NATIONAL ATMOSPHERIC DEPOSITION PROGRAM (NADP) CRITICAL LOADS OF ATMOSPHERIC DEPOSITION (CLAD) 2017-2018 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 2017-2018 Annual Report of CLAD. The Annual Report contains sections that describe CLAD accomplishments, progress on CLAD Working Groups, CLAD products, the Fall 2017 and Spring 2018 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 2017-18 consisted of Jason Lynch (EPA) and Michael Bell (NPS) as the co-chairs, Jeff Herrick (EPA) as the secretary, Jason Lynch as the National Critical Load Database (NCLD) Manager, and Jennifer Phelan as the CLAD Program Manager (now Technical Advisor). This 2017-18 Annual Report was produced by the CLAD Executive Team, reviewed by CLAD members, and accepted on November 6th, 2018.

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 2017 Scientific Symposia.
2. Attendance at CLAD meetings during the Fall 2017 and Spring 2018 NADP meetings was between 27 and 24 participants.
3. Represented CLAD as the U.S. non-official National Focal Centre (NFC) at the combined 18th Joint Expert Group (JEG) on Dynamic Modelling and 34th Task Force ICP M&M meeting that was held in Bern, Switzerland in April 2018.
4. Continued the efforts of the four Working Groups (WGs) and initiated a fifth WG within CLAD. The objective of WG-5 is to develop an outreach and communication strategy to communicate the concept and use of CLs to stakeholder groups.
5. Produced v3.0 of the NADP-CLAD NCLD (October 2017).
6. Developed 2017 Critical Load Map Summary that provides maps of the CLs in v3.0 of the NADP-CLAD NCLD.
7. One journal article published in 2018 (Clark et al., 2018) and a publicly-available online tool (CL Mapper Tool - https://clmapper.epa.gov) are based, in part, on data from the NADP-CLAD NCLD.
8. Completed (and made available) a generic CL PowerPoint presentation that can be used by all CLAD members.

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 is a total of five CLAD WGs.

WG-1 ADDING NEW DATA AND CLS 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. Critical loads to be added soon include: (1) surface water CLs from the Appalachian Trail (AT) Study (Lawrence et al., 2015), (2) surface water CLs for LochVale, 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), (5) CONUS herb species richness CLs based on the equation from Simkin et al. (2016), and (6) N-enrichment CLs for surface waters in the western U.S. (Williams et al., 2017a&b). In addition, work has continued a data publication for the NCLD v3.0. It expected to be completed in early 2019.

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

WG-2 CHARACTERIZING UNCERTAINTY IN CL ESTIMATES

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

During the year, WG-2 held multiple conference calls and webinars and completed a 5-classed scoring system to characterize the uncertainty of tree, lichen and herbaceous biodiversity CLs. The WG also initiated work applying the system to characterize the uncertainties associated with surface water acidification CLs. The primary delays in WG-2 progress this year were necessary; needed to wait for the new tree and lichen CLs to be accepted for publication. The goals of WG-2 for next year will be to: (1) revisit the classification system now that the tree CLs have been accepted for publication and the lichen

CLs are nearing completion, (2) complete the uncertainty scoring systems for surface water and forest ecosystem acidification CLs, and (3) draft at least one report and manuscript from the work (planned for submission at the end of 2019).

WG-3 CL SYNTHESIS

Objective: 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.

For the first part of the year, WG-3 held monthly conference calls focusing on CLs for herbaceous diversity (Mike Bell/Bill Jackson), aquatic acidification (Jason Lynch/Bill Jackson), tree species growth and survival (Chris Clark), and lichen species richness and abundance by functional group (Linda Geiser). WG-3 held a workshop at the Fall 2017 NADP meeting to kick off the Case Study analysis. Once preliminary protocols for CLs for the individual life forms + aquatic acidification had been developed, WG-3 shifted its focus to calculating and synthesizing CLs from three Case Study regions (Inter-mountain West, Southeast, North Central). WG-3 held a workshop at the Spring 218 NADP meeting to present the current approach for synthesizing CLs and to learn more about stakeholder needs. The USFS hosted a 2-day meeting in Washington, DC in June 2018 to review the synthesis process including tables, figures, and communication. As the year ended, revisions were being made to the first round of Case Study CLs outputs in preparation for the Fall 2018 NADP meeting.

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 combine multiple CLs into a single value for an area, (4) create a brief powerpoint presentation targeted towards resource managers, and (5) draft several synthesis manuscripts for journals.

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 the uncertainty 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 held monthly meetings to discuss different measures of uncertainty within N deposition measurements and models. The conversations have led to better communication between the CL and modeling communities, and planning of projects that will help align the interests of both groups. One project, led by the NPS, will evaluate how using different models (CMAQ, TDep, CAMx, and ADAGIO) impacts the exceedance of CLs in Class I areas. A second, led by the EPA, is downscaling deposition model data to land use type to develop more spatially explicit deposition data. Additionally, a subset of the WG completed a chapter for the TDep White Paper on Deposition Uncertainty which summarized and expanded upon previous presentations.

WG-5 CRITICAL LOADS OUTREACH AND COMUNICATION (CLOC)

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.

During the year, WG-5 met on a monthly basis, and developed key products including: Communication Matrix; list of state, regional, and national stakeholders; and federal agency organization charts that outline the sectors within each agency that may have interest in CLs. The Communication Matrix comprehensively summarizes the objectives of WG-5, targeted stakeholders, obstacles, potential solutions, and communication materials and plans. Next steps for WG-5 are to assist the larger CLAD science committee in moving forward on the recommendations in the Communication Matrix.

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 2017-18 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 will be completed and available for download from the NADP-CLAD website in 2018-19.

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. 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.

The maps for surface water CLs were updated with many new CL values as well as a continuous stream reach coverage for the southern Appalachian Mountains based on McDonnell et al. (2014). New to the Map Summary were CLs for Herbaceous Biodiversity based on Simkin et al. (2016). Both plot- and Ecoregion-level CL load estimates are mapped.

5.0 CLAD MEETINGS

The Fall CLAD Meeting was conducted on October 31st during the 2017 NADP Conference from October 30th – November 3rd in San Diego, California. The Spring CLAD meeting was conducted April 10th during the 2018 NADP Spring meeting from April 9th – 12th in Milwaukee, 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 2017 MEETING

The 2017 Fall NADP-CLAD Science Sub-Committee Meeting was held on Tuesday, October 31st from 10:00 am – 12:00 pm in the Shell Room of the Bahia Hotel in San Diego, California. A total of 22 people attended and 5 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 v3.0. WG2 (Linda Pardo) presented on the initial approach for assigning confidence to CLs using a 5-point scale for trees, herbs, and lichen. WG3 (Chris Clark) presented on the tremendous progress made in developing protocols for setting CL values for Surface Water Acidification, Herbaceous Species Richness (Simkin), Lichens, and Trees (Horn). WG4 (Mike Bell) provided an update on the progress of the deposition uncertainty group and early efforts to create a throughfall deposition database. The CLAD WGs also held meetings outside of the CLAD October 31st meeting. CLAD WG-2 and WG-3 met on Monday, October 20th. The WG-2 meeting focused on a discussion of proposed updates to the methodology to characterize uncertainty of CL estimates. The WG-3 meeting involved multiple presentations by WG-3 members, discussion of elements of the CL synthesis approach, and identification of potential locations for case studies.

CLAD Business: CLAD business included accepting the minutes from the Spring 2017 CLAD meeting and the 2016-17 CLAD Annual Report, filling the CLAD Executive Team positions, introducing the CLAD CL presentation being developed by the CLAD ET, reviewing and seeking CLAD approval of including CL exceedance maps in the NADP-CLAD Map Summary, and proposed topics for the Spring 2018 meeting.

Tonnie Cummings ended her term as CLAD co-chair, Mike Bell stepped up from secretary to incoming co-chair of CLAD, and Jeff Herrick was elected as the new CLAD secretary. CLAD accepted the proposal to include CL exceedance maps in the Map Summary. The next Map Summary will include exceedance maps for surface water acidification and herbaceous biodiversity CLs. Uncertainty will also be included as part of the new maps.

5.2 SPRING 2018 MEETING

The 2018 Spring NADP-CLAD Science Sub-Committee Meeting was held on Tuesday, April 10th from 1:30 – 5:30 pm in the Grand Salon 1 of the Intercontinental Hotel in Milwaukee, Wisconsin. A total of 20 people attended and 4 joined remotely. The main topics discussed during the meeting included: an overview of CLAD for new members and Wisconsin State Lab of Hygiene (WSLH) staff, update on the CLAD CL presentation, CLAD WG updates, CL project round robin, and CLAD general business. The minutes from the Fall 2017 CLAD meeting were also approved.

During the CLAD Program Manager update, Jennifer Phelan provided a summary of the ICP M&M meeting. Linda Geiser gave a presentation on the new CLAD WG-5; CL Outreach and Communications. She described the objectives of the WG and the Communication Matrix and Stakeholder analysis produced by the WG. Mike Bell provided an update on WG-4 and how the group is focused on assembling N deposition data from monitoring and study sites, comparing model estimates of deposition, and downscaling deposition to land cover classes.

CLAD Business involved a discussion of: the transition of NADP from University of Illinois to the University of Wisconsin – Madison, and the trial transition of the CLAD Program Manager to CLAD Technical Advisory. This transition will involve shifting from administrative tasks to more technical responsibilities including: developing publications, leading science discussions, and integrating science among the CLAD WGs.

6.0 UNECE ICP M&M WGE-CCE MEETING

The combined 18th Joint Expert Group (JEG) on Dynamic Modelling and 34th Task Force Meeting of the ICP M&M was held in Bern, Switzerland April 18th-20th, 2018. The main objectives of the meeting were:

- CCE and NFC Presentations and discussions regarding the work and results of the call for data 2017-2018 (http://wge-cce.org/Activities/Call_for_Data)
- Update on experimental and modelling results of abiotic and biotic changes of air pollution and climate change
- Progress under the LRTAP Convention in relation to the workplan and 4th joint meeting of the EMEP Steering Body and Working Group on Effects

A total of 47 people from 19 countries were present at the meeting that was hosted by the Swiss Federal Office for the Environment. Jennifer Phelan represented CLAD as the non-official NFC from the U.S., and gave an update on CLAD activities and the CL Mapper Tool being developed by the EPA and supported by the USFS and NPS.

The first day was the JEG Dynamic Modelling meeting. The meeting began with a review of the status of Biodiversity CLs within the Convention, and a discussion of the obstacles and challenges in estimating and adopting biodiversity loads within policy. Complexity of the modelling systems, lack of clarity/consistency in defining biodiversity, and effectively communicating CLs to policy makers were some of the main topics that were discussed. The meeting then proceeded with scientific presentations focused on applications of and updates to the VSD+-PROPS model. During the afternoon sessions, the chairwoman of the WGE, Isaura Rabago, provided an update from the WGE, and Reto Meier (from FOEN) presented conclusions from the Saltsjobaden VI meeting (http://saltsjobaden6.ivl.se/) and updates from the (NEC) directive (https://www.eea.europa.eu/themes/air/national-emission-ceilings/national-emission-ceilings-directive) and ecosystem monitoring.

The second day began with an announcement of the new CCE. Starting in 2019, Germany will be the new host country for the CCE. Marion Wichmann-Fiebig, from the German Environment Agency (https://www.umweltbundesamt.de/en), spoke about the transition from the Netherlands to Germany, and the continued commitment to achieve the goals of the ICP M&M. In the interest of continuing progress, she encouraged all member countries to continue their work on Biodiversity CLs, but said that the new CCE will not be able to accept data after they are established in 2019. The rest of the day was devoted to updates from the Convention National Focal Centres. A total of 8 countries, including the U.S. presented. Most of the presentations provided updates on biodiversity CLs, but France presented on a "CL Mapper Tool" that they have started developing, and Switzerland and Finland presented the results of research evaluating the impacts of N deposition on butterfly diversity and use of lichens as indicators of air pollution in urban environments.

The third day provided updates from the other ICPs (Forests - http://icp-forests.net/, Waters - http://www.icp-waters.no/ and Vegetation - https://icpvegetation.ceh.ac.uk/) and LRTAP topics. The meeting concluded at noon with the announcement that the next ICP M&M will be held in Madrid, Spain in 2019.

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

Anderson, Sarah - US Forest Service, National Forest System, Washington Office

I've been working on two major items that would be of interest to the CLAD community. 1) Working to update deposition data in an ecosystem assessment tool being used by the Forest Service at the national level called the Terrestrial Condition Assessment (TCA). TCA uses 10 indicators (one of which is air quality) to rate landtype associates (a landscape scale ecosystem delineation) from very poor to very good based on ecological condition. The air quality indicator is based on acid deposition and N deposition and uses CLs to set thresholds for delineating very good and very poor conditions. 2) I'm still slowly chipping away at publishing my dissertation work using the stable isotope composition of precipitation and lichens to understand how sources of N deposition have changed over different time scales.

Baron, Jill - U.S. Geological Survey and International Nitrogen Initiative

The International Nitrogen Management System (INMS, www.inms.international) is supported by GEF, the Global Environmental Federation (part of UNEP) to bring together the science community, the private sector and civil society to gather and synthesize evidence that can support international policy development to improve global N management. There are four components to INMS, and Component 1 is to present and evaluate tools for understanding and managing the global N cycle. Activities within Component 1 address system indicators, development of threat/benefit assessment, N fluxes and distribution, and valuation methodologies, flux-impact assessment models for assessment, scenarios, and strategy evaluation, and examination of barriers to achieving better N management. Critical Loads will be among the methods described and referenced for evaluating the threats and benefits of reactive N. A draft Guidance Document will be produced by December 1, 2018. This is a highly international effort. Americans involved include Chris Clark, Jana Compton, Jill Baron, and a number of members of the Long-Term Ecological Research program network.

Bell, Michael – National Park Service Air Resources Division

The majority of my work with CLs has been as co-chair of CLAD and working with Working Groups 3 and 4. I led the effort to determine how the point CLs of N for decline in herbaceous richness could be synthesized into Ecoregion polygon and used to determine CLs in areas where points do not exist. I have also developed maps and graphs to help communicate the outputs of Working Group 3 to land managers.

The NPS has continued to assist with funding and development of the CL Mapper tool to synthesize CLs and deposition data for federal land management areas. We have also funded E&S Environmental to compare how results from various chemical transport models influence CL exceedances. Lastly, we developed an agreement with Washington State University to perform lichen surveys at North Cascades National Park to evaluate N deposition.

Clark, Chris – US Environmental Protection Agency

We are developing several CLs research projects: (1) an assessment of how N deposition and climate change will affect forest composition and ecosystem services in the Northeast based on the Thomas et al. (2010) species-specific tree growth and survival curves (van Houtven et al., accepted), (2) a follow-on study of #1 to assess how N and S deposition and climate change will affect forest composition and ecosystem services across the conterminous U.S. based on the Horn et al. (2018) growth and survival curves, (3) an assessment of the major sources of uncertainty for PROFILE estimates of soil base cation weathering (BCw) for terrestrial acidification CL estimates (Whitfield et al., 2018), (4) a follow on study to #3 to implement improvements to estimates of BCw and terrestrial CLs of acidity for forests (point locations) across the U.S., (4) a meta-analysis of the effectiveness of remediation efforts for forests and grasslands affected by N deposition (Clark et al., in review), (5) new CLs for >300 herbaceous species across the U.S. (Clark et al., in review), (6) a USFS GTR based on the Horn et al. tree growth and survival curves to summarize species vulnerability to N and S deposition and the ecosystem services at risk (USFS, in review), (7) improvements to the VSD+PROPS modeling chain to enhance its performance in the U.S. (McDonnell et al., 2018), and (8) improvements to the CL Mapper Tool including “Profiles” for Federally managed areas that summarizes vulnerability through time to N and S deposition (clmapper.epa.gov).

Lynch, Jason – US Environmental Protection Agency

My focus over the past year included: (1) NCLD development (CLAD WG-1), (2) characterizing uncertainty in aquatic CLs, (3) contributing to CLAD WG-3 synthesis, (4) supporting the update to v2.0 of the CL mapper Tool, and (5) supporting the REA for the Secondary Standard for NOxSOxPM review. For WG-1, I continue to add CL data to the database and make corrections to Version 3 and supporting documents. In addition, I am working on a data publication for the NCLD v3.5, I expect it to be completed in spring 2019. As part of WG-2, I continue to work on understanding the uncertainty in aquatic CLs and among the different methods used to calculate the CLs. Also, I continue to support the update to v2.0 of the CL mapper Tool and CLAD WG-3 synthesis effort. This coming winter and spring, I will also be working on completing the REA for aquatic acidification for the Secondary Standard for NOxSOxPM review.

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

Critical loads of S deposition were developed to protect terrestrial and aquatic biota from acidification effects in the Southern Appalachian Mountains. Critical loads and exceedances thereof were generated for more than 150,000 streams/catchments using the steady-state SSWC model (aquatic) and SMB model (terrestrial). These CLs will be used by USFS for regional forest planning.

In cooperation with Syracuse University and USGS (Troy, NY), site-specific target loads of N and S deposition generated with the PnET-BGC model were extrapolated to more than 400 streams located throughout the Adirondacks using a statistical regression model. Results showed that streams with low target loads can be found throughout much of the Adirondack region and were concentrated in the southwestern portion of the Park.

Target loads of N deposition for protecting understory vegetation community composition at Shenandoah NP and Great Smoky Mountains NP were generated using the ForSAFE-Veg model. Under an anticipated climate change scenario, CLs for protecting current vegetation composition were in the range of 5.0 to 7.4 kg N/ha/yr.

An initial set of statistically-based vegetation response models based on observations from plant and soil surveys in the United States (US-PROPS v1) was generated for establishing CLs of N and S deposition based on biodiversity. More than 300 plant species were characterized in US-PROPS v1 and improvements to the models are currently underway to address model uncertainty and expand the number of species models to more than 1,000 in version 2.

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 estimates soil base cation weathering and lab analyses to estimate soil surface area; two parameters which present significant sources of uncertainty in CL estimates. This project will be completed in the Spring of 2019. 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. Phase I of this work, based on the tree growth and survival relationships produced by Thomas et al. (2010), is currently under review for publication. Phase II is using the relationships developed by Horn et al. (in review) and projected N and S deposition based on U.S. CAA policy and IPCC RCP climate scenarios. It will involve modelling the composition of forests across the conterminous U.S. out to 2100 and assessment of the impacts of changes in forest composition on stand- and tree-based ecosystem services. RTI is also the technical lead supporting the development of the CL Mapper Tool (https://clmapper.epa.gov/), an online tool which integrates deposition, CLs, and exceedances over space and time. The Tool allows users to download data and offers the ability to produce summary reports of deposition, CLs, and exceedances for federal lands. An updated Version 2 of the Tool will be available online this fall. RTI is also continuing to support the review of the U.S EPA NAAQS of NOx and SOx, through work on the Integrated Science Assessment (ISA).

Sullivan, Timothy J. - E&S Environmental Chemistry, Inc.

We updated the EMDS database and expert system to incorporate many additional stream and soil chemistry sites. This update was delivered to the U.S. Forest Service in August, 2018. We continued work on critical and target loads for Adirondack streams. This work has been conducted in cooperation with Syracuse University and USGS (Troy, NY). The research addresses flow-dependent variation in stream chemistry and biological effects of exposure of fish to high Al concentrations and low pH and ANC. We completed a number of projects related to CLs and finalized related publications.

8.0 PUBLICATIONS

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

2018

Amos, H.M., Miniat, C.F., Lynch, J., Compton, J., Templer, P.H., Sprague, L.A., Shaw, D., Burns, D., Rea, A., Whitall, D., Myles, L., Gay, D. Nilles, M., Walker, J., Rose, A.K., Bales, J., Deacon, J., and R. Pouyat. 2018. What Goes Up Must Come Down: Integrating Air and Water Quality Monitoring for Nutrients. Environmental Science & Technology, 52: 11441-11448.

Baldigo, B.P., Kulp, M.A., and J.S. Schwartz. 2018. Relationships between indicators of acid-base chemistry and fish assemblages in streams of the Great Smoky Mountains National Park. Ecological Indicators, 88: 465-484.

Bowman, W.D., Ayyad, A., Bueno de Mesquita, C.P., Fierer, N., Potter, T.S., and S. Sternagel. 2018. Limited ecosystem recovery from simulated chronic nitrogen deposition. Ecological Applications, 28(7): 1762-1772.

Clark, C.M., Phelan, J., Doraiswamy, P., Buckley, J., Cajka, J.C., Dennis, R.L., Lynch, J., Nolte, G.N., and T.L. Spero. 2018. Atmospheric deposition and exceedances of critical loads from 1800-2025 for the conterminous United States. Ecological Applications, 28(4): 978–1002 https://doi.org/10.1002/eap.1703.

Fenn, M.E, Bytnerowicz, A, Schilling, S.L., Vallanob, D.M., Zavaleta, E.S., Weiss, S.E., Morozumi, C., Geiser, H.G., and K. Hanks. 2018. On-road emissions of ammonia: An underappreciated source of atmospheric nitrogen deposition Science of the Total Environment, 625: 909-919. https://doi.org/10.1016/j.scitotenv.2017.12.313.

McDonnell, T. C., Belyazid, S., Sullivan, T.J., Bell, M., Clark, C., Blett, T., Evans, T., Cass, W., Hyduke, A. and H. Sverdrup. 2018. Vegetation dynamics associated with changes in atmospheric nitrogen deposition and climate in hardwood forests of Shenandoah and Great Smoky Mountains National Parks, USA. Environmental Pollution, 237: 662-674.

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