International Cooperative Programme on

Modelling and Mapping of

Critical Levels & Loads and Air Pollution Effects, Risks and

Trends (ICP M&M)

36th Task Force Meeting

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Biodiversity Modeling and Critical Loads Assessment in the USA

Todd McDonnell[1], Gert Jan Reinds[2], Wieger Wamelink[2], Paul Goedhart[3], Max Posch[4], Tim Sullivan[1], Chris Clark[5]

[1]E&S Environmental Chemistry, Corvallis, OR
[2]Wageningen University and Research, Environmental Research, The Netherlands
[3]Wageningen University and Research, Biometris, The Netherlands
[4]International Institute for Applied Systems Analysis (IIASA), Austria
[5]US EPA, Office of Research and Development, Washington, D.C.

Overview

- Background
- Site-level dynamic modeling
- US-PROPS (v2) development
- PROPS-CLF application (3 sites)
- Regional assessment

Background

Significance of understory vegetation

Ecological Function

~80% of vegetation species diversity (temperate forests)

Can control overstory composition

Forage

Ecosystem Services

Food source

Medicinal purposes

Photography

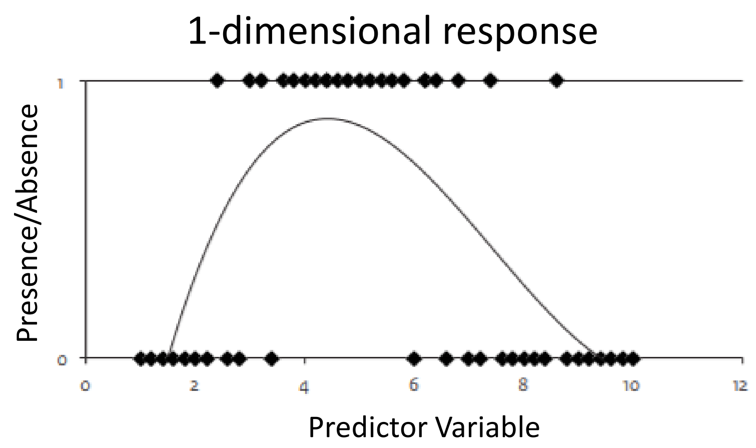
Aesthetics

US-PROPS (v1)

- EU-PROPS
  - Wamelink et al. (2011)
  - Reinds et al. (2014)
- US-based (US)
- Probability of Occurrence of Plant Species (PROPS)
- Version 1 (v1)
  - Vegetation response
  - Critical loads

McDonnell et al. (2018)

- Logistic regression models (species-level)
- Response
  - Species occurrence (1 or 0) from veg surveys
- Predictor variables (n = 5)
  - Temperature
  - Precipitation
  - N deposition
  - Soil C/N ratio
  - Soil pH



- Resulted in 327 species models

US-PROPS (v1)

- Dynamic modeling
  - VSD+PROPS
- Application to three temperate forests sites
- Identified areas for improvement
  - Additional input data
  - Uncertainty

McDonnell et al. (2018)

2018 Publication

Environmental Pollution 234 (2018) 902–914

Contents lists available at ScienceDirect

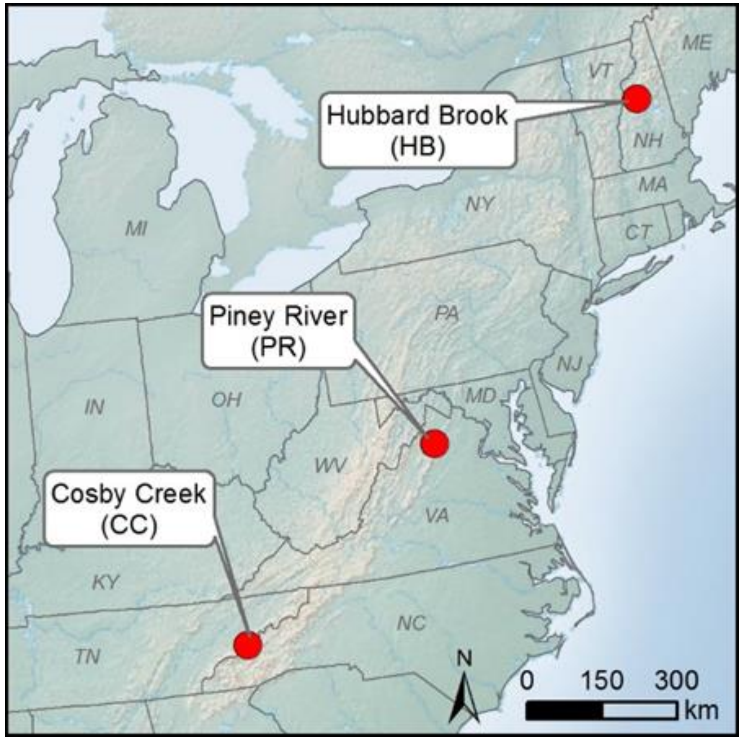
Environmental Pollution

journal homepage: www.elsevier.com/locate/envpol

Feasibility of coupled empirical and dynamic modeling to assess climate change and air pollution impacts on temperate forest vegetation of the eastern United States☆

T.C. McDonnell [a, *], G.J. Reinds [b], T.J. Sullivan [a], C.M. Clark [c], L.T.C. Bonten [b], J.P. Mol-Dijkstra [b], G.W.W. Wamelink [b], M. Dovciak [d]

[a] E&S Environmental Chemistry, Inc., PO Box 609, Corvallis OR 97339, USA
[b] Wageningen University and Research, Environmental Research (Alterra), P.O. Box 47, 6700 AA, Wageningen, The Netherlands
[c] US EPA, Office of Research and Development, National Center for Environmental Assessment, Washington DC, 20460, USA
[d] State University of New York, College of Environmental Science & Forestry, Syracuse NY, USA



US-PROPS (v2)

- US-PROPS (v2) development
- PROPS-CLF application

Recent Publication

ELSEVIER
Environmental Pollution
Available online 11 March 2020, 114351
In Press, Journal Pre-proof

Threshold effects of air pollution and climate change on understory plant communities at forested sites in the eastern United States

T.C. McDonnell[a], G.J. Reinds[b], G.W.W. Wamelink[b], P.W. Goedhart[c], M. Posch[d], T.J. Sullivan[a], C.M. Clark[e]

Show more

https://doi.org/10.1016/j.envpol.2020.114351

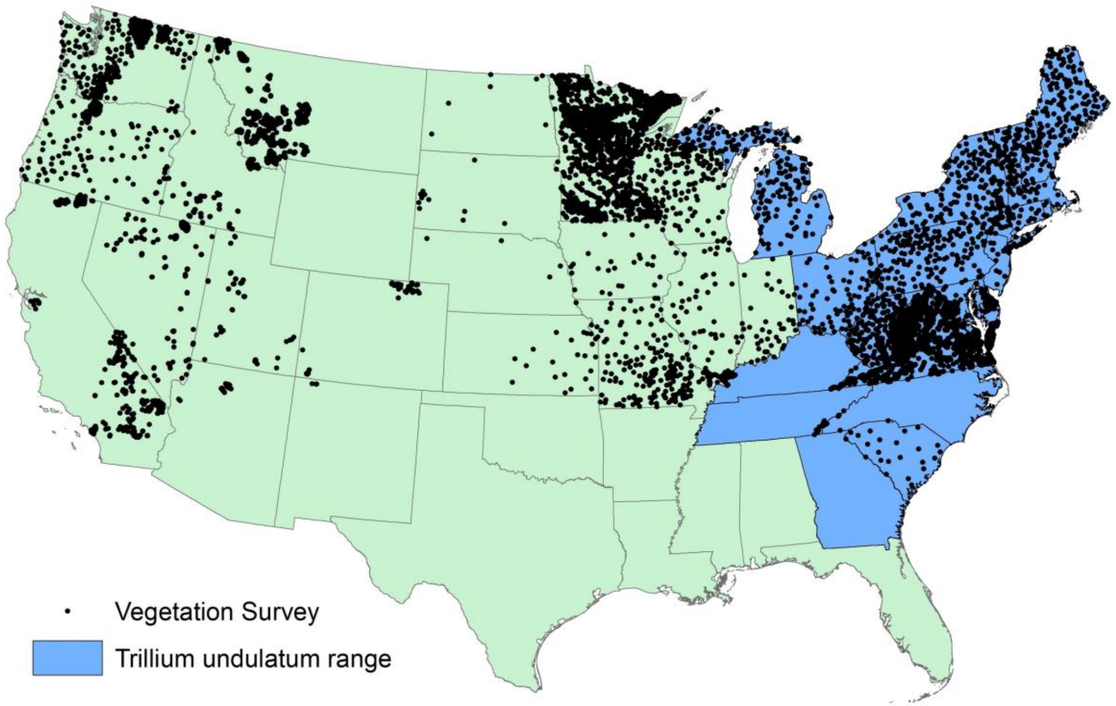
US-PROPS (v2)

- Additional veg surveys
- Additional predictor variables
  - N deposition (30-year avg)
  - Light availability
  - Other soil characteristics
- Addressed uncertainty
  - Leverage scores
  - Extrapolation

- 1,503 species models

McDonnell et al. (2020)

Veg surveys (n = 20,806; 17x more)



US-PROPS (v2) Improvements

Additional candidate predictor variables

- Cumulative N deposition
- Light availability
- Soil conditions

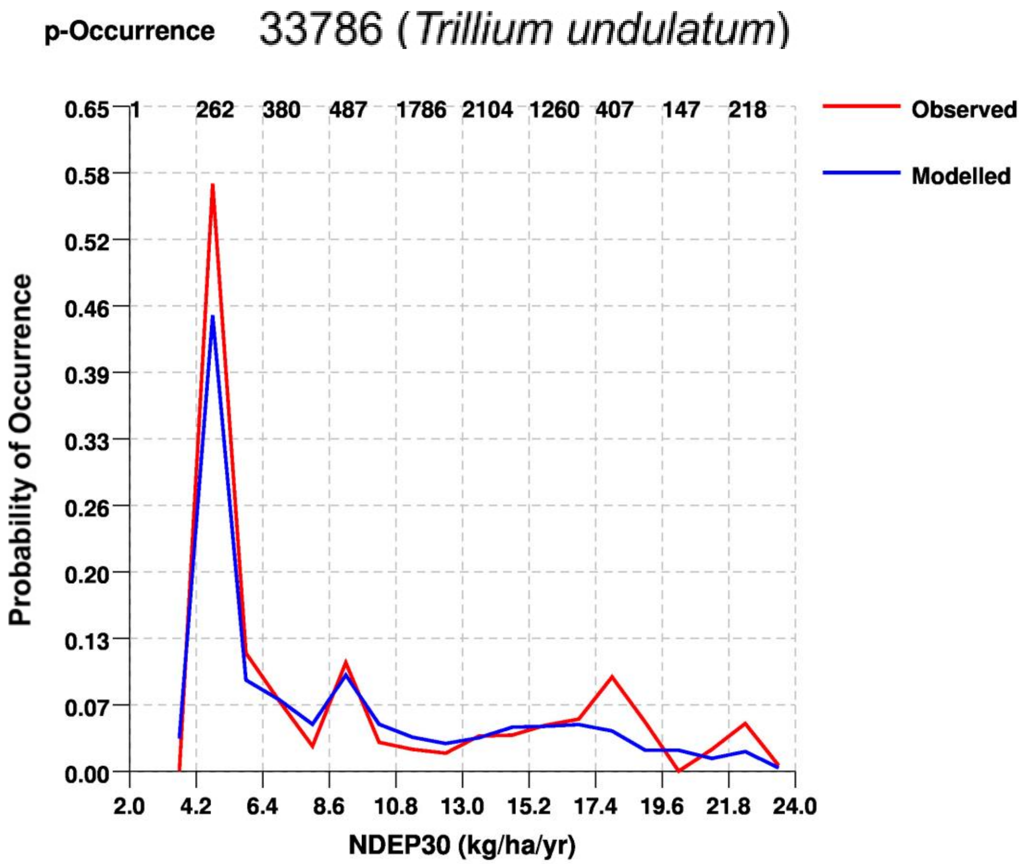
Only significant variables included in model for each species

McDonnell et al. (2020)

Type	Variable Name	Variable Description
Climate	Annual precipitation total	PRISM30-year normal (1981 – 2010) annual precipitation total
	Average annual air temperature	PRISM 30-year normal (1981 – 2010) average annual temperature
Deposition	**Average 30-year annual N deposition**	**Nitrogen (N) supply based on average total N deposition of 30-years leading up to and including the year of vegetation sampling**
Soil physiochemical	Soil pH	Indicator of soil acidity as reflected by pH measurements in 1:1 deionized water
	Soil percent clay	**Aspect of soil texture and related to cation exchange capacity**
	Available water storage	**Available soil water storage as a proxy for soil moisture**
	Soil rooting depth	**Depth of soil to hardpan/bedrock or chemically prohibitive environment for root growth**
Light availability	**Canopy cover**	**Percent forest canopy cover. Data were available for years 2001, 2008, 2010, 2012, and 2014. The year nearest to the year of vegetation survey was used.**
	Incoming solar radiation during May – July	**Total incoming solar radiation during the months of May, June, and July at 200 m resolution.**

Can now be used to evaluate species/community-level response to scenarios of:

- Deposition
- Climate
- Land management (e.g., thinning, clearcut)



Typically occurs with relatively low N deposition

McDonnell et al. (2020)

US-PROPS (v2)
PROPS-CLF

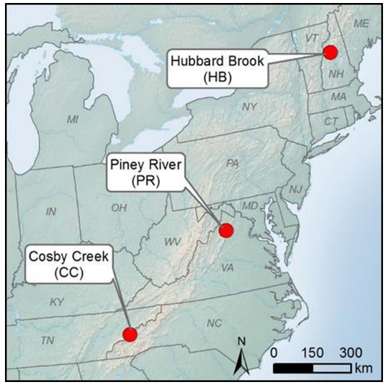
PROPS-CLF (Posch 2017)

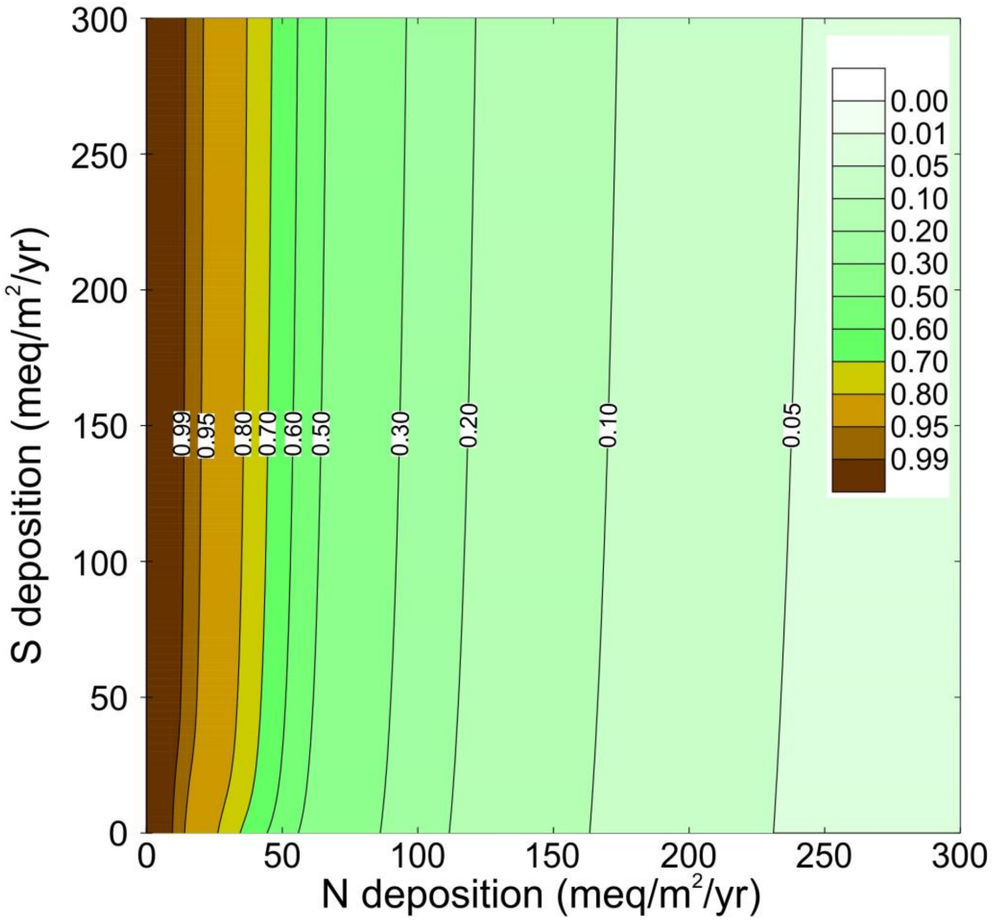
Example:
Trillium undulatum
at Hubbard Brook (HB)

Occurrence probabilities according to combinations of N and S deposition

McDonnell et al. (2020)

Probability Isolines





US-PROPS (v2)
PROPS-CLF

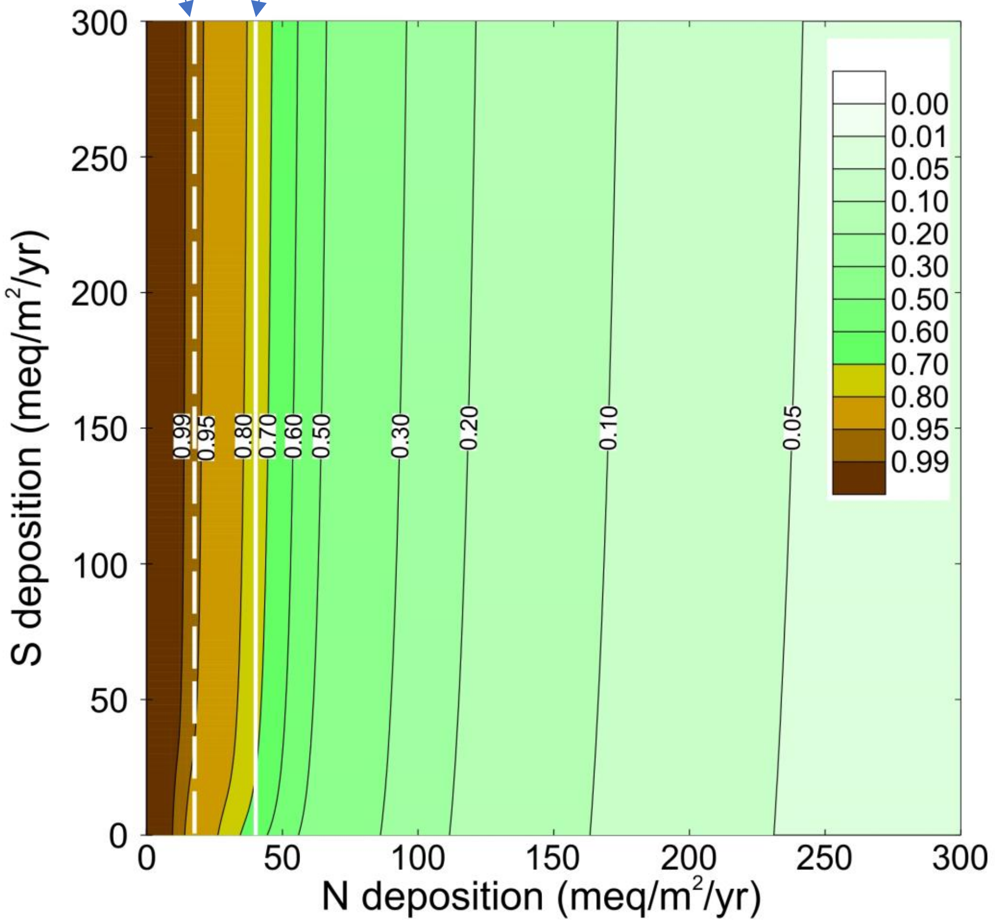
Critical load functions (white lines) specified based on percentage of maximum occurrence probability

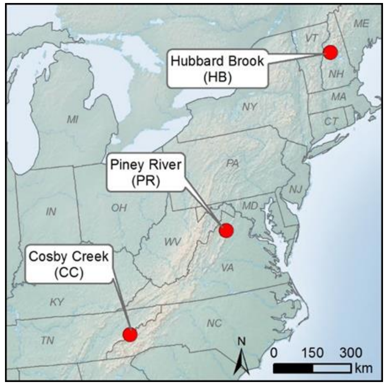
McDonnell et al. (2020)

Critical Load Function

95%

75% of max occurrence probability



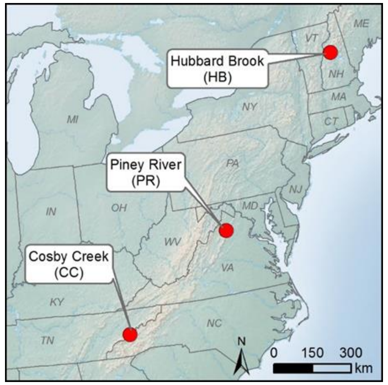


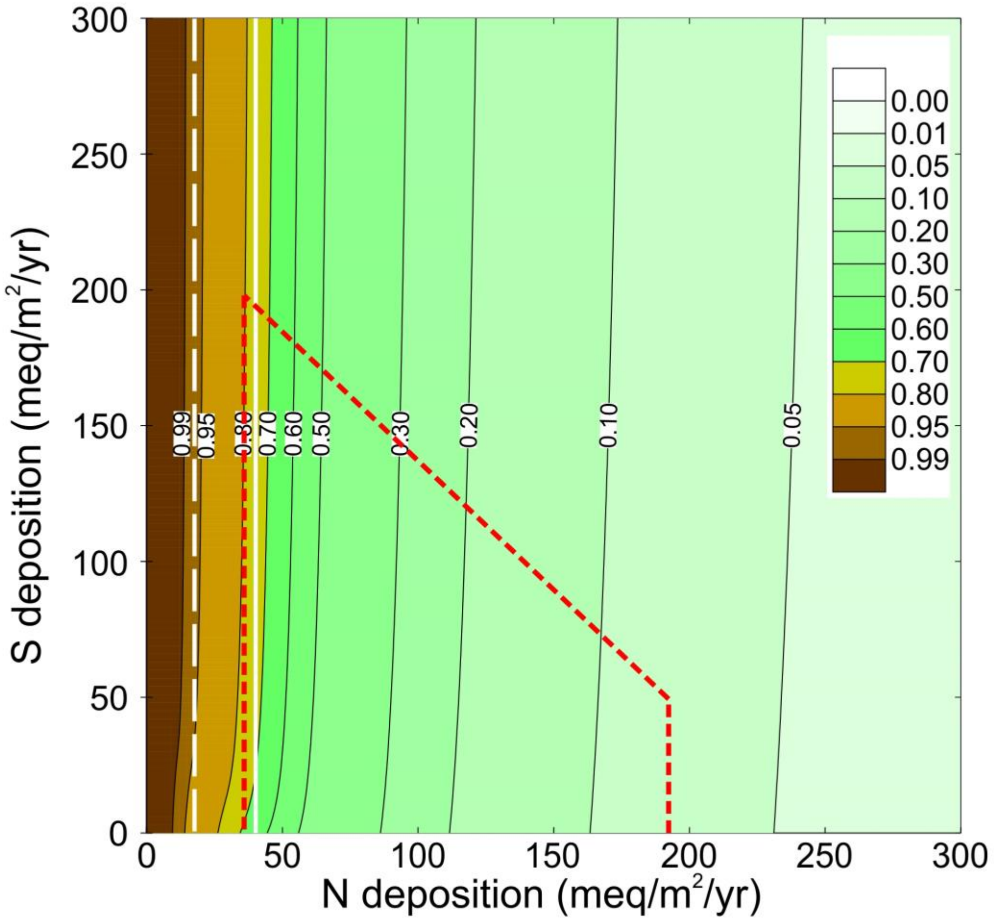
US-PROPS (v2)
PROPS-CLF

Data bounds (red lines) used to build the species model

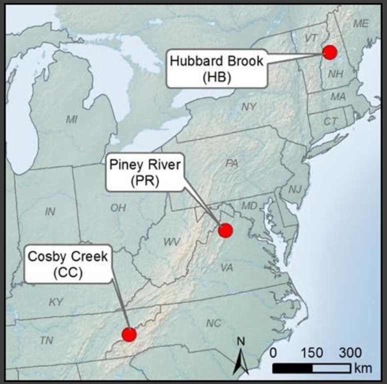
McDonnell et al. (2020)

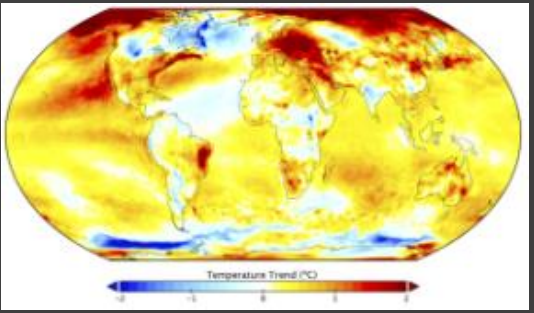
Uncertainty





US-PROPS (v2)
Critical Loads





McDonnell et al. (2020)

Current Air Temperature

+ 1.5 °C

+ 3.0 °C

			Ambient Temp.		+1.5 ºC		+3 ºC	
Site	**Species Number**	**Species Name**	**CL95 of N (at Ambient S Dep)**	**CL95 of S (at Ambient N Dep)**	**CL95 of N (at Ambient S Dep)**	**CL95 of S (at Ambient N Dep)**	**CL95 of N (at Ambient S Dep)**	**CL95 of S (at Ambient N Dep)**
HB	10020	*Acer pensylvanicum*[1]	65 (9.1)	44 (7)	67 (9.4)	46 (7.4)	61 (8.5)	40 (6.4)
HB	10024	*Acer saccharum*	51 (7.1)	7 (1.1)	48 (6.7)	1 (0.2)	**NA**	**NA**
HB	10120	*Fagus grandifolia*	> 300 (>42)	> 300 (>48)	> 300 (>42)	> 300 (>48)	> 300 (>42)	> 300 (>48)
HB	10125	*Fraxinus americana*	> 300 (>42)	51 (8.2)	> 300 (>42)	190 (30.4)	> 300 >(42)	> 300 (>48)
HB	10201	*Picea rubens*	22 (3.1)	> 300 (>48)	20 (2.8)	> 300 (>48)	15 (2.1)	> 300 (>48)
HB	31274	*Dennstaedtia punctilobula*	> 300 (>42)	88 (14.1)	> 300 (>42)	148 (23.7)	> 300 (>42)	105 (16.8)
HB	31401	*Dryopteris intermedia*	26 (3.6)	> 300 (>48)	21 (2.9)	> 300 (>48)	17 (2.4)	> 300 (>48)
HB	32426	*Maianthemum racemosum*	39 (5.5)	4 (0.6)	39 (5.5)	8 (1.3)	39 (5.5)	10 (1.6)
HB	32442	*Medeola virginiana*[1]	62 (8.7)	41 (6.6)	64 (9)	43 (6.9)	65 (9.1)	44 (7)
HB	32692	*Oxalis montana*[1]	> 300 (>42)	> 300 (>48)	> 300 (>42)	> 300 (>48)	> 300 (>42)	> 300 (>48)
HB	33750	*Trientalis borealis*	60 (8.4)	> 300 (>48)	59 (8.3)	> 300 (>48)	57 (8)	> 300 (>48)
HB	33786	*Trillium undulatum*	18 (2.5)	> 300 (>48)	17 (2.4)	> 300 (>48)	15 (2.1)	> 300 (>48)
PR	10020	*Acer pensylvanicum*[1]	210 (29.4)	158 (25.3)	203 (28.4)	151 (24.2)	199 (27.8)	148 (23.7)
PR	10070	*Carya ovata*	74 (10.3)	34 (5.4)	78 (10.9)	46 (7.4)	76 (10.6)	41 (6.6)
PR	10125	*Fraxinus americana*	152 (21.3)	18 (2.9)	152 (21.3)	17 (2.7)	155 (21.7)	15 (2.4)
PR	10241	*Prunus virginiana*	86 (12)	30 (4.8)	86 (12)	30 (4.8)	87 (12.2)	31 (5)
PR	10248	*Quercus alba*	158 (22.1)	51 (8.2)	159 (22.2)	53 (8.5)	160 (22.4)	55 (8.8)
PR	30035	*Actaea racemosa*[1]	153 (21.4)	104 (16.6)	154 (21.5)	105 (16.8)	154 (21.5)	104 (16.6)
PR	32010	*Hydrophyllum virginianum*	146 (20.4)	9 (1.4)	147 (20.6)	3 (0.5)	**NA**	**NA**
CC	10020	*Acer pensylvanicum*[1]	192 (26.9)	150 (24)	164 (22.9)	123 (19.7)	154 (21.5)	114 (18.2)
CC	10024	*Acer saccharum*	61 (8.5)	27 (4.3)	59 (8.3)	22 (3.5)	57 (8)	19 (3)
CC	10275	*Quercus rubra*	> 300 (>42)	60 (9.6)	> 300 (>42)	20 (3.2)	**NA**	**NA**
CC	30052	*Ageratina altissima*	102 (14.3)	7 (1.1)	102 (14.3)	6 (1)	102 (14.3)	5 (0.8)
CC	32142	*Laportea canadensis*	75 (10.5)	9 (1.4)	**NA**	**NA**	**NA**	**NA**
CC	32426	*Maianthemum racemosum*	77 (10.8)	21 (3.4)	76 (10.6)	20 (3.2)	76 (10.6)	18 (2.9)

[1]Critical loads for these species only represent acidifying effects from N and S

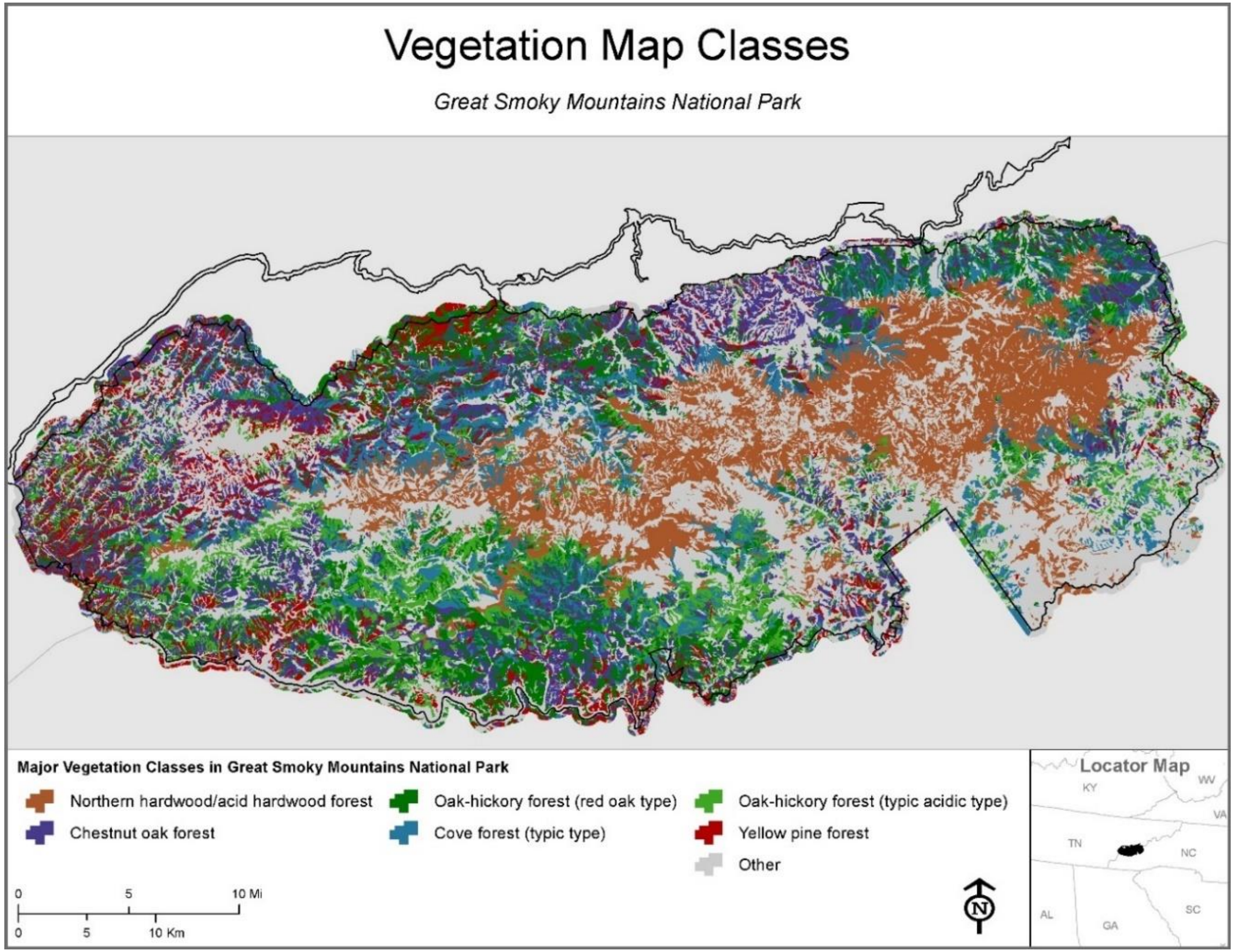
US-PROPS (v2)
Regional Application

Great Smoky Mountains National Park

- Map occurrence probability for characteristic species
- Develop CLs/scenarios

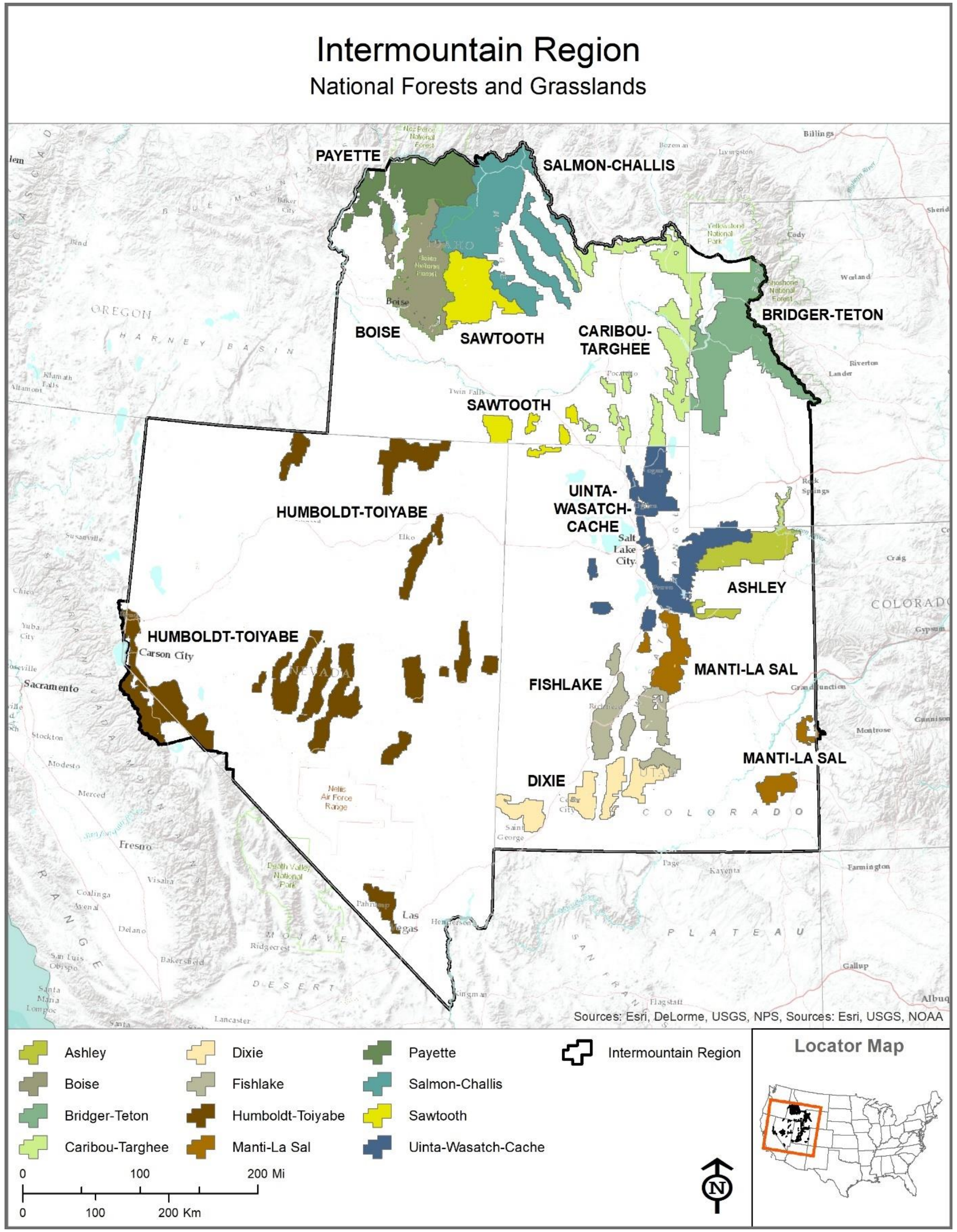
  (In Preparation)

- Regional VSD+PROPS
  - Track changes through time
  - soil pH, N deposition, light availability



Critical load assessment for US Forest Service Intermountain Region

- Lichen richness/abundance
- Tree growth and survival
- Surface water eutrophication/acidification



McDonnell et al. (2019) – Report to USFS

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