Lakeland Industry and Community Association
8237, 5107W - 50 Street, Bonnyville, AB T9N 2J5
780 812-2182 780 812-2186 www.lica.ca

Acid Deposition Monitoring Program Expansion Committee

Meeting Minutes

Thursday, December 2, 2021
9:00 a.m. – 12:00 p.m.
LICA Boardroom and via Microsoft Teams

Present:	Heather Harms Desiree Parenteau Brent McGarry Clarence Makowecki Wally Qiu Jennifer O'Brien Leo Paquin Fin MacDermid Andrea Woods
Observers and Guests:	Nikita Lattery Kenneth Foster Eric Edgerton Dianne McIssac
Staff and Contractors:	Kristina Morris, LICA Executive Director Michael Bisaga, Manager, Environmental Monitoring Programs Eveline Hartog, LICA Administrative Professional
Regrets:	Sean Mercer Larry Turchenek Colin Cooke Salim Abboud Amanda Avery-Bibo Lindsay Hollands

1.0 CALL TO ORDER

Heather Harms Committee Chairperson, called the meeting to order at 9:02 a.m.

1.1 Territorial Acknowledgement

1.2 Introductions

1.3 Vision, Mission and Values

1.3 Roll Call

The Manager of Environmental Monitoring Programs indicated that AEP has not yet identified their appointed representative on this Committee and for the time being Bob Myrick will sit in as LICA's AEP representative. It was also noted that Larry Turchenek has removed himself as a standing committee member and will act as a resource person moving forward. His name will be removed from the attendance list moving forward.

1.5 Approval of Agenda

1.5.1 December 2, 2021

#1 Moved by Andrea Woods AND CARRIED that the December 2, 2021, Agenda be approved as amended, such that:

- **Item 2.1 include two presenters: Eric Edgerton and Kenneth Foster.**

1.6 Approval of the Minutes

1.6.1 October 21, 2021

#2 Moved by Leo Paquin AND CARRIED that the October 21, 2021, minutes be approved as presented.

2.0. ONGOING BUSINESS

2.1 Wood Buffalo Environmental Association (WBEA) Acid Deposition Monitoring Program by Dr. Eric Edgerton and Kenneth Foster

Kenneth Foster from Wood Buffalo Environmental Association (WBEA) was the initial speaker of the two-part presentation. He was informed that LICA currently has passive monitoring and a soil acidification program but recently, with the new AER approval requirements and increasing acidifying emissions in the area, LICA is expanding these activities to develop a more comprehensive monitoring program. The Manager of Environmental Monitoring Programs also informed him that currently LICA monitors sandy acid-sensitive soils (that typically have jack stands) however forest health will likely not initially be a component of the LICA acidification monitoring program.

Kenneth Foster gave a brief introduction to the WBEA TEEM Forest Health Monitoring Program which began in 1998. He felt that over his years being involved with the program there were key elements to remember when developing LICA's monitoring program and those were:

- have a clear objective statement to keep the program focused
- adopt a procedures manual and a system of protocols and set them in place early; this will assist in keeping the program on track and keep costs in check

- have variability in monitoring sites to mitigate danger of adverse environmental influences (such as forest fires). WBEA has now over fifty sites monitored at 3-year intervals with a comparison done on both interior and edge forested areas
- recommended monitoring jack pine forests since they give earliest indication of acidification
- WBEA's program also monitors tree needle health as part of their soil acidification monitoring
- in establishing sites look at your emission source and radiate sites from there (source to receptor area); have sites both near and far from the emission source but remember it is important to do other monitoring as well, for example, passives
- avoid the temptation to do the sampling of "while you're at it;" do not take samples just for the sake of sampling since extra samples increase the cost and will also give too much data. Stay focused on the purpose of your sampling
- stay focused on your findings, WBEA's data does not match with the GEM-MACH predictions but are valuable in their own right

The second presenter was Eric Edgerton who had worked on WBEA's *Estimation of Potential Acid Input (PAI) to WBEA Forest Health Monitoring Sites.* His key points for the Committee to consider were:

- commended LICA in choosing to monitor sandy, jack pine forest areas
- consider the forest canopy when calculating the potential acid input into the soil since the canopy uses calcium and additions and subtractions of these elements need to be considered in calculating the PAI
- deposition gradients for key components of PAI will give information to consider where LICA may want to locate monitoring sites
- PAI is also broken down between wet and dry deposition
- he recommended the approach of measuring wet (S, N, BC); measuring ambient gases and PM, SO2 and NO2 via passives and HNO3 and NH3 using denuders, PM10 using partisol sampler; estimate dry components using deposition velocity approach; use dry deposition box model (MLM); use literate values for vd and use modeling values for vd (i.e., GEN_MECH or CMAQ)
- indicated that there was already a lot of information for wet deposition in the LICA region. He recommended that LICA consider using the Stony Mountain site; Elk Island, Beaver Lodge Cold Lake and Fort McMurray are other areas where wet deposition monitoring had occurred between 2014-2016
- highly recommended LICA define their objectives and methodologies at the start
- suggested that the GEM-MACH modeling was very state of the art and yielded accurate rates for estimating emissions and deposition however it was also important to get a good handle on the base cation in the sites LICA is considering
- even though LICA region has boreal, agricultural and parkland areas it is important to use the same methodologies in each area; try to keep as consistent as possible using the correct system of measurement that each area will require

Kenneth Foster also noted that aspen forest areas have also been monitored for acidification effects. Complications arise in the sampling methodology because aspen stands often form from single seedling that stems of from a common root system (all trees share the same DNA). Single aspen "trees" don't respond as individuals to acid inputs but rather respond as an entire organism. He also added that it is beneficial to overlap two analyses of samples and state what steps were different when sampling. Also, different labs have different systems and will yield different results, and this will be something to explore.

Kenneth Foster also indicated that a WBEA procedures manual, either the 2016 version or updated 2018 version could be shared with LICA. LICA's Manager of Environmental Monitoring Programs will get a copy of this from Diane McIssac of WBEA.

3.0 OTHER BUSINESS

3.1 Surface Water Acidification Next Steps

LICA's Manager of Environmental Monitoring Programs indicated to the Committee that he is trying to secure a speaker conduct to deliver a presentation on the water component of acid deposition monitoring within the next week and this would likely be in addition to the next Committee meeting. Committee members agreed that a presentation on water would be beneficial and have agreed to arrange their schedules to accommodate this additional presentation. The Manager of Environmental Programs also indicated the desire to record the presentation for the purpose of note taking.

Due to time constraints, this item is tabled until next Committee meeting.

3.2 Draft Monitoring Plan Table of Contents

It was determined by the Committee chair that this discussion be tabled until the next committee meeting.

The Executive Director reminded the Committee that the development of the draft Plan has a deadline of December 31, 2021. This draft plan is subject to Board approval and should it be developed after the December Board of Directors meeting, an email motion will be required, unless a deadline extension is granted.

4.0 ACTION LIST

4.1 Follow-up on Action List

4.1.1 October 21, 2021

The Committee reviewed the ADMPEC Action List from October 21, 2021, meeting noting:

- Item 1.2 Bob Myrick will be our contact from AEP
- Item 2.2.1 investigating forest soil areas for acid deposition monitoring will be address in the ADMPEC plan discussion set for December 15, 2021
- Item 2.1.4 Manager of Environmental Monitoring Programs is still working on securing a 3rd speaker to address the water component of acid deposition
- Item 2.2 IWMP will identify priority lakes for monitoring in LICA region

5.0 UPCOMING MEETING DATES

5.1 Board Meeting – December 16, 2021

Initials

5.2 Next ADMPEC Meeting

The next ADMPEC meeting will be December 15, 2021, from 9:00 am -12:00 pm.

6.0 ADJOURNMENT

Meeting adjourned at 12:05 p.m.

#3 Moved by Andrea Woods AND CARRIED that the meeting be adjourned.

Approved on: ____________________________
Date

____
Signature

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Acid Deposition Monitoring Program Expansion Committee

Meeting Minutes

Thursday, October 21, 2021
1:00 p.m. – 3:00 p.m.
LICA Boardroom and via Microsoft Teams

Present:	Heather Harms Desiree Parenteau Salim Abboud Amanda Avery-Bibo Greg Wentworth Brent McGarry Clarence Makowecki Wally Qiu Jennifer O'Brien Leo Paquin Fin MacDermid Andrea Woods Lindsay Hollands (Arrived 1:33 p.m.)
Observers and Guests:	Nikita Lattery
Staff and Contractors:	Kristina Morris, LICA Executive Director Michael Bisaga, Manager, Environmental Monitoring Programs Eveline Hartog, LICA Administrative Professional Tina Johnson, LICA Administrative Professional
Regrets:	Sean Mercer Larry Turchenek Colin Cooke

1.0 CALL TO ORDER

Heather Harms Committee Chairperson, called the meeting to order at 1:01p.m.

Initials

1.1 Territorial Acknowledgement

1.2 Introductions

Greg Wentworth, the Committee member representing AEP, indicated that his last day at AEP would be November 12, 2021. The Committee was also notified that Colin Cooke from AEP currently does not have the time to serve on the Committee but would be available as a reference person.

1.3 Vision, Mission and Values

1.4 Roll Call

1.5 Approval of Agenda

#1 Moved by Desiree Parenteau AND CARRIED that the October 21, 2021, Agenda be approved as presented.

1.6 Approval of the Minutes

1.6.1 September 16, 2021

#2 Moved by Amanda Avery-Bibo AND CARRIED that the September 16, 2021, minutes be approved as presented.

2.0. ONGOING BUSINESS

2.1 Review of Post-Meeting Feedback and Requests For Additional Information

2.1.1 Objectives of Monitoring Program and Monitoring Sites

The Committee discussed what was required in terms of the ADMPEC committee objectives. The proposed objective of the monitoring program is:

"To develop, implement, and operate a long-term program to detect and characterize the effects of acidifying emissions on terrestrial and aquatic ecosystems, and traditional resources."

The scope of the monitoring program will entail wet and dry deposition monitoring, soil and vegetation monitoring and aquatic environment monitoring. This objective will be captured in phase one of the Plan.

The Committee inquired where the best sites for consideration for monitoring could be found and the Manager of Environmental Monitoring Programs indicated that best sites are determined by the modeling and expected emissions results. He also mentioned that LICA's current air monitoring program does cover some of the acid deposition objectives but not all.

#**3 Moved by Heather Harms and CARRIED that the Committee adopt the proposed objective for the Acid Deposition Monitoring Program Plan.**

Initials

2.1.2 Monitoring Agricultural Soils vs Forest Soils

The Manger of Environmental Monitoring Programs discussed the comparison of monitoring agricultural soils vs. forest soils, the latter of which would be preferred in terms of acidification monitoring. Critical loads of acidity on terrestrial ecosystems cannot be determined for agricultural soils due to inputs such as of fertilizer, manure, etc. Pristine sandy soils with jack pine stands are ideally suited for monitoring due to the decreased complexity between cause and effect in these ecosites as the contributing variables to determining the degree and rate of acidification are simplified.

Additionally, grazing lands are not typically considered in identifying acidifying effects on crop growth. Due to variability in agricultural practices from farm to farm, it is nearly impossible to differentiate acidification effects from those caused by agricultural modification of soils. The most accurate indication of soil acidification is therefore pristine soil sites that respond quickly to acid deposition, i.e., forest soils where the only influence is from atmospheric inputs. It was determined that LICA would be looking at these areas for the acid deposition monitoring program.

2.1.3 Clarify on Critical Loads and ADMF

Clarity on explaining critical loads came from the Alberta Acid Deposition Management Framework (ADMF) document. Critical load is a quantitative estimate of an exposure below which significant harmful effects do not occur. Critical loads differ from location to location; the risk of acidifying impacts from sulphur and nitrogen is looked at in relation to the critical loads at a specific location.

Monitoring focuses on areas where potential exceedances may or are predicted to occur. Critical loads for Alberta are presented as a grid on a map covering the entire province; critical load is based on acid sensitivity of soils, the water regime, plants, and other factors in each grid cell. Locations where there is a confluence of high deposition and low critical loads are the areas that LICA will likely identify as sites to monitor.

LICA's monitoring plan will be guided by the critical load maps and management framework outlined in Alberta Acid Deposition Management Framework.

2.1.4 Water Chemistry and Aquatic Ecosystems Monitoring From An Acid Deposition Perspective

The Program Manager indicated that the most recent research is the 2018 modeling study which suggests that acid buffering capacity within watersheds in the Fort McMurray area is insufficient; modelling suggests that exceedances may occur at current acid deposition rates. In general, we have a good understanding of the potential effects of acid deposition on soils in the LICA region but much less is known about lakes and aquatic systems (from an acid deposition and acid sensitivity perspective). The Committee will seek outside expertise and advice on monitoring the effects of acid deposition on surface water.

2.1.5 WBEA: Deposition Monitoring Program

The Program Manager presented the information from the Wood Buffalo Environmental Association regarding terrestrial effects of acid deposition; a project that was first established in 1995. The objective of the TEEM program is to monitor air related impacts on the ecosystem and to provide early detection of acid deposition effects, early enough to affect change on terrestrial areas.

The Committee was presented with a conceptual model diagram that helps describe WBEA's acid deposition monitoring program. LICA has equivalent components of this program in place, but some monitoring elements have not been implemented or considered. The Manger of Environmental Monitoring Programs felt it was worthwhile for the Committee to have a presentation from WBEA on this program and hear what their experience has been. Comparisons of methodologies could be presented to help LICA understand the value they would add to our program. Although the oil sands development in the Fort McMurray area differs from that of the LICA region, there is value in using similar monitoring methods and technologies.

2.2 Initial Results of GIS/Mapping Overlay

The Manager of Environmental Monitoring Programs presented slides of the Geographic Information System (GIS)/mapping overlay to the Committee. The maps were adapted from the recently released Alberta Monitoring, Evaluation and Reporting (MER) Framework to show the areas that are highly suited for deposition effects monitoring. The suitability for deposition monitoring was colour coded: red = low suitability; green = high suitability. A map which superimposed LICA's current monitoring program on the MER suitability classes for deposition monitoring was presented. It was indicated to the Committee that it would make sense for LICA to use the suitability classes in the MER to inform the expansion of LICA's deposition monitoring program. The atmospheric deposition map was informed by the GEN-MECH model.

2.3 Identification of Potential Monitoring Areas

The Manager of Environmental Monitoring Programs requested that information from LICA be included in the next modeling run.

3.0 OTHER BUSINESS

3.1 Update on GEM-MACH Modelling Outputs

The Committee was informed that we are currently using the 2013 emissions information but from August 2018 to October 2021 a new run of model concentrations and deposition rates would be available and would help determine the areas that LICA should focus on. This new modeling should be ready in December 2021.

It was inquired if LICA should delay our monitoring program to include the new GEN_MECH information but the Committee agreed it is best not to wait on these deliverables. The Manager of Environmental Monitoring Programs agreed, and if this is the gold standard there is other information, we can use that is also current.

4.0 ACTION LIST

4.1 Follow-up On Action List

4.1.1 September 16, 2021

The Committee identified some items to be added from the September 16th Action List:

- Add oil sand leases to the critical load map under Item 3.2.1
- Priority lakes under 3.3.1 should merge with LICA's Integrated Watershed Management Plan

5.0 UPCOMING MEETING DATES

5.1 Board Meeting – November 25, 2021

5.2 Next ADMPEC Meeting

The Manager of Environmental Monitoring Programs would like to have a presentation by either Wood Buffalo Environmental Association or ECCC given to the Committee on acid deposition monitoring; consequently, the next meeting date will be determined once a presenter and their availability is determined. The Committee will be informed of the next meeting dates choices via email and Doodle Poll.

The Executive Director indicated that if the monitoring plan decision is to be made in December, it will need to be included in the Board of Directors meeting agenda for December 16th, otherwise a motion may be requested via email.

6.0 ADJOURNMENT

Meeting adjourned at 3:04 p.m.

#4 Moved by Amanda Avery-Bibo AND CARRIED that the meeting be adjourned.

Approved on: ____________________
Date

____
Signature

Acid Deposition Monitoring Program Expansion Committee (ADMPEC)

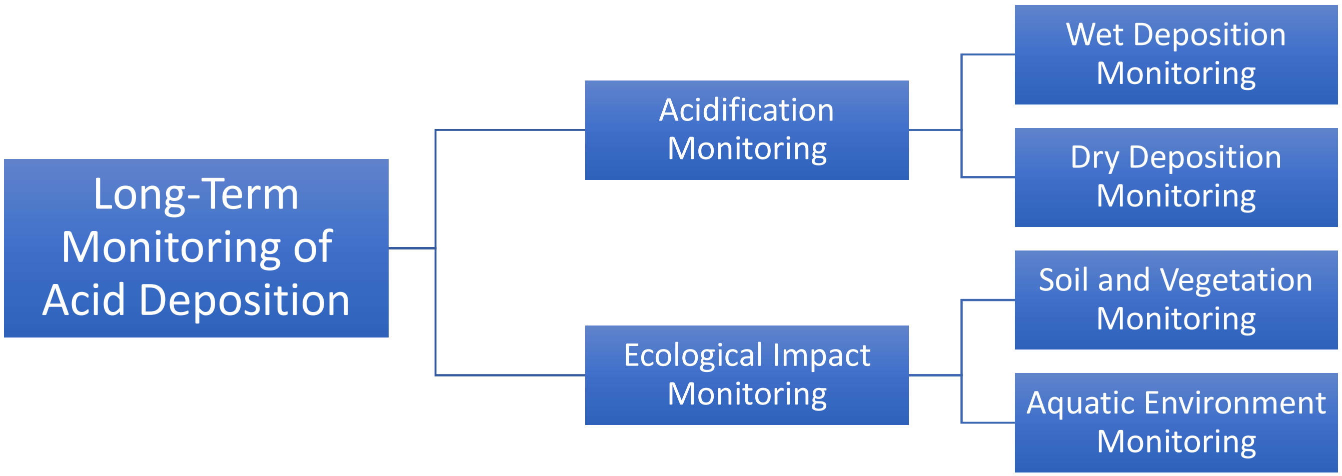
Meeting Support Slides

October 21, 2021

2.1.1 Objectives of monitoring program and monitoring sites

Proposed Objective

- To develop, implement, and operate a long-term program to detect and characterize the effects of acidifying emissions on terrestrial and aquatic ecosystems, and traditional resources.



Oil Sands Monitoring Program Objectives

- To Track Impacts from Oil Sands Development
- To Conduct Comprehensive and Inclusive Monitoring
- To Inform Management and Regulatory Action
- To Implement Rigorous Monitoring
- To be Cost-effective
- To Inform Trans-boundary Issues
- To Ensure Transparency
- To Incorporate Indigenous Monitoring, Endpoints, and Community-Based Monitoring

Regulatory Needs

a) for air:
   a) a plan to monitor dry and wet deposition from project activities;

b) for soil:
   i. identification of soils that are sensitive to acid deposition and will likely receive aerial deposition inputs from project activities;
   ii. a plan to monitor soil quality at locations representative of the soils identified in (b) (i);
   iii. a description of how soil quality data collected under this program will be used to determine potential acidification effects under periods of increased sulphur dioxide emissions;

c) for water:
   i. a summary of existing water quality data collected to date and analysis of the results;
   ii. a plan to monitor water quality for water bodies which will likely receive aerial deposition inputs from project activities;
   iii. identification of local water bodies that are sensitive to acidification;
   iv. a description of how water quality data collected under this program will be used to determine potential acidification effects under periods of increased SO2 emissions;
   v. a plan to develop triggers for further enhanced surface water quality monitoring to determine impacts of aerial deposition inputs;

d) reporting schedule for monitoring activities conducted for (a) through (c)

LICA
ENVIRONMENTAL STEWARDS

2.1.2 Monitoring agricultural soils vs forest soils

Determination of Critical Loads of Acidity for Terrestrial Ecosystems in Alberta, 2020 AEP

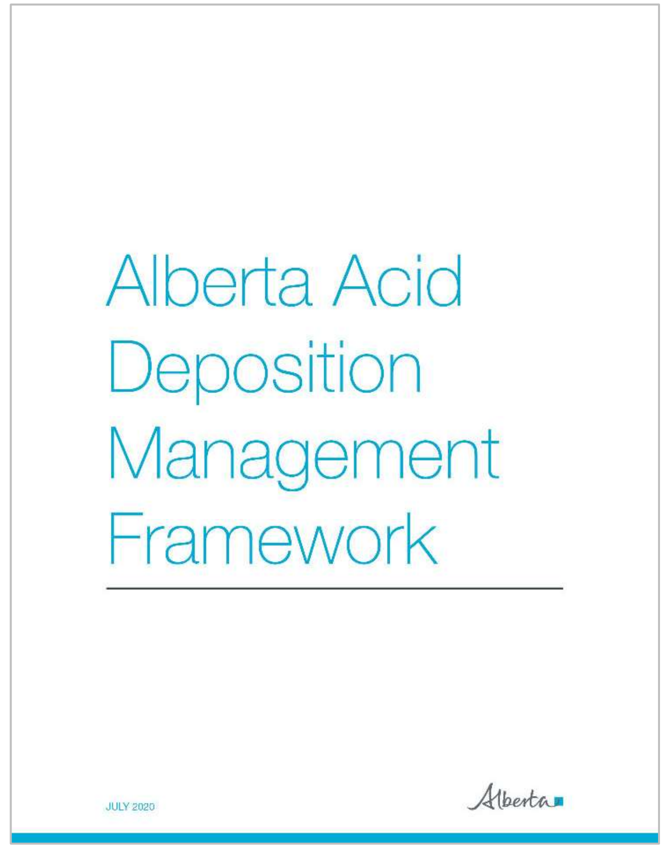
- This work does not take into account the high nitrogen input and removal, and base cation removal associated with fertilizer application and agricultural production on cultivated agricultural land.
- Critical loads of acidity were not derived for cultivated agricultural land.
- Areas identified as rock, exposed soil, water, ice or developed were also not included.

LICA ENVIRONMENTAL STEWARDS

2.1.3 Clarity on critical loads and ADMF

ADMF: Critical Loads

- A quantitative estimate of an exposure below which significant harmful effects do not occur.
- Alberta soil characteristics, dominant vegetation cover, run off, base cation deposition and the impact of wildfires were used to derive critical loads of acidity for sulphur and nitrogen.
- The critical loads approach is useful in environmental management.
- Determination of exceedances of critical load values are part of management framework implementation.


Alberta Acid Deposition Management Framework

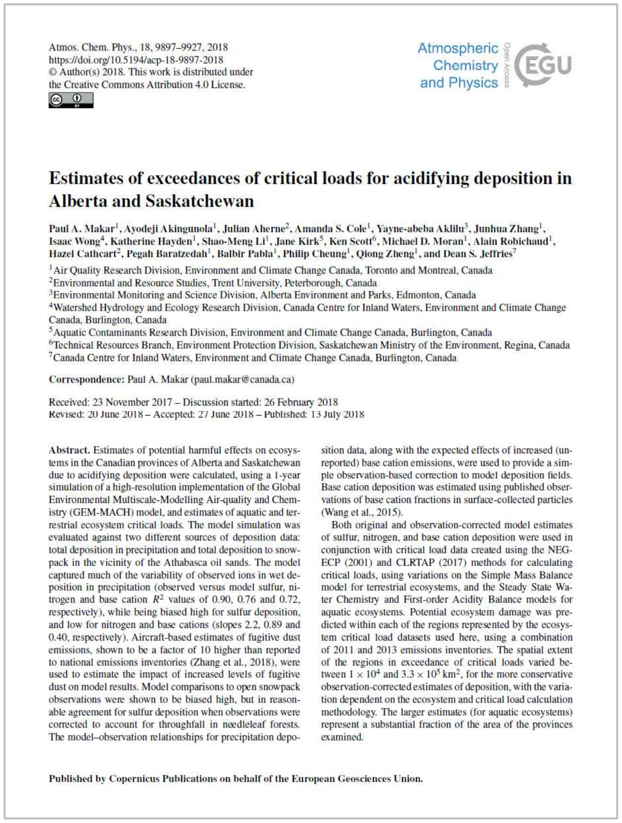
JULY 2020

Alberta

2.1.4 Water chemistry and aquatic ecosystems monitoring from an acid deposition perspective

Current Status

- ADMF focuses on soil sensitivity and critical loads.
- An Alberta framework to guide surface water acidification effects monitoring and management does not exist.
- 2018 GEM-MACH modelling study:
  - Aquatic ecosystem critical load data suggest that the buffering capacity within watersheds is insufficient.
  - Potential ecosystem changes may be taking place.
  - Future work:
    - models to determine damage and/or recovery.
    - monitoring studies to detect the presence of ecosystem change.



Atmos. Chem. Phys., 18, 9897–9927, 2018
https://doi.org/10.5194/acp-18-9897-2018

Atmospheric Chemistry and Physics

Open Access

EGU

Estimates of exceedances of critical loads for acidifying deposition in Alberta and Saskatchewan

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Correspondence: Paul A. Makar (paul.makar@canada.ca)

Received: 23 November 2017 – Discussion started: 26 February 2018
Revised: 20 June 2018 – Accepted: 27 June 2018 – Published: 13 July 2018

Abstract. Estimates of potential harmful effects on ecosystems in the Canadian provinces of Alberta and Saskatchewan due to acidifying deposition were calculated, using a 1-year simulation of a high-resolution implementation of the Global Environmental Multiscale-Modelling Air-quality and Chemistry (GEM-MACH) model, and estimates of aquatic and terrestrial ecosystem critical loads. The model simulation was evaluated against two different sources of deposition data: total deposition in precipitation and total deposition to snowpack in the vicinity of the Athabasca oil sands. The model captured much of the variability of observed ions in wet deposition in precipitation (observed versus model sulfur, nitrogen and base cation R^2 values of 0.90, 0.76 and 0.72, respectively), while being biased high for sulfur deposition, and low for nitrogen and base cations (slopes 2.2, 0.89 and 0.40, respectively). Aircraft-based estimates of fugitive dust emissions, shown to be a factor of 10 higher than reported to national emissions inventories (Zhang et al., 2018), were used to estimate the impact of increased levels of fugitive dust on model results. Model comparisons to open snowpack observations were shown to be biased high, but in reasonable agreement for sulfur deposition when observations were corrected to account for throughfall in needleleaf forests. The model–observation relationships for precipitation deposition data, along with the expected effects of increased (unreported) base cation emissions, were used to provide a simple observation-based correction to model deposition fields. Base cation deposition was estimated using published observations of base cation fractions in surface-collected particles (Wang et al., 2015).

Both original and observation-corrected model estimates of sulfur, nitrogen, and base cation deposition were used in conjunction with critical load data created using the NEG-ECP (2001) and CLRTAP (2017) methods for calculating critical loads, using variations on the Simple Mass Balance model for terrestrial ecosystems, and the Steady State Water Chemistry and First-order Acidity Balance models for aquatic ecosystems. Potential ecosystem damage was predicted within each of the regions represented by the ecosystem critical load datasets used here, using a combination of 2011 and 2013 emissions inventories. The spatial extent of the regions in exceedance of critical loads varied between 1×10^4 and 3.3×10^5 km^2, for the more conservative observation-corrected estimates of deposition, with the variation dependent on the ecosystem and critical load calculation methodology. The larger estimates (for aquatic ecosystems) represent a substantial fraction of the area of the provinces examined.

Published by Copernicus Publications on behalf of the European Geosciences Union.

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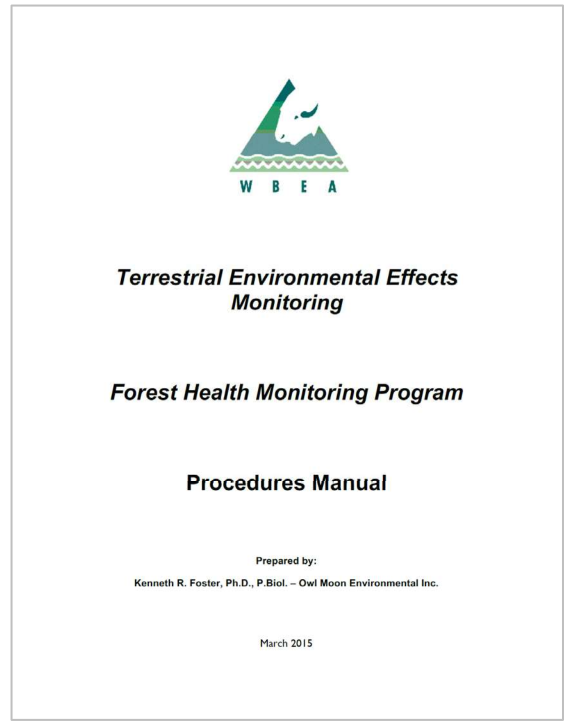
2.1.5 WBEA: Deposition monitoring program

Wood Buffalo Environmental Association (WBEA):
Terrestrial Environmental Effects Monitoring Program

- The WBEA's Terrestrial Environmental Effects Monitoring (TEEM) program is designed to detect, characterize, quantify, and report on emission-related effects to terrestrial ecosystems and traditional land resources in the region.
- The TEEM program monitors air related (cause) impacts on natural ecosystems (effects) so that stakeholders can make informed decisions.
- This work is carried out through the Forest Health Monitoring Program.


W B E A

Terrestrial Environmental Effects Monitoring

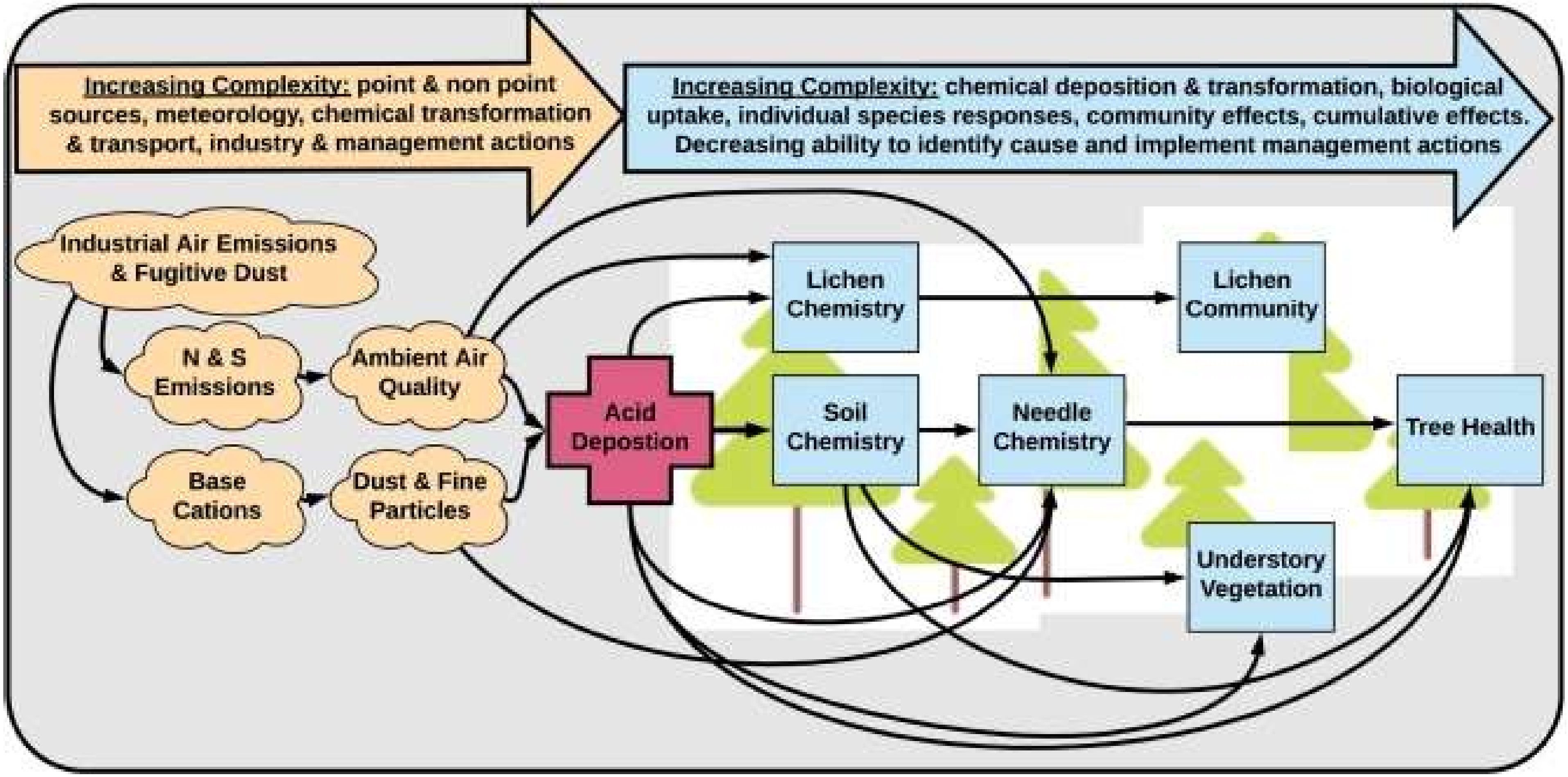
Forest Health Monitoring Program

Procedures Manual

Prepared by:

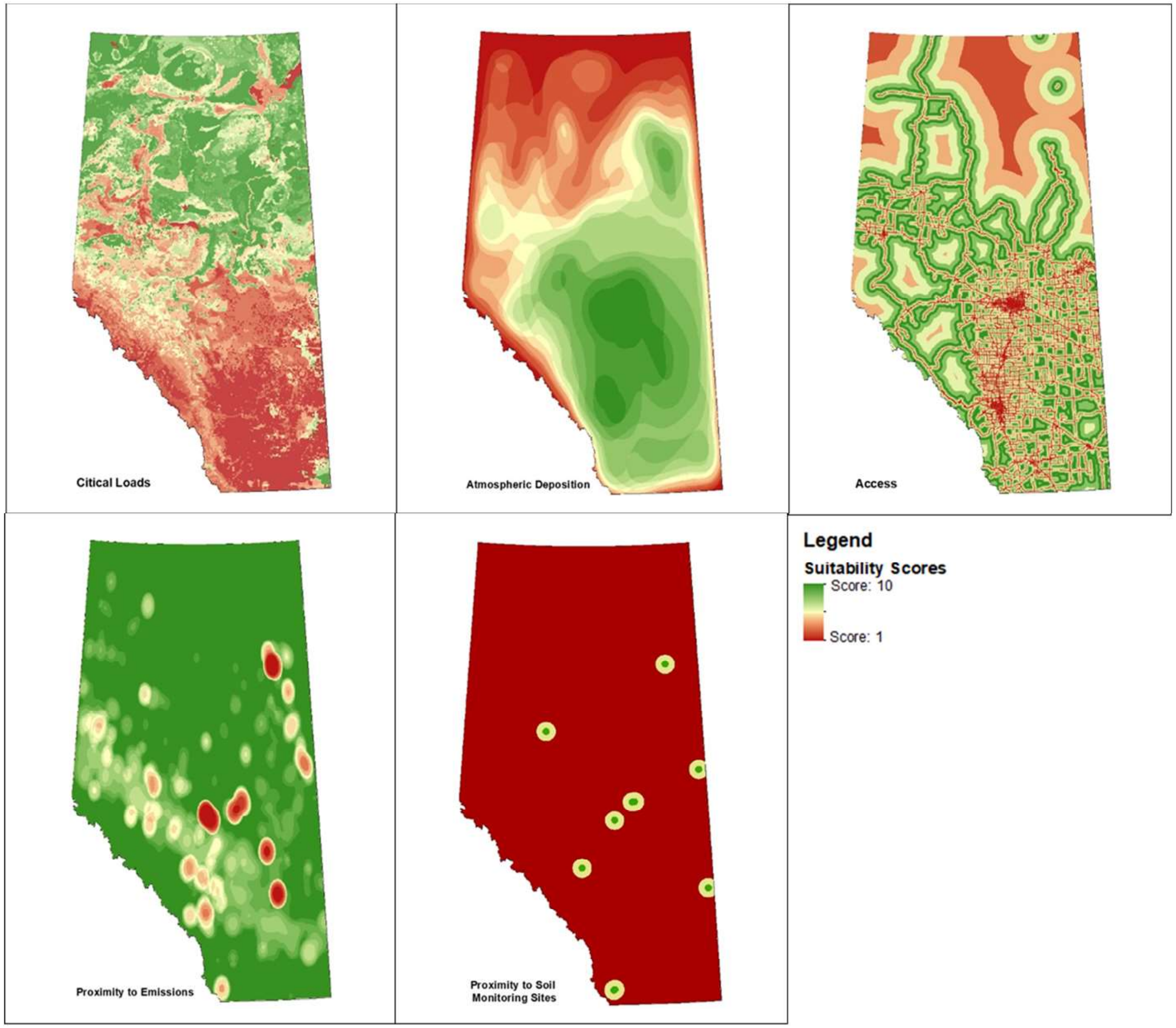
Kenneth R. Foster, Ph.D., P.Biol. – Owl Moon Environmental Inc.

March 2015



LICA ENVIRONMENTAL STEWARDS

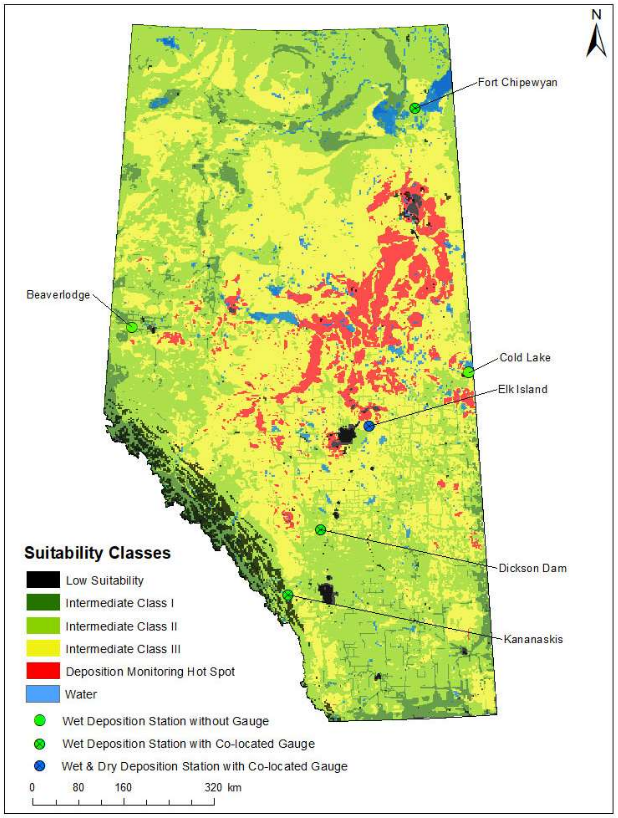
2.2 Initial results of GIS/mapping overlay
2.3 Identification of potential monitoring areas

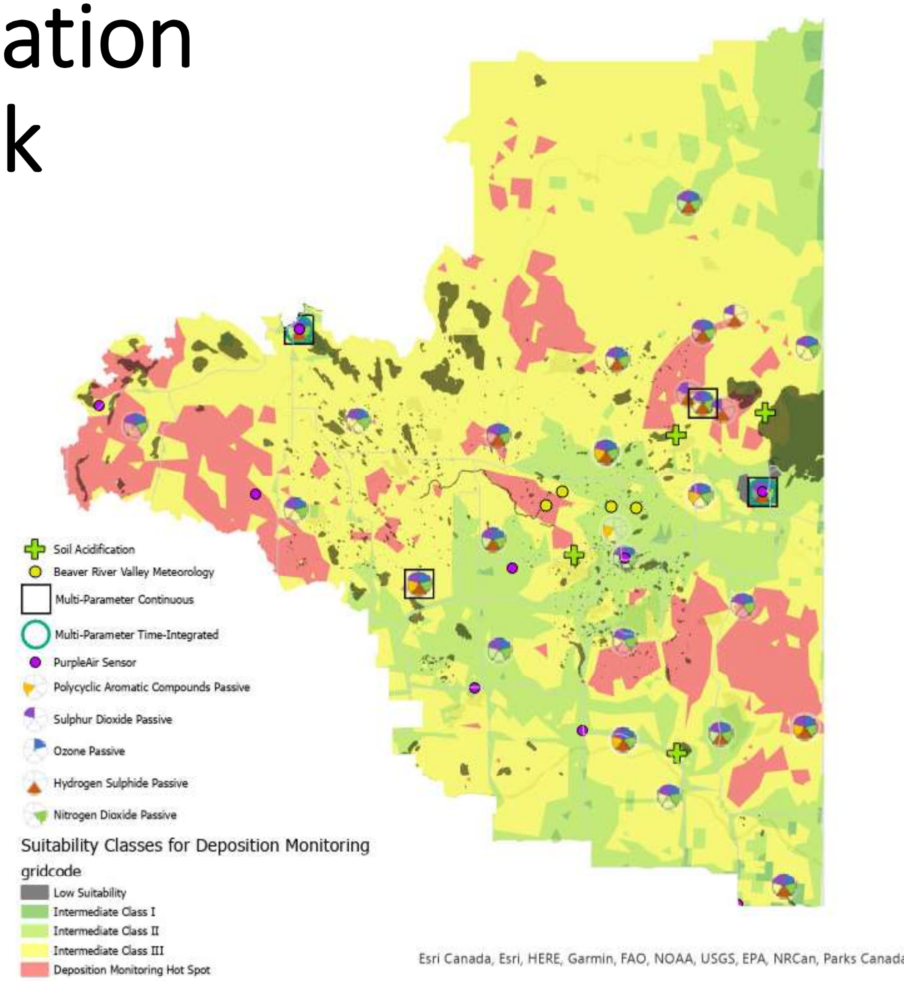


Classification input layer maps

LICA ENVIRONMENTAL STEWARDS

Alberta Monitoring Evaluation and Reporting Framework





LICA ENVIRONMENTAL STEWARDS

WOOD BUFFALO ENVIRONMENTAL ASSOCIATION

WBEA

WBEA TEEM Forest Health Monitoring Program

SOCIETY OF ENVIRONMENTAL TOXICOLOGY AND CHEMISTRY

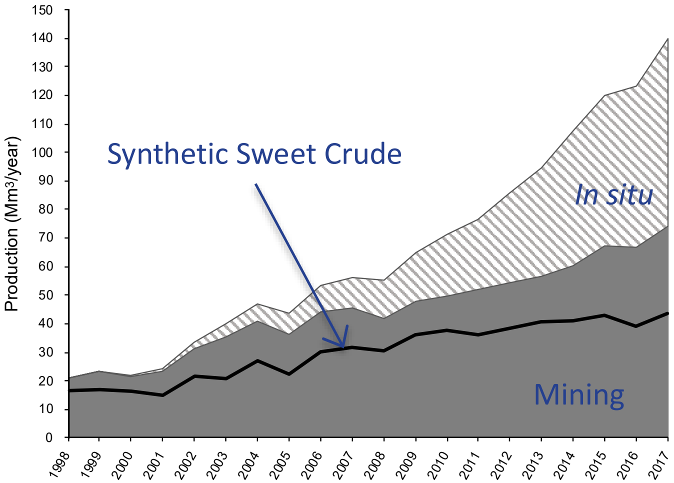
NOVEMBER 5, 2019

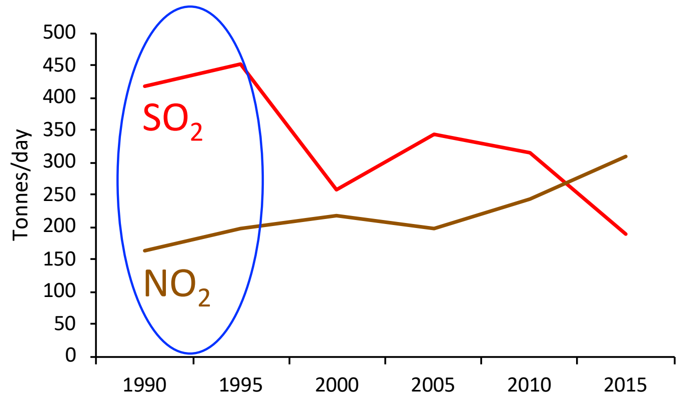
KENNETH R. FOSTER, CARLA DAVIDSON, RAJIV NEAL TANNA, DAVID SPINK, ERIC EDGERTON, DEREK MACKENZIE, SEBASTIAN DIETRICH, SAMUEL BARTELS, ELLEN MACDONALD & MATT LANDIS

OIL SANDS MONITORING PROGRAM

Genesis of the Forest Health Monitoring Program

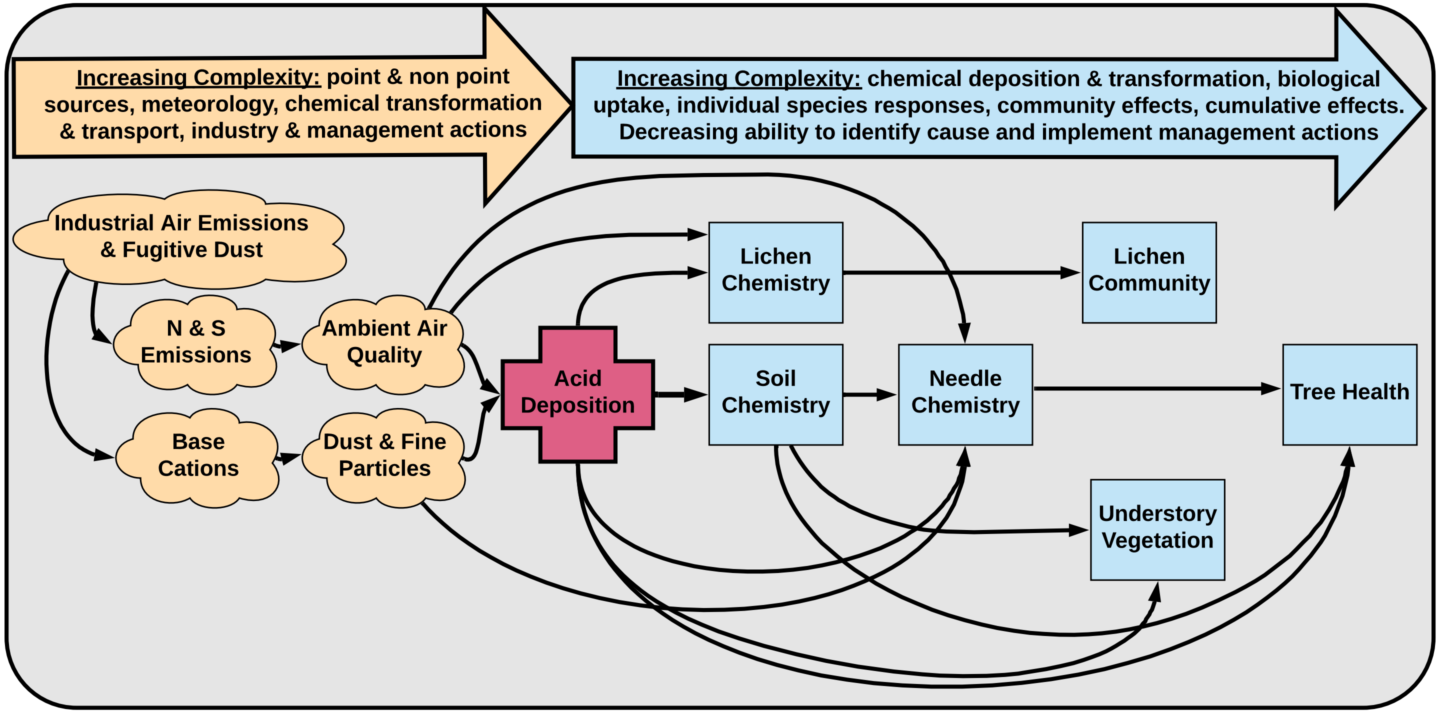
Applications for new & expanding oil sands operations beginning in the early 1990's lead to the creation of the WBEA TEEM multi-stakeholder committee





To develop and operate a long-term program to detect and characterize the effects of oil sands emissions on terrestrial and aquatic ecosystems, and on traditional resources and hence on traditional resource users (1996)

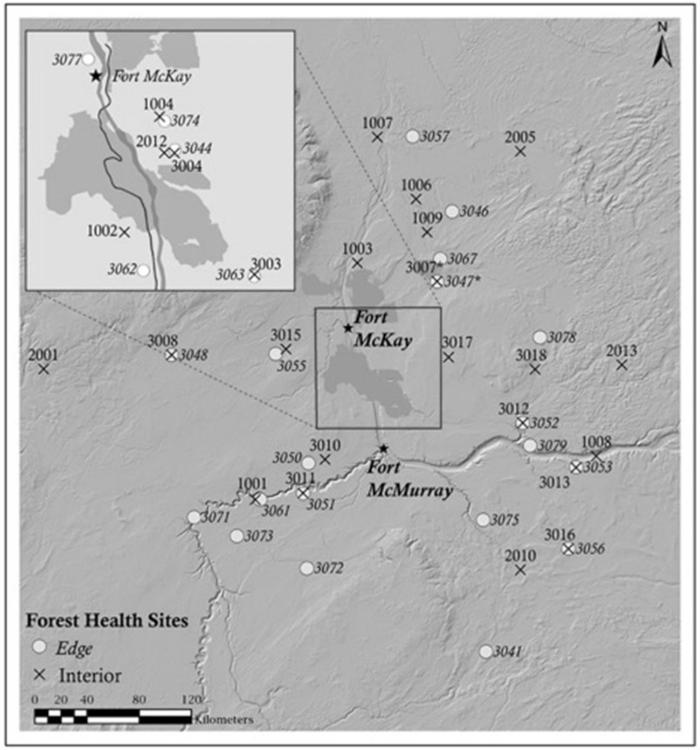
Acid Deposition Effects Monitoring Conceptual Model

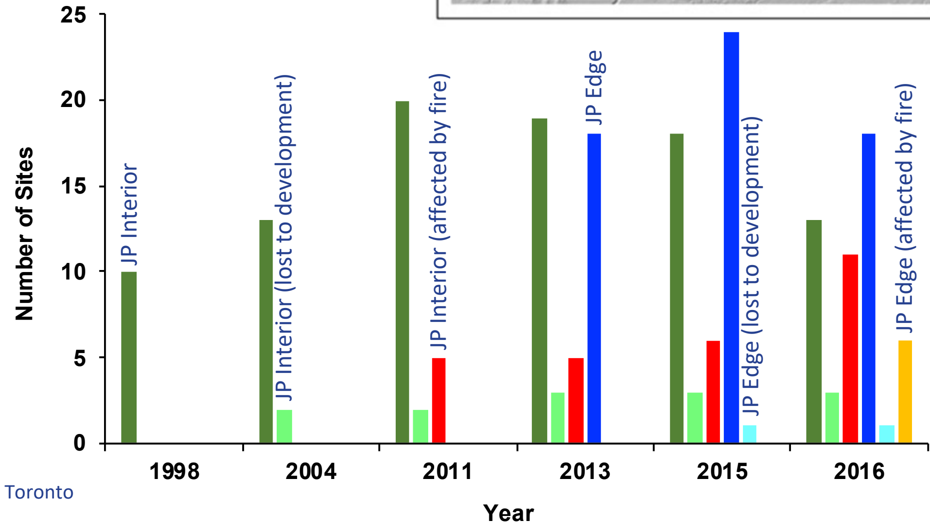


Although environmental acidification progresses from left (stressors) to right (effects), TEEM elected to initiate effects monitoring and to work from right to left. This created an ecological monitoring program prior to the anticipated expansion of the industry

Forest Health Monitoring Program Design

- Acid-sensitive jack pine forest
- Initially 10 sites (1998; forest interior) increasing to 49 sites (interior & edge)
  - Canadian *Acid Rain Network Early Warning System* protocols
  - 6-year intensive sampling cycle, more frequent targeted sampling
  - Fire-affected sites continue to be monitored



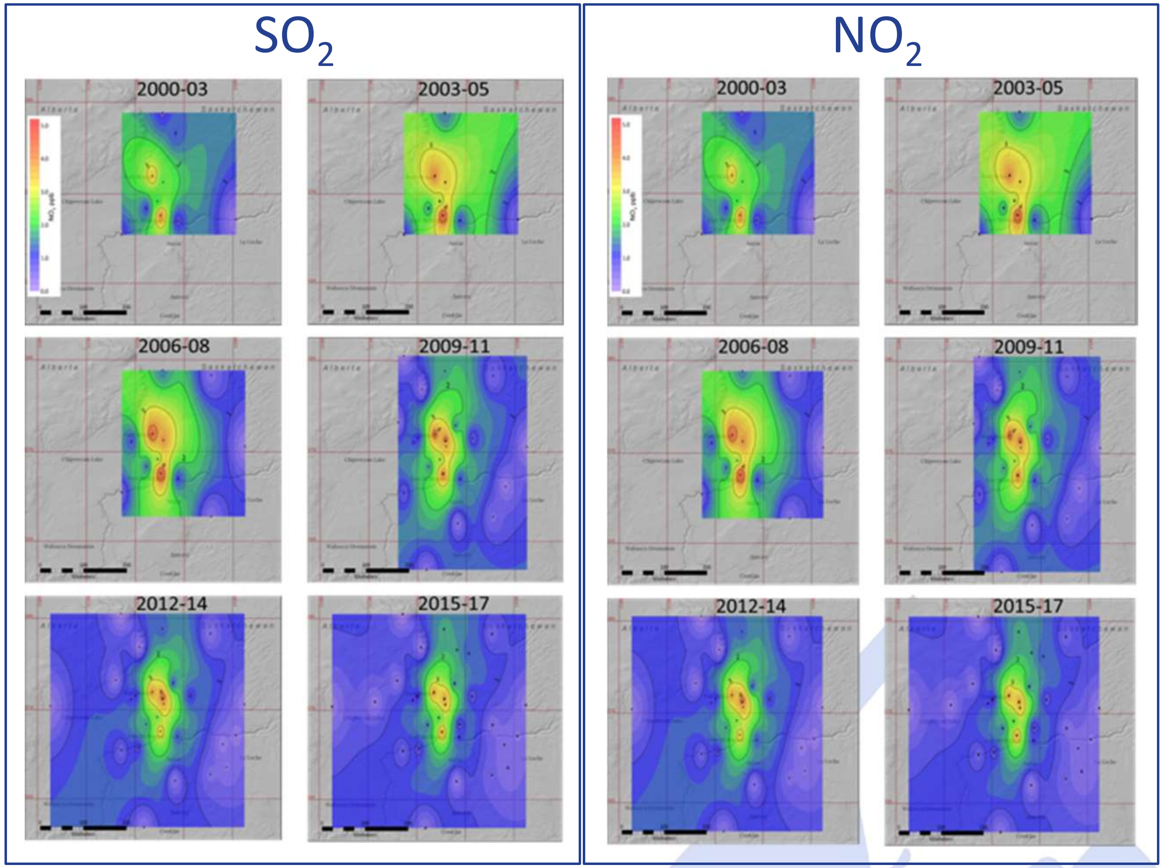


Forest Health Monitoring Program
Air Quality and Deposition Monitoring

- Passive SO_2, NO_2 and O_3 monitoring initiated in 1999; NH_3 and HNO_3 in 2005
- WBEA's AMS network (initiated 1999) provides continuous and intermittent air quality data
- Ion-exchange resin (acid, base) deposition monitoring initiated in 2007
- Cultural, traditional foods study in early 2000's, and since 2010, a Fort McKay First Nation – WBEA berry study
- Source apportionment studies (initiated 2007) to characterize source types and their relative contributions to air quality and deposition

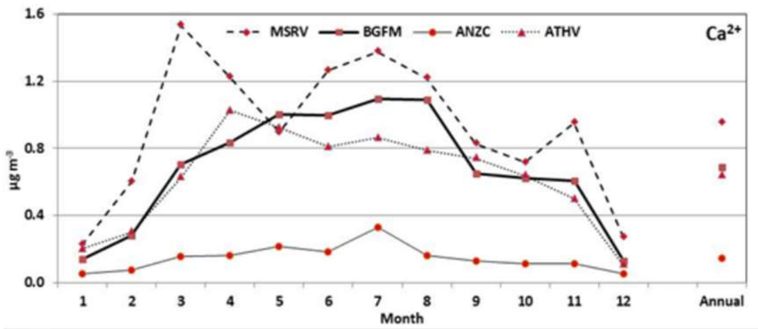
Ambient Air Quality

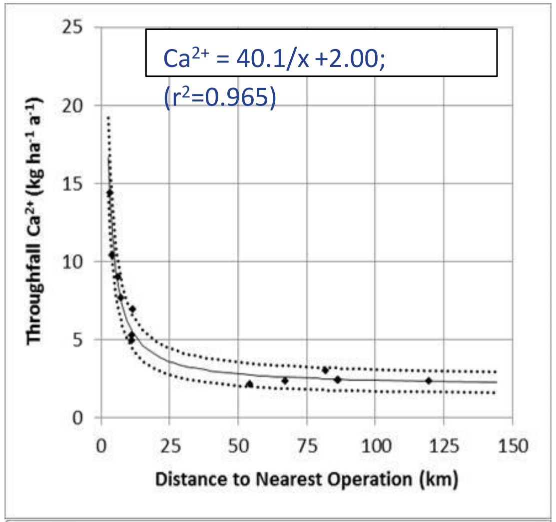
- SO_2: strong (5-10x) gradients across the region, decreased ~40% since 2000
- NO_2: strong (5-10x) gradients across the region, increased from 2000 to 2008, then plateaued or declined slightly
- Weak (2x) gradients for HNO_3, NH_3 & $PM_{2.5}$, but not enough data to determine trends
- Wildfires contribute significant amounts of NH_3

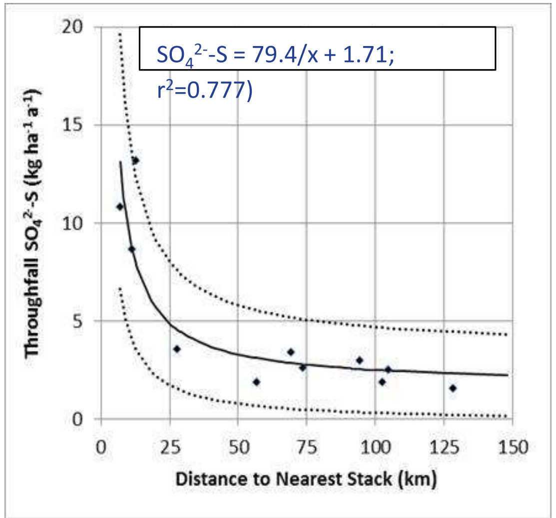


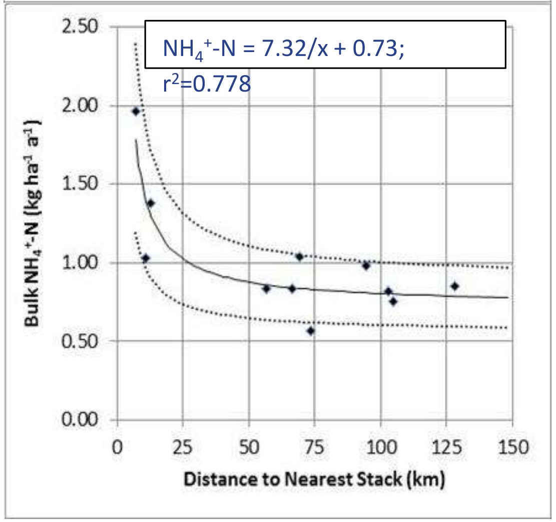
Deposition Gradients for Key Components of PAI

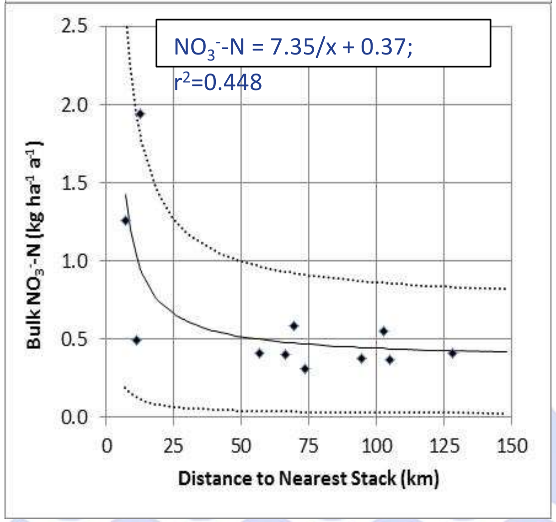
- Deposition of S, N, and base cations (BC) show strong gradients, reaching near background levels 10 to 50 km from nearest sources
- PM_{10} deposition data limited to community/industrial sites, but indicate high alkalinity, strong spatial gradients and high seasonality







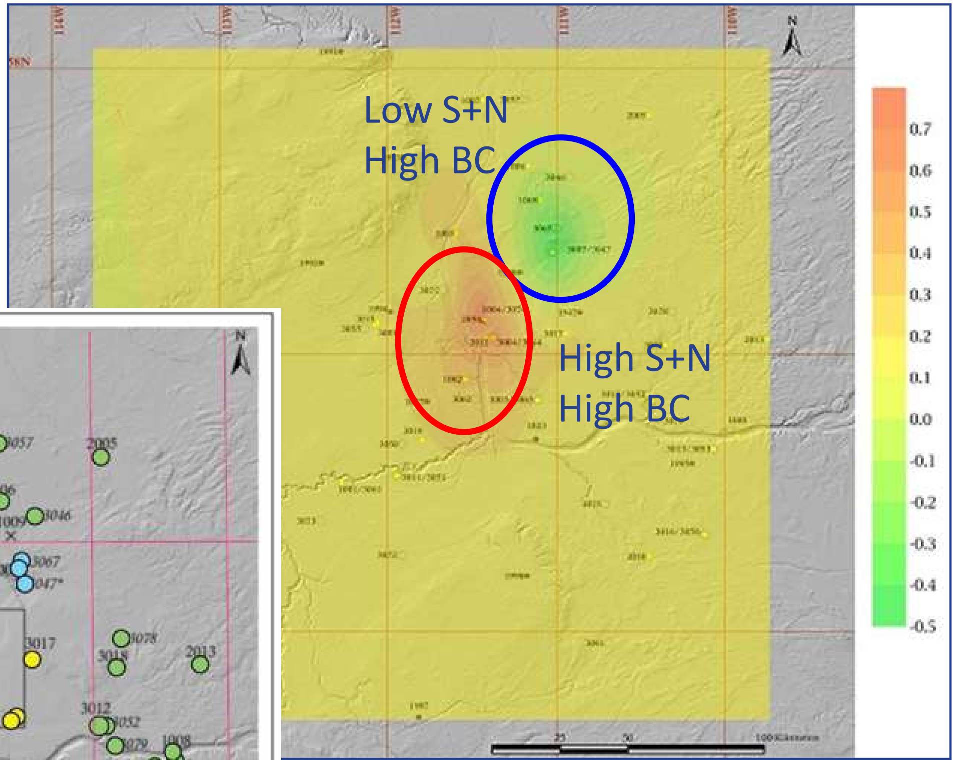


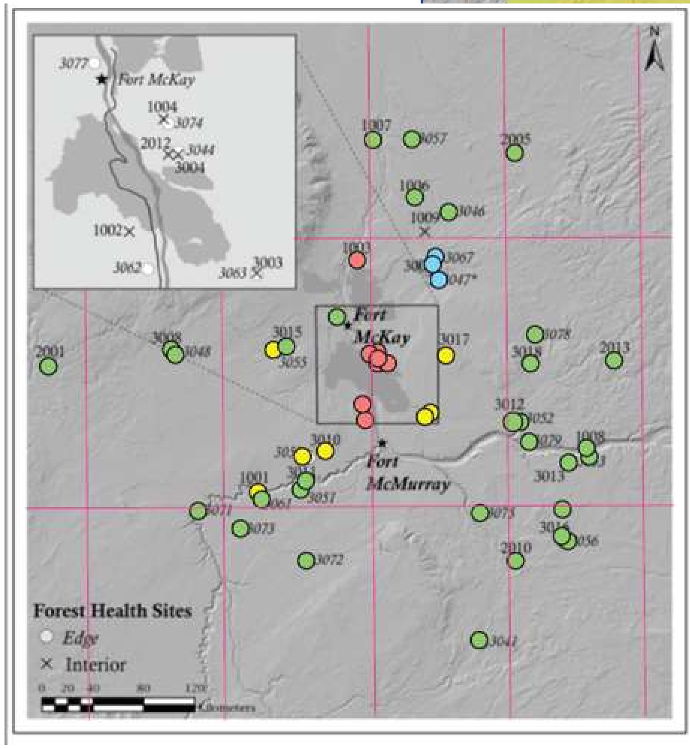


Estimated PAI at TEEM FHM Sites (2011-2012)

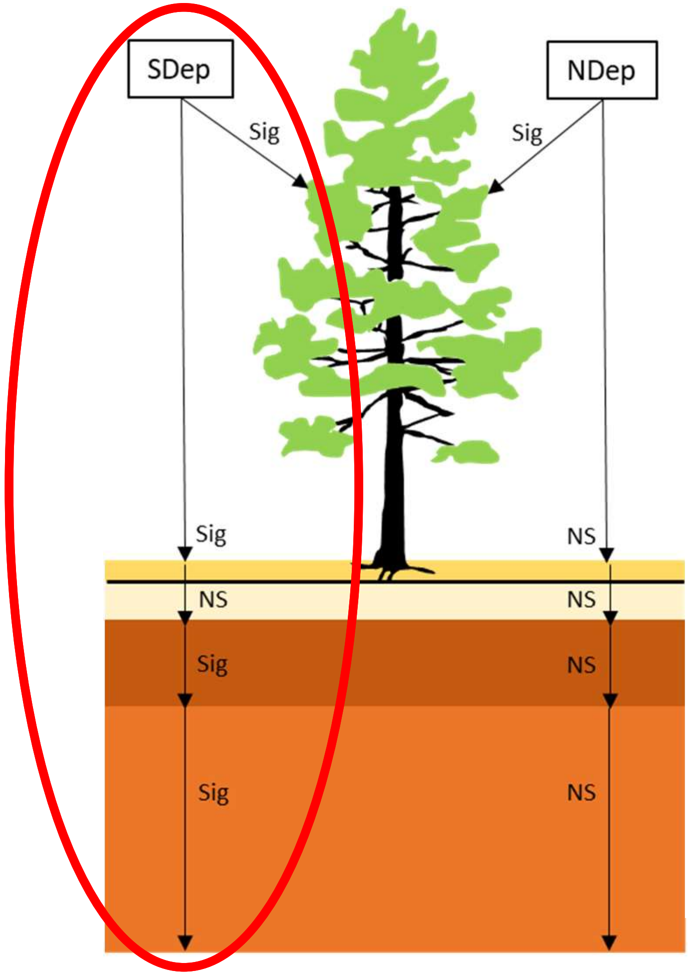
- Potential Acid Input (PAI) <0.2 keq H^+/ha/yr at most sites, ranging from -0.6 keq H^+/ha/yr (alkaline) to 0.8 keq H^+/ha/yr (acidic)

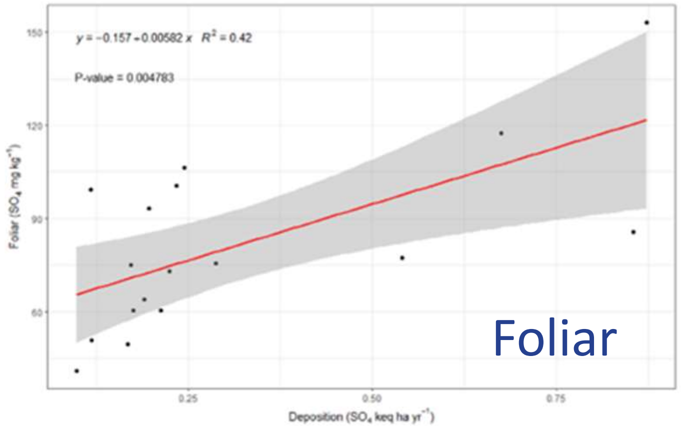
  - >0.25 keq H^+/ha/yr
  - >0.17 and <0.25 H^+ keq/ha/yr
  - <0.17 and >0.00 H^+ keq/ha/yr
  - <0.00 keq H^+/ha/yr (alkaline)

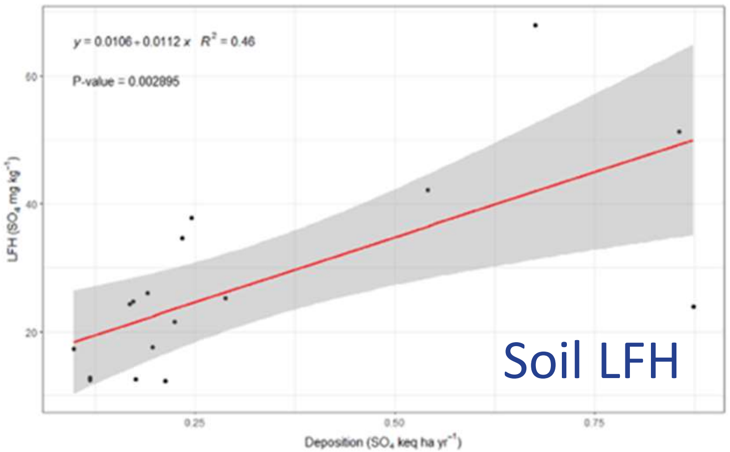


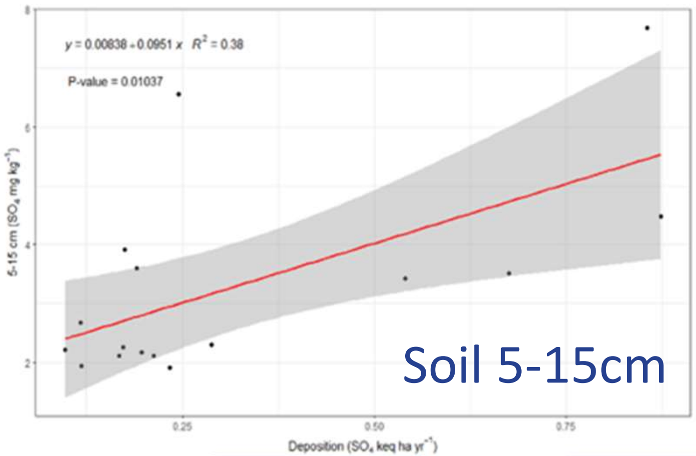


Sulphur in Tree Needles and Soil

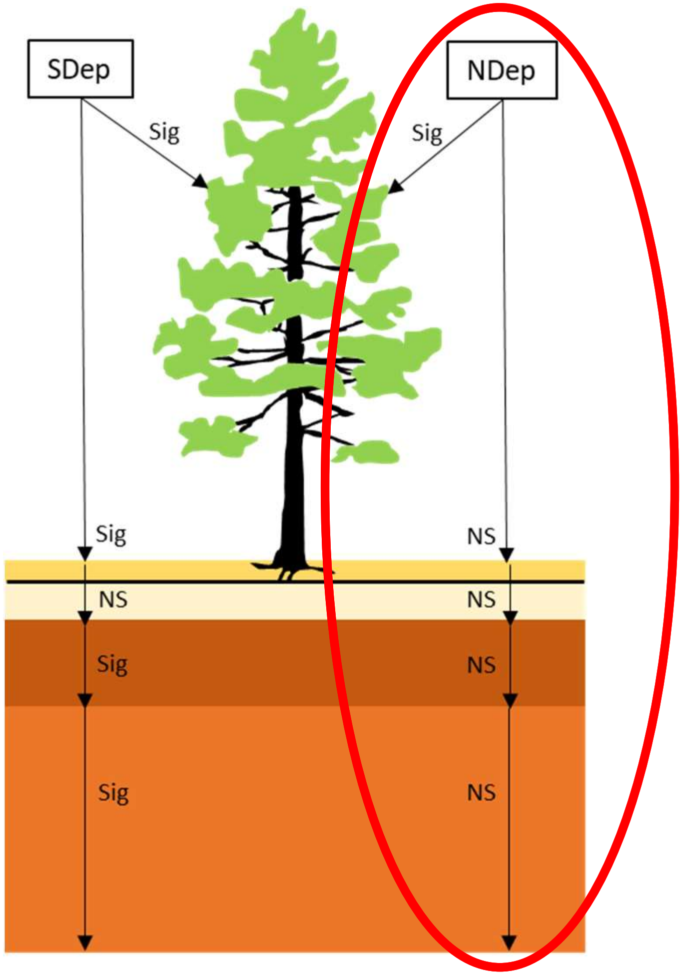


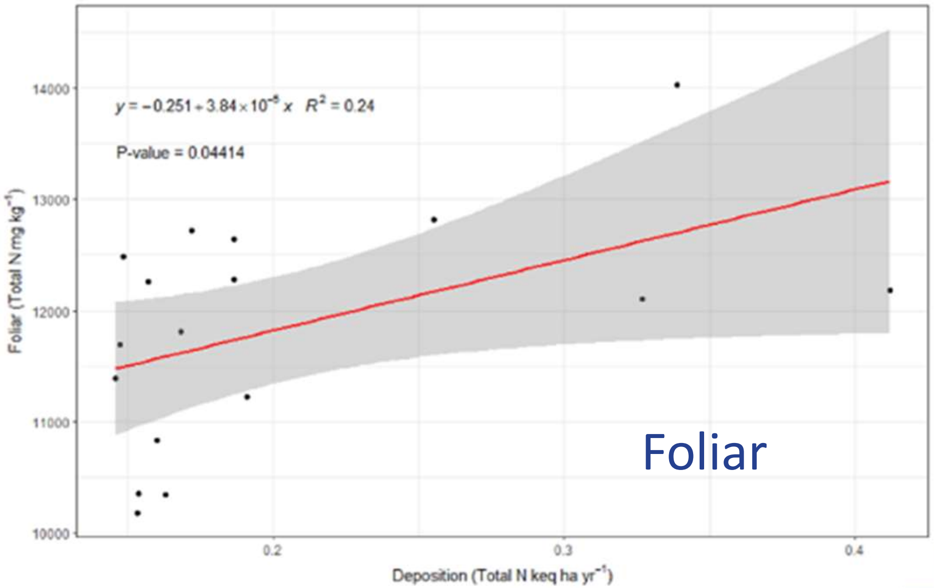






Nitrogen in Tree Needles and Soil





Evaluation of Atmospheric Deposition on Tree Growth and Understory Vegetation

Jack Pine Trees

BAI **increased** with N, S and BC deposition

BAI **higher** in pre-mining era compared with current period & natural gradients appear to be present

Understory Vegetation

Vascular plant cover, richness, and diversity **increased** in relation to N and S deposition

- Atmospheric deposition was **not detrimental** to tree growth or understory vegetation
- **Possible fertilization effect** due to enhanced atmospheric deposition of nitrogen compounds

Key Findings
20 Years of Forest Health Monitoring in the Athabasca Oil Sands

- There is alignment among air, deposition, soil, needle and lichen monitoring showing that deposition, increased elemental concentrations, and ecological responses are detectable within 50 km of the nearest oil sands emission sources, beyond which deposition occurs at near-background levels
- An area within the core of mining and upgrading operations is receiving deposition at levels that may exceed the critical load (acidification) for sensitive ecosystems. High, local base cation deposition levels was an unexpected finding
- No negative effects of deposition on jack pine tree growth have been observed, however, nitrogen deposition may be functioning as a fertilizer that is resulting in community composition changes (understory)

Thank You

WWW.WBEA.ORG

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TEEM Committee members past & present, Sanjay Prasad, Dianne McIsaac, Cody David, Yu-Mei Hsu, Kelly Munkittrick, Shanti Berryman, Martin Hansen, Emily White & numerous specialists and contractors

https://www.sciencedirect.com/journal/science-of-the-total-environment/special-issue/10LW6CG6CPT

Estimation of Potential Acid Input (PAI) to WBEA Forest Health Monitoring (FHM) Sites

Eric S. Edgerton

LICA ADMPEC Virtual Meeting

December 2, 2021

Ambient Concentrations and Total Deposition of Inorganic Sulfur, Inorganic Nitrogen and Base Cations in the AOSR

Eric S. Edgerton, Yu-Mei Hsu, Emily M. White, Matthew S. Landis, Mark E. Fenn

PAI Defined

- $PAI_i = S_{dep} + N_{dep} – BC_{dep}$
  $= (S_{wet} + N_{wet} – BC_{wet}) + (S_{dry} + N_{dry} – BC_{dry})$
  Where, i is ith land use, BC = base cations (Ca^{2+}, K^+, Mg^{2+}, Na^+), and units are kequiv/ha.

  Ca^{2+} is the dominant base cation

  N_{dry} is estimated from ambient concentrations of NO_2, HNO_3, NH_3 and site-specific deposition velocity (V_d)

WBEA Approach

- $PAI_{JP} \sim N_{bulk} + N_{dry} + S_{throughfall} – adjBC_{throughfall}$
  Where, JP are jack pine sites, bulk refers to open IER deposition and throughfall refers to throughfall IER deposition

4 Key Measurements Used to Estimate PAI to Jack Pine Sites

- Bulk deposition of NH_4^+ and NO_3^-
- Active and passive concentrations of NO_2, HNO_3 and NH_3
- Throughfall deposition of SO_4^{2-}
- Throughfall deposition of base cations

Note: particulate NH_4^+ and NO_3^- are assumed to be minor components of deposition, and can be inferred from measurements at other sites

Canopy Interactions (What does jack pine add/subtract from incoming deposition?)

<u>Subtractions</u>

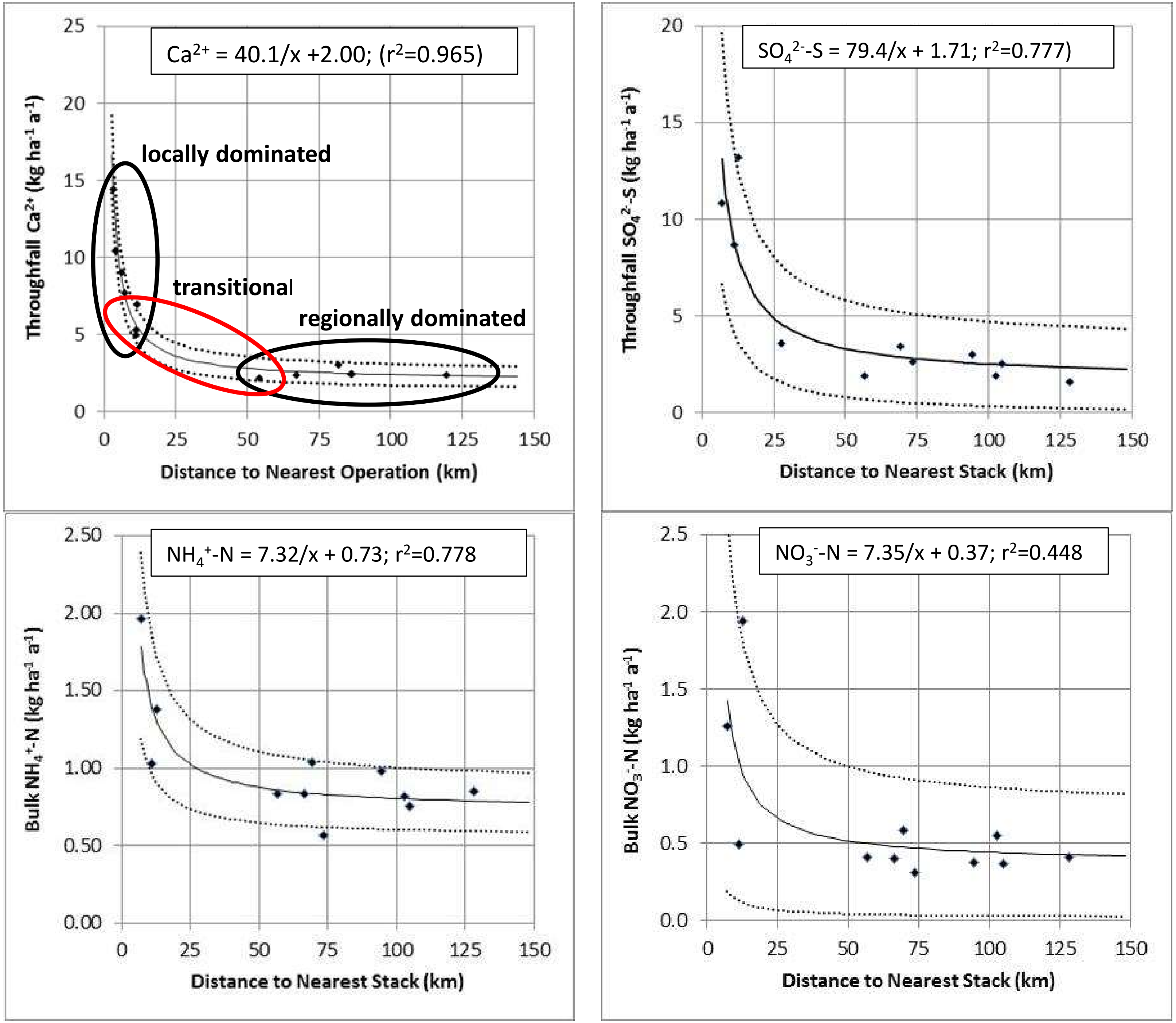
NH_4^+ ~ 50%
NO_3^- ~ 50%
SO_4^{2-} 0-20%?

<u>Additions</u>

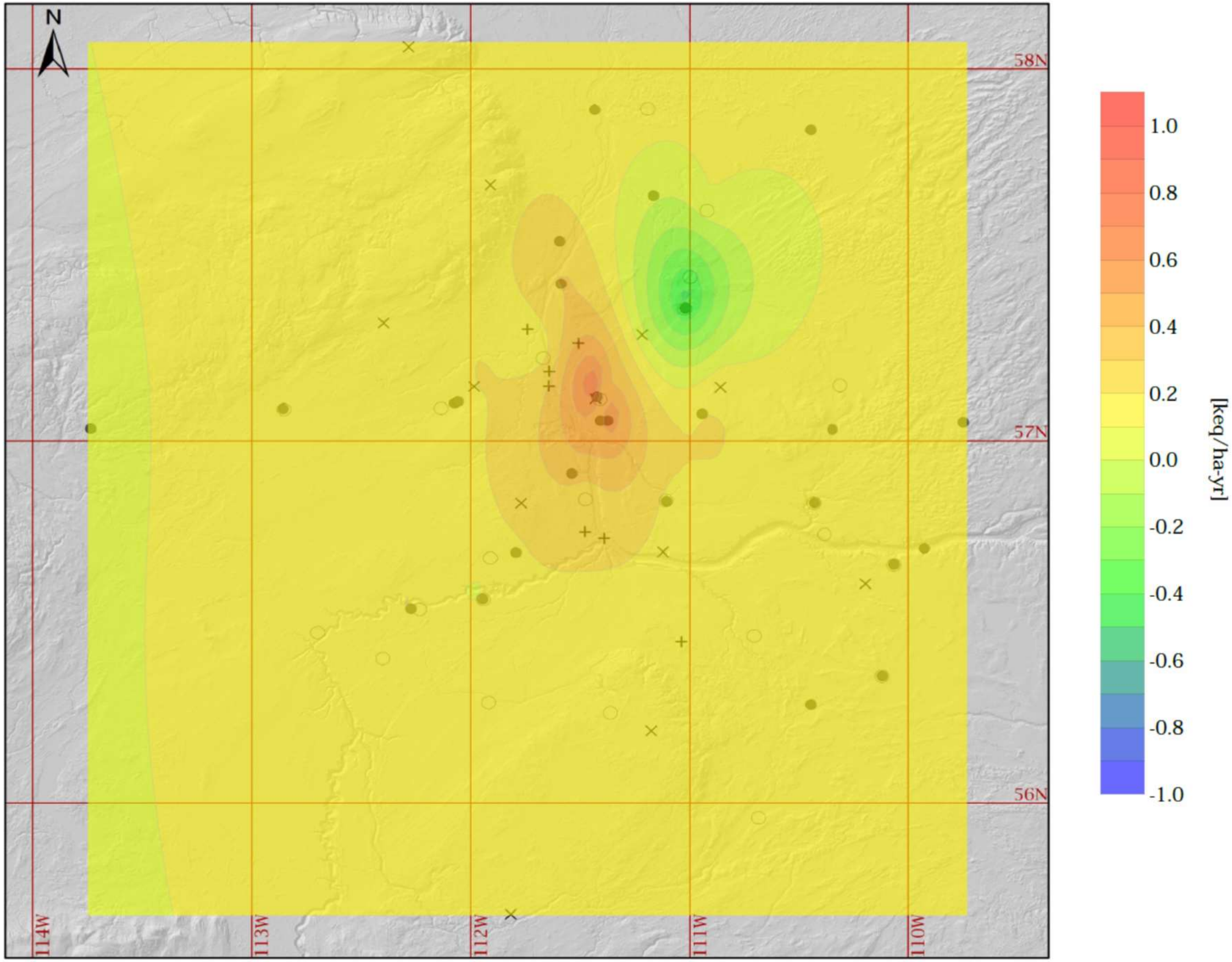
K^+ ~100%
Mg^{2+} ~40%
Ca^{2+} ~0-10%
Na^+ 0*

* assumed conservative

Deposition Gradients for Key Components of PAI



Estimated Potential Acid Input (2011-12)



PAI Defined

- $PAI_i = S_{dep} + N_{dep} – BC_{dep}$

  $= (S_{wet} + N_{wet} – BC_{wet}) + (S_{dry} + N_{dry} – BC_{dry})$

  Where, i is i^{th} land use, BC = base cations (Ca^{2+}, K^+, Mg^{2+}, Na^+), and units are kequiv/ha.

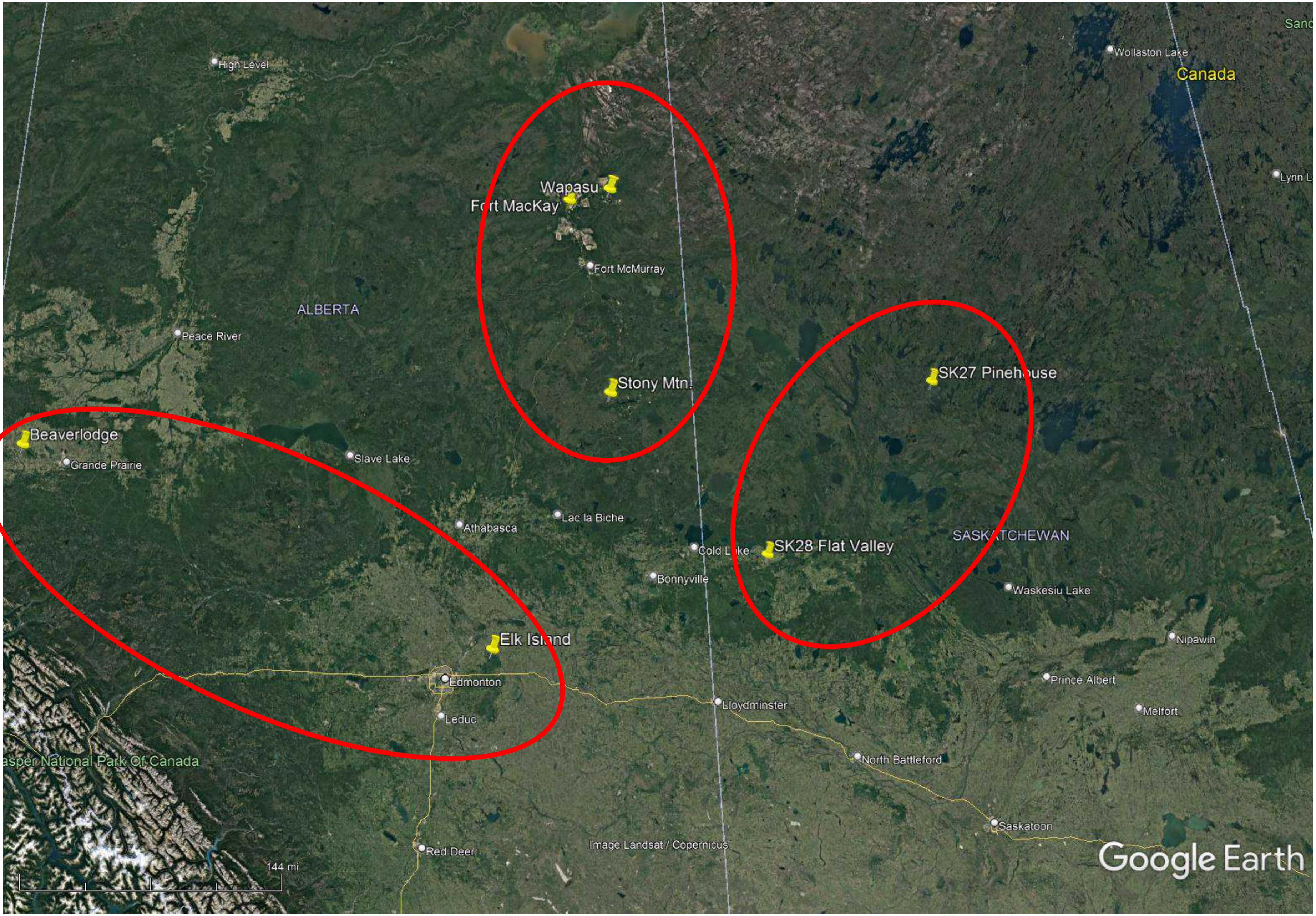
  Ca^{2+} is the dominant base cation

  N_{dry} is estimated from ambient concentrations of NO_2, HNO_3, NH_3 and site-specific deposition velocity (V_d)

Another Approach for PAI for Multiple Land-Use Application

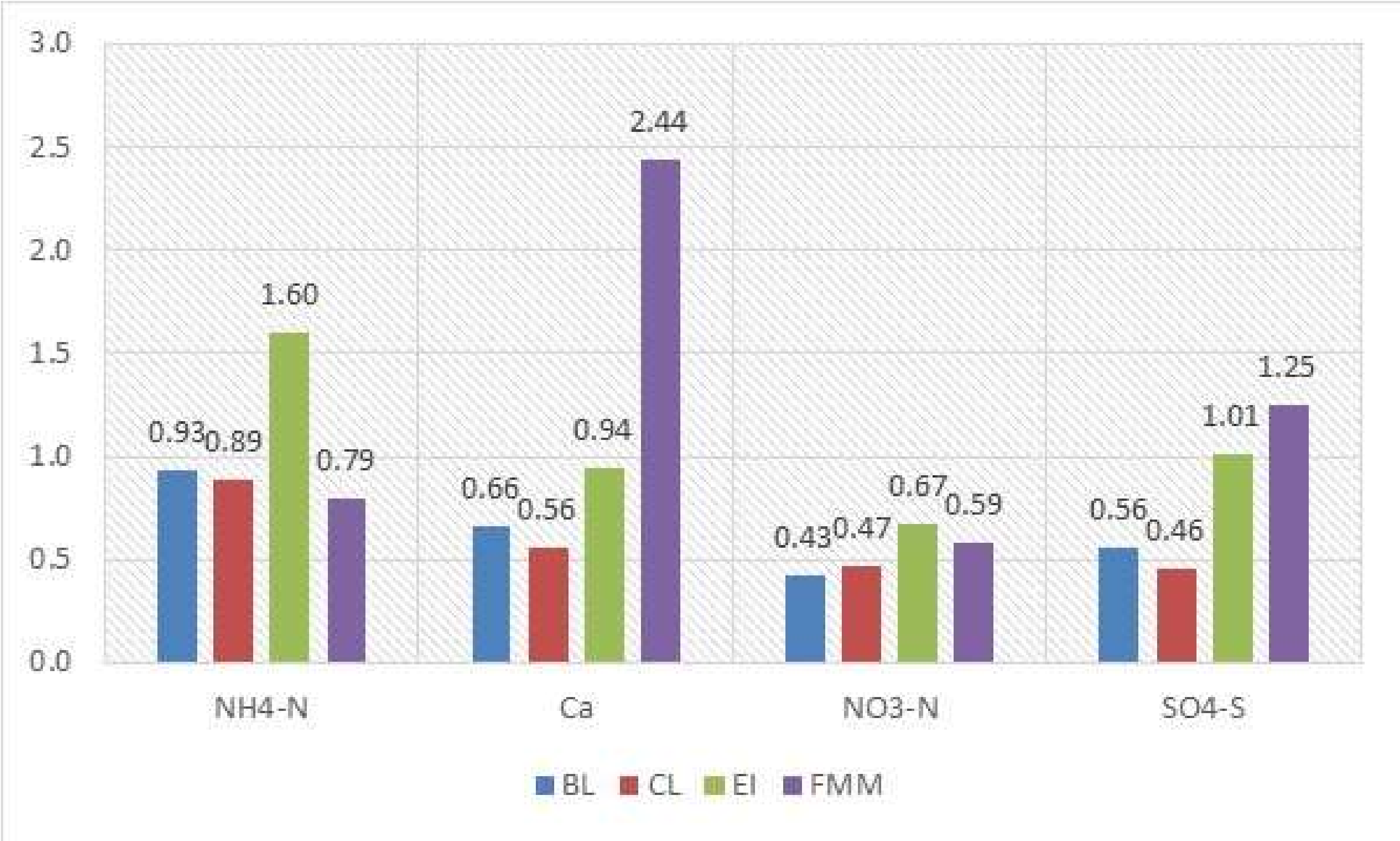
- Measure Wet Deposition (S,N,BC)
- Measure Ambient Gases and PM
  - Already measuring SO_2 and NO_2 via passives
  - Add HNO_3 and NH_3 using denuders
  - Add PM_{10} using partisol sampler
- Estimate Dry Components using Deposition Velocity Approach
  - Implement a dry deposition box model (MLM)
  - Use literature values for Vd
  - Use modelled values for Vd (GEM-MACH, CMAQ, etc.)

Wet Deposition Sites in Region of Interest



Multiple Networks with Current or Historical Data

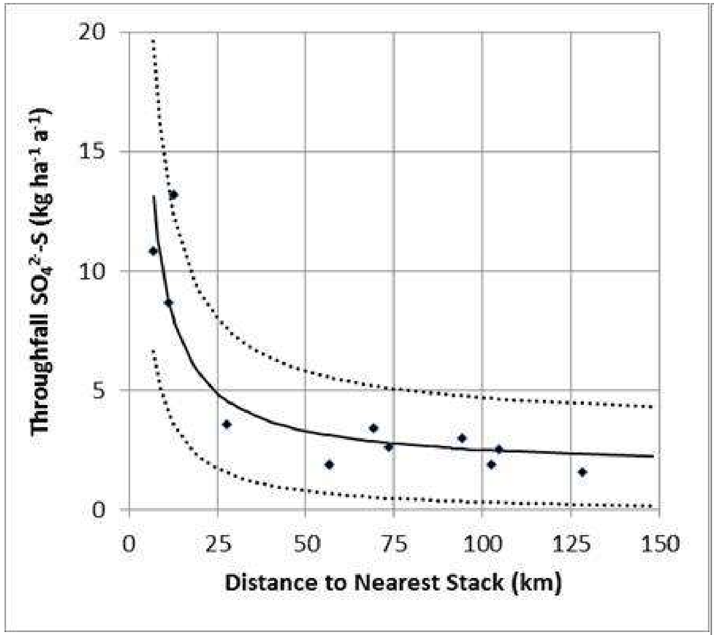
Wet Deposition at AB Sites 2014-16
(kg/ha)

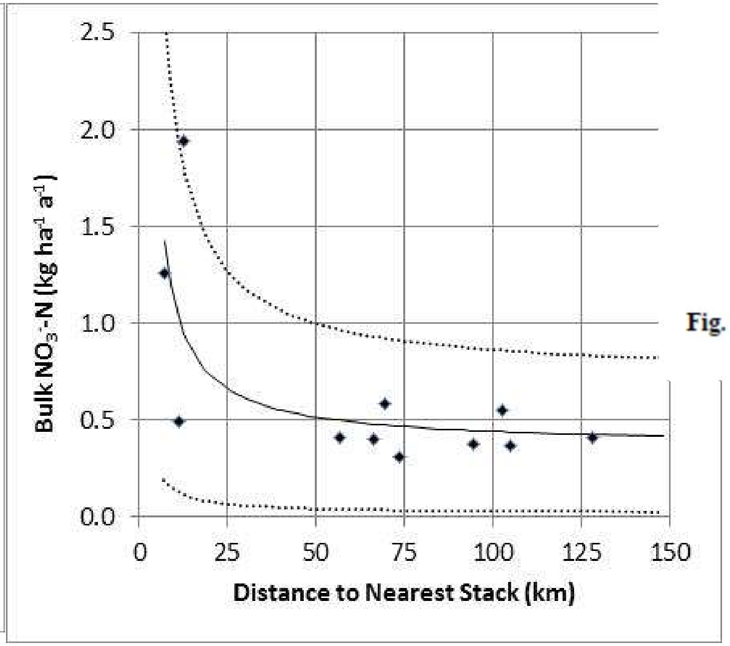


BL=Beaverlodge CL=Cold Lake EI=Elk Island FMM=Fort McMurray (AMS6)

What does 1 ppb of ambient concentration imply for dry deposition calculations?

kg/ha-yr			
SO2-S	NH3-N	HNO3-N	NO2-N
2.2	0.9	3.6	0.5





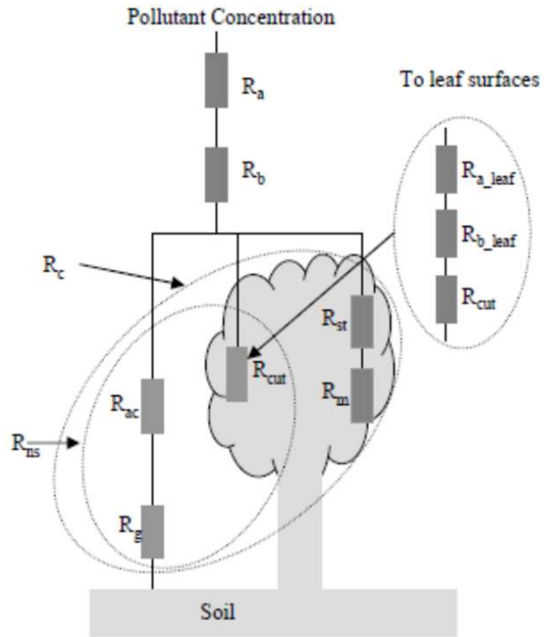
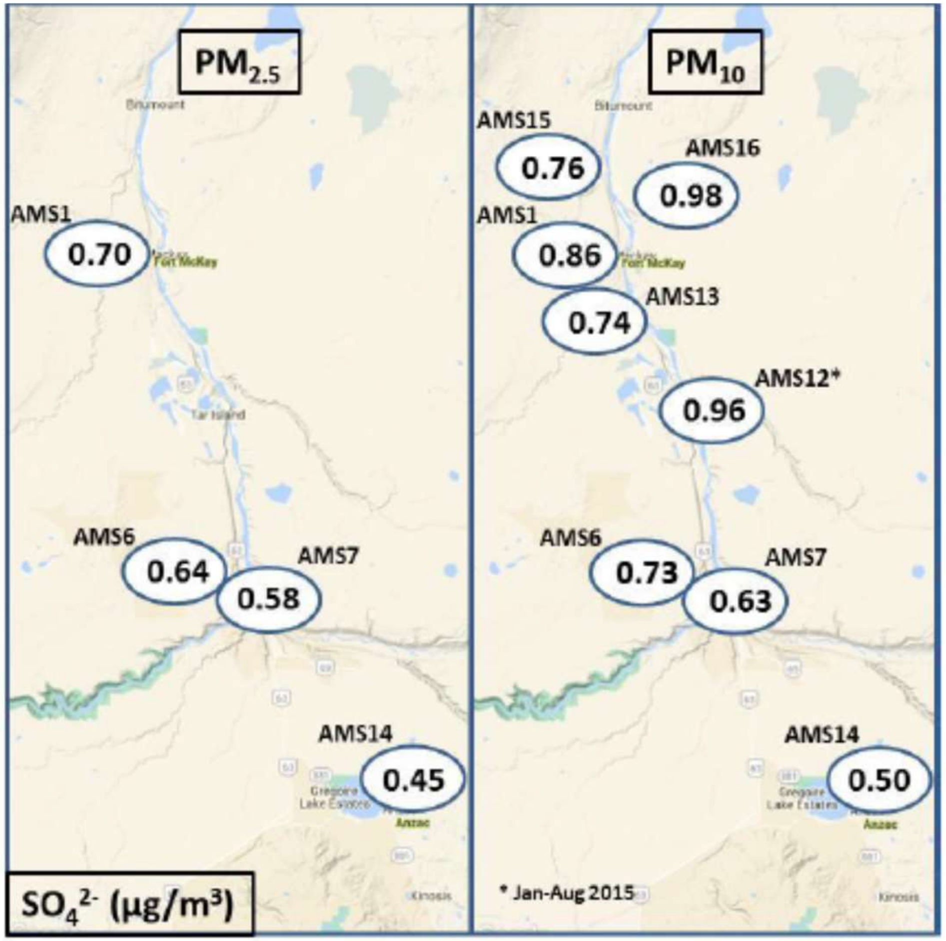


Fig. 1. Scheme of resistance analogy.

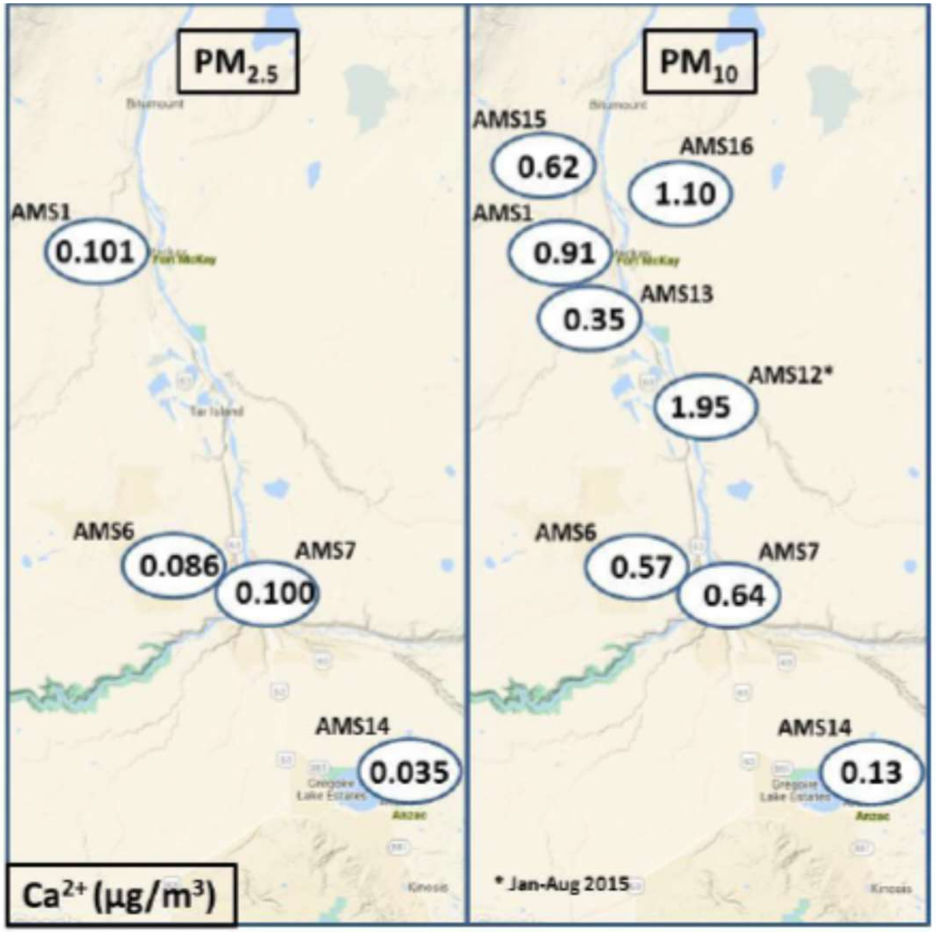
SO_4^{2-} and Ca^{2+} by Size Range

SO_4^{2-}



75-90% in $PM_{2.5}$

Ca^{2+}



75-90% >$PM_{2.5}$

Example Literature Values for Gas Phase Deposition Velocity

Table 2. Campaign-Average Dry Deposition Velocities[a]

	HNO_3	NO_3^-	NO_2	PAN	Other NO_y	NH_3	NH_4^+
FRS1	1.32	0.11	0.17	0.14	0.19	0.43	0.14
FRS2	1.38	0.20	0.27	0.21	0.26	0.43	0.16
EGB1	1.43	0.15	0.11	0.09	0.17	0.46	0.18
KEJ1	1.53	0.16	0.29	0.22	0.27	0.52	0.11
KEJ2	2.11	0.20	0.27	0.21	0.30	0.63	0.15
ALG1	1.06	0.09	0.09	0.07	0.12	0.35	0.09
ALG2	0.98	0.14	0.16	0.12	0.17	0.33	0.08
LED1	1.30	0.17	0.27	0.20	0.25	0.51	0.11
LED2	1.21	0.10	0.16	0.12	0.17	0.32	0.10
CHA1	0.61	0.09	0.06	0.05	0.09	0.12	0.10
CHA2	1.10	0.15	0.20	0.14	0.19	0.48	0.10
SPR1	1.09	0.16	0.22	0.17	0.21	0.44	0.10
SPR2	0.89	0.10	0.11	0.09	0.13	0.28	0.09
BRL1	1.02	0.14	0.07	0.05	0.13	0.32	0.15

[a]Unit is $cm\ s^{-1}$.

Dry deposition of individual nitrogen species at eight Canadian rural sites

L. Zhang,[1] R. Vet,[1] J. M. O'Brien,[1] C. Mihele,[1] Z. Liang,[1] and A. Wiebe[1]

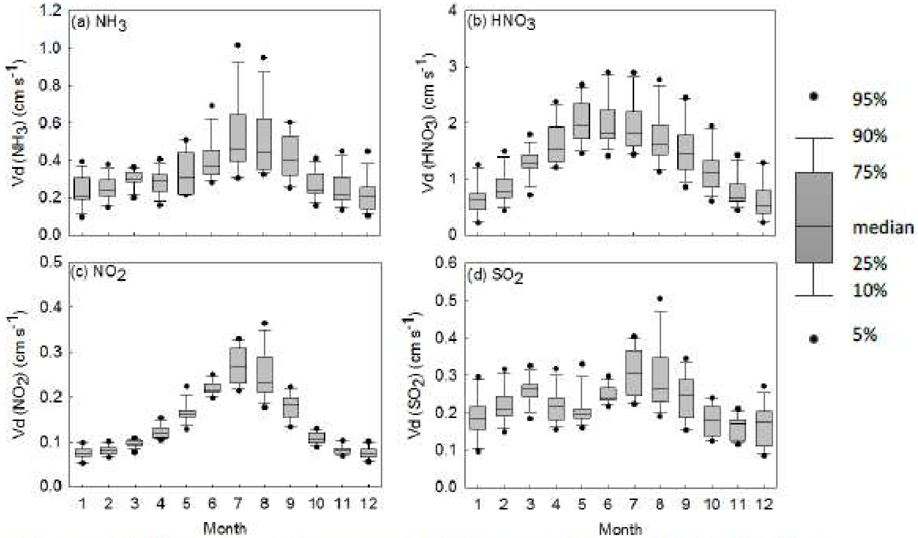


Figure 2. 15 Monthly deposition velocities of (a) NH_3, (b) HNO_3, (c) NO_2 and (d) SO_2 at AMS 1 (from 2000 to 2012) calculated by MLM.

2015 Forest Health Report

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ADMPEC Monitoring Plan