ICP Integrated Monitoring

Key results in relation to GP review questions

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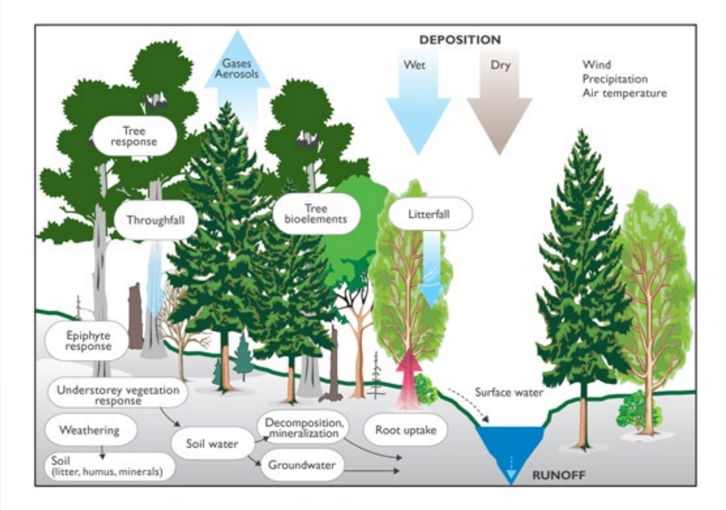
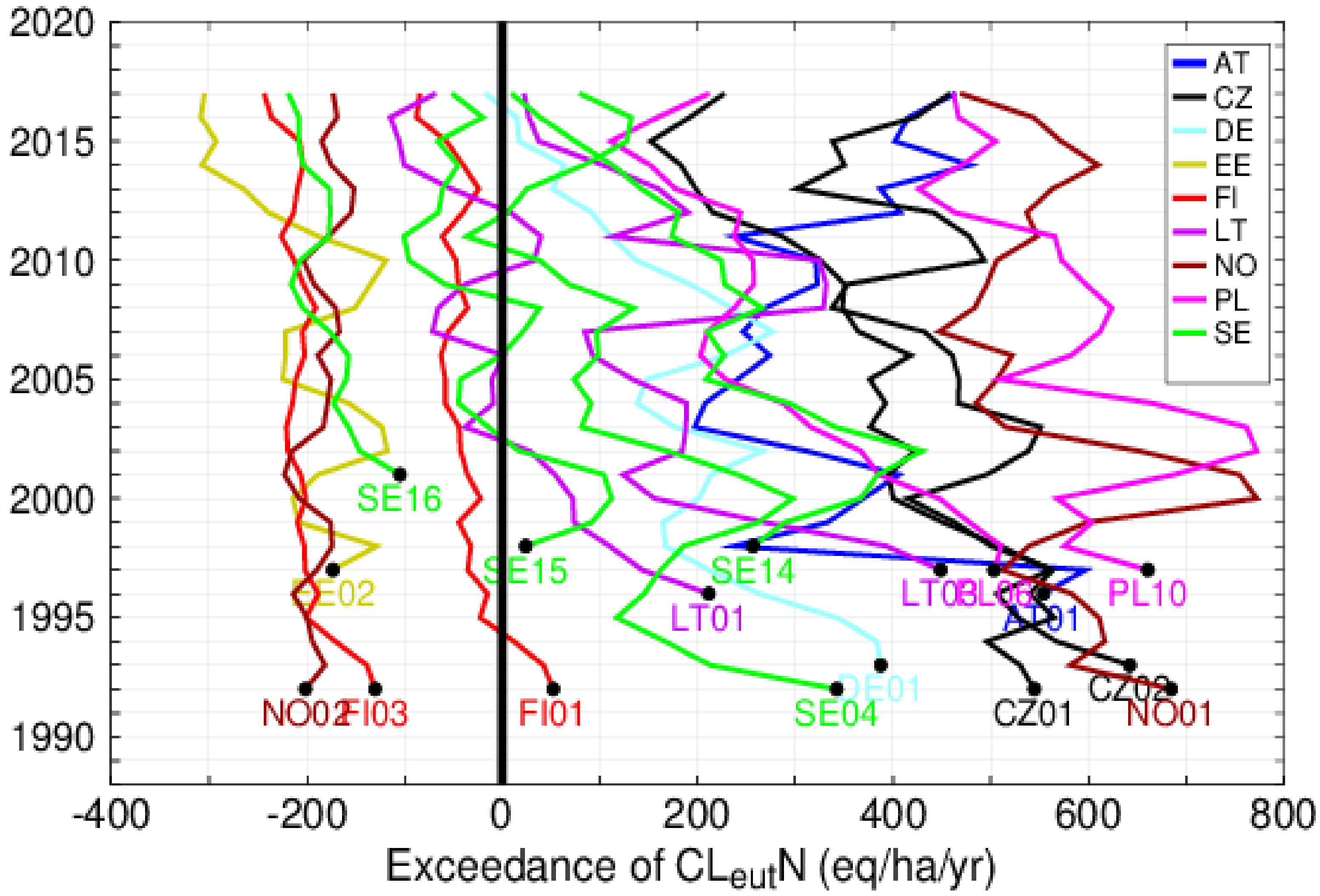


Question 2.2.b: What is the annual change (or change every 5 years) in exceedance of critical loads for acidification and eutrophication between1990 and 2018/2019 in terms of percentage ecosystems with exceedances and accumulated excess, based on current critical loads. What are projected changes up to 2030 and beyond?

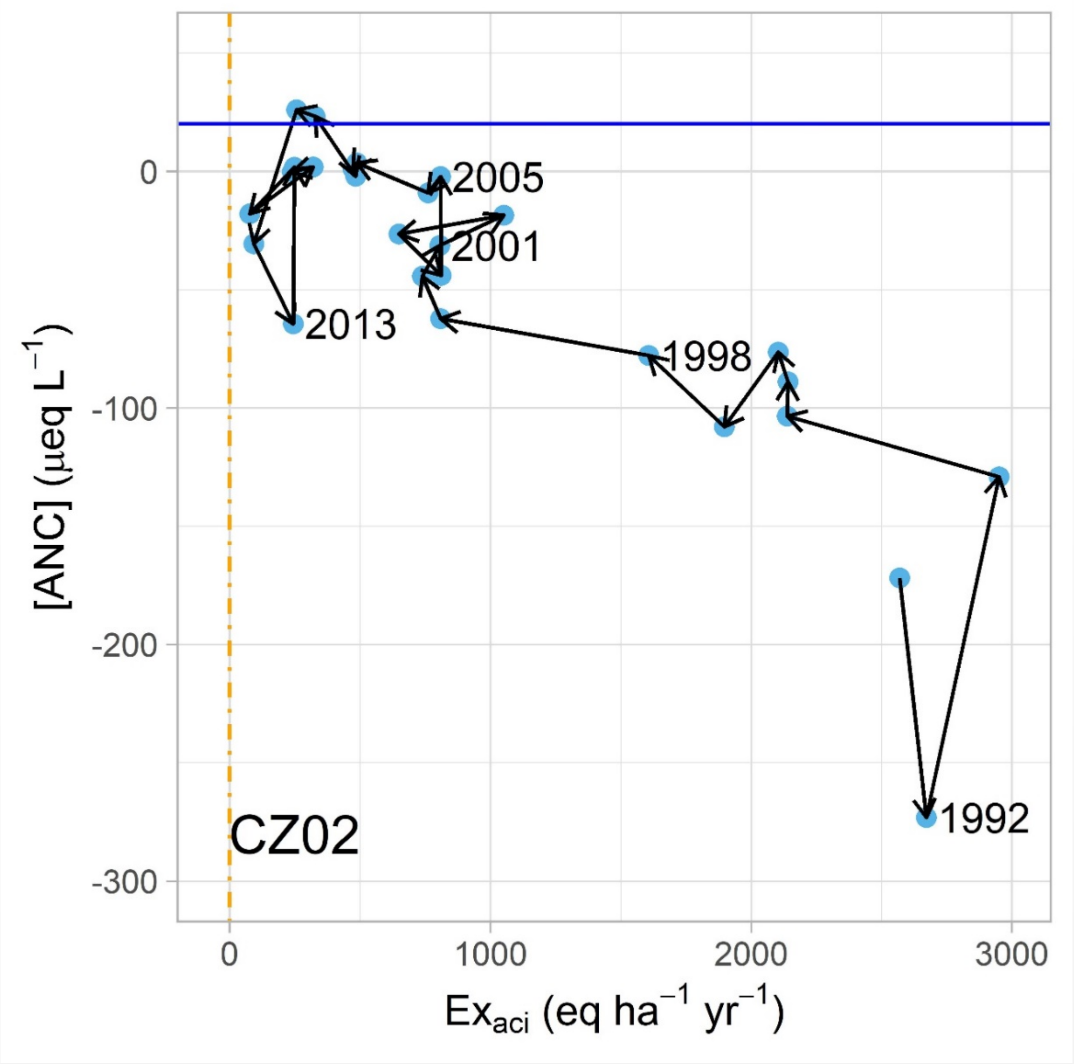
Calculations of site-specific exceedances of critical loads (CLs) for acidification and eutrophication:

Assessing links between time-series of CL exceedances and measured site data, using long-term measurements 1990–2017 (Forsius et al. 2021):

- There was a relation between calculated exceedance of the CLs and measured runoff water concentrations and fluxes, and most sites with earlier higher CL exceedances showed larger decreases in both total inorganic nitrogen (TIN) and H^+ concentrations and fluxes.
- Sites with higher cumulative exceedance of eutrophication CLs (averaged over 3 and 30 years) generally showed higher TIN concentrations in runoff.
- **The results confirm that emission abatement actions are having their intended effects on CL exceedances and ecosystem impacts.**
- **The temporal developments of the exceedances of the CLs indicated the more effective reductions of S deposition compared to N at the sites.**
- **The results provided evidence on the link between CL exceedances and empirical impacts, increasing confidence in the methodology used for the European-scale CL calculations.**



Exceedance of eutrophication critical loads ($CL_{eut}N$) over time at the 17 ICP IM sites using the total N deposition measurements at the sites (from Forsius et al. 2021, https://doi.org/10.1016/j.scitotenv.2020.141791).



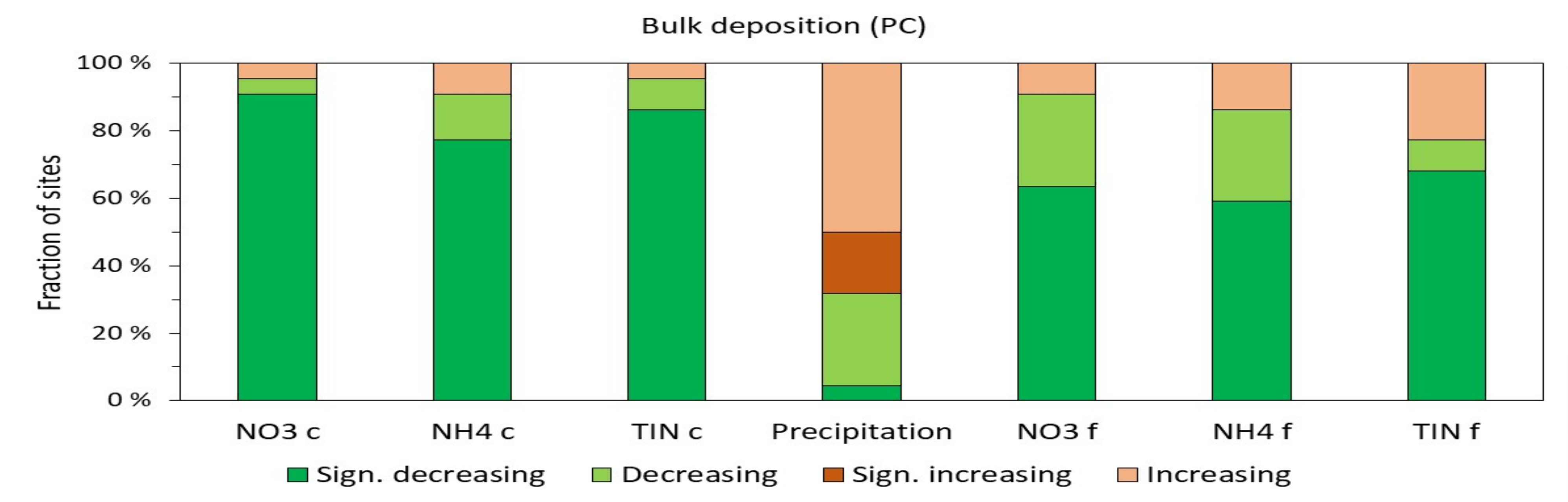
Chemical criterion for CL

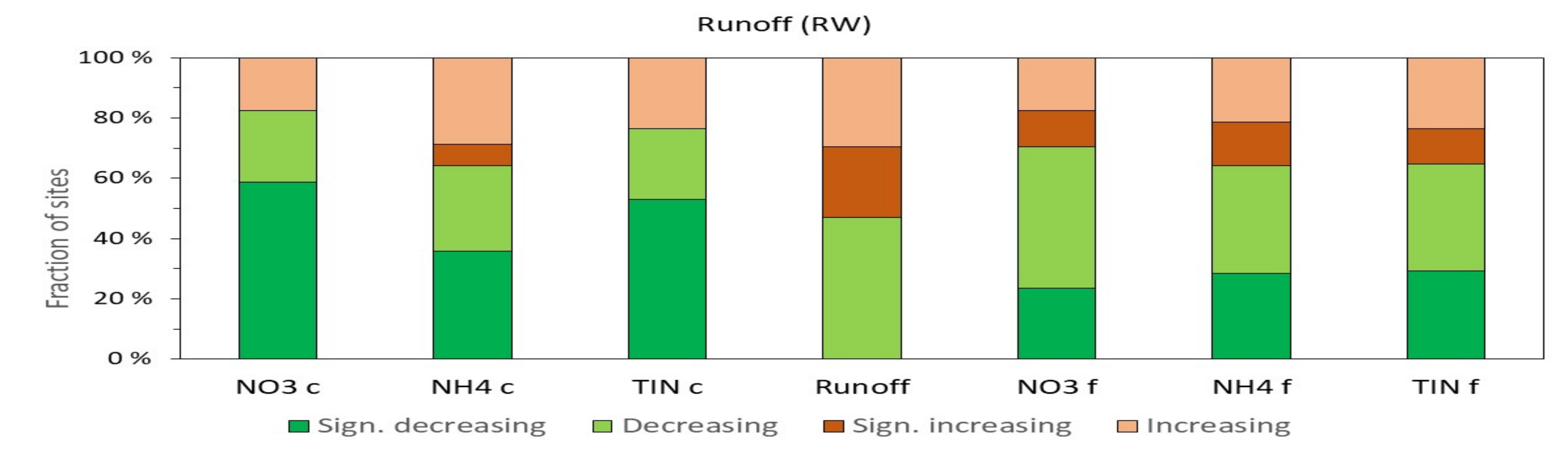
Response trajectory of ICP IM site CZ02 to the exceedance of the acidity critical load (Ex_{aci}) (from Forsius et al. 2021, https://doi.org/10.1016/j.scitotenv.2020.141791). The site barely moves across borders of non-exceedance of the critical load and the subsequent non-violation of the chemical criterion (ANC_{limit} = 20 μeq L^{-1}).

Question 2.2.c: What is the annual change (or change every 5 years) in water, soil and ecosystem quality indicators between 1990 and 2018/2019? What are projected changes up to 2030 and beyond?

Key messages based on **statistical trend assessments** (Vuorenmaa et al. 2018; 2020, Forsius et al. 2021):

- ICP IM sites showed dominantly negative trend slopes of total inorganic nitrogen (TIN) in concentrations (95% of the sites; mean slope -1.08 μeq L^{-1} yr^{-1}) and fluxes (91% of sites, mean slope -0.84 meq m^{-2} yr^{-1}) of bulk/wet deposition between years 1990 and 2017.
- Concentrations of TIN in runoff water for years 1990-2017 exhibited dominantly downward trend slopes (76% of sites, mean slope -0.48 μeq L^{-1} yr^{-1}), and for fluxes 69% of the sites (mean slope -0.21 meq m^{-2} yr^{-1}), respectively.
- Decrease of NO_3 and NH_4 in concentrations was significant at 59% (-0.36 μeq L^{-1} yr^{-1}) and 36% (-0.05 μeq L^{-1} yr^{-1}) of the sites, but the decrease in fluxes was significant only at 25% (-0.18 meq m^{-2} yr^{-1}) and 31% (-0.04 meq m^{-2} yr^{-1}) of the sites, respectively.
- **Results of the ICP IM monitoring network confirm the positive effects of the continuing emission reductions**.
- **Decreasing trends for S and N deposition reduction responses in runoff water chemistry tended to be more gradual since the early 2000s.**
- **Responses regarding N impacts were more varying than for S, indicating the complexity of the catchment responses.**





Vuorenmaa et al. 2020, https://helda.helsinki.fi/handle/10138/317512

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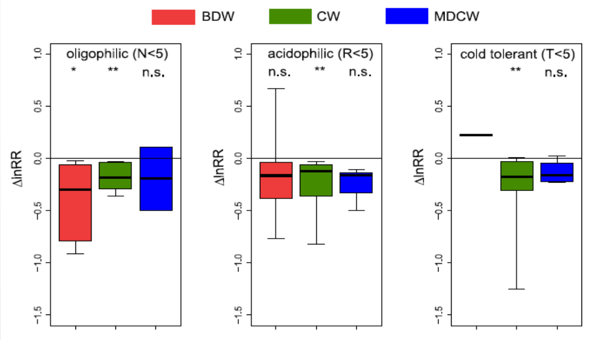
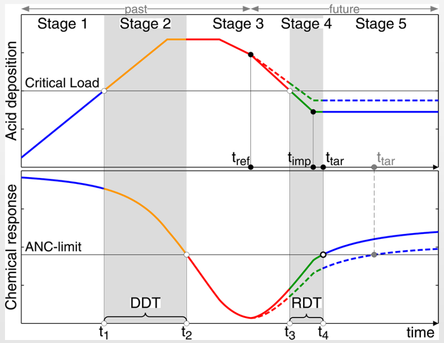
Key messages based on **dynamic modelling/assessment of future trends** (Dirnböck et al. 2018, Posch et al. 2019):

- Dynamic models are needed in order to assess the times scale of impacts and recovery from changes in air pollutant emissions. Interaction with changes in climate variables is also of key importance.
- Model predictions indicated that oligophilic (favouring nutrient-poor conditions) forest understory plant species will further decrease. This result is partially due to confounding processes related to climate effects and to major decreases in S deposition and consequent recovery from soil acidification.
- **Decreases in N deposition under the current legislation emission scenario (CLE) will most likely be insufficient to allow recovery from eutrophication, particularly regarding sensitive plant species.**
- **Emission reductions of oxidized and reduced N compounds need to be considerably greater to allow full ecosystem recovery from the impacts of chronically high N deposition.**
- **The target load calculations indicated that emission reductions beyond the Gothenburg Protocol are required to ensure surface water recovery from acidification of the most sensitive sites by 2050.**





https://doi.org/10.1088/1748-9326/aaf26b

https://doi.org/10.1021/acs.est.8b06356

Question 2.8: What are the expected impacts of new scientific findings on environmental and health effects assessments, for example on:

- ***critical loads***
- ***critical levels of ozone, particulate matter, nitrogen dioxide and ammonia***
- ***dynamic modelling of ecosystem recovery***
- ***inclusion of marine ecosystems protection***
- ***interactions between air pollution, climate change, nitrogen fluxes and other stress factors for biodiversity (e.g. land use changes)***
- ***additional or new metrics on health, damage to crops, ecosystems and/or materials?***

Key messages (Dirnböck et al. 2018, Holmberg et al. 2018, Posch et al. 2019, Weldon and Grandin 2021):

- **A systems approach is needed to study future integrated impacts** air pollution and climate on ecosystem processes and biodiversity → concept developed.
- Simulated future soil conditions improved under projected decrease in deposition and current climate conditions: higher pH, base saturation and C:N at 21, 16 and 12 of the 26 simulated sites, respectively.
- When climate change projections were included, soil pH increased in most cases, while base saturation and C:N increased in about half of the cases. Hardly any climate warming scenarios led to a decrease in pH.
- The advantage of target loads over critical loads is that one can define the deposition **and the point in time** when the critical limit is no longer violated.
- Epiphytic lichens which are known to be good indicators of air quality, are of limited indicative ability of recovery after large-scale disturbances such as air pollution → **Reiterate the need of long-term ecological monitoring**.

Modelling ecosystem impacts of multiple drivers

https://doi.org/10.1016/j.scitotenv.2018.05.299