Ecosystem Recovery from S and N Deposition and Associated Critical Loads in Context of Changing Climate

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NADP Fall Meeting, Santa Fe, NM – November, 2016

Funding Support

U.S. EPA

NYSERDA

Forest Service

National Park Service

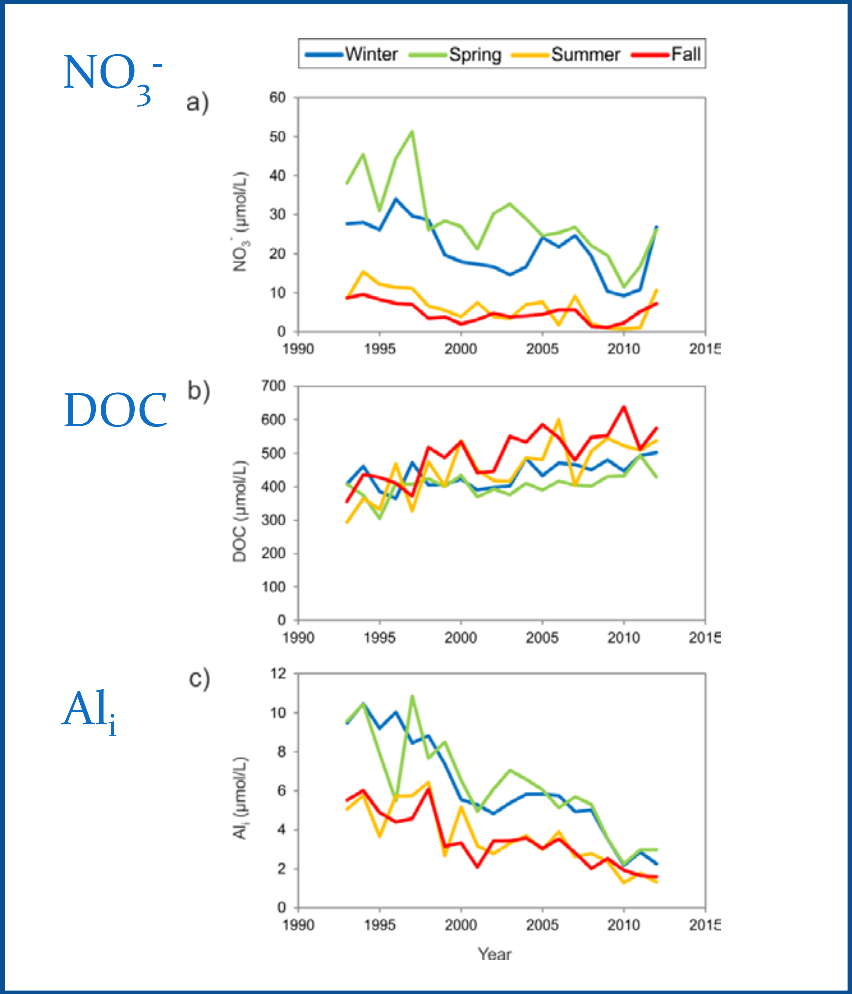
USGS

Focus

1. Influence of climate on Adirondack lake recovery
2. Habitat squeeze in southern App. Mt. streams
3. Terrestrial plant biodiversity (For-SAFE-VEG, VSD+-PROPS)
4. Understory plant responses to soil acidification (Adr.)
5. CLs of S deposition at Cohutta W.A., GA
6. Other Studies

1. Influence of climate on recovery of Adirondack lake chemistry from acidification
    McDonnell et al. in revision
    NYSERDA
- 29 acid-sensitive lakes
- Focus on lake NO_3^-, Al_i, DOC, fraction of Al_m in inorganic form
- Monitoring data 1993-2012

Lake water monitoring mean annual results for a) NO_3^-, b) DOC, and c) Al_i concentrations over time for the 10 study lakes having lowest ANC



NO_3^- Results

Predicting NO_3^- - stronger relationships when climate variables were included along with N deposition, especially:

- Max seasonal average air temp (spring) (-)
- Last date of recorded snowpack (summer) (+)
- Max depth of late season snowpack (summer) (-)
- Seasonal precipitation amount (winter, fall) (+)

DOC Results

Predictions of lake DOC

- precipitation
- average max air temperature
- last date of recorded snowpack

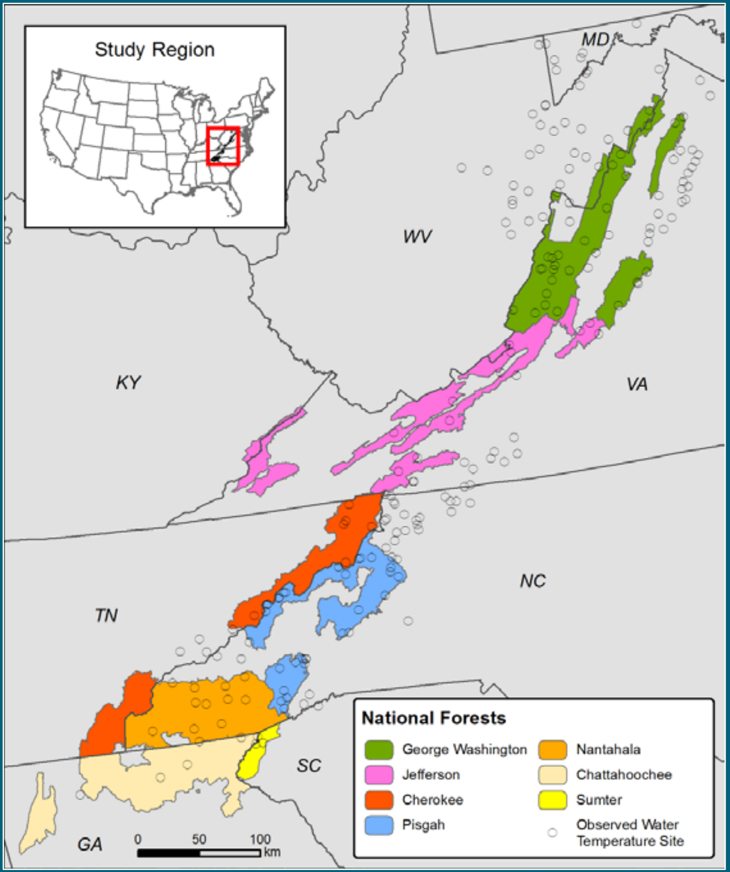
Inclusion of climatic variables increased explanatory power in 2/3 of the lakes, often explaining an additional 20% to 30% of variation in seasonal DOC.

Al_i Results

Inclusion of climatic variables typically explained an additional 10-25% of variation in seasonal Al_i.

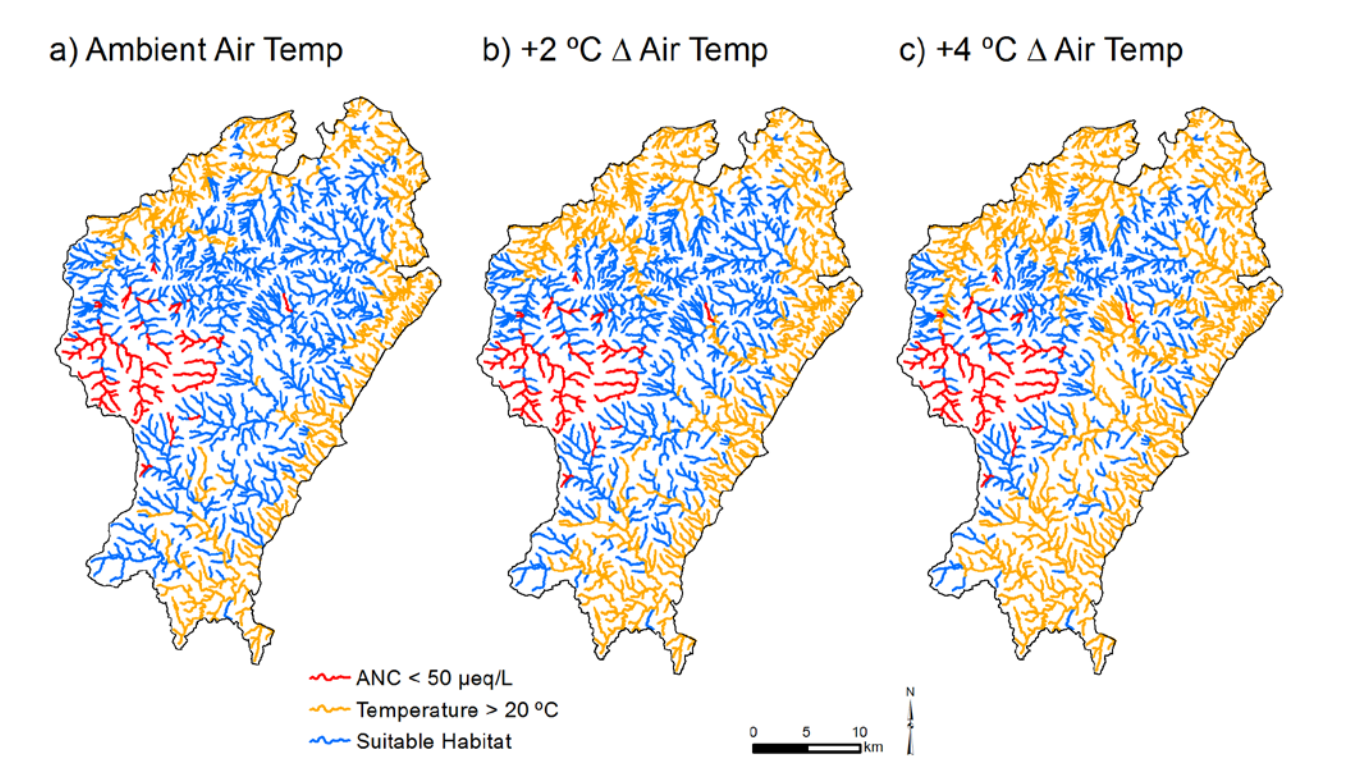
2. Habitat squeeze
   (McDonnell et al. 2015)

National forest boundaries and stream water temperature monitoring sites



McDonnell, T.C., et al. 2015. Downstream Warming and Headwater Acidity May Diminish Coldwater Habitat in Southern Appalachian Mountain Streams. PLoS ONE 10(8):e0134757.

Pisgah Ranger District (2.8% of the stream length in the study region)

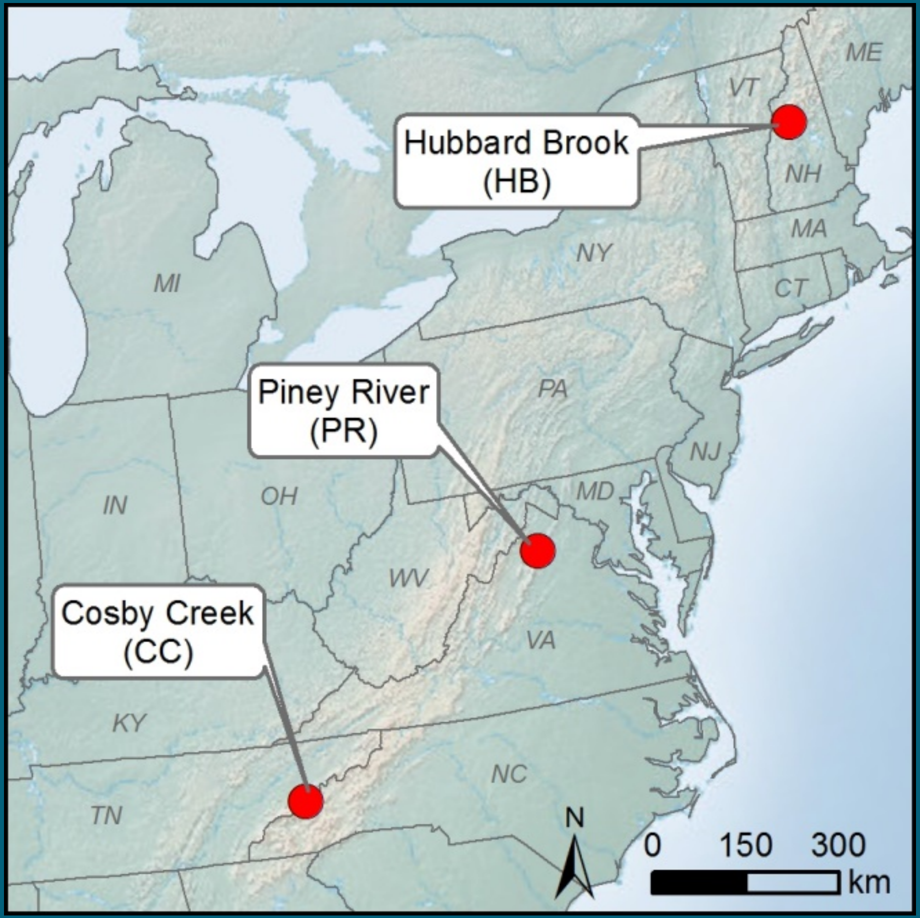


McDonnell, T.C., et al. 2015. Downstream Warming and Headwater Acidity May Diminish Coldwater Habitat in Southern Appalachian Mountain Streams. PLoS ONE 10(8):e0134757.

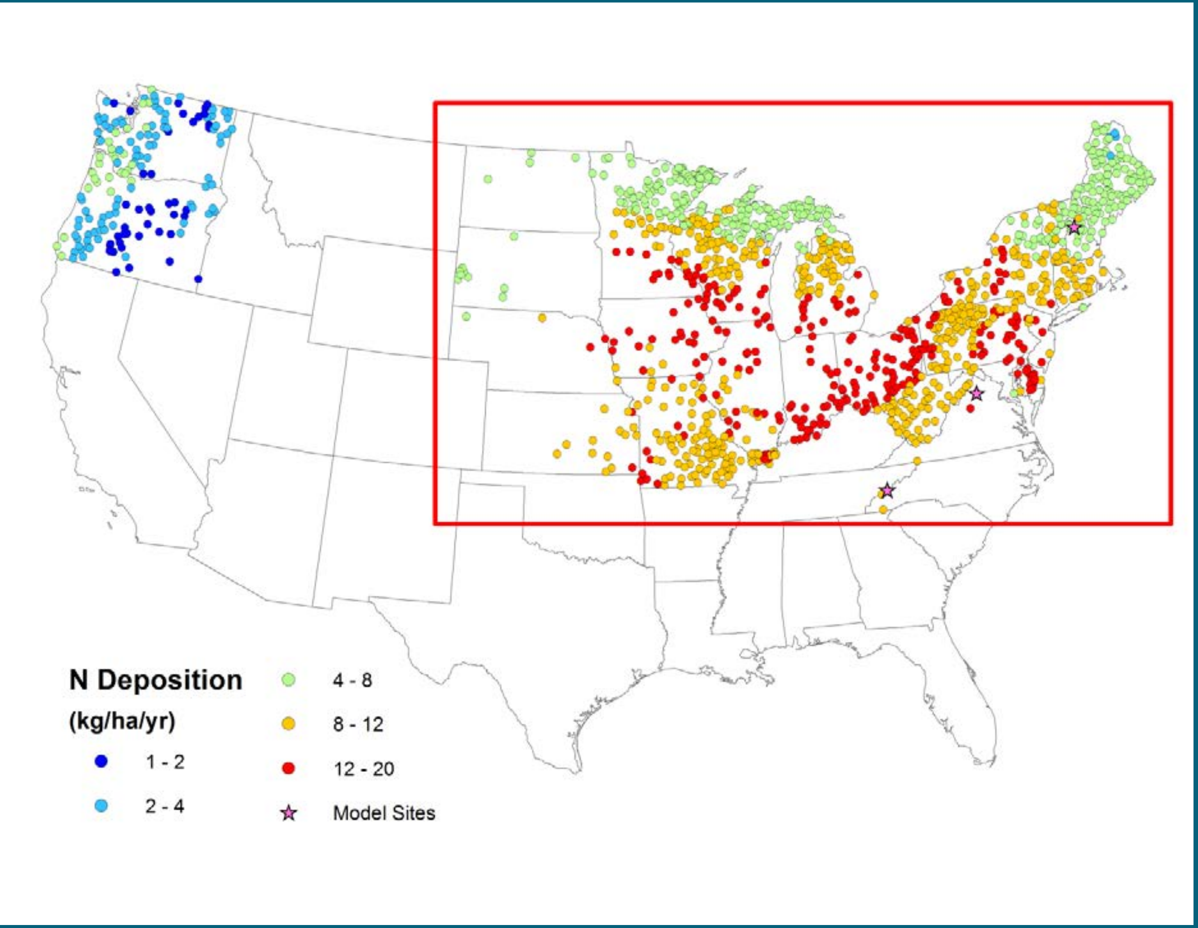
3. Terrestrial plant biodiversity modeling
(McDonnell et al., In Preparation a,b)

VSD+PROPS Modeling

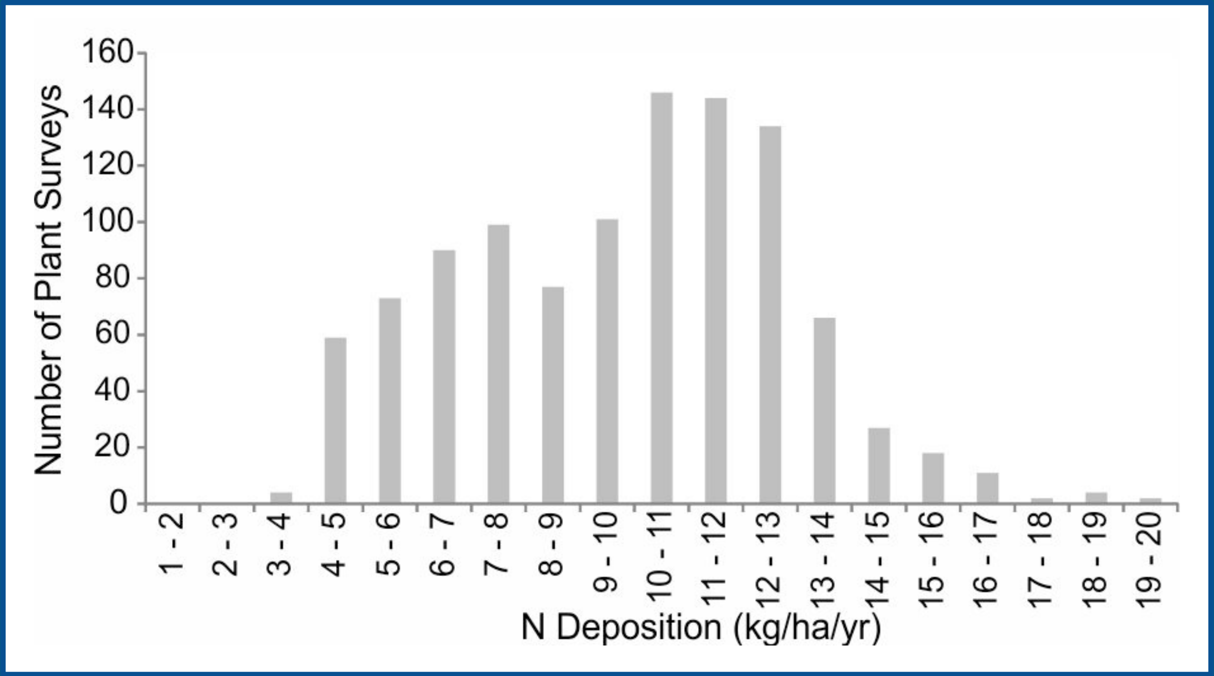
Location of VSD+PROPS model sites



Co-located soil and vegetation data

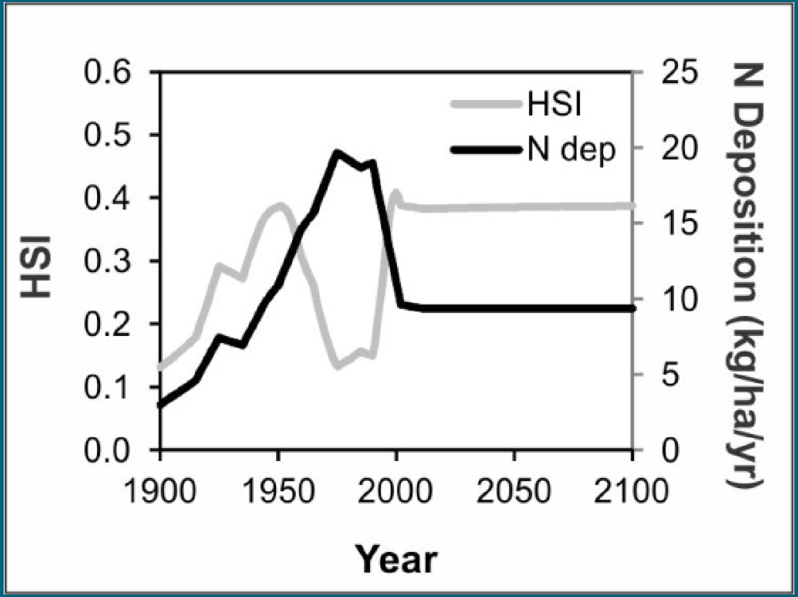


Distribution of total N deposition among sites located in the northern and eastern U.S. (n = 1,057) used for US-PROPS model development



VSD+-PROPS Habitat Suitability Index and the main drivers of biological response

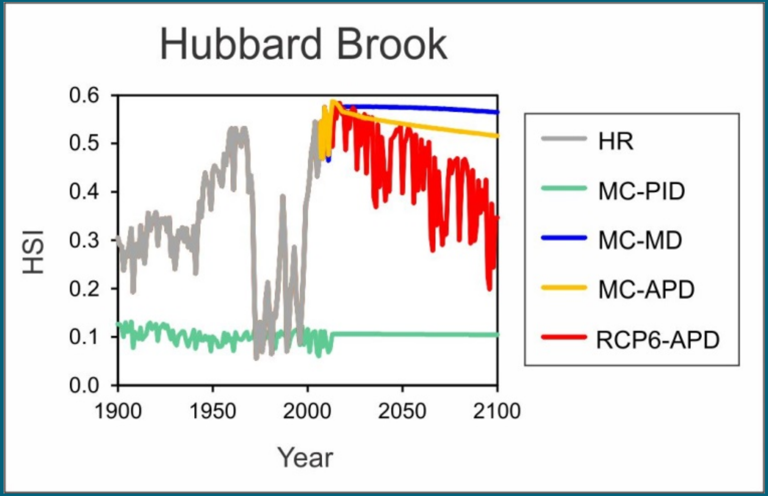
- Modern Climate-Modern Deposition scenario
- Cosby Creek



Other Drivers:

- Soil pH
- Soil C:N
- Precipitation
- Air Temp

VSD+-PROPS modeled Habitat Suitability Index scenario responses at Hubbard Brook



- Habitat suitability increased with gradually increasing N deposition in early part of the record
- Habitat suitability decreased during high deposition period after 1950
- Climate warming will partially counteract recovery

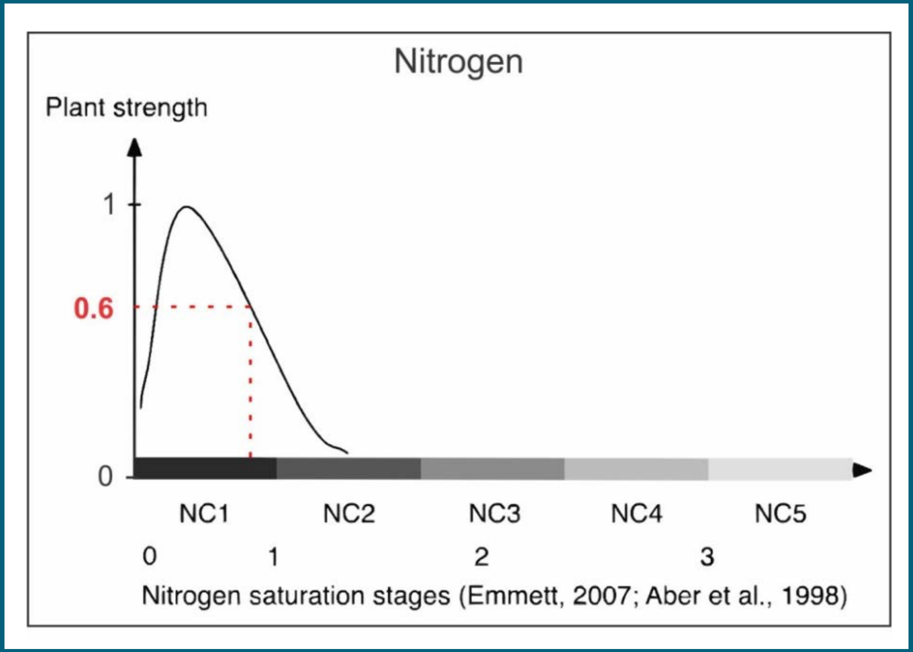
ForSAFE-VEG Modeling

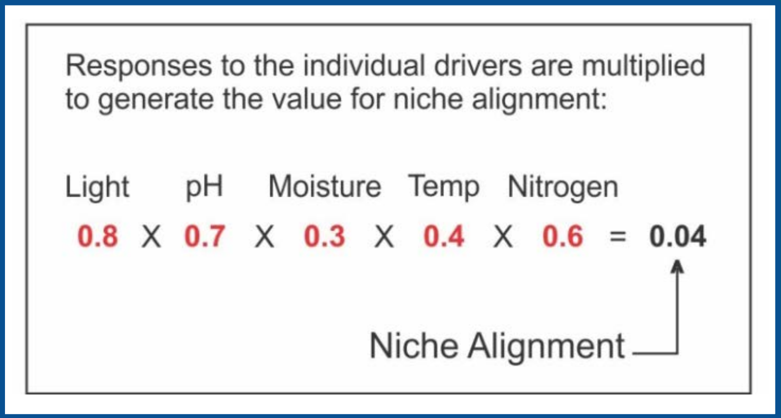
Cosby Creek, GRSM

Piney River, SHEN

VEG Niche Alignment

Illustrative example of how niche alignment is determined with ForSAFE-Veg. Black lines indicate the specified niches for a hypothetical plant species. Red dotted lines and numbers indicate values for plant strength for a hypothetical model site/scenario.





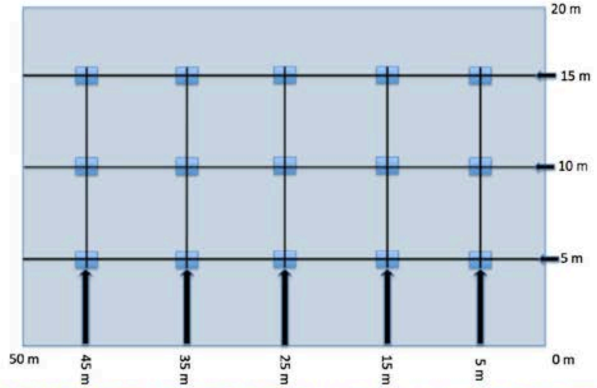
PROPS driven by empirical data
VEG driven by expert judgement

4. Understory plant responses to soil acidification in Adirondacks

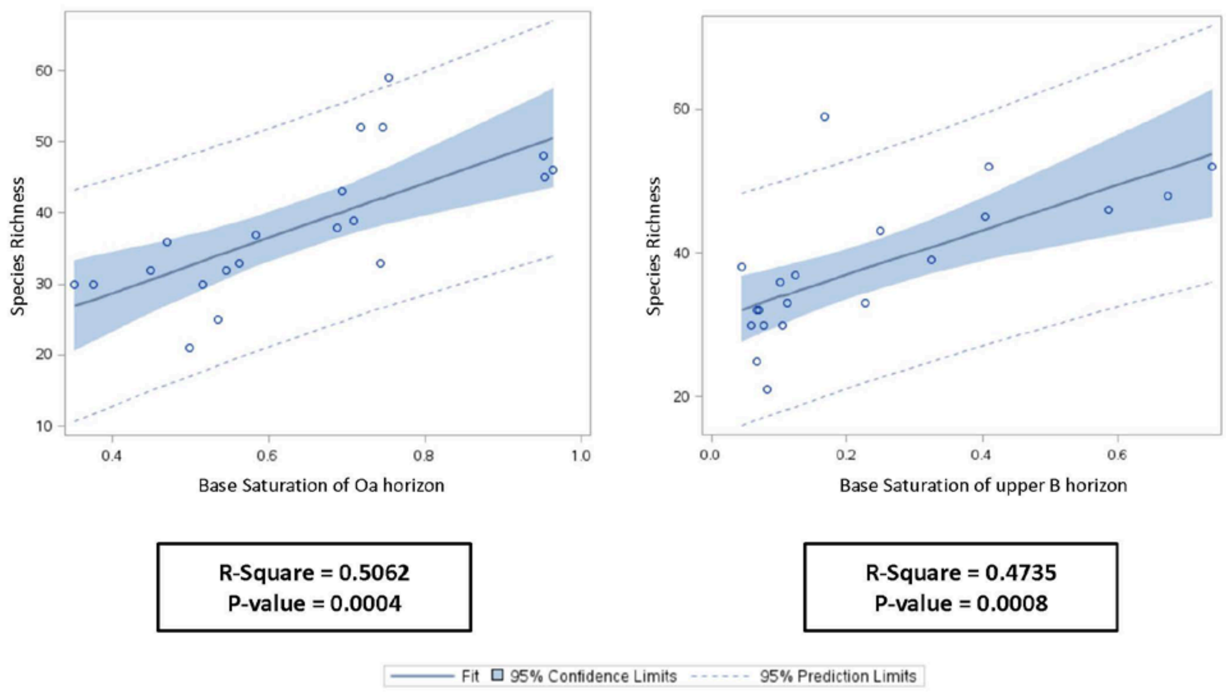
(Whalen, Dovciak et al., In Preparation)

Methods

- Survey of % species cover
- Time search for rare species
- NMS ordination and Indicator Species Analysis in PC-ORD
- Simple linear regression in SAS



Effects of Base Saturation on Species Richness



Indicators of Base Saturation < 12% in the upper B horizon

Species	Indicator Value	P-value
Dennstaedtia punctilobula	77.6	0.0056
Acer rubrum	70.8	0.012
Acer pennsylvanicum	65.4	0.023
Dryopteris intermedia	59.6	0.007

Note: "Indicator Value" represents relative abundance and constancy in either group

Indicators of Base Saturation > 12% in the upper B horizon

Species	Indicator Value	P-value
Arisaema triphyllum	81.6	0.0004
Fraxinus americana	80	0.0008
Acer saccharum	78.6	0.0002
Viola rotundifolia	64.1	0.0426
Prenanthes alba	60	0.0106
Tiarella cordifolia	56.8	0.019
Lonicera canadense	56.4	0.0106

Note: "Indicator Value" represents relative abundance and constancy in either group

5. CL and TL modeling at Cohutta and Sipsey WAs

(McDonnell et al., In Review)

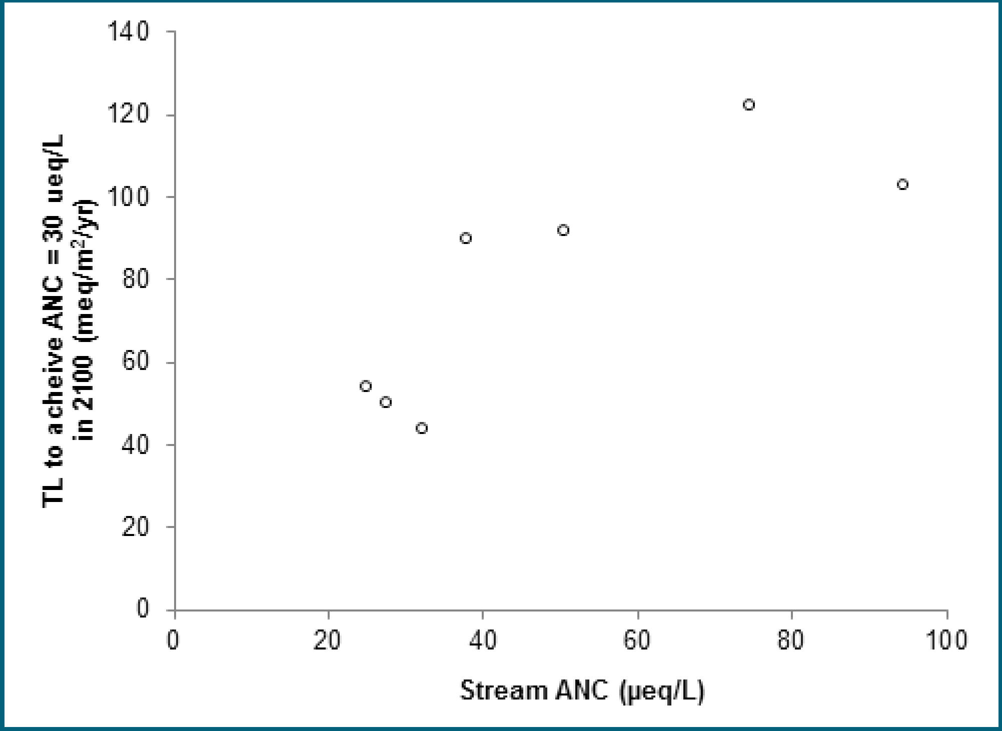
5 streams

MAGIC (TL), SSWC (CL)

Resource management and PSD reviews

Cohutta and Sipsey WAs

Target load of S deposition required to achieve stream acidification/recovery of ANC to a target value of 30 μeq/L in year 2100 versus the stream ANC in 2013.



Other studies

Target loads for Adirondack streams (SU, USGS)
(Driscoll et al., in preparation)

EMDS revision for southern Appalachian Mts. (FS)
(McDonnell et al., in preparation)

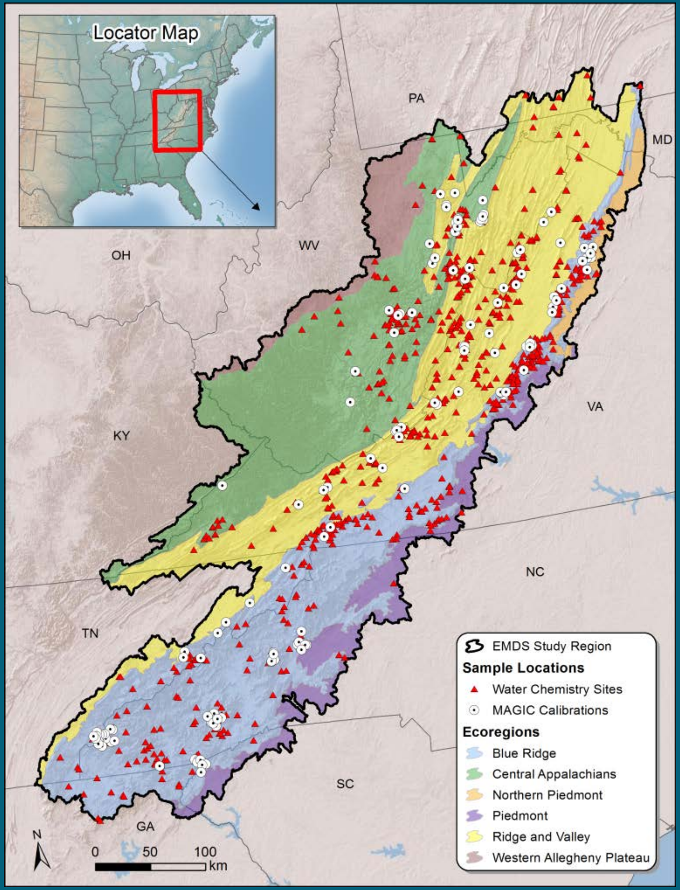
Book on air pollution and its impacts on U.S. national parks
(CRC Press; Sullivan, February 2017)

Adirondack CL Analyses

Research Partners: SU, USGS, E&S
Support: NYSERDA
Site-specific modeling of up to 50 streams
PnET-BGC model
CL simulations
Extrapolate to regional context
Compare lake/stream TLs

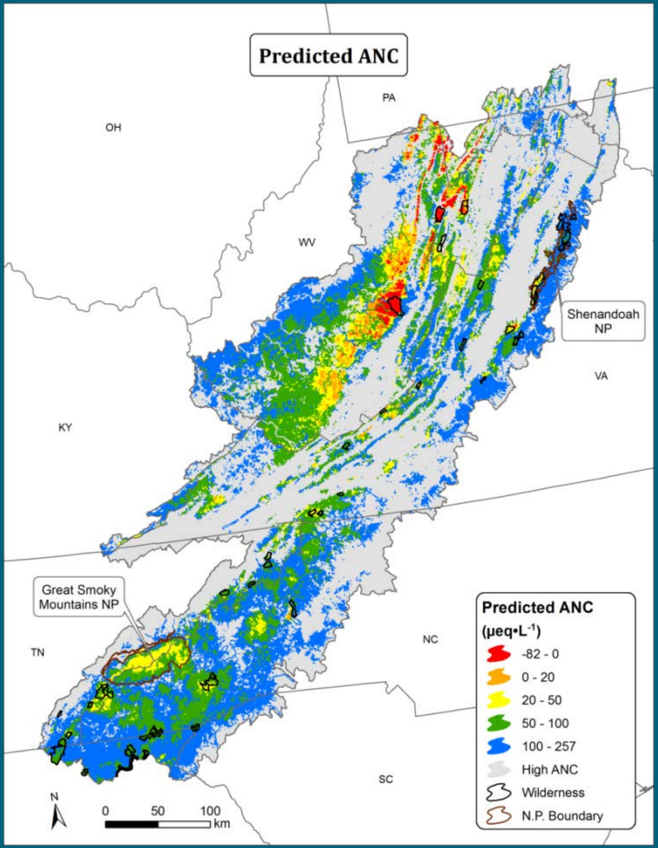
EMDS Revision

Sampled water chemistry sites, MAGIC calibration sites, and ecoregions within the EMDS study region



McDonnell, T.C. et al. 2014. Steady-state sulfur critical loads and exceedances for protection of aquatic ecosystems in the U.S. southern Appalachian Mountains. J. Environ. Manage. 146:407-419.

Predicted response classes for stream ANC



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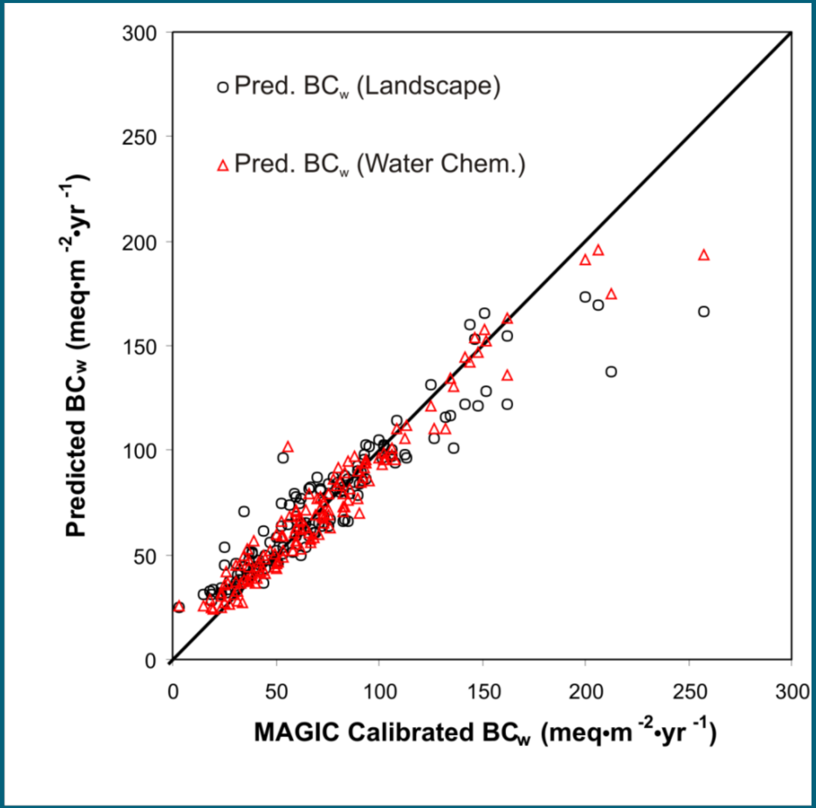
Relationship between predicted and MAGIC calibrated BC_w. The black line shows the 1:1 relationship.

Limitation – Under-predicts ANC, BC_w at high end; over-predicts ANC, BC_w at low end



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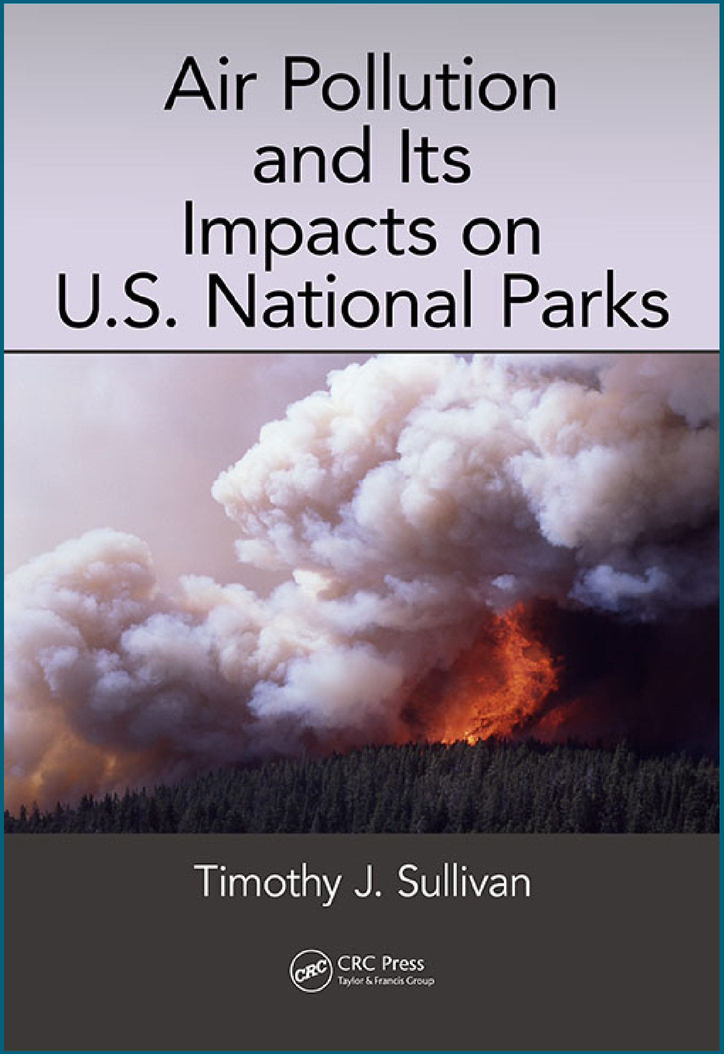
EMDS Revision

Solution - Add more soil and stream sites and revise regional modeling

Objective – Support FS management and review of PSD permit applications


Air Pollution
and Its
Impacts on
U.S. National Parks
Timothy J. Sullivan
CRC Press
Taylor & Francis Group

SUMMARY

- ✓ Lot of CL work ongoing
- ✓ Focus on resource recovery and biodiversity
- ✓ Climate plays an important role
- ✓ Results feeding into management and policy
- ✓ Synthesis documents coming available (Parks book, ISA)