Evidence, priorities and indicators from ECLAIRE and recent science

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Take Home Messages

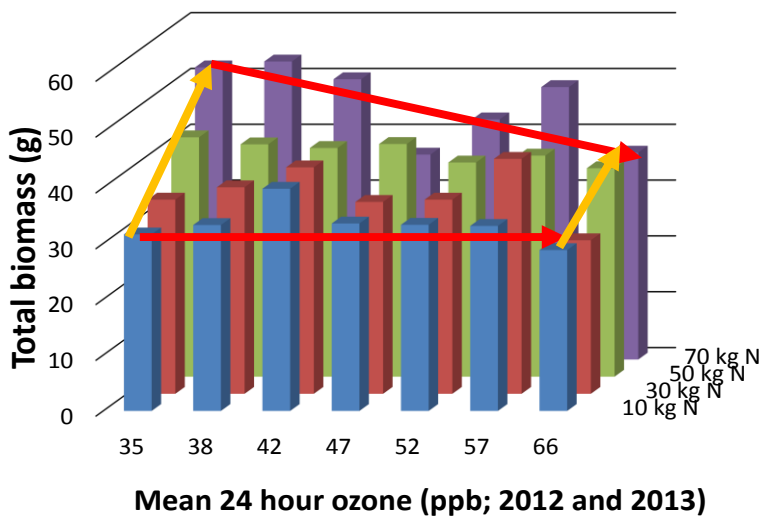
- WGE to include new endpoints of eco-effects of air pollution and climate change, including more focus on:
  - *The resilience of biodiversity and ecosystem services against climate change through protection from effects of air pollution*
  - *Interactions between eco-effects of nitrogen and ozone under climate change*
  - *New metrics for "Safe Limits" (e.g. ECLAIRE novel O_3 D-R functions; biodiv. Critical loads; O_3 & N interaction indicators)*
  - *Long term monitoring to assess combined effects of climate change and air pollution*
- EMEP to include climate dependent "receptor" scenarios:
  - *Landuse (incl. agriculture) scenarios under climate change (IAM ?)*
  - *"receptor scenarios" for climate change driven regional variability of temperature, precipitation, wet/dry deposition*
- LRTAP Convention Science to Link up with relevant global and EU policy strategies (Air, COP21+, Biodiversity, Sustainability)

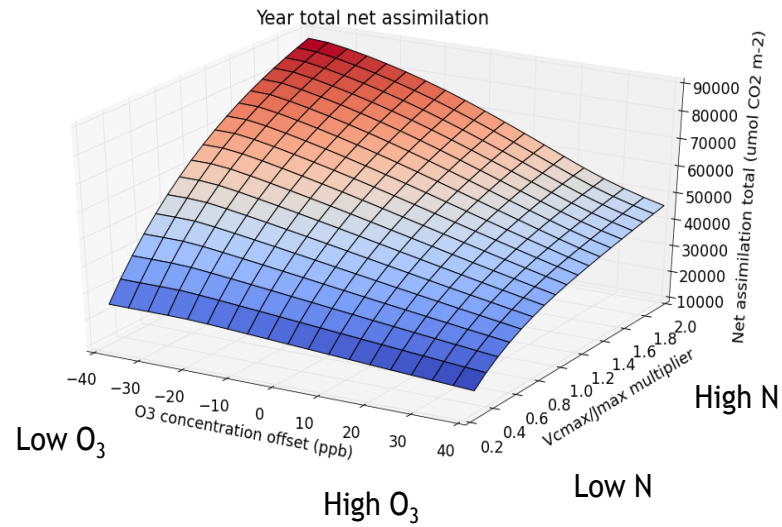
Interacting effects of climate, N and O_3

Evidence selected from ECLAIRE:

- Plant productivity increases by N and CO_2, decreases by O_3 while O_3 decreases nitrogen use efficiency
- *N impacts on forest growth occur below 15 kg N $ha^{-1}yr^{-1}$* but pairs of environmental drivers (N, O_3, CO_2 temperature) may be opposing; O_3 can almost completely cancel the productivity benefit of N inputs.
- Dry air/soil and elevated CO_2 may counteract O_3 effects, but chronic exposure to O_3 decreases plant tolerance to drought
- Higher temperatures
  - and longer growing seasons will aggrevate O_3 effects in Northern Europe, may increase species richness but also cause loss of cold tolerant species
  - *will worsen effects of N on biodiversity* and air/water quality
- A changing climate
  - will affect spatial patterns and magnitudes of impacts through changes of emissions, landuse, atmospheric processes and precipitation patterns

Example of exciting development from ECLAIRE: 3D response surfaces for O_3 and N interactions





Experiments – solardomes, CEH
Same pattern: Spain, Italy

DO_3SE-C modelling of seasonal total assimilation

- No simple cancelling-out or additive effects exist when environmental drivers such as N and O_3 occur together

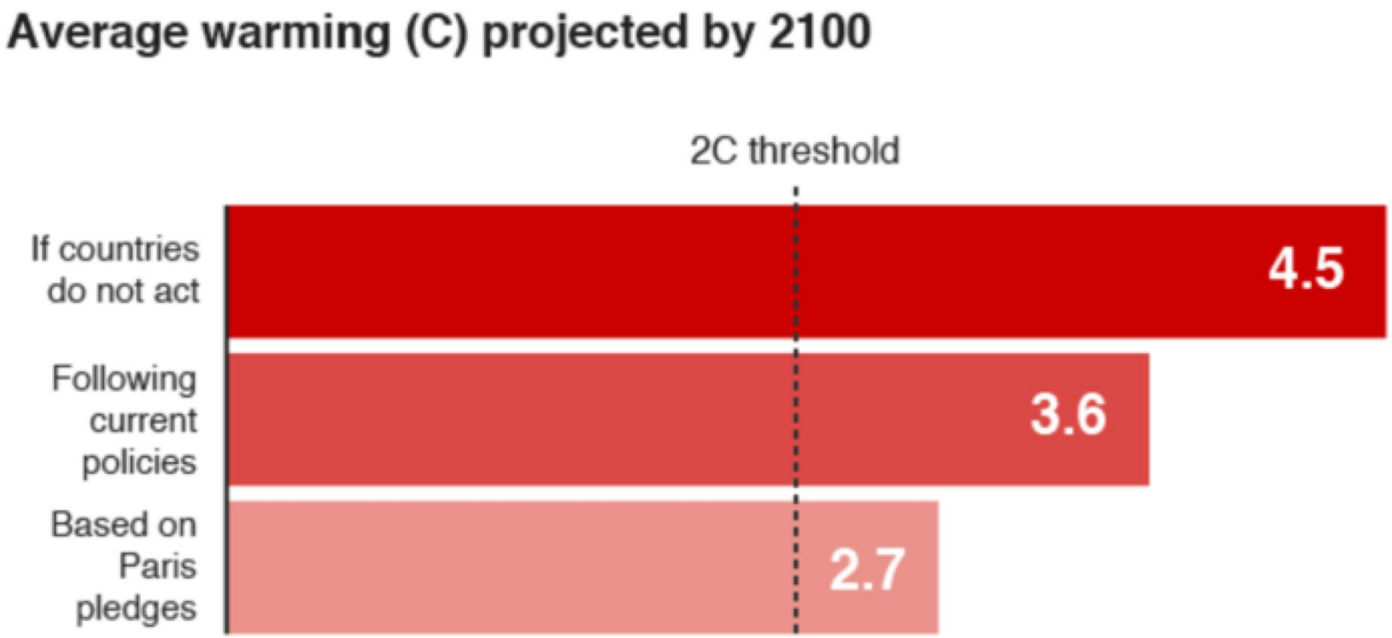
Loss of biodiversity affects resilience of Earth System

Other evidence:

- The planetory boundaries framework has provided a science based analysis of the risk of human activities for the resilience of the earth system. (Steffen *etal.* (2015). *Science* 347(6223))
  - Climate change, Biospheric integrity, Land-system change, Biochemical flows contribute to "safe limits" being put at risk.
- Biodiversity intactness within most (grassland) biomes, biodiversity hotspots and wilderness areas is inferred to be beyond the planetory boundary…undermining efforts towards long-term sustainable development (Newbold *et al.* (2016). *Science* 353(6296))
- "Monitoring, experiments, and models evaluating multiple change drivers are needed to detect and predict vegetation changes in response to 21st century global change" (Franklin *et al.*(2016). *PNAS* 113(14))
  - Global change, i.e. rising atmospheric concentrations of CO_2, other GHGs, climate change, nitrogen deposition, biotic invasions, altered disturbance regimes and land use change (Franklin *et al.*, *ibid)*

A tentative CCE assessment of the impact of temperature change on European nitrogen critical loads of biodiversity

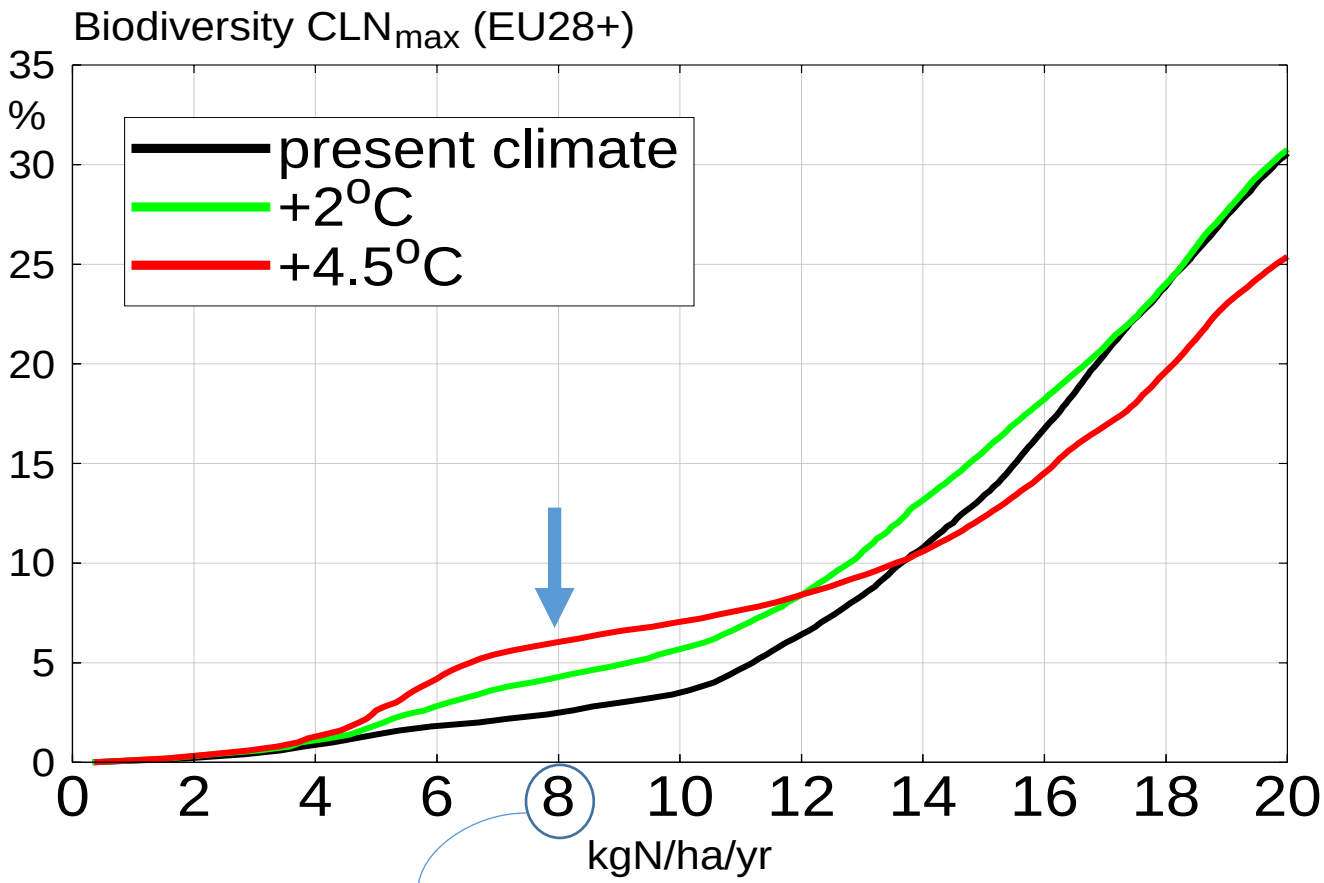
COP21 projections of temperature change



Source: Climate Action Tracker, data compiled by Climate Analytics, ECOFYS, New Climate Institute and Potsdam Institute for Climate Impact Research.

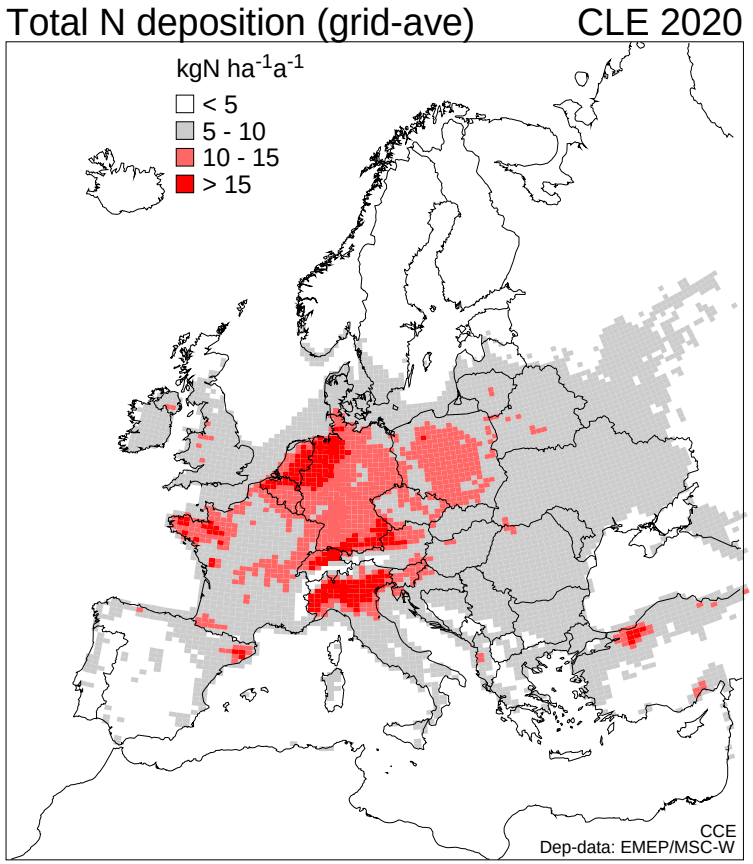
Increased risk for biodiv. at higher temperature for Ndep between 2 and 12 kg $ha^{-1}yr^{-1}$ …

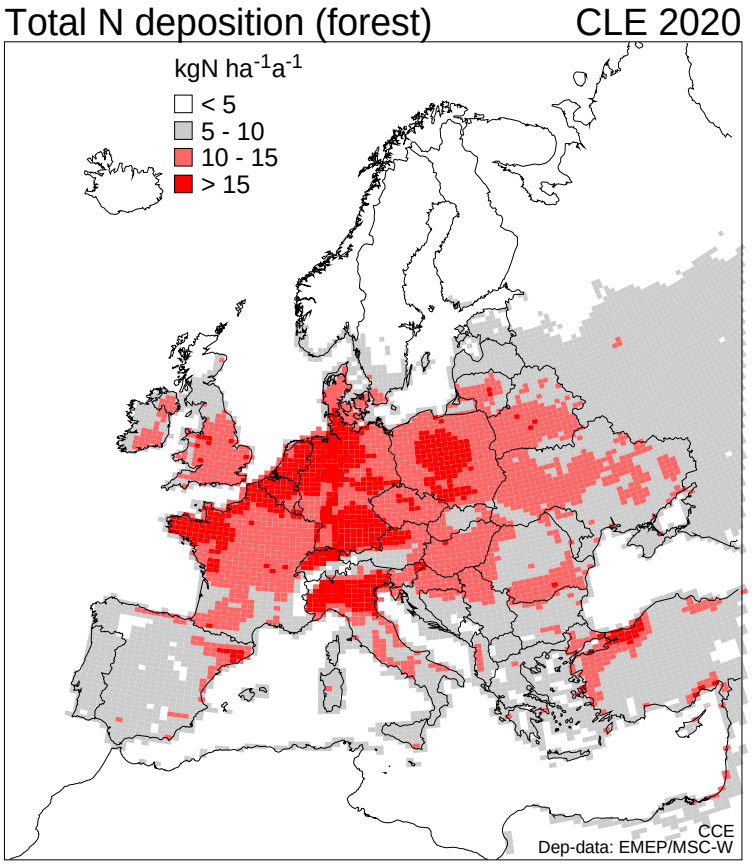
(Source: CCE, 2016 using European background database)



At Ndep of 8 kg $ha^{-1}yr^{-1}$, the area at risk at 2 and 4.5 °C is about 4% and 7% respectively

…However spatial variability of deposition patterns also depends on climate (landuse, precipitation,..) hence a need for climate specific "receptor scenarios"





Thank you.

…Effect of landuse on terrestrial biodiversity…

(See: Newbold *et al*.(2016), Science **353**:288-291)

If the Safe limit of the Biodiversity Intactness Index (BII) is set to 90% then:

- 58% of the terrestrial ecosystem is biotically compromised …if it is assumed that only originally present species contribute to ecosystem function
- 48% …if also novel species contribute to the same ecosystem function
- 9 out of 14 biomes have exceeded the safe limits of the BII

Results vary with assumptions on " safe limits"