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SCIENCE AND EDUCATION FOR SUSTAINABLE LIFE

WEAK RECOVERY OF EPIPHYTIC LICHENS IN SWEDEN AFTER DECLINES IN AIRBORNE POLLUTANTS

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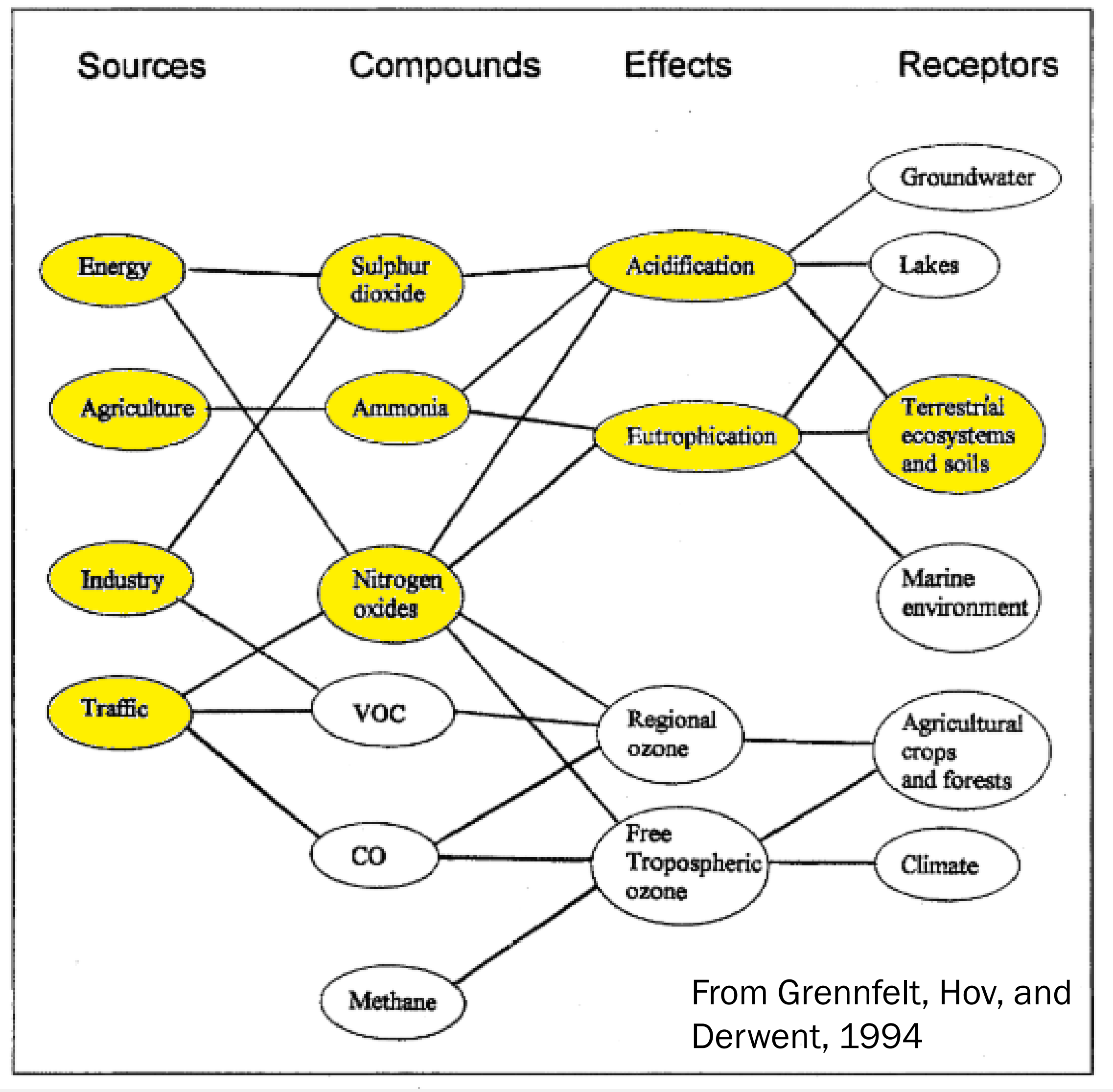
Airborne pollutants



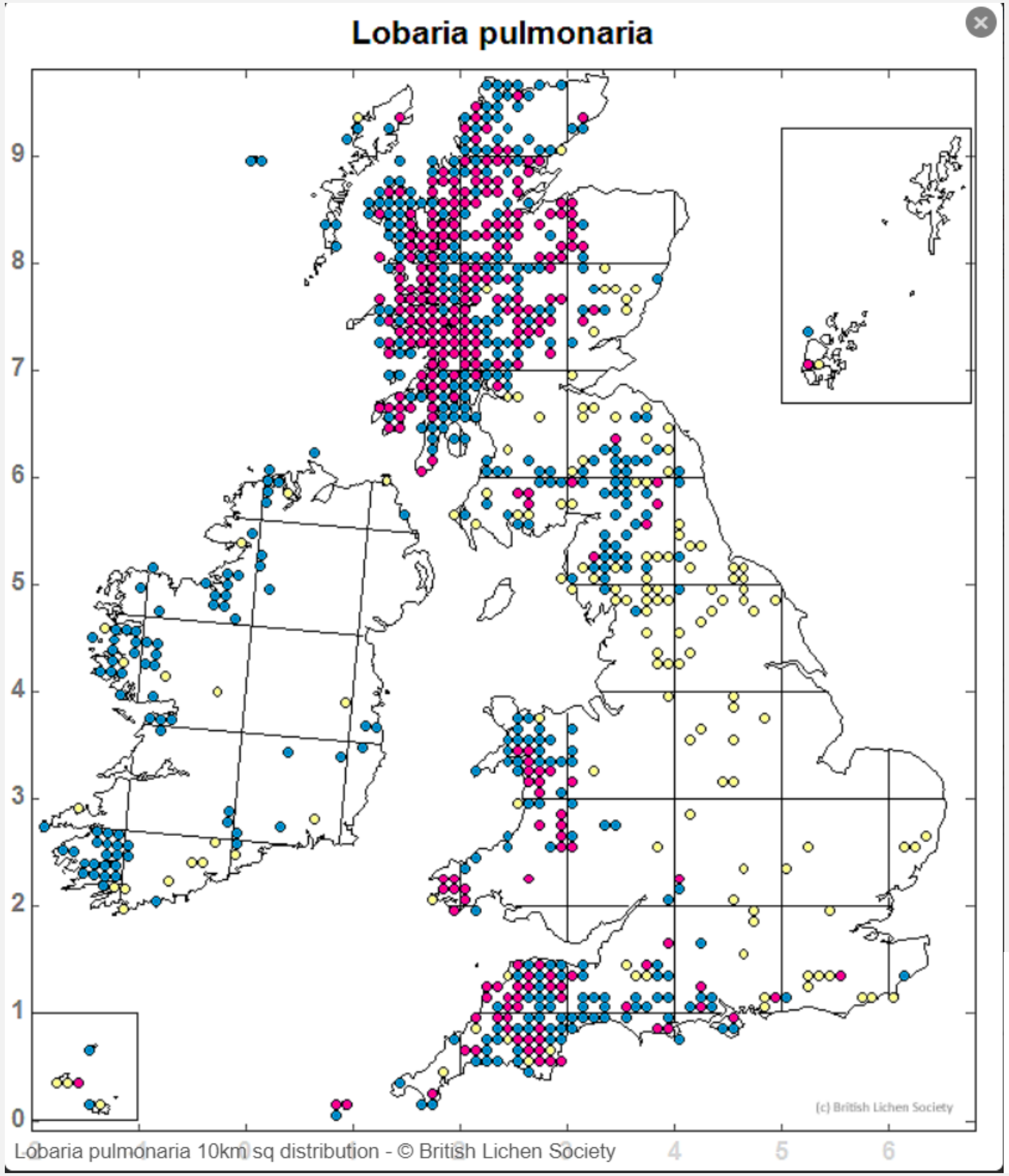
From Grennfelt, Hov, and Derwent, 1994

Epiphytic lichens

- Good indicators of air quality
- A thallus surface without protection and a nonspecific uptake of mineral nutrients- vulnerable to pollution effects.
- Slow growth rate, growth on substrates often exposed to air pollution, and an ability to absorb more sulphur dioxide at a given concentration than most vascular plants

Lobaria pulmonaria. Photo by Bernd Haynold CC BY-SA 3.0

Epiphytic lichens as indicators



Lobaria pulmonaria. Photo by Bernd Haynold CC BY-SA 3.0

Key to Map Date Classes

- 2000 +
- 1960 - 1999
- 1650 - 1959

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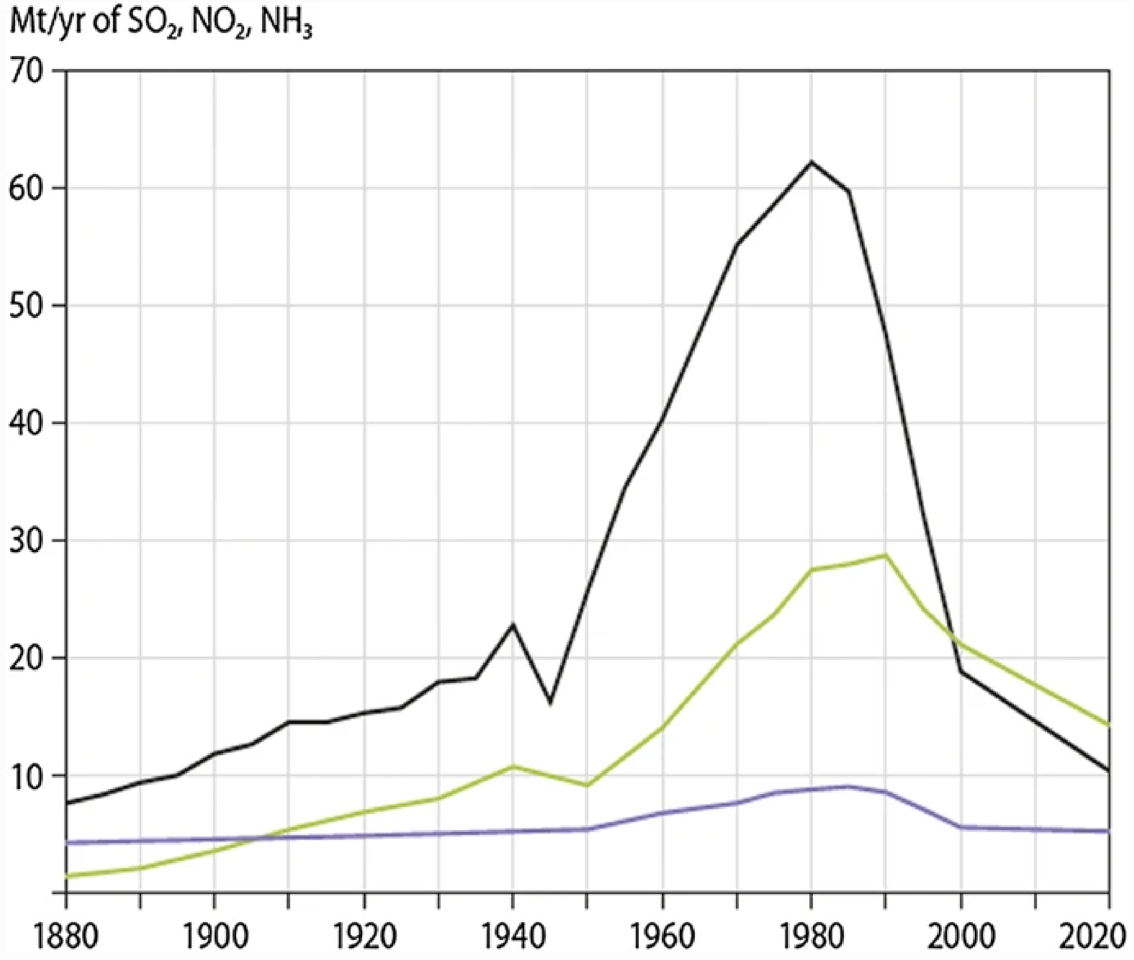
Fig. 1



European emissions of sulphur dioxide (SO_2—black), nitrogen oxides (NO_X, calculated as NO_2—green) and ammonia (NH_3—blue) 1880–2020 (updated from Fig. 2 in Schöpp et al. 2003)

Peak emissions and declines

- Sulphur dioxide emissions peaked in Europe in the early 1980s
- Nitrogen oxide emissions peaked around 1990
- Ammonia emissions also peaked in the 1980’s, but less dramatic changes
- Strong declining trend since, particularly in sulphur
- A success story?

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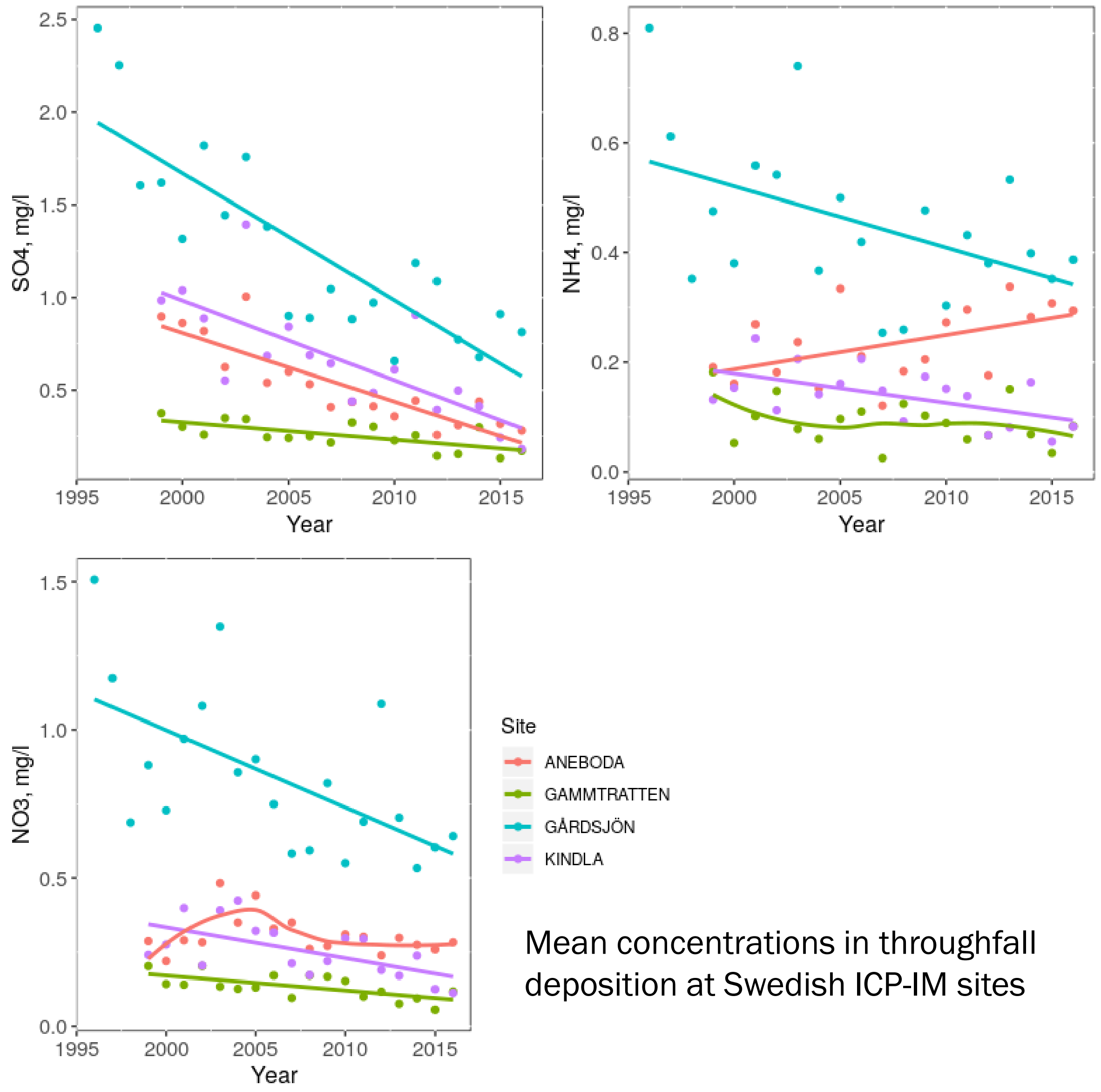
Monitoring data from ICP-IM sites in Sweden

- Lichen monitoring is conducted at five randomly selected mature trees from four randomly selected monitoring plots
- All epiphytic lichens are recorded, every fifth year, resulting in four inventories at each site, as of 2020
- Selection of trees is randomised but spruce (*Picea abies*) is the most common tree
- Disturbances at Aneboda 2005 onwards!



Mean concentrations in throughfall deposition at Swedish ICP-IM sites

Declines in deposition at Swedish sites

What were we expecting to find?

- Lichen communities in polluted sites were depleted at the start of the monitoring period and will show a recovery during the studied years, while the lichen community in the pristine northern site should not show any temporal trends.
- However, as S deposition has declined more than N deposition, we expect the mean S sensitivity of the lichen community to increase at the polluted sites while the mean nitrogen preference at those sites will show more limited decreases.

Methods

- For each tree, a weighted community mean value of the air pollution sensitivity values provided by Hultengren et al. (1991)
- Hultengren sensitivity values range from 0 to 9 and is mainly an indicator of sensitivity to SO_2. The higher value the less tolerant to acidity
- Community weighted mean preference for nitrogen based on the values given in Wirth (2010) with values ranging from oligotrophic (1) to eutrophic (9)
- Shannon diversity index values for each site/year combination

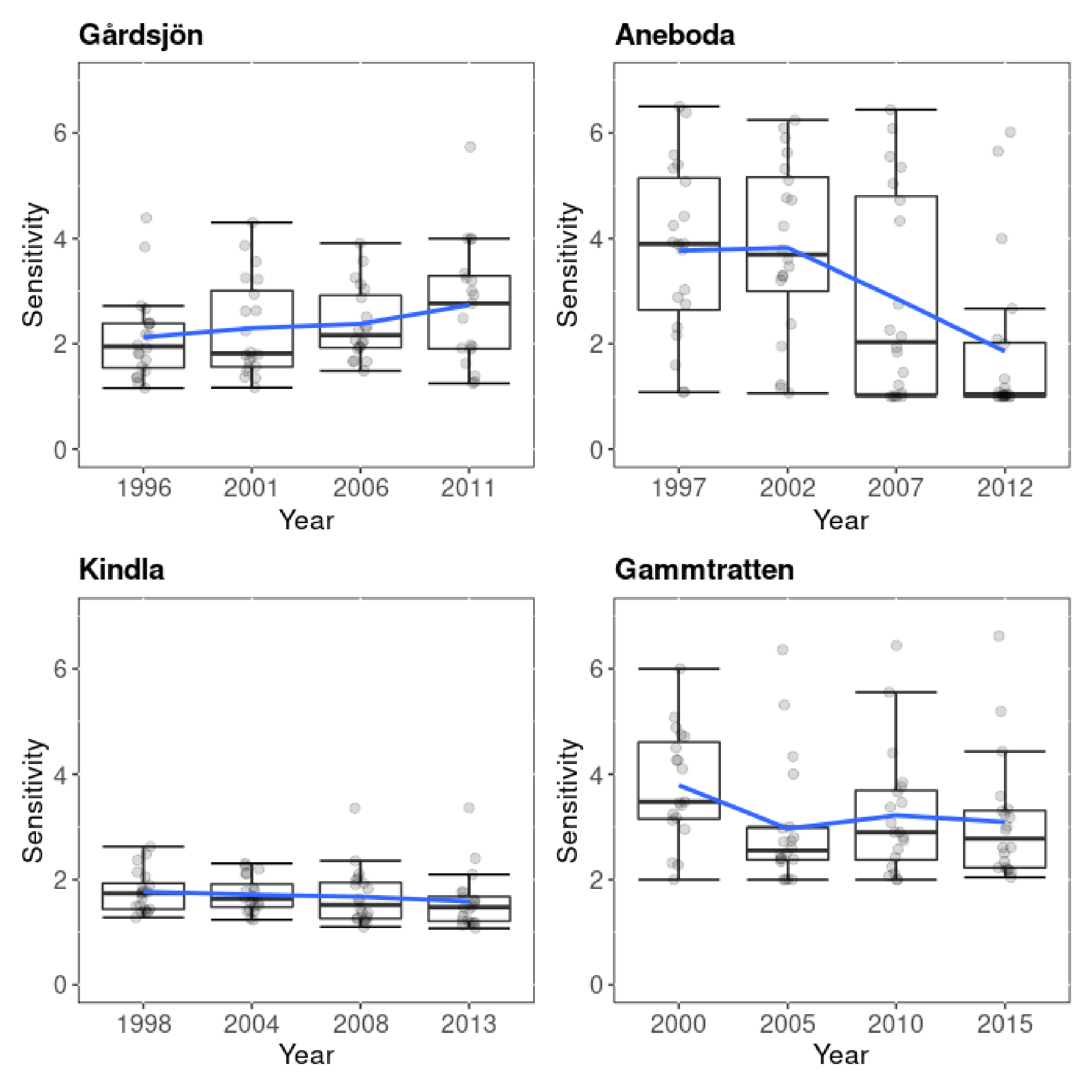
Methods

- Changes in beta diversity are decomposed into turnover and nestedness- are changes are driven by species replacement or community homogenisation?
- Temporal trends in diversity and the lichen community indices assessed using a mixed model (nested nature of observations) and an autocorrelation structure (repeated observations over time).

Sensitivity to sulphur

- Lichen sensitivity index increased at Gårdsjön
- Decreased at Kindla and Gammtratten
- Showed no significant change at Aneboda

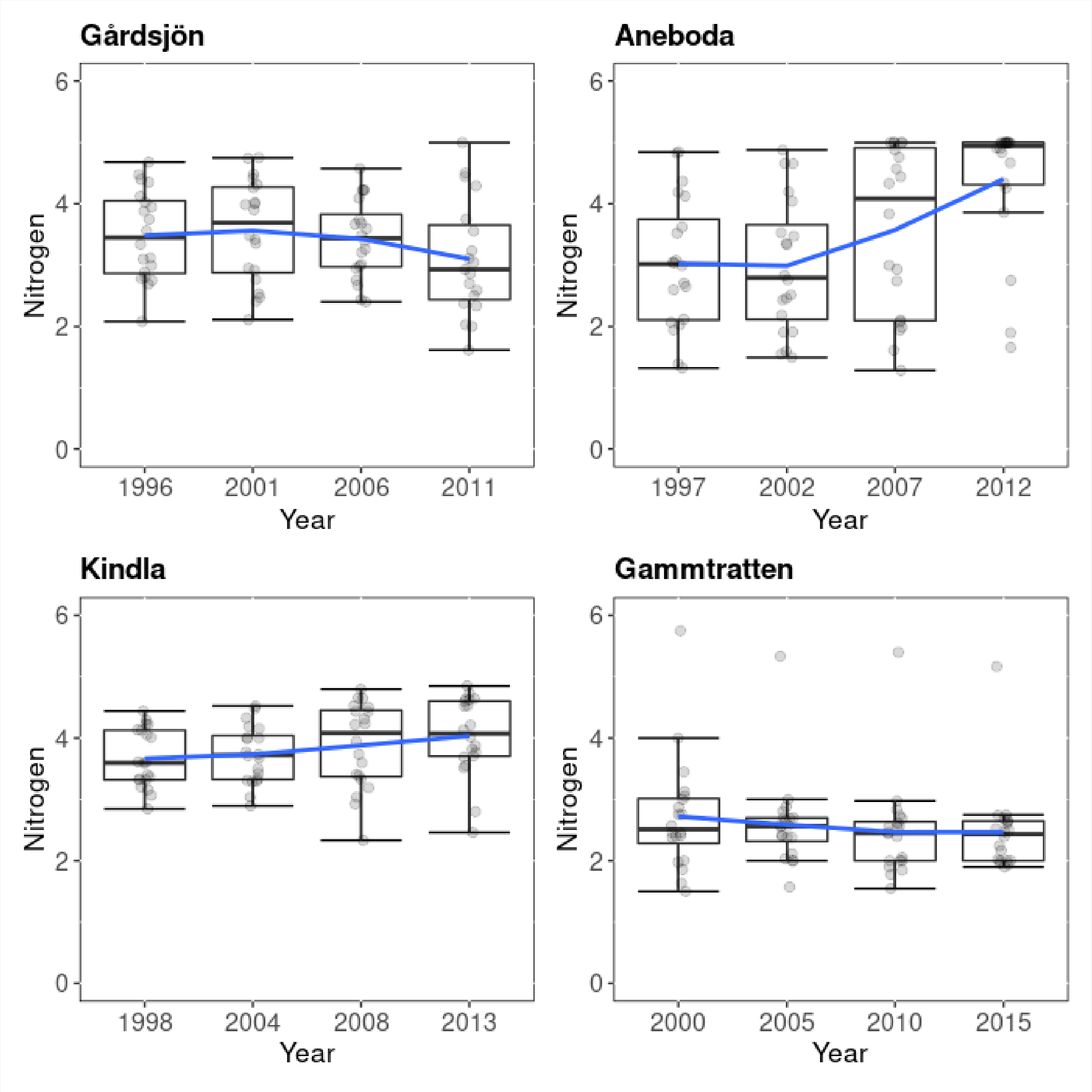
Site	Temporal coefficient	F-ratio	p-value
Gårdsjön	0.041	7.377	**0.009**
Aneboda	-0.036	1.398	0.248
Kindla	-0.014	4.995	**0.029**
Gammtratten	-0.048	16.284	**0.0004**



Nitrogen preference

- Community weighted mean Ellenberg nitrogen value decreased at Gårdsjön
- Increased at Kindla
- Showed no significant change at Gammtratten and Aneboda

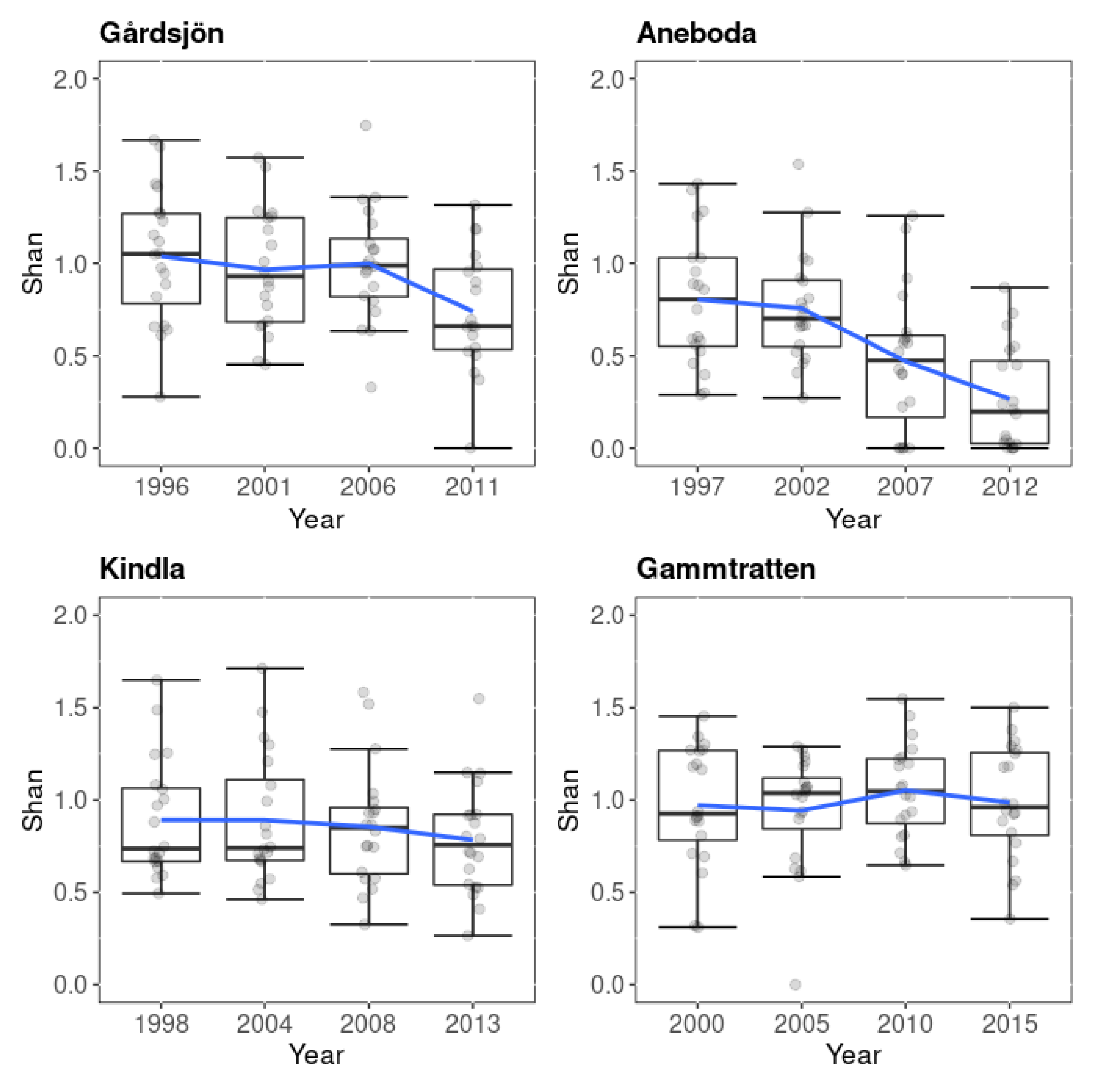
Site	Temporal coefficient	F-ratio	p-value
Gårdsjön	-0.0272	4.0595	**0.049**
Aneboda	0.0307	2.208	0.149
Kindla	0.0280	9.975	**0.003**
Gammtratten	-0.0171	2.822	0.098



Taxonomic diversity

- Lichen species alpha diversity (Shannon index) decreased at Gårdsjön and Aneboda
- Showed no significant change at Kindla and Gammtratten

Site	Temporal coefficient	F-ratio	p-value
Gårdsjön	-0.0186	7.301	**0.009**
Aneboda	-0.0198	8.938	**0.006**
Kindla	-0.0023	0.304	0.584
Gammtratten	0.0022	0.195	0.660

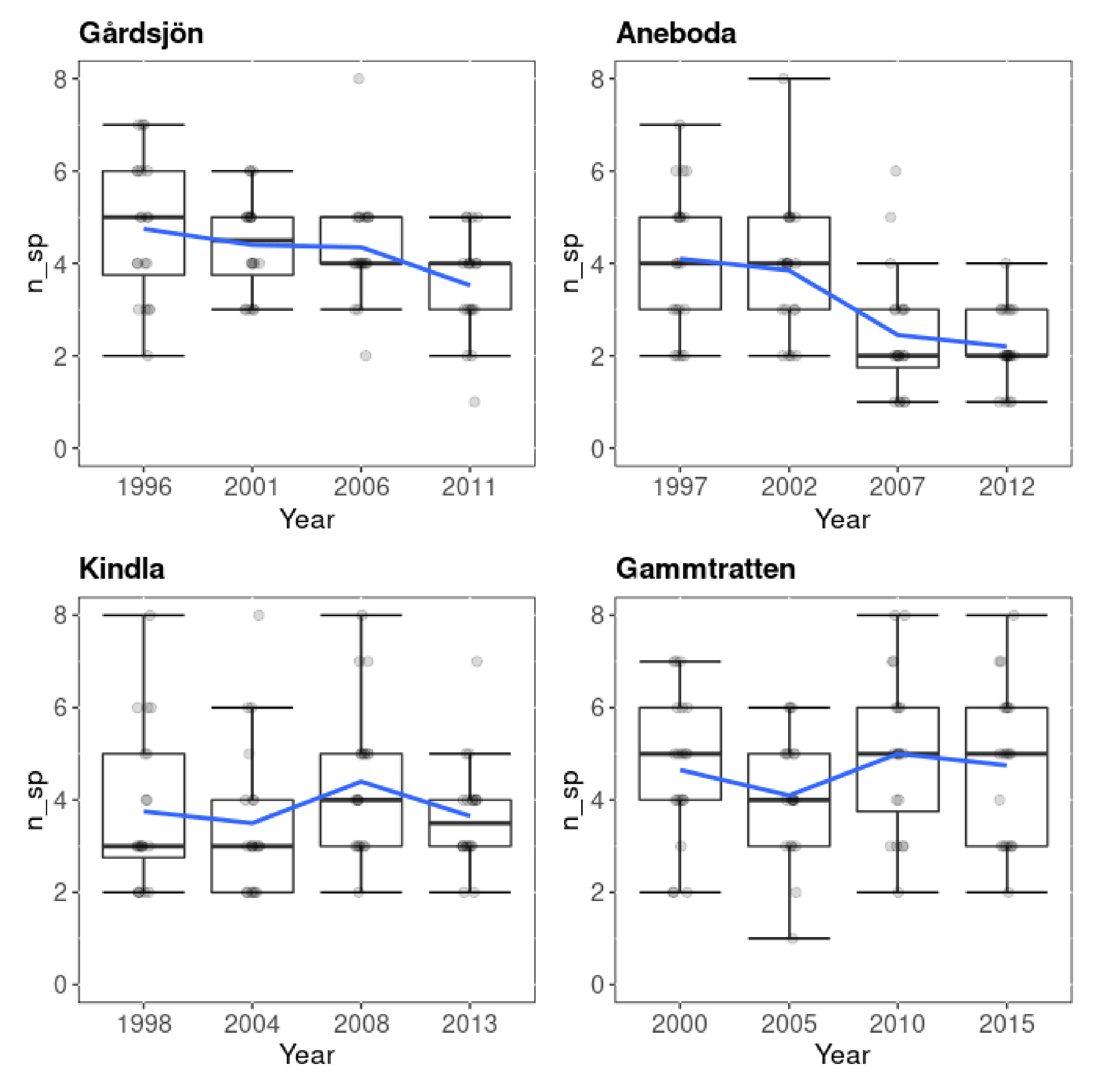


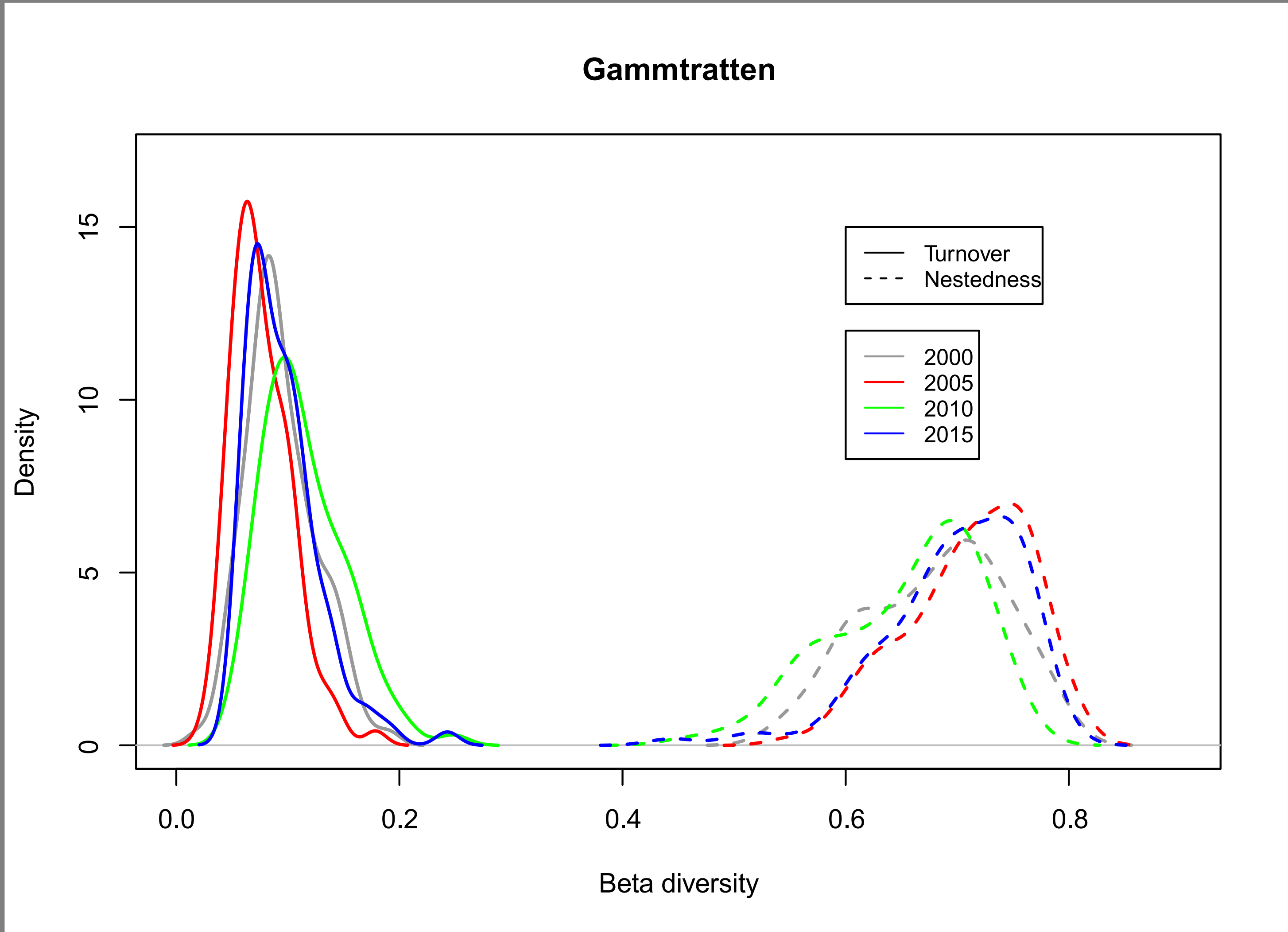
Number of species

- Lichen species richness decreased at Gårdsjön and Aneboda

- Showed no significant change at Kindla and Gammtratten

Site	Temporal coefficient	F-ratio	p-value
Gårdsjön	-0.0781	9.417	**0.003**
Aneboda	-0.0657	4.699	**0.039**
Kindla	0.0157	0.612	0.437
Gammtratten	0.0179	0.796	0.376





DECOMPOSITION OF BETA DIVERSITY

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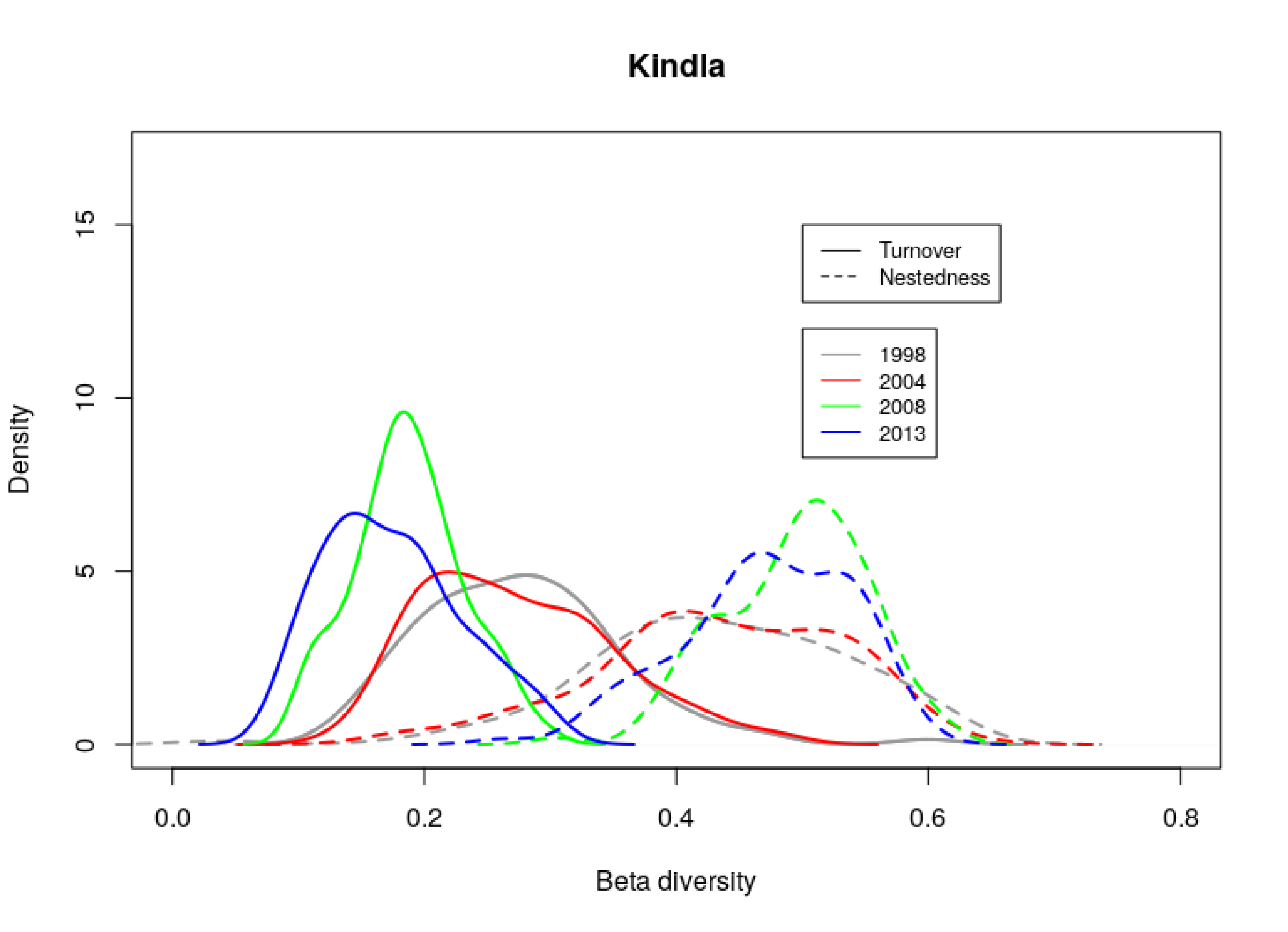

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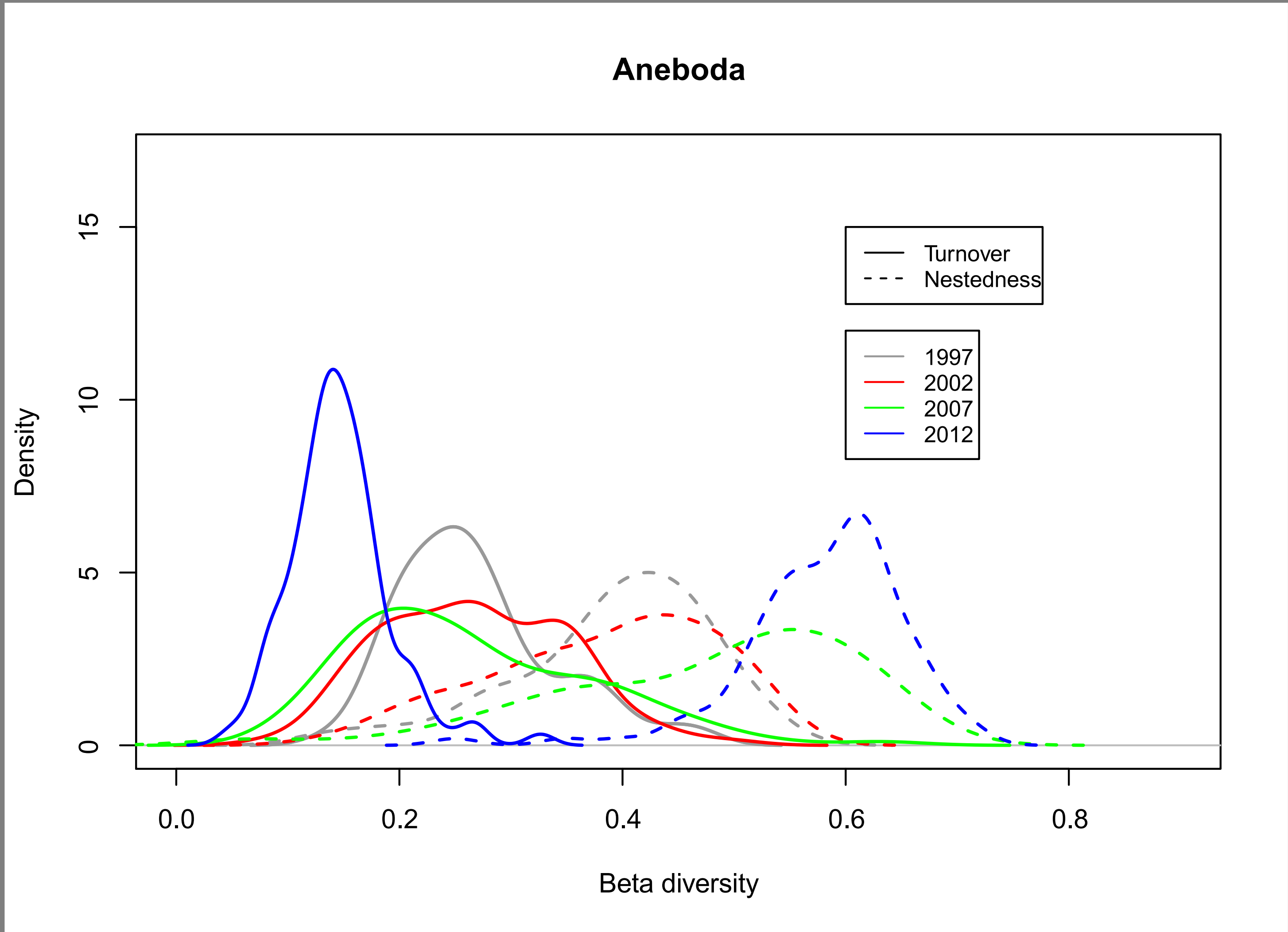

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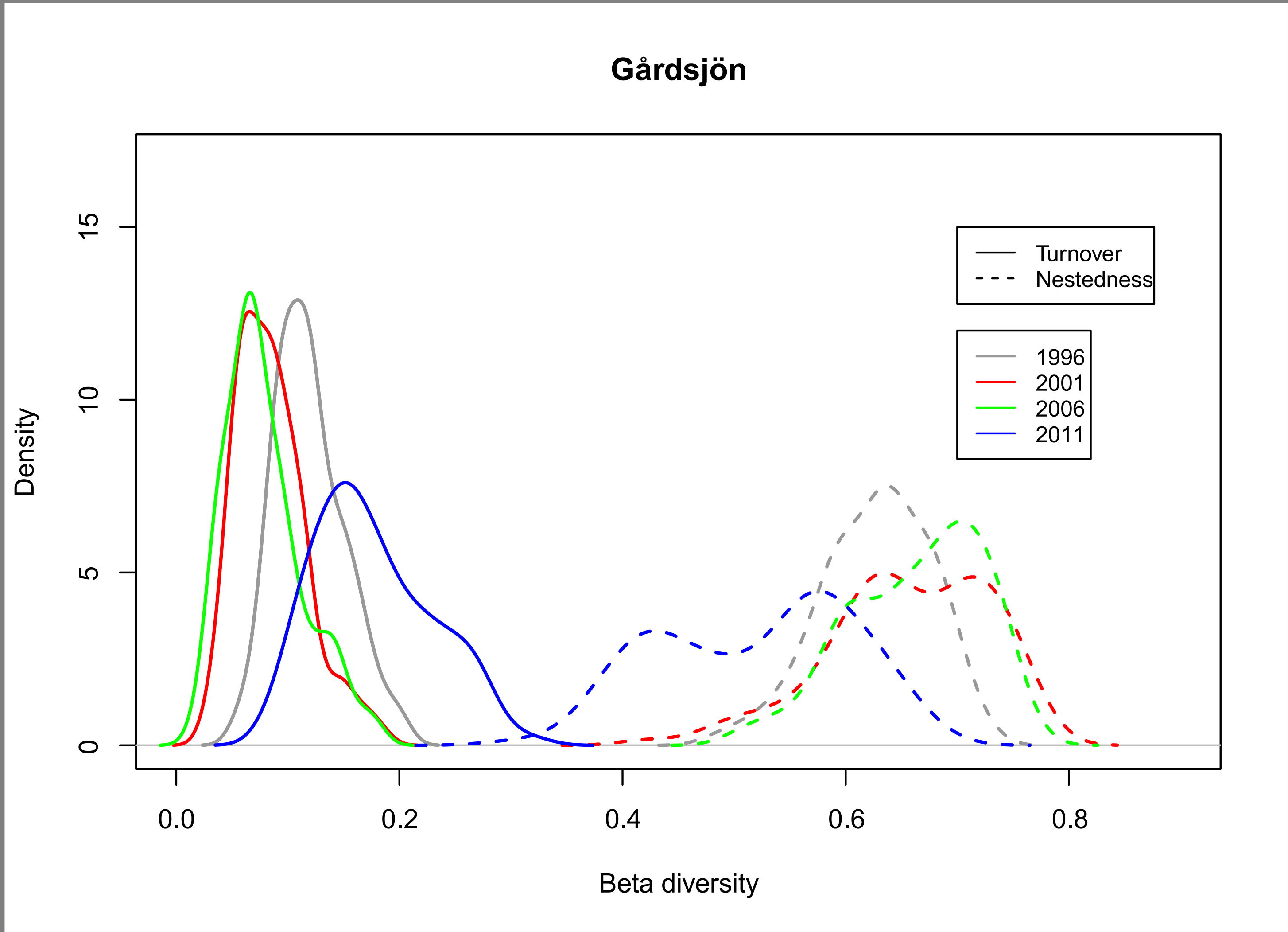

DECOMPOSITION OF BETA DIVERSITY

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Summary- weak, or no recovery

- Most polluted site Gårdsjön, improvements in S sensitivity and N preference (also + turnover - nestedness). But also a decline in richness/diversity.
- “Pristine” northern site Gammtratten, decline in S sensitivity despite low deposition levels
- Kindla, decline in S sensitivity, eutrophication and some homogenization in beta diversity
- Aneboda, changes probably dominated by other disturbance effects

Highest S, N deposition → *Lowest S, N deposition*

	Gårdsjön	Aneboda	Kindla	Gammtratten
Sensitivity	+*	ns	-**	-*
Nitrogen	-*	ns	+*	ns
Richness	-**	-*	ns	ns
Diversity	-*	-**	ns	ns

* = $p < 0.05$, ** = $p < 0.01$. Red background indicates a significant decrease, while a green background indicates a significant increase. “ns” indicates a non-significant change

Why is the recovery so weak?

- Sensitive lichens can be lost quickly- good indicators during deposition increase
- Even low-level deposition can have a cumulative effect
- Air pollution is a disturbance over large areas and long periods
- The regional species pool is therefore likely depleted
- This implies long distances for recolonisation to occur over
- Recolonisation is slow (e.g. 35 metres over 9 years in Öckinger et al., (2005) !)
- Implications for using lichens as bioindicators during deposition decrease?

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Thank you for listening