara Blett (NPS):

- FOCUS Phase I paper is out
- Critical Loads session at UFOR in Salt Lake, Utah
- Poster – in NADP session focused on Greater Yellowstone/Southern Appalachians area / pulling together CL information and summarizing in policy context

Claire O'Dea (USFS):

- Will be giving presentation on USFS CL Portal during Thursday NADP CL session
- FS Air Quality Portal is now LIVE!

Linda Pardo (USFS):

- CL and Climate Change – Linda giving talk during Thursday NADP CL sessions
- Developing GIS tool for forest managers
- Been developing CL for individual tree species (poster during NADP)
- Poster on uncertainty in CL
- Poster from Powell Center looking at relationships between soil chemistry and plant detrimental responses
- NE project on CL interaction and climate, developing CLs for individual tree species (see poster), uncertainty framework (see poster), Powell Center forest group (see poster)

Chuck Sams (USFS): papers out

Doug Burns (USGS):

- Meeting last week attended by NGOs, academics, and agency reps and focused on / Charlie Driscoll proposed that NY state speak with a "unified voice" and CL to frame air quality and ecosystem health

Robin Dennis (USEPA):

- Have completed 2002-2012 (10-yr time series) CMAQ N and S deposition runs (will be presented during Thursday NADP CL session)

Shaun Watmough (Trent U.):

- S emissions and critical loads in British Columbia
- Alberta – importance of mines and base cation deposition / found that the increased deposition counteracts acid deposition (reduces CL exceedances)
- Saskatchewan – forests (impacts of soil sand developments) / trying to come up with BCw rates
- Ontario – linking diversity to N deposition / trying to get better estimates of forest N exposure

Tonnie Cummings (NPS - Pacific West Region):

- CLs in the Pacific Northwest. – In the summer of 2014, we published an NPS, USFS, USGS report that: describes current understanding of CLs in the region, lists ongoing research efforts, identifies data gaps, and outlines a strategy to use CLs in policy and planning arenas (will give talk about the report on Thursday).
- Several CL projects are underway in Pacific West parks. - In Santa Monica Mountains National Recreation Area in CA, a graduate student is looking for differences in effects of N deposition on burned versus unburned coastal sage scrub communities. In Mount Rainier, North Cascades, and Olympic NPs in
- WA, there are three graduate student projects trying to identify CLs for diatoms in high elevation lakes and for high-elevation soil and vegetation communities.

Jennifer Phelan (RTI):

- ForSAFE-Veg project evaluating impacts of N deposition and climate change
- Completed BCS weathering rates – published, __modeling in NE w climate change and elevation, Forest composition and climate model, pairing CL and CLDB and CMAQ and year 2025

Bill Jackson (USFS):

- Sites in Tennessee and Virginia for monitoring water chemistry
- EMDS: Focused on areas where streams are not likely to obtain ANC of 50 and areas that may be timber harvested

Jeff Herrick (USEPA):

- Starting up NOxSOx ISA / Tara Greaver and Jeff will make sure that all relevant CLAD articles are included in the review
- Proposed rule on NAAQS for ozone, trying to get reengaged in CLAD – starting up NOx/Sox review again – hoping to have some draft material in the spring, stay tuned for author's meetings

Randy Waite (USEPA): nothing at this time

Julian Aherne (Trent U.):

- EC – CL in Alberta and Saskatchewan and Oil sands region (Steady-state modelling – lakes) and Jack Pine forests on understory species

11:00-12:15 General Discussion and CLAD Business

1. CLAD Webinars have been ongoing and successful! Please let Jason know if you have a topic you would like to present.

2. VSD Workshop (*J. Phelan*) - Dr. Gert Jan Reinds will be presenting VSD workshop on Friday

3. Critical Load Maps (*J. Lynch*)

a. Purpose:

i. Education

ii. To be able to illustrate CL

iii. Identify data gaps and needs for additional research

b. Static maps:

c. Aggregation depending on critical load type

i. But keep them simple and portray them in the scale they were produced

d. Map caveats

e. Within DB have 8 possibilities for Cl maps

f. Challenges of maps:

i. Data

ii. Spatial scale

iii. Uncertainty represented by number of sites

iv. Don't want to over – represent

g. Surface water acidity:

i. Use 36 x 36 km map

ii. Average values of CL

iii. 20 ANC for western

iv. 50 ANC for eastern

v. 5th and 10th percentile

vi. Comment: should replace "uncertainty" term with "number of sites" to be less misleading

h. Results:

i. Very little difference between 10th and percentile due to low number of records

ii. Map that compares sensitivity of forest vs. surface water acidity / challenge

iii. Empirical CL of N:

iv. Linda Pardo's: No aggregation / just portrayed by Ecoregions

v. Linda Geiser's: portrayed on 4 km grid scale

i. Comments:

Tamara Blett (NPS) - Would like to include surface water eutrophication. Would like more time with the CL maps to review in greater detail and spend time on the caveats, etc.

Jason Lynch (USEPA) - could definitely set up a follow-up webinar, but Jason would like to move forward with NADP to discuss how to get these on the CLAD website / Jason's goal is to have the maps completed by Spring meeting

Need for an Advisory Committee meeting

Cindy Huber (NADP) - very clear that we need more webinars between meetings to cover important presentations and topics

4. Uncertainty Framework development (*L. Pardo and C. Clark*): developing a systematic way of reporting uncertainty for CLs to be used more broadly in the US for resource management and policy.

Proposing to move from a more subjective European method (3 points) to a new 5-point scale for developing CLs (there will be a workshop discussion this afternoon from 3:45-5). Categorizing uncertainty for different kinds of data sets (large homogeneous, large heterogeneous, small heterogeneous) – qualitative and quantitative approaches to categorizing uncertainty. Factors include: representativeness of study for region, sample size, influence of environmental factors, accuracy of N dep model and gradient, strength of response, clarity of threshold). Approach is to rate criteria but still working out qualitative vs. quantitative approaches. Next step is to refine rating systems and explore approaches for statistical assessment of larger data sets.

Large-scale heterogeneous datasets (meta-analysis); different methods and different parameters

a) Small heterogeneous datasets where smaller number of studies are combined

b) Looking at quantitative and qualitative assessments of uncertainty

c) Factors that affect uncertainty:

d) Representativeness of study region

e) Sample size/influence of area of study

f) Influence of environmental factors

g) Accuracy of N deposition

h) Strength of response

i) Clarify of threshold

j) Use these factors to produce 5 level uncertainty rating

k) How many samples should there be for each rating

Tim Sullivan (E&S) - Empirical critical loads are really "target loads" / gradient study vs. dose-response study (getting at question in a very different study) / should gradient studies by "screening tools" with dose-response studies used to determine critical load

Julian Aherne (Trent University) - Concerns re: interpretation of European 3-tiered system vs. how applied in U.S. / 3-tiered system have a range, so they already include uncertainty / 5-tiered adds additional "uncertainty"

5. FIA Response (*J. Lynch*): filled out CLAD survey response and letter of support for FIA dataset.

6. Annual Report for CLAD – is a detailed minutes sufficient for an annual summary of various products? Discussion: minutes aren't same as an annual report, but with some embellishment it could be (more background info need on FOCUS working groups, e.g.), should include a list of posters and publications.

Tamara Blett (NPS) - We should move towards having an embellished version of the minutes as an annual report for CLAD, and a separate summary specific to the FOCUS working groups and should be send out sooner and invite responses and additions.

Recommendations:

- List of publications during year
- List of poster and presentations during NADP meetings
- Some background information (objectives, definitions)
- Send it out in advance to allow people to add additional information to the annual
- Will have a separate Annual Report of FOCUS that will be prepared by Cindy Huber

7. Election for CLAD Co-Chair and Secretary. Clarie O'Dea (USFS) accepted nomination for Co-Chair and Jennifer Phelan (RTI) for Secretary. All in favor? Aye!

8. Open Discussion: New topics/issues for CLAD/Spring 2014 meeting (Jason Lynch & Jennifer Phelan):

- Have started looking at impacts/interactions of climate change and critical loads should be or could be a webinar that reviews projects and key findings

Doug Burns (USGS) - topic of climate change in Acid Rain conference in 2015? Proposed 10 sessions, still deciding on basic sessions. Has been an oral session reserved for critical loads. Will need to identify session chair and contributed presentations. If want to extend CLAD session may need to go into Sunday (schedule for Acid Rain conference is pretty "squeezed" already)

12:00 Meeting Adjourn

2.2 SPRING 2015 MEETING

Monday, April 13th

10:40-10:50 AM Welcome and CLAD Business

The participants introduce themselves:

In person: Jason Lynch (USEPA), Claire O'Dea (USFS), Cindy Huber (CLAD), Tamara Blett (NPS), Linda Geiser (USFS), Jeff Herrick (USEPA), Tim Sullivan (E&S Environmental Chemistry), Chuck Sams (USFS), Rick Haueber (USEPA), Ralph Perron (USFS), Rich Pouyat (USFS). Phone/Online: Jennifer Phelan (RTI), Alan Van Arsdale (USEPA), Bill Jackson (USFS), Chris Clark (USEPA), Drew Bingham (NPS), Jason Williams (Washington State University), Kevin Horn (VT), Linda Pardo (USFS), Mike Bell (NPS), Randy Waite (USEPA), Tonnie Cummings (NPS)

10:50-11:50 AM Presentations

Three presentations were scheduled for this session.

1. Critical loads (CLs) and lichens (*Linda Geiser*)

   Lichens are sensitive to both the eutrophying and acidifying impacts of N and S deposition. Location in the canopy is very important. Lichens seem to respond most to total deposition, as opposed to individual wet and/or dry chemical species.

   Lichen response relationships and critical loads (CLs) were determined using lichen surveys (mainly from USFS FIA dataset). There are approximately 9000 lichen survey sites, and within these sites 520 species have been detected. Responses were modelled at individual and community levels using HyperNiche software. Responses were modelled at national, ecoregion, and east versus west spatial scales.

   The east vs. west models were strongest. Sulfur deposition is a strong predictor in the east and N is a strong predictor in the west. The individual species response relationships indicated that species in the west are generally more sensitive to deposition than species in the east. Community response models that included the evaluation of 12 different predictive variables determined:

   - Significant N deposition model in East – lichen communities were most sensitive to total N deposition, August temperature and hardwood forest component, with deposition and climate being the strongest predictors.
   - Significant N deposition model in West - 9 variables influenced lichen communities, with N deposition, minimum December temperature, and precipitation being the strongest predictors).
   - Higher temperatures general shifted species to the eutrophic ones.
   - Significant S deposition model for East – most significant predictors were S deposition and distance to coast.
   - Significant S deposition model West – not much of a relationship because of the low levels of S deposition in the west. However, places closer to coast exhibited stronger relationships.

Chuck Sams (USFS) – Who should make the decision regarding which lichen CL to adopt? Should NADP-CLAD come up with recommendations?

Rick Haueber (USEPA) – The CL to adopt is a management and policy decision. Each manager within each agency has to decide what to protect and what level(s) of protection are desirable, and whether protection should be focused on % losses or individual species. It shouldn't be the role of NADP-CLAD to make these decisions. These decisions are too political and agency-specific. The role of NADP-CLAD should be to provide science-based CLs and communicate atmospheric deposition – ecological impact relationships of interest.

Alan Van Arsdale (USEPA) – If we want to convince managers to protect lichens, a lot of science and good "talking points" are needed. Perhaps NADP-CLAD can play this role and translate the science into a "language" that can be used and understood by managers.

Chris Clark (USEPA) – Our role is to do the science that relates deposition with biological response(s) that managers care about.

Jason Williams (Washington State University) – pointed out the amount of uncertainty in CL and deposition estimates. There needs to be a greater understanding and communication of this uncertainty and how it should be factored into decisions and recommendations.

Tim Sullivan (E&S) – Different agencies may have different levels of desired protection for ecosystems (e.g., EPA vs. NPS vs. USFS). We need to recognize these differences and these differences in approach are okay.

Rich Pouyat (USFS) – Yes, "determining the desired level of protection" is an important component of USFS Federal Land Mangers decisions.

2. EPA Critical Load (CL) Online Tool (*Chris Clark*)

The presentation provided an update on the CL Online Tool being developed by EPA ORD. The goal is to produce an online tool to allow users to explore "what if" scenarios for different ecological end points and N/S deposition scenarios. It will encourage a greater understanding of CLs and help identify and prioritize CL estimates that should be improved. It is being developed as a "living tool" that can be updated as needed.

The primary audience of the tool is EPA OAQPS and regional air quality managers (e.g., NPS, USFS). The timeline of the tool is: beta version in summer 2015, with final version completed in September to December 2015. The home page will be on EPA Global Change Impacts and Adaptation group website with plans for links to relevant EPA, NPS, USFS, NADP/CLAD websites and CLAD publications. The development of the tool will learn from/adopt approach used by NPS (Tamara Blett) and USFS (Claire) CL websites.

Details that are being considered for the tool include:

- Desire to provide different CLs and different deposition datasets to do pairings of interest to the user

- Adopt an Interface that allows the user to select deposition, CLs or CL exceedances, while also allowing functionality to define locations (ecoregions, states, counties, Class 1 areas, etc.) of interest
- There are still many decisions that need to be made regarding the details of what to include in the "selection" options. For example, how much flexibility do we want to build in? Should we just provide simple overlays or allow the user to "open up the hood" and allow work with data (e.g., combine CLs or deposition layers – averaged over 10 years)?

Linda Pardo comment – looks like a great tool! For the tool that USFS is working on for the NE U.S., we are using a series of screening questions to help the user determine what they want to look at (e.g., uncertainty, area of interest, appropriate CL type for application). A large reason for this approach is to meet the user's needs and prevent miss-use of CLs.

Chris Clark (USEPA) – Yes, we are also thinking of including a "user's guide".

Cindy Huber (NADP) – Do you think this will be ready to "go live" sometime in September – December 2015?

Chris Clark (USEPA) – May not, but I am optimistic!

Rich Pouyat (USFS) – It sounds like you/EPA has contracted out the development of the website. However, when contract runs out, do you have plans to maintain the website?

Chris Clark (USEPA) – Yes, that is why the website is "nestled" within a larger EPA architecture. So, there will be funds to support maintenance.

Tamara Blett (NPS) – I really like that the tool provides "basic tools" for simple users. For the geographical location options, NPS administrative boundaries should also be added an option.

Cindy Huber (NADP) – I am currently working on a project for the USFS wilderness project that this EPA Online CL Tool will really complement

Jason Lynch (USEPA) – Please set up webinar for input from CLAD members to assist with tool development

3. Terrestrial CL for Forest Soils (*Steve McNulty*)

Steve wasn't present on the call due to time change. So, the presentation did not proceed.

11:50 AM-12:00 PM Target Load Discussion

Due to time constraints, this discussion was postponed to a future intermeeting webinar. As described by Jason Lynch, it is important for CLAD to wrestle with and clearly define CL (and other CL terms). Jason will sent out a questionnaire after the meeting to ask for proposed definitions from CLAD.

12:00-1:00 PM Lunch

1:00-1:45 PM Target Load Discussion Continued

Skipped due to time constraints (see notes from 11:50-12:00 session)

1:45-3:15 PM Critical Load (CL) Maps (*Jason Lynch*)

Jason provided an updated on the current status of the CLAD CL maps. The maps are currently in their 4th edition, and are a product of two intermeeting webinars that were devoted to the presentation and discussion of the CL maps. The objectives of the current CLAD presentation was to:

- present the final decisions that were adopted for the maps
- get approval from this session to "move forward" with the CLAD CL maps
- discuss "vehicles" or means by which to get these maps out to the public and end users.

The purposes of maps are to:

- To educate
- To illustrate CLs in the national CL database
- To identify data gaps and additional needs

Tamara Blett (NPS) – need to further define "who" to educate about "what".

Jason described the challenges with the maps and proceeded to outline the main decisions that were made for each of the sets of maps for each CL type:

1. Empirical CLs of N (based on Pardo et al. (2011) work):
    - No aggregation
    - Presented at national level at EPA Level I Ecoregions (the same scale as CL development - USFS GTR)

Todd McDonnell (E&S) – recommended that the study locations be added to the maps.

Linda Pardo (USFS) – identified that including the study locations would be too problematic.

2. Empirical CLs of N for lichens (based on Geiser et al. (2010) work):
    - Presented at 4km PRISM resolution
    - Current CL dataset for the PNW (Washington, Oregon, Idaho and Montana) needs to be updated

Linda Geiser (USFS) – And the maps will include the updates, right?

Jason Lynch (USEPA) – Yes, as soon as we have the framework in place, the updates will be possible and likely included in the CLAD maps.

3. Forest Ecosystem Acidity:
    - Have two datasets in CLAD CL Database for Forest Ecosystem Acidity – McNulty et al. (2007) and Duarte et al. (2011)
    - Decided not to aggregate, but to present the data at the scale that each were developed
    - Uncertainty will be added to the maps
    - Will also add new data from Appalachians (E&S Environmental Chemistry) and Pennsylvania (RTI)

- Jason is working with Steve McNulty to try and represent uncertainty; Steve has reworked some of the data and will providing an updated CL map

4. Surface Water Acidity:
    - Held an intermeeting CLAD webinar that sorted out all the details
    - Slide presents all the decisions that were made during the webinar with CLAD participation and input
    - Presented the maps that are the product of all the decisions

Jason then proceeded to describe what is left "to do" to prepare the maps for posting on the CLAD website?

- Caveats for each map still need to be developed
- Should have 3 webinars; one for each end point to iron out remaining details
- Still need to determine how to present the information:
    - As a bunch of maps?
    - Best way/format to present the information?
        - Summary document that provides background information, database information, limitations, key pieces of information, references, and maps of each CL end point
        - Goal should be to provide context

Rick Haueber (USEPA) – Will this document go up on CLAD?

Jason Lynch (USEPA) – Yes, the document will be presented in the Joint Session for approval for posting on website.

Rick Haueber (USEPA) – Should have a conversation with EROS prior to presenting at Joint to get their feedback (i.e., follow NADP protocol to inform prior to presenting at Joint, so that EROS isn't surprised)

Alan Van Arsdale (USEPA) – I am a member of the EROS group and strongly support Rick's suggestion. John Walker is chair of EROS. So, it would be good to approach John.

Jason Lynch (USEPA) – Do I have the backing of CLAD as a "vehicle" to present the CLAD maps to EROS and Joint?

CLAD response – All (unanimous) in favor of proceeding with CLAD CL maps. Jason will approach John Walker with proposed method.

Claire O'Dea (USFS) – Has any of the text been written?

Jason Lynch (USEPA) – No, not yet. We have some ideas and a very rough draft. We will need some assistance writing the sections.

3:15-3:30 PM Break

3:30 – 5:30 PM CLAD/TDEP Joint Session

There were five topics that were discussed during the Joint Session.

1. Critical Loads (CLs) and Deposition Exceedances for National Parks – NPS website (Tamara Blett)
   http://www.nature.nps.gov/air/Studies/criticalLoads/Ecoregions/index.cfm

NPS calculated CL exceedances for National Parks. NPS started by using the empirical CLs for nutrient N from Linda Pardo's GTR (Pardo et al. 2011) for: forests, herbaceous plants and shrubs, lichens, fungi, and nitrate leaching receptors at the Level I Ecoregion scale. Drew Bingham (NPS GIS Specialist) calculated exceedances of these CLs using TDEP N deposition estimates (2010-2012 3-year average). The highest N deposition estimate for the area within each NPS boundary was used as the deposition value for the Park when running exceedance calculations. These calculations enable NPS to provide CL and CL exceedance values for each National Park, which help NPS determine where CLs are exceeded and therefore where NPS should be concerned about air quality effects. CL exceedances are currently only provided for nutrient N CLs only, as a coarse-scale national look into CL exceedances.

The website provides background information on CLs, and, for each ecoregion, also provides tabs of information for each of the five CL receptors. Each receptor tab provides the CL exceedance data (in numeric and map form), as well as descriptions of how the data should be used, including caveats, an explanation of confidence, and an explanation of what the minimum and maximum values of the CL range represent. Several examples were shown and the maps were explained. For the exceedance maps, blue depicts areas where deposition is below the CL, yellow depicts areas where deposition is at the CL (+/- 1 kg N/ha), orange depicts areas where deposition is greater than the minimum CL but lower than the maximum CL, and red depicts areas where deposition is greater than the maximum CL.

A table is also provided on the website to show the CL and CL exceedance values for each NPS unit. The table lists the NPS unit, ecoregion, highest N deposition value within the unit boundaries, and minimum and maximum CLs and CL exceedance values for that unit.

This information is being used to: assess ecosystem health where there is no available monitoring data, assist with PSD/NEPA reviews (where areas are experiencing effects), support land management planning, assess efficacy of emissions controls programs, and develop state and regional plans to improve air quality consistent with land management goals. NPS uses a system of red/yellow/green indicators to provide a quick assessment of park condition, and this indicator includes visibility and ozone effects, as well as the effects of atmospheric deposition. N and S deposition used to be used as the deposition component of this indicator, but NPS is now moving to the use of CL exceedances as the metric.

Next steps include obtaining and incorporating fine scale CL information that is more realistic to individual park units. The CL range provided at the ecoregion scale includes the effects of many species likely not found in a given NPS unit. By determining whether specific species or ecosystem types are actually located within an NPS unit, NPS can refine the CL accordingly to obtain more realistic estimates. In addition, NPS wants to work with other agencies to link existing CLs efforts (specifically the USFS Air Quality Portal and the new EPA CLs Online Tool). It is important to continue joint TDEP/CLAD discussions so that we continue to move in the same direction and provide the most useful data.

Donna Schwede (USEPA) - TDEP provides deposition information based on land use that could be incorporated to assist and improve any future spatial refinement of CL exceedance calculations (and that in the future TDEP could possibly provide ozone information).

2. Uncertainty (Gary Lear and Jason Lynch)

At the 2014 Fall Meeting CLAD/TDEP was not ready to deal with uncertainty, but this is a topic worth bringing up so it is addressed when possible. How do we characterize uncertainty within TDEP to be useful for CLAD? What would that look like? TDEP is not able to produce confidence limits. Would high/low characterizations be useful?

The metadata provides a broad characterization of limitations and biases. Are there areas of the country where estimates are more resolved than others? (For example, fewer monitoring site and terrain in the west might result in less accuracy.) This information could be provided as an uncertainty map or as a qualitative description in the "read-me" file.

The Pardo et al. (2011) USFS GTR provides three categories of uncertainty: expert judgement, fairly reliable, and reliable (now working towards further refinement into five categories). TDEP could create categories (quantitative or qualitative or spatial representation).

Distance from monitoring sites or percent of estimate due to model/measurement could be used to develop grid cell based uncertainty. Distance from monitoring site is not a good proxy because complex terrain will affect estimates even in close proximity, but this is not the case where terrain is less complex.

Are there ways to use other measurements of deposition (throughfall, lichen tissue, snowpack) to help determine uncertainty? This information is only available regionally and therefore results would be different in different regions. Comparing CMAQ to throughfall data is comparing apples to oranges – not sure about comparisons with lichen tissue. TDEP can consider the implications of using these data.

Deposition estimates are important for all CL exceedance calculations. Deposition is not used in calculating CLs of acidity for surface waters, but it is used in some empirical CL calculations. Monte Carlos have been used to determine the contribution of different parameters to the CL estimate.

3. TDEP Sea Salt Discussion

Request was made to add sea salt sulfate and non-sea salt sulfate as additional variables to TDEP, but this is more complicated than originally appeared. CMAQ uses a different approach than the empirical approach. CMAQ uses a factor in coming up with estimates; wet sea salt is easier/more direct. The World Meteorological Organization approach to get sea salt sulfate (observed) is to use a cascading series of range tests. If the ratio is good, WMO uses sodium as a percentage to determine sea salt sulfate contribution (70%). If sodium is not available, use magnesium (25%). If neither is available, use chloride (5%). WMO stops using a correction 100km from the coastline (TDEP can extend further and reduce slowly to 200km to not get abrupt step).

Linda Geiser (USFS) – believes the effect of sea salt ends within the 100km used by WMO.

Wet sea salt sulfate can be used as percent of wet sulfate on the map. But how should this be applied to dry deposition? CASTNET/Search ions can be used with the same gradient method on a weekly basis and aggregated for annual sea salt sulfate. These should not be subtracted from the total S grid, but can be used separately.

Bias issues are similar to those associated with base cations. How do we merge these sea salt sulfate estimates with CMAQ values because the different methods don't align. If we're going forward with base cations based on measured only and not CMAQ, then sea salt can proceed accordingly. TDEP can do this but is not sure how good it is.

Linda Geiser (USFS) – explained that in the PNW, there is more sea salt sulfate intrusion in mountains than along the Columbia River Gorge, demonstrated through the elemental analysis of lichens. The TDEP maps don't correlate with what is seen on the ground. There are no measurement sites from this area included in the TDEP estimates. Lichens show sulfate dropping off rapidly from the coast (30-40km), with sodium dropping off a little further. The lichen measurement data can be used qualitatively as a reality check on map estimates, if not quantitatively.

Within 100km, TDEP assumes that all sodium dry deposition is marine in origin. If the

Na:Mg ratio is the same as seawater ratio, then sodium is due to seawater. If there is

deviation from this ratio then there is likely another source of sodium.

4. TDEP Trends Discussion

The 2014 TDEP estimates were not appropriate for use calculating trends because of the many emissions scenarios used to represent different model years. The 2015 version of TDEP has consistent emission scenarios. There are still changes in inventory resulting in an artifact in the estimates (e.g., the 2007 change in methodology for NH3 inventory). Ultimately, trends should be better/more plausible with new runs (all same model version, more consistent modeling platform for meteorology and emissions).

Keep in mind that the model will continue to be updated and incorporate the best science. The next CMAQ version will be released in fall 2015 (include organic N, change N estimates). As the model changes, we will start to violate conditions necessary for accurate trends assessment. It takes 3 weeks of CPU time to run 1 year of CMAQ at a 12km grid. The resources involved to generate a time series is significant, and more than budget allows. Therefore, if CMAQ runs are not produced for pre-2011, we will have a break point in the model and an associated wrinkle in the consistency of estimates (this is an issue in base CMAQ estimates, not just specific to TDEP).

2011 is new base year. Hopefully there will be overlap between old and new models.

When the new 2015 TDEP estimates are released, we will have a good record for assessing trends. Use the annual average estimates to examine trends (not 3-year rolling averages) because the emissions and meteorology data are year specific. If doing single point comparisons, use 3-year average because end points could be very different, but if using entire period use each year separately.

5. Future CLAD and TDEP Spring Meeting

There is interest from the communities in attend both CLAD and TDEP meetings. CLAD and TDEP have more in common than other committees and benefit from an overlap in attendance. We would therefore like to see CLAD and TDEP meetings on different days. A motion was passed to ask the Executive Committee to consider having CLAD on Monday, TDEP on Tuesday, Business Meeting on Wednesday and Thursday, and Executive on Friday. CLAD and TDEP would alternate their Monday/Tuesday positions. This motion is only for Spring Meetings. Additional food should be the only cost associated with extending the meeting.

CLAD agreed that the level of detail provided by TDEP during the presentations was appropriate.

Tuesday, April 14th

The participants introduce themselves:

In person: Jason Lynch (USEPA), Claire O'Dea (USFS), Cindy Huber (CLAD), Tamara Blett (NPS), Linda Geiser (USFS), Jeff Herrick (USEPA), Tim Sullivan (E&S Environmental Chemistry), Chuck Sams (USFS), Rick Haueber (USEPA), Ralph Perron (USFS), Rich Pouyat (USFS). Phone/Online: Jennifer Phelan (RTI), Bill Jackson (USFS), Chris Clark (USEPA), Drew Bingham (NPS), Doug Burns (USGS), Ginger Tennant (USEPA), Jason Williams (Washington State University), Kevin Horn (VT), Linda Pardo (USFS), Randy Waite (USEPA), Leonard Levin (EPRI)

8:00 AM – Call to order

8:02-8:17 AM Critical Load (CL) and Ecosystem Service Workshop (*Tamara Blett*)

Tamara Blett provided an overview of the Air Quality – Ecosystem Services (AQES) Workshop that was held in Thousand Oaks, California from February 24 – 26, 2015. The purpose of the workshop was to link CLs with ecosystem services (as defined by the EPA Final Ecosystem Goods and Services (FEGS) classification system), and to: 1. support the NOxSOx secondary standards review, 2. communicate air quality impacts on federal lands, 3. provide forum for experts to discuss different ES approaches (FEGS, NESCS, MEA), and 4. develop a tool/approach for linking ecosystem stressors to end users (ecological production functions).

The workshop focused on air quality ecosystem endpoints of terrestrial and aquatic acidification and eutrophication (and not other pollutants). It was based on the concept that if a CL is exceeded, there is most likely an impact on ecology and human welfare. The workshop also stressed the need to be able to explain the chain connecting ecosystem impairment resulting from atmospheric deposition (e.g., change in surface water pH) to something that your "next door neighbor" cares about (e.g., trout).

Ecosystem services consist of two components; ecological production function and economic valuation function. The workshop focused on the first component. Ecological production functions, or ecological chains, were built that linked CL biological indicators (aquatic organisms (fish and macroinvertebrates), diatoms, lichens, herbaceous and shrub species, invasive plants, and forest systems) with ecosystem services defined by the FEGS classification system. The ecological chains were produced by four small break-out groups within the workshop, with each group focusing on the CL biological indicators associated with one of the four CL types: aquatic acidification, terrestrial acidification, aquatic eutrophication, or terrestrial eutrophication. The ecological chains that were produced consisted of a

series of cause-and-effect relationships that connected changes in the biological indicator to a final service (FEG) that people care about. In addition, each step within each ecological chain was assigned a "strength of science" score to indicate the degree to which each step was supported by a documented or tested relationship. A variety of approaches to document the chains were attempted, including flow charts and spaghetti diagrams. The following lists the total number of ecological chains identified by each of the break-out groups:

- Aquatic acidification – 76 total chains identified
- Aquatic eutrophication – 653 chains identified
- Terrestrial acidification – 77 chains identified
- Terrestrial eutrophication – 211 chains identified

At the end of the workshop, each break-out group selected a set of ecological chains to present the connections between CL biological indicators and FEGS for their CL type. Each group demonstrated how the chains could be presented as user-friendly "stories" that connected air quality to deposition to a CL to a service that people cared about (e.g., impact of N and S deposition on terrestrial acidification that ultimately impacts Christmas, bunnies, baseball, and rock-n-roll)

Next steps identified by the workshop included: 1. Writing a workshop report, 2. Developing approximately four journal articles (featured collection or issue), and 3. A follow-on workshop to identify key FEGS to bring into "benefits" assessments (valuation).

8:17-8:45 AM FOCUS

The FOCUS session consisted of updates on FOCUS, the National Critical Load (CL) Database, and the UNECE Call For Data.

1. FOCUS Update (*Cindy Huber*)

    - FOCUS work that was recently completed or is on-going includes:
        - call for data (April 2014)
        - uncertainty analysis
        - update CL database (v2.5) (March 2015)
        - bringing work of other people into FOCUS/CLAD (Linda G lichen research and CLs and Linda P work in the NE US to create spatially refining CLs)
    - Other accomplishments:
        - Forest Response to N deposition workshop (Powell Center)
        - AQES Workshop
    - What's next:
        - Prepare for Acid Rain 2015
        - FOCUS Annual Reports:
            - Complete and post reports for FY2011-FY2014
            - FY2015 report ready for the Fall CLAD meeting
            - Document response to "Call for Data 2014"
            - FOCUS poster for Acid Rain 2015 that highlights the FOCUS projects/products and how they fit into CLAD

2. National Critical Load Database (NCLD) (*Jason Lynch*)

    - Original NCLD released online in April. Updates that have been done to this original dataset include:
        - Updated metadata
        - Expanded SW CL for acidity
        - Corrections
        - Format changed to CSV from Access
        - Switched to using ORACLE
    - Revised NCLD should be released in the next couple of weeks on website

3. UNECE Call for Data (*Jason Lynch*)

    - Response to Call for Data that will be included in NCLD – Surface Waters and Forest Soils (6 different datasets)
    - Hope that by Acid Rain 2015, these new data will be incorporated into NCLD database

8:45-9:55 AM Critical Loads (CLs) Projects: Status and Results "Round Robin"

CLAD members were asked to provide an update on the CL work that are currently conducting or are involved with:

Linda Pardo (USFS):

- Empirical CL for forest ecosystems in the NE U.S. – assessing how abiotic factors influence CL of N for 22 species in NE; producing a GIS tool and General Technical Report (GTR)

Claire O'Dea (USFS):

- Just got funding to make some videos for USFS CL Portal – overview video, video on methodology (perhaps include interviews with the scientists who have developed the CLs, etc.); videos will be geared for land managers

Rich Haueber (USEPA) – AQES workshop products could be used to develop the video (e.g., present as "story")

Randy Waite (USEPA):

- Just starting project with ORD, OW, and RTI to look at FW systems and deposition loading to these systems; objective of project will be to try and determine what "threshold" to use for the selected FW systems; want to determine where air is the dominant source of N and S versus locations where air deposition is pushing the system over the "tipping" point

Tamara Blett (NPS):

- Mike Bell is the new NPS hire to fill Ellen Porter's position; Mike is a plant ecologist

Kevin Horn (VT):

- Currently working on the Forest Response to N Deposition – Powell Center Project; Using TDEP N deposition gradient (mean of 2000-2012) paired with FIA data (growth rates of trees that have been measured at least twice – one measurement cycle) to identify range of N deposition that each species is exposed to and the responses of each species to N deposition.

Tamara Blett (NPS) - What point along the curve do you define CL? In NPS, land managers use "when base line conditions are changed" (e.g., when growth is increased vs. the proposed approach that identifies the plateau/peak where growth shifts from positive to negative growth).

Chuck Sams (USFS) – Perhaps what Tamara is referring to is target load and not CL

Linda Pardo (USFS) – Tree responses can be defined as "detrimental response" in different ways (positive, negative, any change, etc.). "Detrimental response" has to be based on management objectives and priorities.

Tim Sullivan (E&S):

- Aquatic Effects Methods book – published
- NY Air Pollution Effect book –in press
- USFS Habitat Squeeze analysis
- NYSERDA project looking at impacts of soil acidification on yellow birch, sugar maple, and other tree species to determine species-specific sensitivities
- NYSERDA – climate interactions (snow pack, precipitation, and temperature) and recovery from acidification (20 lakes in Adirondack) with reduced deposition
- NYSERDA – CL Primer (outreach document to communicate with policy makers)
- EPA-ORD – feasibility of applying VSD+/PROPS model in US – applied at three sites (Great Smoky Mountains, Shenandoah, and Hubbard Brook)
- USFS – CLs for streams in two USFS wilderness areas
- EPA NOxSOx Integrated Science Assessment (ISA) – helping RTI with NAAQS review
- AQRV report for NPS – looking at air pollution impacts on parks all across the U.S.
- Appalachian Trail Report – final report documenting terrestrial and aquatic effects of acidifying deposition

Doug Burns (USGS):

- NY state is using CL as an official approach to guide air policy; workshop in February brought together scientists to determine what scientific work still needs to be done to develop CL policy); goal is to create a series of CL options; considering use of models to determine pre-industrial ANC values for each water body

Jeff Herrick (USEPA):

- Taking over Kris Novak's position representing EPA ORD at NADP-CLAD meetings
- EPA ORD NOxSOx ISA review to support the review of the secondary NOxSOx standards

Ralph Perron (USFS):

- Working with Linda Geiser and Linda Pardo on USFS projects

Chuck Sams (USFS):

- Target and CL being considered by USFS
- Restarting process for watershed restoration effort

Bill Jackson (USFS):

- Conducting water sample chemistry on ~ 1000 sites
- Have resampled spruce plots established by Texas Valley Authority (TVA) and how soil chemistry has changed (base saturation and sulfur); timber harvesting may be having more of an impact of removing base cations than S deposition
- Exploring VSD as a model where the MAGIC model can't be used

Chris Clark (USEPA):

- developed CLs for herbaceous layers based on N gradient meta-analysis

Jennifer Phelan (RTI):

- EPA NOxSOx ISA support
- ForSAFE-Veg model to evaluate the interactive impacts of deposition and climate change in the sugar maple-beech-yellow birch forests of the NE U.S.
- New Integrated N Project
- Comparison of CL with deposition from 1850-2025; CMAQ model runs under emission reduction scenarios based on EPA SAB Integrated Nitrogen report
- Projected changes in forest composition and associated ecosystem services with N deposition in the NE U.S.
- Summary and Integration of N Project

9:55 AM Adjourn for the morning

5:00-6:00 PM CLAD Business (*Jason Lynch and Claire O'Dea*)

A motion passed to approve the 2014 fall minutes and summary.

Webinar Update

Since the Fall 2014 meeting, CLAD has held three intermeeting webinars (one to present research by Chris Clark and two to discuss the development of the CL maps).

Webinar set for April 30 is "Threshold of acceptable loss." This webinar will discuss the concept of setting a CL to protect X% of species (or protect a species to x% of abundance).

Future webinar (date not yet determined) to facilitate a conversation about CL definitions, specifically related to target loads. This webinar will likely occur in June. The webinar will discuss the definitions and application applications of the terms.

We welcome other webinars. Please communicate webinar ideas to Jason and/or Claire.

Fall Meeting

CLAD 2015 Fall Meeting will coincide with 2015 Acid Rain Conference. CLAD will have a maximum of 2 hours on Monday (maybe less). We will elect a new co-chair at this meeting. Tamara Blett is organizing a CLs session for the conference, tentatively scheduled for Tuesday from 1:30-3:30PM. There will be one invited and four other speakers. Tamara has invited, but hasn't heard back from Jean-Paul regarding his attendance.

CLAD should consider developing posters (e.g., a FOCUS poster to tell the CLs story in the U.S.) Jason Lynch will be submitting an abstract for surface water CLs. Chris Clark may submit an abstract for his CL project work. The USFS and NPS will submit posters that describe their CL tools.

CLAD information can be presented at the NADP and/or an agency table. In addition, CLAD CL posters can be moved to the table(s) after the poster session. The EPA, NPS, and USFS could demonstrate their online tools at the CLAD table. CLAD brochures and the final CLAD map publication will be displayed/available at the CLAD and/or agency table(s). The brochure does not need to be updated. What do we want from that table? Are we trying to promote international or national membership for CLAD? We may need to recruit an international scientist (e.g., a Chinese speaking scientist) to be present at the CLAD booth to facilitate communication. Think about our key messages; what would we want them to communicate to Chinese scientists?

CL Load Publications

If you have any CL publications, send them to Jason Lynch and Claire O'Dea for posting to CLAD website. Send the DOI for posting. Researchgate shows 246 views on the FOCUS paper (126 in US, 42 in China). References/publications on the CLAD website are organized by year (2008-present, generally in alphabetical order).

CLAD website

If there are any issues with the CLAD website, contact Jason or Claire. Currently, there may be an issue with automatically signing up for CLAD listserve. Cindy has updates for the FOCUS page to link to the publication. The CLAD CL database documentation will be made more accessible. Additional links and pages can also be added.

CLAD renewal

CLAD, as a NADP science sub-committee was supposed to be renewed by the NADP Executive Committee last year. CLAD co-chairs developed a presentation asking the Executive Committee for renewal. We went back to our mission and charges from handbook and provided examples to show what we have done/are doing to meet those objectives. We also developed a fact sheet listing 31 accomplishments since 2011, along with a section on current/future projects. We can include this document at CLAD table during the 2015 Acid Rain conference.

New CLAD Business and General Discussion

There are many version of calculations of anthropogenic (background) emissions, varying from 0.2-1 kg/ha N. Sulfur is ~0.5kg/ha.

A question was asked about the use of NADP data for ammonia (fertilizer plants going up rapidly near oil and gas (O&G) to collocate near O&G supply? In the future, we will see NH3 increasing around O&G sites NADP data shows NH3 migrating towards O&G areas.

There will be a discussion about spring schedules in the Joint and Executive Meetings. In the future, committee chairs will get together before meetings to better coordinate the schedules and determine how much time subgroups need before finalizing agendas. EROS will put forth this motion. Spring meetings will likely be held closer to Illinois to save costs for the Program Office. Spring 2016 meeting will be in Madison, WI. EROS and NADP are also working on addressing sound issues.

6:00 PM Meeting Adjourns

3.0 INTER-MEETING WEBINARS

During the 2014 – 2015 NADP-CLAD year, there were a total of six inter-meeting webinars. Three of these webinars were focused on the CLAD Critical Load maps, one discussed critical load thresholds, and two reviewed critical load definitions.

The three meetings that discussed the CLAD Critical Load maps were held on February 2nd, March 18th and May 11th. During these meetings, critical load maps for terrestrial acidification, aquatic acidification, and empirical critical loads of nitrogen for biological end points including mycorrhizae, lichen, forest ecosystems, and herbaceous plants/shrubs were presented. The goals of the maps are to: 1. educate, 2. illustrate critical loads in the National Critical Load Database (NCLD), and 3. identify data gaps and additional needs. Jason Lynch led these meetings and posed questions to the attendees regarding the end points, map scales and resolution, representation of multiple critical loads, critical load threshold values, and caveats that should be documented with the maps. The next steps in the development of the Critical Load maps are a draft maps and write-up combined by September 1, 2015 and submission of the maps and document to NADP thereafter.

A webinar was held on April 30th to discuss critical load thresholds of acceptable loss for species/systems. The webinar was led by Chris Clark and Linda Geiser. During this webinar, the importance of considering different functional forms of response, different definitions of thresholds, cascade of changes, and potential importance of other variables (e.g., climate change) were discussed. In general, participants agreed that it was important to consider all these factors when determining critical load thresholds and that selection of thresholds would differ by agency and management objective. Many participants suggested that it may be useful for CLAD critical loads to be translated into a matrix based on different thresholds and corresponding levels of protection.

Two inter-meeting webinars were held to review critical load definitions that could be adopted by NADP-CLAD. These webinars were held on July 30th and September 1st. All terms related to critical loads along with proposed and alternate definitions were compiled by the CLAD co-chairs and secretary. These terms and definitions were circulated to CLAD members for review and comments. The final list of terms and definitions was presented and reviewed during the webinars. During the webinars, additional changes

were made to the definitions based on the comments of the webinar attendees. The draft terms and definitions will be presented at the Fall 2015 meeting. The final terms and definitions will be presented and approved by NADP-CLAD at the Spring 2016 meetings. The final approved list of terms and definitions will be posted on the NADP-CLAD website.

4.0 CLAD RE-CERTIFICATION

CLAD, as a NADP science committee, has to be reviewed and renewed every four years. The latest renewal was scheduled to occur in 2014. CLAD co-chairs developed a presentation that was presented to the Executive Committee during the Spring 2015 meeting to request renewal of CLAD. The presentation documented the CLAD mission and provided examples of how the mission has been and is continuing to be met. A fact sheet listing 31 accomplishments since 2011 was also compiled, along with a section on current/future projects. NADP-CLAD Science Subcommittee was successfully renewed by the NADP Executive Committee on April 15, 2015. See Appendix I for a summary of the NADP-CLAD Accomplishments from 2011 to 2015.

5.0 PUBLICATIONS

Critical load-related publications that were added to the CLAD website prior to the Fall 2015 meeting included the following.

2015

Clow, David W., Heidi A. Roop, Leora Nanus, Mark E. Fenn, Graham A. Sexstone. 2015. Spatial patterns of atmospheric deposition of nitrogen and sulfur using ion-exchange resin collectors in Rocky Mountain National Park, USA. Atmospheric Environment 101 (2015) 149-157. doi:10.1016/j.atmosenv.2014.11.027

Mast, M. Alisa, David W. Clow, Jill S. Baron, and Gregory A. Wetherbee. 2015. Links between N Deposition and Nitrate Export from a High-Elevation Watershed in the Colorado Front Range. Environmental Science Technology doi:10.1021/es502461k

2014

Blett, T.F., J.A.Lynch, L.H. Pardo, C. Huber, R Haeuber, R. Pouyat. 2014. FOCUS: A pilot study for national-scale critical loads development in the Unites States. Environmental Science and Policy. 38:225-236. doi:10.1016/j.envsci.2013.12.005

Cox, R. D., K. L. Preston, R. F. Johnson, R. A. Minnichc, E. B. Allen. 2014. Influence of landscape-scale variables on vegetation conversion to exotic annual grassland in southern California, USA. Global Ecology and Conservation 2 190–203. doi:10.1016/j.gecco.2014.09.008

Cummings, T., T. Blett, E. Porter, L. Geiser, R. Graw, J. McMurray, S. Perakis and R. Rochefort. 2014. Thresholds for protecting Pacific Northwest ecosystems from atmospheric deposition of nitrogen: State of knowledge report. Natural Resource Report NPS/PWRO/NRR—2014/823. National Park Service, Fort Collins, Colorado. (link)

McDonnell T.C., S. Belyazid, T.J. Sullivan, H. Sverdrup, W.D. Bowman, E.M. Porter. 2014 Modeled subalpine plant community response to climate change and atmospheric nitrogen deposition in Rocky Mountain National Park, USA. Environmental Pollution 187. doi:10.1016/j.envpol.2013.12.021

McDonnell, T.C., and T.J. Sullivan. 2014. Comparison of Regional Stream ANC Predictions for the George Washington National Forest Using Spatial and Non-Spatial Regression Modeling. Final Report USDA Forest Service, Asheville, NC. E&S Environmental Chemistry, Inc. pp. 37. (link)

McDonnell, T. C., T. J. Sullivan. 2014. Total Atmospheric Nitrogen and Sulfur Deposition in Forest Service Wildernesses and National Forests Throughout the Conterminous United States. E&S Environmental Chemistry, Inc. Corvallis, OR (link)

McDonnell, Todd C., Timothy J. Sullivan, Paul F. Hessburg, Keith M. Reynolds, Nicholas A. Povak, Bernard J. Cosby, William Jackson, and R. Brion Salter. 2014. Steady-state sulfur critical loads and exceedances for protection of aquatic ecosystems in the U.S. southern Appalachian Mountains. Journal of

Environmental Management, Volume 146, 15 December 2014, Pages 407–419, doi:10.1016/j.jenvman.2014.07.019

McMurray, J. A., D. W. Roberts, L. H. Geiser. 2014. 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

New York State Energy Research and Development Authority (NYSERDA). 2014. CRITICAL LOADS FOR AIR POLLUTION: MEASURING THE RISKS TO ECOSYSTEMS. NYSERDA Report 14-24. Prepared by the Wildlife Conservation Society and E&S Environmental Chemistry. (link)

Phelan, Jennifer, Salim Belyazid, Daniel Kurz, Scott Guthrie, James Cajka, Harald Sverdrup, Randall Waite. 2014. Estimation of Soil Base Cation Weathering Rates with the PROFILE Model to Determine Critical Loads of Acidity for Forested Ecosystems in Pennsylvania, USA: Pilot Application of a Potential National Methodology. Water Air Soil Pollut (2014) 225:2109, doi:10.1007/s11270-014-2109-4

Povak, N. A., P. F. Hessburg, T. C. McDonnell, K. M. Reynolds, T. J. Sullivan, R. B. Salter, and B. J. Cosby. 2014. Machine learning and linear regression models to predict catchment-level base cation weathering rates across the southern Appalachian Mountain region, USA, Water Resour. Res., 50, doi:10.1002/2013WR014203

Scheffe, R. D J. A. Lynch, A. Reff, J. T. Kelly, B. Hubbell, T. L. Greaver, J. T. Smith. 2014. The Aquatic Acidification Index: A New Regulatory Metric Linking Atmospheric and Biogeochemical Models to Assess Potential Aquatic Ecosystem Recovery. Water Air Soil Pollution 225:1838. doi:10.1007/s11270-013-1838-0

Schirokauer, D., L. Geiser, A. Bytnerowicz, M. Fenn, and K. Dillman. 2014. Monitoring air quality in Southeast Alaska's National Parks and Forests: Linking atmospheric pollutants with ecological effects. Natural Resource Technical Report NPS/SEAN/NRTR—2014/839. National Park Service, Fort Collins, Colorado (link)

Shaw G. D., R. Cisneros, D. Schweizer, J. O. Sickman, M. E. Fenn. 2014. Critical Loads of Acid Deposition for Wilderness Lakes in the Sierra Nevada (California) Estimated by the Steady-State Water Chemistry Model. Water Air Soil Pollution (2014) 225:1804. doi:10.1007/s11270-013-1804-x

Sheibley, R. W, M. Enache, P. W. Swarzenski, P. W. Moran, J. R. Foreman. 2014. Nitrogen Deposition Effects on Diatom Communities in Lakes from Three National Parks in Washington State. Water Air Soil Pollution (2014) 225:1857. doi:10.1007/s11270-013-1857-x

Watmough, Shaun A., Colin J. Whitfield , Mark E. Fenn. 2014. The importance of atmospheric base cation deposition for preventing soil acidification in the Athabasca Oil Sands Region of Canada. Science of the Total Environment 493 (2014) 1–11. doi:10.1016/j.scitotenv.2014.05.110

APPENDIX I

CLAD 4-year Accomplishments (2011-2015)

Direct and indirect accomplishments where CLAD initiated, supported, or funded the work.

1. Sponsored a critical load session at the Fall NADP Scientific Symposia for the past 4 years - 2011 to present

2. Attendance at CLAD meetings during the Spring and Fall NADP meetings is between 18 and 41 participants

3. Represented CLAD at the UNECE ICP Modelling and Mapping Task Force Meetings: L. Pardo and J. Phelan (2011), J. Lynch (2012), C. Clark (2014)

4. Supported and funded (NPS and EPA) Rocky Mountain ForSAFE-Veg Workshop 2011 (T. Sullivan, H. Sverdrup) and publication Sverdrup et al. 2012, McDonnell et al. 2014

5. CLAD-FOCUS submission of compiled U.S. critical load data to the UNECE in 2011 (T. Moore, J. Lynch)

6. CLAD-FOCUS competed 1.0v National Critical Load database (NCLD) and FOCUS Phase I Report 2011 (T. Moore, J. Lynch)

7. Funded (EPA) the development of empirical nitrogen critical loads for ecoregions of the United States (L. Pardo) and publications Pardo, et al. 2011 a, b

8. CLAD developed a NADP Critical Loads Brochure 2011 (T. Blett)

9. CLAD Webinar - NADP-CLAD National Critical Load Database (NCLD) of Empirical and Modeled Critical Loads of Nitrogen and Sulphur 2012 (J. Lynch)

10. CLAD connected critical loads to AQ management in several EPA products/processes (Acid Rain and CAIR Annual Reports for 2010 to present, US-Canada Reports 2013 and 2015) (R. Haeuber and J. Lynch)

11. Funded (EPA and USGS), contributed critical loads and support to the NAPAP 2011 (D. Burns, R. Haeuber)

12. Funded (EPA and USFS) the development of Steady-state sulfur critical loads and exceedances for protection of aquatic ecosystems in the U.S. southern Appalachian Mountains 2012-2014 (T. Sullivan and W. Jackson) and publication McDonnell et al. 2014, Povak et al. 2014 & other publications

13. CLAD-FOCUS Phase II Workplan Completed, establishing five “workgroups” to review specific critical load issues and research needs. These group include: a) Improve the Forest Ecosystem Critical Load Estimates, b) Improve the CLs of Nutrient Nitrogen for Epiphytic Lichens, c) Improve

Empirical CLs of Nitrogen, d) Improve Surface Water CL Calculations and Uncertainty, and e) Maintain and Expand the CL Database 2012 (C. Huber)

14. CLAD-FOCUS completed a review of the methodologies and identification of potential approaches to improve the base cation weathering (BCw) and ANC leaching (ANCleach) parameters of the Simple Mass Balance (SMB) model/equation used to calculate terrestrial/forest ecosystem CLs in the U.S. 2012 (J. Phelan)

15. CLAD-FOCUS completed improvements of the CL model for lichens by calibrating it for each EcoRegion in the US. Linda Geiser and the USFS are utilizing the Forest Inventory and Analysis (FIA) lichen species, as well as associated tree species, information from plots across the country to expand the lichen dataset for the CL model 2012 (L. Geiser)

16. CLAD provided scientific information and critical load data for review of the NAAQS Secondary Standard for NOx and SOx 2013 (J. Lynch and R. Scheffe) and publication - Scheffe et al. 2014

17. Funded (EPA) the development and test of a national methodology to estimate Soil Base Cation Weathering Rates with the PROFILE model to support terrestrial/forest ecosystem CLs 2013 (J. Phelan and R. Waite) and publication Phelan et al. 2014.

18. CLAD-FOCUS added a workgroup to address biodiversity and critical loads. The group will respond, informally, to the UNECE-CCE "Call for Data" (C. Clark)

19. CLAD-FOCUS publication of the National Critical Load database (NCLD) 2013 (T. Blett) and publication Blett et al. 2014

20. CLAD-FOCUS sponsored John Wesley Powell Center for Analysis and Synthesis Project - Forecasting Forest Response to N Deposition: integrating data from individual plant responses to soil chemistry with a continental-scale gradient analysis 2013-present (L. Pardo, T. Blett, C. Huber)

21. CLAD-FOCUS completed 2.0v National Critical Load database (NCLD) 2013 (J. Lynch and C. Huber)

22. Supported the John Wesley Powell Center Analysis and Synthesis Project - Nitrogen Meta-analysis of impacts of N deposition on understory species composition 2013- present (C. Clark)

23. CLAD Webinar - National Ecosystem Services Classification System (NESCS) 2014 – (P. Sinha and G. V. Houtven, RTI). Attended by 30 participants.

24. CLAD Webinar/Discussion - Critical Loads of Hg Deposition in the US: Overview and Some Considerations 2014 (D. Burns). Attended by 45 participants.

25. CLAD Webinar/Discussion - Critical Load and Uncertainty 2014 (L. Pardo). Attended by 15 participants.

26. CLAD Workshop - Very Simple Dynamic Model (VSD) by Dr. Reinds, Senior Scientist at Wageningen University & Research Centre 2014 (J. Phelan, T. Blett)

27. Contributed to the Development and release of the Air Quality Portal for Land Management Planning: The application and use of critical loads for management and policy decisions 2013-ongoing (C. O'Dea)

28. CLAD Webinar/Discussion - National meta-analysis of impacts from nitrogen deposition on terrestrial plant biodiversity: Overview and updates 2015 (C. Clark). Attended by 30 participants.

29. CLAD Workshop - Air Quality and Ecosystem Services Workshop 2015 (T. Blett, J. Phelan, Eric Davidson, Cindy Huber). Attended by 25 participants.

30. CLAD Webinar - Critical Load Maps 2015 (J. Lynch). Attended by 35 participants.

31. CLAD competed 2.5v National Critical Load database (NCLD) 2015 (J. Lynch and C. Huber)

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