National Atmospheric Deposition Program

Critical Loads of Atmospheric Deposition Science Committee

NATIONAL ATMOSPHERIC DEPOSITION PROGRAM (NADP) CRITICAL LOADS OF ATMOSPHERIC DEPOSITION (CLAD) 2018-2019 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 2018-2019 Annual Report of CLAD. The Annual Report contains sections that describe CLAD accomplishments, progress on CLAD Working Groups, CLAD products, the Fall 2018 and Spring 2019 CLAD 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, projects conducted by members of CLAD, and CL-related publications added to the CLAD website during the year.

The CLAD Executive Team for 2018-19

Co-Chairs: Michael Bell (NPS), Jeff Herrick (EPA)
Secretary: Linda Geiser (USFS)
National Critical Load Database (NCLD) Manager: Jason Lynch (EPA)
CLAD Technical Advisor: Jennifer Phelan (until June 2019)

Additionally, CLAD has an Advisory Board made up of past-chairs, working group leads, and federal agency representatives who help guide CLAD activities and maintain cohesion across working groups.

CLAD Advisory Board: Tamara Blett, Chris Clark, Tonnie Cummings, Emmi Felker-Quinn, Rick Haeuber, Linda Pardo, Claire O'Dea, Mark Fenn,

This 2018-19 Annual Report was produced by the CLAD Executive Team, reviewed by CLAD members, and accepted on November 5th, 2019.

2.0 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 a CL session (Critical Loads: Acidification and Excess Nitrogen Thresholds) at the Fall 2018 Scientific Symposia. Held a session on recovery for cessation of N and S deposition at the 2019 NADP Spring Meeting.
2. Attendance at CLAD meetings during the Fall 2018 and Spring 2019 NADP meetings was between 45 and 32 participants.
3. Represented NADP/CLAD as the U.S. non-official National Focal Centre (NFC) at the combined 19th Joint Expert Group (JEG) on Dynamic Modelling and 35th Task Force ICP M&M meeting that was held in Madrid, Spain in April 2019.
4. Continued the efforts of the five Working Groups (WGs) within CLAD.
5. CLAD members had three core journal articles published that provide significant advancements in our knowledge about how ecosystem components are responding to nitrogen and sulfur deposition on a national level; herbaceous species (Clark et al. 2019), tree growth and survival (Horn et al. 2018), and lichen community richness (Geiser et al. 2019).
6. Updated publicly-available online CL Mapper Tool to v2.1 (https://clmapper.epa.gov) based, in part, on data from the NADP-CLAD NCLD.

3.0 CLAD WORKING GROUPS

Working Groups (WGs) have been a component of CLAD since 2011. The objectives of the CLAD WGs are to increase our understanding and ability to estimate, represent, and communicate CLs of deposition in the U.S. There are a total of five CLAD WGs.

3.1 WG-1 ADDING NEW DATA AND CRITICAL LOADS TO THE NADP-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 NADP-CLAD NCLD.

During the year, WG-1 continued to add CL data and make corrections to Version 3.0 of the NADP-CLAD NCLD and supporting documents. A new release (Version 3.1) of the database is planned for the end of 2019. Critical loads added include: (1) surface water CLs from the Appalachian Trail (AT) Study (Lawrence et al., 2015), (2) surface water CLs for Loch Vale, CO (Sullivan et al.,2005), (3) surface water CLs for Great Smoky Mountains National Park (Fakhraei et al., 2016), (4) surface water CLs for the Adirondacks, NY (Sullivan et al., 2012), and (5) new version of CONUS herb species richness CLs based on the equation from Simkin et al. (2016). The new herb species richness CLs will be only for Ecoregions III and IV where enough plot data is present. In addition, National Landcover classes for “open” and “closed” canopy ecosystems are only present in the new GIS layer. Areas where these CLs don’t apply are removed. Given that landcover data is at a 30 meter resolution, producing vector based GIS layers that are small enough in size to be shared has been difficult. Also a database for N-enrichment CLs for surface waters in the western U.S. (Williams et al., 2017a&b) is currently under development.

Fakhraei, H., Driscoll, C.T., Renfro, J.R., Kulp, M.A., Blett, T.F., Brewer, P.F., and J.S. Schwartz. 2016. Critical loads and exceedances for nitrogen and sulfur atmospheric deposition in Great Smoky Mountains National Park, United States. Ecosphere 7(10):e01466. doi:10.1002/ecs2.1466

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 K.C. Weathers. 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.

Simkin, S.M., Allen, E.B., Bowman, W.D., Clark, C.M., Belnap, J., Brooks, M.L., Cade, B.S., Collins, S.L., Geiser, L.H., Gilliam, F.S., Jovan, S.E., Pardo, L.H., Schulz, B.K., Stevens, C.J., Suding, K.N., Throop, H.L., 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 113(15): 4086-91.doi:10.1073/pnas.1515241113

T. J. Sullivan, T.J., Cosby, B.J., Tonnessen, K.A., and D. W. Clow. 2005. Surface water acidification responses and critical loads of sulfur and nitrogen deposition in Loch Vale watershed, Colorado. Water Resource Research 41: W01021. doi:10.1029/2004WR003414.

Sullivan, T.J., Cosby, B.J., Driscoll, C.T., McDonnell, T.C., Herlihy, A.T., and D.A. Burns. 2012. Target loads of atmospheric sulfur and nitrogen deposition for protection of acid sensitive aquatic resources in the Adirondack Mountains, New York. Water Resource Research 48 (W01547): 1-16. doi:10.1007/s13412-011-0062-8

Williams, J., and S.G. Labou. 2017. A database of georeferenced nutrient chemistry data for mountain lakes of the Western United States. Scientific Data. doi:10.1038/sdata.2017.69

Williams, J. J., J. A. Lynch, J. E. Saros, and S. G. Labou. 2017. Critical loads of atmospheric N deposition for phytoplankton nutrient limitation shifts in western U.S. mountain lakes. Ecosphere 8(10):e01955. doi:10.1002/ecs2.1955

3.2 WG-2 CHARACTERIZING UNCERTAINTY IN CRITICAL LOAD ESTIMATES

<u>Objective</u>: The objective of this WG is to provide estimates of uncertainty for CLs in a standardized way to support the comparison of the strength of critical loads between critical load types and datasets.

Working Group 2 continued to refine the 5-point scores for confidence in five critical loads (i.e. herb species richness, herb species, tree species, lichen, aquatic acidification). These scores included several criteria based on data quality, methodology employed, and statistical strength. We hope to complete the effort in the Fall 2019 and write it up either as a single stand-alone paper on critical load confidence, or as a component of individual papers focused on specific critical loads (e.g. trees), or as some combination (decision planned for fall meeting).

3.3 WG-3 CRITICAL LOAD SYNTHESIS

<u>Objective</u>: The objective of this WG is to develop a methodology/process for combining and representing multiple CLs in a rigorous, reproducible, and defensible manner to provide guidance in synthesizing and mapping CLs and in interpreting CL outputs. Different methodologies will be developed to meet the needs of the different federal agencies: EPA, NPS, USFS, BLM, and FWS.

This year WG-3 worked to gather all critical load and exceedance information for the Bridger-Teton National Forest to help develop a report to show managers what ecosystem components are at risk. The Bridger-Teton National Forest has critical loads of N for herbaceous species richness, tree species growth, tree species survival, reduced lichen detectability (4 types), and aquatic eutrophication. It has critical loads of acidification for decreased ANC in lakes and streams, tree species growth, tree species survival, and reduced lichen detectability (4 types). The report summarizes critical load exceedances based off of TDep Total N and Total S for 2015-2017. The intent of the report is to show the risk to the various ecosystem components in a standardized way that can be applied to all federal lands.

WG-3 had to put off a workshop planned for February 2019 due the government shutdown. The workshop was held in April 2019 in Washington, DC and focused on refining the PowerPoint presentation for managers and defining the content of the report for the case studies including the format of the figures and tables. The a brief PowerPoint presentation targeted towards resource managers was presented during the Joint Sub-committee meeting in May 2019 by Mike Bell and was well received. Over the rest of the year, WG-3 addressed topics including how to set CLs and continued working on finalizing the report content and format.

The goals of WG-3 for next year will be to: (1) finalize decisions for each of the CL types, (2) develop a manual for describing the processes for determining the CL for a specific area (with highlighted differences for each agency if they exist), (3) determine how to synthesize multiple CLs for an area, (4) finalize the case study report format, (5) decide whether to create reports for all case studies, (6) complete phases 1 an 2 of the case studies, and (7) complete case study reports , and (8) draft several synthesis manuscripts for journals.

3.4 WG-4 UNCERTAINTY IN DEPOSITION MODELS AND ESTIMATES

Objective: The objectives of this WG are to understand the uncertainty that exists in measurements and models used to estimate the deposition of nitrogen (N) and sulfur (S) to the ecosystem. Deposition measurements being assessed by this WG at this time include bulk precipitation collectors, IER resin columns, snow pack, and lichen tissue. Models being evaluated are CMAQ, TDEP, CAMx, and ADAGIO. Measurements and models will be compared to attempt to assess the spatial variability of uncertainty of deposition across the contiguous US. This will benefit CL analysis by developing a framework of how CLs developed from different sources can be compared and used in unison.

During the year, WG-4 worked to integrate the conversations that took place the previous year into a qualitative metric (weighted deposition uncertainty metric, WDUM; Walker et al. 2019) to define the uncertainty of the TDep map. This was based on the relative uncertainty of each deposition type based on measurement and modeling methods. The WDUM was then compared to critical loads in areas that were near exceedance to get a sense of how the dominant form of uncertainty may over- or under-estimate an exceedance.

Walker, J.T., Bell, M.D., Schwede, D., Cole, A., Beachley, G., Lear, G., and Z. Wu. 2019. Aspects of uncertainty in total reactive nitrogen deposition estimates for North American critical load applications. Science of the Total Environment 690:1005-1018. doi: 10.1016/j.scitotenv.2019.06.337.

3.5 WG-5 CRITICAL LOADS OUTREACH AND COMUNICATION

Objective: CLAD has successfully produced extensive CL materials (NCLD, CLAD website, CL definitions document, CL presentation, CL Tools, etc.), and continues to actively develop additional resources such as methods to characterize uncertainty in deposition and CL estimates and a method to synthesize multiple CLs. The CLAD Advisory Board, therefore identified the need for improved CL extension and communications, and in January 2018, initiated CLAD WG-5. The goal of this WG is to develop an outreach and communication strategy to communicate the concept and use of CLs to stakeholder groups.

This year, WG-5 has been working in collaboration with the US Forest Service, USFS Missoula Technology Development Center, and USDA media center to develop a set of videos that will provide visually appealing, information rich, easily accessible introductions to critical loads and air pollution sensitive components of ecosystems for managers, regulatory agencies, and interested publics.

Seven 6-8 minute films are planned: Introduction, Lichen CLs, Herb CLs, Tree CLs, Aquatic acidification CLs, Aquatic eutrophication CLs, Synthesis and application of CLs. Scripts completed for Introduction, Lichen CLs, and Aquatic Acidification CLs, and are in progress for Herb, Tree, and Aquatic Eutrophication CLs. Filming was completed for lichen video in summer 2019 in the Columbia River Gorge National Scenic Area (OR and WA) and some footage filmed for other videos. Additionally, existing professional footage in the USDA library will be used. One or two additional filming trips will likely be needed, possibly to the SE US, Rocky Mountains, or southern CA.

4.0 CLAD PRODUCTS

CLAD produces documents, maps, datasets, and other materials to support advancing the estimation and representation of CLs in the U.S. During the 2018-19 year, two CLAD products were developed; CL Presentation and Map Summary.

4.1 CRITICAL LOAD PRESENTATION

CLAD members identified the need for a presentation that describes CLs as both a scientific concept and management tool. Therefore, CLAD developed a generic PowerPoint presentation consisting of over 35 slides that define and provide information about CLs and atmospheric deposition for audiences that vary in their background knowledge on the subjects. The presentation was first started in 2016-2017 and the final draft was produced in 2017-2018. The final version was uploaded to the NADP-CLAD website in 2019 and is now available for download.
(http://nadp.slh.wisc.edu/committees/clad/CladPresentation.aspx).

4.2 MAP SUMMARY

The Critical Load Map Summary provides a compilation of empirical and calculated CL values from a variety of regional- and national-scale projects. These maps illustrate CLs in the NADP-CLAD NCLD and help to identify spatial gaps in information, as well as additional research needs. These maps focus on CLS of sulfur and nitrogen deposition and the effects on terrestrial and aquatic environments. The first Critical Load map Summary was developed in 2015.

In October 2017, a second Critical Load Map Summary was released, and presents maps based on the NADP-CLAD NCLD v3.0 (http://nadp.slh.wisc.edu/committees/clad/CLMapSummary/). It contains maps for the following CLs:

- Surface Water Critical Loads for Acidity
- Forest Soil Critical Loads for Acidity
- Empirical Critical Loads for Nitrogen
- Critical Loads for Herbaceous Biodiversity.

A 3rd version of the Critical load Map Summary is currently under development and is expected to be released at the end of 2020 with up to date critical load information and exceedances based on current TDep data. The main updates will include the updated Ecoregion herb species richness CLs, new exceedance maps for aquatic acidification, plot level herb species richness CLs, and lichen species richness CLs. Exceedance uncertainty will be incorporated into the calculation and map representation. The exceedance maps will be accompanied with an explanation for how the values were calculated and what they represent.

5.0 CLAD MEETINGS

The Fall CLAD Meeting was conducted on November 6th during the 2018 NADP Fall Symposium from November 5th – November 8th in Albany, New York. The Spring CLAD meeting was conducted May 14th during the 2019 NADP Spring Meeting from May 13th – 16th in Madison, Wisconsin. The minutes from the Fall Conference and Spring Meetings are available on the NADP-CLAD website (http://nadp.slh.wisc.edu/committees/clad/minutes.aspx).

5.1 FALL 2018 MEETING

The 2018 Fall NADP-CLAD Science Sub-Committee Meeting was held on Tuesday, November 6th from 10:20 am – 12:15 pm in the Grand Salon 1 Room of the Hilton Hotel in Albany, New York. A total of 39 people attended and 6 joined remotely. The main topics discussed during the meeting included: review of CLAD Annual Accomplishments, updates from four CLAD Scientific Working Groups (WGs), announcement of CL papers and posters that were presented at the NADP science symposium, CLAD members sharing updates on the current CL-related work, and CLAD business.

CLAD WG Updates: WG1 (Jason Lynch) presented updates to the NCLD v3.5. WG2 (Chris Clark) gave a verbal update on characterizing uncertainty and a 5-point scale for trees, herbs and new lichen information. WG3 (Linda Pardo) updated the group on WG3 meeting on the previous day. Made progress on Case Studies in 3 regions. Developing a Powerpoint for Joint. WG4 (Mike Bell) provided an update on the progress of the deposition uncertainty group and a summary of the bulk deposition versus throughfall measurements given.

Major Projects and Reports discussed:

- Tree Critical Loads (Horn et al.) (Chris Clark, Linda Pardo, Mike Bell): Horn et al. paper published. It is an assessment of the growth and survival response of 94 tree species to N and S deposition across the U.S.
- Lichen Species and Functional Group CLs (Linda Geiser and Peter Nelson): Lichen database with FIA. Characterize sensitivity to N & S. Discussed the question of what does one CL really mean for managers?
    - EPA/NOxSOxPM Update (Jeff Herrick [ISA] and Ginger Tennant [REA/PA]): Public review by CASAC for 2nd draft ISA in September. Risk and Exposure Assessment plan reviewed and waiting for feedback from CASAC.
    - Profile Modeling, Base Cation Weathering, and Forest Soil Acidification Critical Loads update (Jennifer Phelan)
    - Update on the USFS 3-volume GTRs – Trees (v.1, Clark), Lichen (v.2, Geiser), Herbs (v.3, Clark)
    - A presentation on Critical Loads Development and Assessment - Habitat Suitability for Understory Vegetation (Todd McDonnell, Chris Clark and Mike Bell)

- CLAD Business: CLAD business included accepting the minutes from the Spring 2018 CLAD meeting, filling the CLAD Executive Team positions, and proposed topics for the Spring 2019 meeting. Jason Lynch ended his term as CLAD co-chair, Jeff Herrick stepped up from secretary to incoming co-chair of CLAD with Mike Bell as the other co-chair, and Linda Geiser was elected as the new CLAD secretary.

5.2 SPRING 2019 MEETING

The 2019 Spring NADP-CLAD Science Sub-Committee Meeting was held on Tuesday, May 14th from 1:30 pm – 5:00 pm in the Madison Concourse Hotel in Madison, WI. A total of 29 people attended and 3 joined remotely.

- **Mike Bell** (NPS), lead for the CLAD executive team and CLAD board, called the meeting to order, led introductions, and shared how CLAD is organized.
- **Jason Lynch** (EPA), CLAD exec team, presented 5 and 10 year awards to recognize long-standing CLAD members
- **Jen Phelan** (RTI) reviewed the Critical Loads slide show sponsored by CLAD's board and posted on the CLAD website; reviewed a draft manuscript on naming conventions for critical loads; and shared takeaways from the ICP M&M meeting in which she represented CLAD.
- **Jason Lynch** presented a talk on *Trends in water quality in the northeastern US*. Strong declines in sulfates have been documented in Maine, Vermont, and New York but not Virginia. While lakes in the NE are recovering chemically, future ANC recovery is likely to be limited by increases in DOC and base cation recovery. Greening and browning are occurring.
- **Barry Baldigo** presented a talk on *Evidence for recovery and modeling biological responses to decreases in acid deposition in streams of New York*. Acid deposition is decreasing and with it aluminum (Al) and pH. Fish are starting to recover in the Catskills but recoveries in acidified Adirondack streams are delayed. On the positive side, duration of highly toxic Al was shorter in 2015-2017 than in 1990s at Buck Creek.
- **Michael Bell** presented on *N fertilization effects on vegetation communities in California*. The experiment took place south of Riverside, CA. Added 10-15 kg N ha yr for approximately 10 yrs. measuring control and fertilized plots every year and ten more years after fertilization stopped. Native forbs had equivalent cover in fertilized and control plots 11 years after fertilization. Shrubs and grasses were favored by fertilization over the long run.
- **Carly Stevens** provided a *European perspective on recovery from nitrogen deposition*. She showed a general correlation between species richness and N deposition in a range of habitats. Of 36 global studies, vegetation was slow to recover in the majority and continued critical load exceedance was a major barrier to recovery. Below ground communities and soil processes also recovered slowly while soil chemical properties responded more quickly. Reducing deposition to levels that are low enough is the bottom line. Prescribed fire can help reduce soil N.
- **Chris Clark** discussed *Recovery of terrestrial ecosystems from long term exposure to elevated N*. Plant community recovery depends on how much the community has shifted, presence of viable seeds in the seed bank, seed dispersal rates, and reducing the stressor by processing or leaching N stored in soil, litter, or biomass. Fast cycling components like soil nitrate leaching, tissue N

concentrations, soil inorganic N concentrations, living plant biomass recover quickly compared to slow cycling components like soil N, litter mass and N, plant community composition, net N mineralization. Intermediate variables are microbial biomass and composition. Regarding forests, C addition reduced soil N availability but did not affect soil pH or diversity. Liming increased soil N availability and increased soils alkalinity. Prescribed burning and thinning increased soil N availability and had no effect on soil pH or species diversity.

- **Ryan McCammon** gave an *Update on BLM use of Critical Loads in oil and gas NEPA*. Federal land management agencies aren't setting CLs, they are using published CLs to document emissions concerns justifying mitigation. BLM does not have legal authority to protect CLs but it does have directives to protect natural resources. Ryan gave an example of CL exceedances and project emission increases on surrounding Class I areas for a new oil and gas field in Wyoming.

5.3 CLAD MEMBERSHIP AWARDS

Starting in Spring 2019, CLAD began to acknowledge the long term participation of its members. CLAD started in 2006 and has had over 610 attendees to the Spring and Fall Meetings in 13 years. This attendance comes from over 175 individual attendees from over 66 organizations. Tamara Blett, one of CLAD's co-founders has the highest number of meetings attended with 24 of 25 total meetings. The agencies that have the highest meeting attendance are:

1. Environmental Protection Agency (127)
2. US Forest Service (USFS) (125)
3. National Park Service (NPS) (68)
4. US Geological Survey (USGS) (32)
5. E&S Environmental Chemistry, Inc (29)

10 Year Awards

Doug Burns
Jason Lynch
Linda Pardo
Rich Pouyat
Rick Haeuber
Tamara Blett
Tim Sullivan

5 Year Awards

Bill Jackson
Chris Clark
Chuck Sams
Cindy Huber
Claire O'Dea
Eladio Knipping
Ellen Porter
Ginger Tennant
Jack Cosby
Jennifer Phelan
Jill Webster
Kevin Horn
Linda Geiser
Randy Waite
Rich Scheffe
Robin Dennis
Selma Isil
Todd McDonnell
Tonnie Cummings

6.0 UNECE ICP M&M WGE-CCE MEETING

The 35th Task Force Meeting of the ICP M&M was hosted by the Spanish CIEMAT agency in Madrid, Spain on April 2-4, 2019.

Dr. Jennifer Phelan, presenting on behalf of National Atmospheric Deposition Program (NADP)-Critical Loads of Atmospheric Deposition (CLAD), the non-official National Focal Centre for the United States (U.S.), provided an update on critical load work conducted in the U.S. during the past year. Scientific working groups within NADP-CLAD have focused efforts on developing methods to summarize and represent multiple critical loads within land units such as National Parks and Forests. In addition, there have been efforts to characterize the uncertainty associated with deposition estimates, and how these uncertainties could potentially influence the reliability of critical load exceedance estimates. Ultimately, new critical loads and uncertainties will be captured within the Critical Load Mapper Tool, an online Tool used by National Resource Managers.

As the 35th Task Force was the first meeting jointly led by the German Environment Agency (new WGE-CCE) and Alice James (new ICP M&M chair), a large portion of the meeting was focused on a review of the structure, goals, and mandates of the ICP M&M WGE-CCE. Scientific updates from the National Focal Centres (7 countries) and other ICPs comprised the rest of the meeting. The 2020 36th ICP M&M Task Force meeting will be held April 21st – 23rd in in Stockholm, Sweden.

7.0 NEW AND ON-GOING CL WORK CONDUCTED BY CLAD MEMBERS

Anderson, Sarah – USDA Forest Service, Forest Management Range Management and Vegetation Ecology staff, Washington, DC

Over the past year, I've been using critical loads for two air quality metrics in the Forest Service's terrestrial ecosystem assessment tool, the Terrestrial Condition Assessment (TCA). CLs are being used as thresholds within this model to determine very good to very poor condition. The TCA has spent the last year being updated to version 2 and is in the process of being developed as a performance measure for the Forest Service.

Ash, Jeremy – US Forest Service – Region 9

- Evaluating critical loads and exceedances in assessment report to support forest plan revision for Wayne National Forest.
- Developing summaries of critical loads/exceedance trends for 5 National Forests and 1 Tallgrass Prairie in my zone of Region 9
- Part of EPA Technical Team mapping tree species critical load exceedances using FIA and raster-based abundance estimates at national level
- Using critical loads data generated by E&S Environmental Chemistry Inc. (from report: Atmospheric Deposition Effects Modeling for Resource Management on Southern Appalachian National Forests) to support Wilderness Stewardship Performance on Monongahela National Forest

Bell, Michael – National Park Service Air Resources Division

NPS ARD is currently funding five main projects associated with critical loads. 1) Fertilizing grasslands in Carlsbad Caverns National Park to evaluate soil and herbaceous vegetation responses in the Chihuahua Desert, 2) Evaluating lichen communities across elevation and N deposition gradients in North Cascades National Park to associate with lichen CLs set through FIA data, 3) evaluating how using either CMAQ or TDep maps change CL exceedances from 2000 to 2012, 4) developing regional focused tree critical loads to follow up on the Horn et al. 2018 analysis (with EPA through RTI), and 5) continuing to fund updates to the CL Mapper Tool (with EPA, USFS, and RTI).

NPS ARD is using critical loads in our planning and policy branch assist managers in identifying risks to resources from air pollution and to help them respond to new pollution sources near NPS boundaries. The main way they are used is through the development of Resource Stewardship Strategies. Each park is developing a ten year plan to respond to emerging threats to resources. In areas where critical loads are exceeded, we are able to insert language to bring awareness to risk during future planning and prioritization. Additionally we have been using CLs to identify potential consequences to resources on NPS lands due to new pollution sources and either work with developers during pre-NEPA or to respond during public comment.

Felker-Quinn, Emmi—National Park Service Air Resources Division

I joined CLAD this year and have been collaborating with the working groups as well as supporting Mike Bell in the NPS CL work that he leads.

Geiser, Linda - US Forest Service

This past year I engaged in multiple collaborative activities: 1) serving on the CLAD executive and advisory boards, 2) promoting communications between CLAD and our agency's air specialists, particularly in the arena of synthesizing critical loads for management applications, 3) spearheading the preparation of six videos designed to educate a broad audience about critical loads, and 4) publishing national scale critical loads for lichens using mission focused metrics to quantify deposition effects on biodiversity, ecological integrity, and species of conservation concern. I am highly encouraged by the progress made by CLAD, by the high level of participation by air specialists across the federal agencies, and by the growing functionality of the EPA critical loads mapper.

Lynch, Jason – US Environmental Protection Agency

My focus over the past year included: (1) adding new data and making corrections to the NCLD (CLAD WG-1), (2) working on the next NCLD version (3.1) and producing the 3rd version of the map summary, (3) characterizing uncertainty in aquatic CLs as part of WG-2, (4) contributing to CLAD WG-3 synthesis, (5) supporting the updates to the CL mapper Tool, and (6) supporting the REA for the Secondary Standard for NOxSOxPM review. As part of WG-2, I continue to work on understanding the uncertainty in aquatic CLs and how CLs from different methods compare. Currently, CLs comparisons among the different methods are completed. I'm now working on running Monte Carlo's simulations on the SSWC CLs to determine 95 CI. Lastly, I have been working on two publications. The first is with Jen, Mike, Chris and Linda G. related to the naming of CLs. We hope to submit this manuscript in early 2020 if not sooner. I am also writing another manuscript that looks at the past 30 years since the passage of the Clean Air Act amendment of 1990. This manuscript will focus on surface water recovery since 1990 and the future of acidification in the US.

McDonnell, Todd – E&S Environmental Chemistry, Inc.

An assessment of the expected risk to various biological endpoints within all National Forests and wilderness areas of the US Forest Service Intermountain Region (Region 4). Risk was characterized with critical loads of atmospheric N deposition to protect against species levels of effects on aquatic biota, lichen communities, and individual tree species. It was determined that substantial portions of the Intermountain Region are exposed to levels of N deposition that exceed protective critical loads, which may be causing adverse impacts to biota. This assessment was documented in a report for the US Forest Service.

A revised set of statistically-based vegetation response models based on observations from plant and soil surveys in the United States (US-PROPS v2) was generated for establishing critical loads of N and S deposition based on biodiversity. More than 300 plant species were characterized in US-PROPS v2. Several improvements to the models, relative to v1, were included. These models were used within the PROPS-CLF model to generate critical loads of N and S deposition under ambient and expected future climate conditions. A manuscript describing results from this study has been prepared for peer-reviewed journal submission.

An assessment of sustainable timber harvesting in the context of atmospheric N and S deposition was developed for the Daniel Boone National Forest (DBNF). The VSD+ model was used to evaluate the effects of timber harvesting and historical impacts from acidic deposition on soil nutrient supply at two sites. Results showed that ridgetop locations, and likely other areas, of the DBNF have experienced extensive soil nutrient depletion as a result of historical nitrogen and sulfur deposition. Simulated future decreases in deposition are expected to allow only marginal recovery in soil nutrient status in the coming centuries at these sites. Although future harvest scenarios father reduced soil nutrient status, these decreases were minimal relative to the extent of impact from historical nitrogen and sulfur deposition. This assessment was documented in a report for the US Forest Service.

A report documenting the effectiveness of experimental stream liming at two sites in the Upper Santeetlah watershed of western North Carolina was developed for the US Forest Service. Stream chemistry between the two sites showed variable response to liming, which was at least partially attributed to the location of lime application.

McMurray, Jill – Bridger-Teton NF/ R4 USFS

- Currently working on publishing the critical load assessment report for all National Forests in R4 highlighted below in the publications and reports section.
- GYCC funded project between USGS and GYCC CAP. Evaluating nitrogen and sulfur measurements from different air quality monitoring networks across the Greater Yellowstone Area.
- GYCC funded project between USFS, SFSU, UME-Orono. Paleolimnological assessment of high-elevation lakes exceeding critical loads of nitrogen deposition across the Greater Yellowstone Area.
- Waiting on funding: Spatial patterns in sources of atmospheric nitrogen deposition across the Greater Yellowstone Area using nitrogen isotopes in multiple ecosystem indicators.

Mueller, Sean - USDA U.S. Forest Service, Air Resource Specialist, Northern Region Regional Office

The project will analyze different N estimation approaches and produce a few different maps to examine side-by-side and using regression to compare correlations of the different approaches. This work is especially important to assess model's value at the regional scale, especially in the Rocky Mountain Region, given that research indicates discrepancies between CMAQ and lichen indices because of complex terrain, relatively large proportion of dry N deposition, and climate effects.

We have 20+ years of lichen community data in the region but do not have an easy way to synthesize and incorporate new plot data to determine location of CL exceedances, the magnitude of an exceedance, or how to accurately assess uncertainty. A community gradient model was created for the region as part of a USFS/Montana State collaboration in 2014, but considerable work must be done to incorporate new plot data (taxonomic reconciliation between different data sources, model validation, etc.). I am part of an effort with USFS WO and FIA groups to re-fit the lichen community gradient model to add newly surveyed plots to streamline analysis and improve regional understanding air pollution and ecosystem affects. The benefits of going through this process will be that we can have a well-documented gradient model where new or revisited plots can be easily be added. In addition to the operational usage, comparing this to other models will show discrepancies in N deposition, and highlight uncertainties which can be prioritized for field work to ground truth and improve existing models.

Phelan, Jennifer - RTI International

RTI International is supporting the U.S EPA, NPS, and USFS with several on-going projects related to CLs and the impacts of air pollutants on ecosystems. We are estimating terrestrial CLs of acidity for forest ecosystems across the conterminous U.S. The goal of this work is to provide updated CL estimates, improved by the use of the PROFILE model to estimate soil base cation weathering (BCw). In addition, with available data, we will compare different methods to estimate soil BCw and specific surface area (SSA) to determine any geospatial trends and improve our understanding of the uncertainties in these estimates. The CL estimates from this work will be added to the NADP-CLAD NCLD and published in a journal article. A second project involves the evaluation of the impacts of future deposition and climate scenarios on the composition of U.S. forests and ecosystem services provided by the nation's forests. This project is using the tree growth and survival relationships developed by Horn et al. (2018) and 20 future N and S deposition and climate scenarios. To date, forest composition in response to the future scenarios has been modelled out to 2100, and associated impacts on four ecosystem services (above-ground carbon, biodiversity, sawtimber, and pulpwood) have been calculated. The results of this work will be analyzed and published in a journal article. RTI is also continuing to support the development of the CL Mapper Tool (https://clmapper.epa.gov/), an online tool which integrates deposition, CLs, and exceedances over space and time. Version 2.1 of the Tool was made available online in June 2019. In addition, RTI is continuing to support the review of the U.S EPA NAAQS of NOx and SOx, through work on the Integrated Science Assessment (ISA) and supporting the development of manuscripts documenting key topics and findings from the ISA.

Sams, Chuck - USDA Forest Service Air Program

Recently incorporated critical loads of N and S to a Class I Wilderness AQRV analysis during a PSD permit review for a steel production facility in Alabama. Our analysis was submitted to the ADEQ's public meeting record as an enclosure to the National Forests of Alabama's FLM PSD permit response letter.

8.0 PUBLICATIONS

CL-related publications that were added to the CLAD website this year included the following.

2019

Belyazid, S., Phelan, J., Nihlgard, B., Sverdrup, H., Driscoll, C., Fernandez, I., ... Clark, C. (2019). Assessing the effects of climate change and air pollution on soil properties and plant diversity in northeastern US hardwood forests: Model setup and evaluation. Water Air and Soil Pollution, 230(5), [106]. https://doi.org/10.1007/s11270-019-4145-6

Clark, C. M., Richkus, J., Jones, P. W., Phelan, J., Burns, D. A., de Vries, W., ... Watmough, S. A. (2019). A synthesis of ecosystem management strategies for forests in the face of chronic nitrogen deposition. Environmental Pollution, 248, 1046–1058. https://doi.org/10.1016/j.envpol.2019.02.006

Clark, C. M., S. M. Simkin, E. B. Allen, W. D. Bowman, J. Belnap, M. L. Brooks, 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. 2019. Potential vulnerability of 348 herbaceous species to atmospheric deposition of nitrogen and sulfur in the United States. Nature Plants 5:697-705.

Geiser, L. H., P. R. Nelson, S. E. Jovan, H. T. Root, and C. M. Clark. 2019. Assessing Ecological Risks from Atmospheric Deposition of Nitrogen and Sulfur to US Forests Using Epiphytic Macrolichens. Diversity 11:87.

Pardo, L. H., J. A. Coombs, M. J. Robin-Abbott, J. H. Pontius, and A. W. D'Amato. 2019. Tree species at risk from nitrogen deposition in the northeastern United States: A geospatial analysis of effects of multiple stressors using exceedance of critical loads. Forest Ecology and Management 454:117528.

Sickman, J. O., A. E. James, M. E. Fenn, A. Bytnerowicz, D. M. Lucero, and P. M. Homyak. 2019. Quantifying atmospheric N deposition in dryland ecosystems: A test of the Integrated Total Nitrogen Input (ITNI) method. Science of the Total Environment 646:1253-1264.

Simpson, A. C., D. Zabowski, R. M. Rochefort, and R. L. Edmonds. 2019. Increased microbial uptake and plant nitrogen availability in response to simulated nitrogen deposition in alpine meadows. Geoderma 336:68-80.

Symstad, A. J., A. T. Smith, W. E. Newton, and A. K. Knapp. 2019. Experimentally derived nitrogen critical loads for northern Great Plains vegetation. Ecological Applications 29:e01915.

Van Houtven, G., Phelan, J., Clark, C., Sabo, R., Buckley, J. J., Thomas, Q., ... LeDuc, S. (2019). Nitrogen deposition and climate change effects on tree species composition and ecosystem services for a forest cohort. Ecological Monographs. https://doi.org/10.1002/ecm.1345

Walker, J. T., M. D. Bell, D. Schwede, A. Cole, G. Beachley, G. Lear, and Z. Wu. 2019. Aspects of uncertainty in total reactive nitrogen deposition estimates for North American critical load applications. Science of the Total Environment 690:1005-1018.

Walker, J. T., G. Beachley, H. M. Amos, J. S. Baron, J. Bash, R. Baumgardner, M. D. Bell, K. B. Benedict, X. Chen, D. W. Clow, A. Cole, J. G. Coughlin, K. Cruz, R. W. Daly, S. M. Decina, E. M. Elliott, M. E. Fenn, L.

Ganzeveld, K. Gebhart, S. S. Isil, B. M. Kerschner, R. S. Larson, T. Lavery, G. G. Lear, T. Macy, M. A. Mast, K. Mishoe, K. H. Morris, P. E. Padgett, R. V. Pouyat, M. Puchalski, H. O. T. Pye, A. W. Rea, M. F. Rhodes, C. M. Rogers, R. Saylor, R. Scheffe, B. A. Schichtel, D. B. Schwede, G. A. Sexstone, B. C. Sive, R. Sosa, P. H. Templer, T. Thompson, D. Tong, G. A. Wetherbee, T. H. Whitlow, Z. Wu, Z. Yu, and L. Zhang. 2019. Toward the improvement of total nitrogen deposition budgets in the United States. Science of the Total Environment 691:1328-1352.

2018

Horn, K. J., Thomas, R. Q., Clark, C. M., Pardo, L. H., Fenn, M. E., Lawrence, G. B., ... Watmough, S. 2018. Growth and survival relationships of 71 tree species with nitrogen and sulfur deposition across the conterminous U.S. PLoS One, 13(10). https://doi.org/10.1371/journal.pone.0205296