Response of more than 1000 herbaceous species across 20 vegetation alliances to atmospheric deposition of nitrogen in the United States

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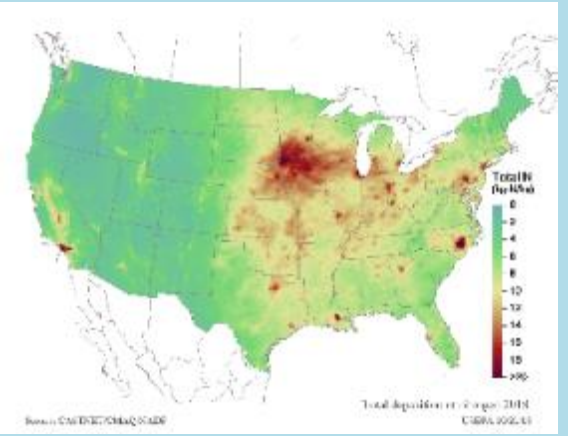
Background

- Nitrogen deposition (NDep) declining over the last decade in the US but remains elevated above background levels
- Clark et al. (2019) → species level vulnerability to N and sulphur deposition using partial derivatives approach (data source: Simkin et al., 2016)
- Build upon that work: use Taxon Indicator Threshold Analysis (TITAN) to determine species- and community-level change points (CPs) across NDep gradient



←Total NDep 2018, CASTNET/CMAQ/NADP

↓Clark et al. (2019)

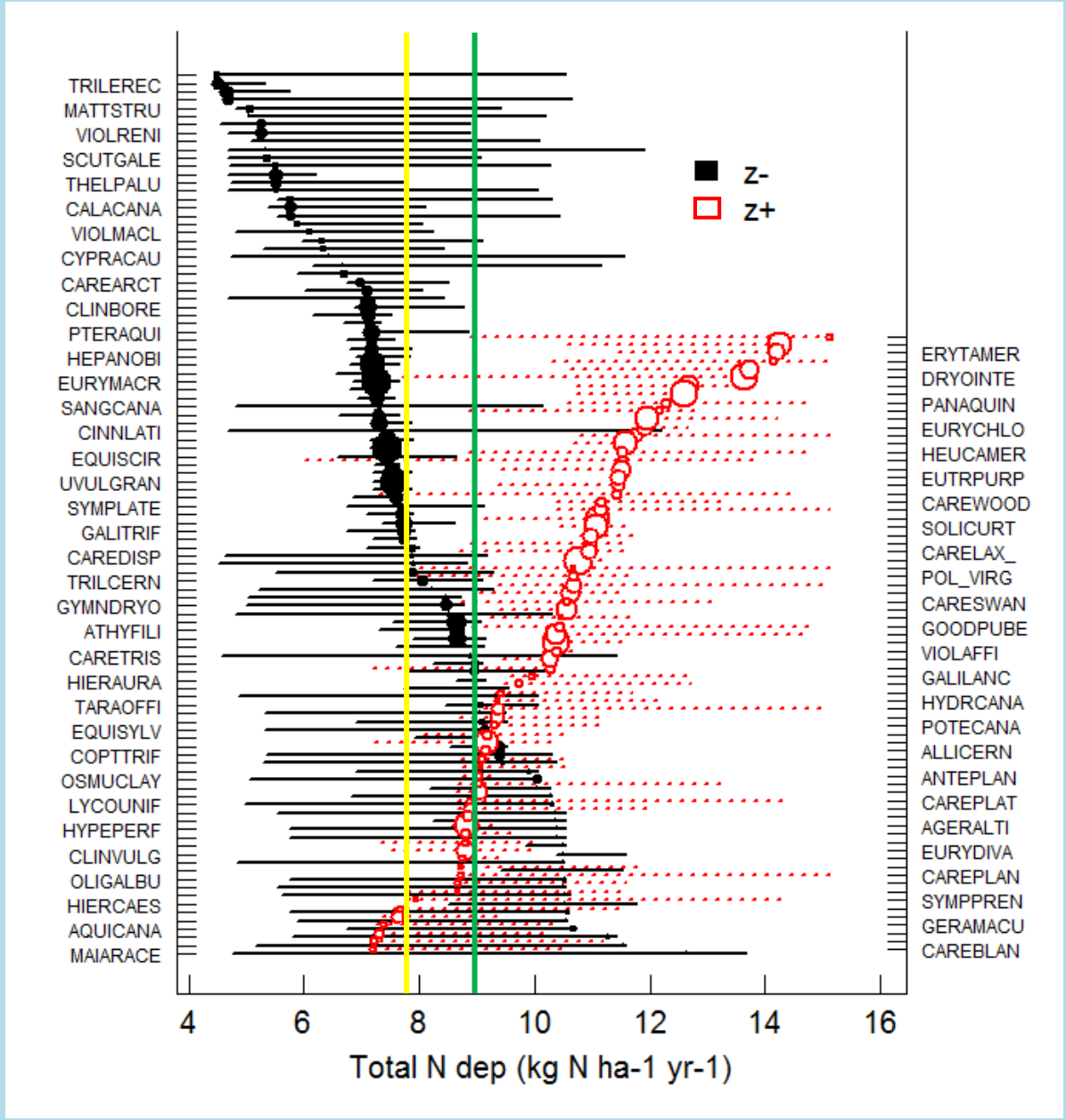
Table 1 | Summary of responses and vulnerability to N and S deposition

		S relationship			
		Decrease	**None**	**Increase**	**Total**
N relationship	**Decrease**	11[a] (6)	5[b] (3)	14[c] (7)	30 (15)
	None	5[b] (3)	15[d] (8)	1[e] (1)	21 (11)
	Increase	26[c] (13)	6[e] (3)	8[f] (4)	40 (20)
	Unimodal	81[c] (41)	6[c] (3)	20[c] (10)	107 (54)
	Total	123 (62)	32 (16)	43 (22)	198 (100)

The number of species out of the 198 (with percentages in parentheses) with robust results for N or S that monotonically decreased, showed no response, monotonically increased or had a unimodal relationship (N only) with N or S deposition. Species with 'U-shaped' N relationships (45 species) are omitted as not being ecologically realistic and species names in each category are in Supplementary Tables 1 and 2. Superscript letters represent levels of vulnerability: [a]high (decrease with both), [b]moderate (decrease with one and unaffected by the other), [c]conditional (either contrasting relationships or conditional on the rate of deposition) or [d]neutral (no relationship with either). [e]Species that partially benefit (increase with one and unaffected by the other) and [f]species that strongly benefit (increase with both) are also indicated.

Threshold Indicator Taxon Analysis (TITAN)

- Change point (CP): the point along the environmental gradient at which the difference in cover is maximized
- Species are analyzed separately by habitat type
- Community-level CP suggested where species CPs demonstrate most synchrony



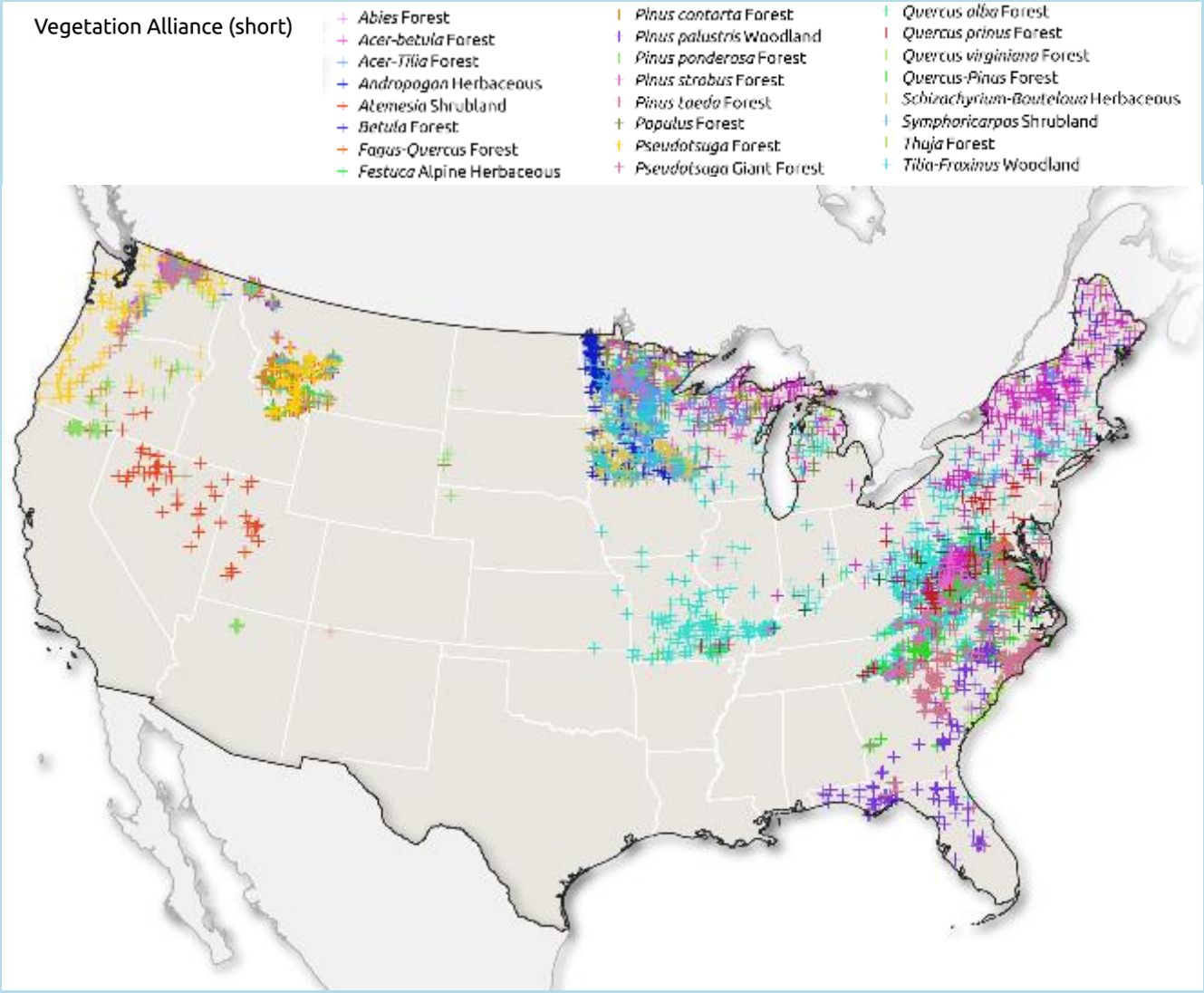
Acer saccharum - Betula alleghaniensis - (Fagus grandifolia) Forest Alliance

———— = 5-95% quantiles from the bootstrapped change point distribution

○ = change point (sized in proportion to z score)

Results overview

- Species abundance data:
  - 26 vegetation alliances
  - 12,000 sites
  - 1000+ species
- Environmental gradient: Total NDep long-term averages
- We determined:
  - Species-level z- CPs for 585 species (1.3−16.8 kg N ha^{-1} yr^{-1})
  - Species-level z+ CPs for 523 species (1.7−18.0 kg N ha^{-1} yr^{-1})
  - no CP for 792 species
  - Community-level CPs for 20 alliances (1.8−14.3 kg N ha^{-1} yr^{-1})



Vegetation Alliance	N(plots)	N (species)	n (z- species)	n (z+ species)	CP (z-) kg N ha^{-1} yr^{-1}	CP (z+) kg N ha^{-1} yr^{-1}
Abies lasiocarpa - Picea engelmannii Forest Alliance	355	86	16	26	1.99	4.25
Acer saccharum - Tilia americana - (Quercus rubra) Forest Alliance	556	146	34	60	9.2	10.94
Andropogon gerardii - (Sorghastrum nutans) Herbaceous Alliance	236	156	39	35	8	10.56
Artemisia tridentata Shrubland Alliance	332	76	9	45	1.83	2.52
Fagus grandifolia - Quercus rubra - Quercus alba Forest Alliance	101	48	4	9	14.34	16.19
Festuca idahoensis Herbaceous Alliance	330	127	14	43	2.37	4.23
Pinus contorta Forest Alliance	613	178	21	68	2.78	3.4
Pinus palustris Woodland Alliance	352	287	196	32	9.65	12.04
Pinus ponderosa Forest Alliance	251	57	13	15	2.11	3.95
Pinus strobus Forest Alliance	344	184	45	81	8.71	10.41
Pinus taeda Forest Alliance	684	379	144	42	8.85	11.29
Pseudotsuga menziesii Forest Alliance	344	167	31	31	2.79	4.62
Pseudotsuga menziesii Giant Forest Alliance	118	21	4	4	2.53	2.89
Pseudotsuga menziesii Woodland Alliance	654	100	14	57	2.38	2.58
Quercus spp. - Pinus (rigida, echinata) Forest Alliance	1011	426	104	102	9.25	11.15
Schizachyrium scoparium - Bouteloua curtipendula Herbaceous Alliance	323	142	43	23	11.24	11.84
Tilia americana - Fraxinus americana - (Acer saccharum) Woodland Alliance	121	89	43	18	9.37	11.4
Acer saccharum - Betula alleghaniensis - (Fagus grandifolia) Forest Alliance	953	293	107	75	7.99	8.89
Populus tremuloides Forest Alliance	681	166	26	72	3.5	8.32

In Progress…

- Do change points = critical loads?
- How do CPs compare for individual species across alliances?
- Run TITAN for sulphur deposition gradient

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References:

Clark, C., et al. (2019). Potential vulnerability of 348 herbaceous species to atmospheric deposition of nitrogen and sulfur in the United State. *Nature Plants*. 5: 697-705.

Simkin, S., et al. (2016). Conditional vulnerability of plant diversity to atmospheric nitrogen deposition across the United States. *PNAS*. 112 (15): 4086-4091.