# Climate change hampers endangered species by stronger water-related stresses

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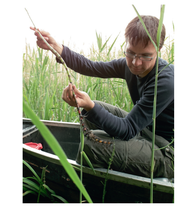

## Introduction

Extremes in meteorological conditions are forecast to increase globally, and to affect vegetation composition [1]. More prolonged dry periods will alternate with more intensive rainfall events, both within and between years, which will change soil moisture dynamics [2]. We show the effect of climate change on the variability in both wet and dry extremes in stresses faced by plants (oxygen and drought stress, respectively), and the impact on endangered plant species.

## Methods

- Simulate oxygen and drought stress in terms of respiration and transpiration reduction, respectively, for terrestrial vegetation plots from a temperate climate, with a novel, process-based approach, incorporating in detail the interacting processes in the water-soil-plant-atmosphere system [3, 4];
- Relate the number of endangered species of each vegetation plot to oxygen and drought stress;
- Predict the effect of future (2050) oxygen and drought stress on the future number of endangered species per plot.

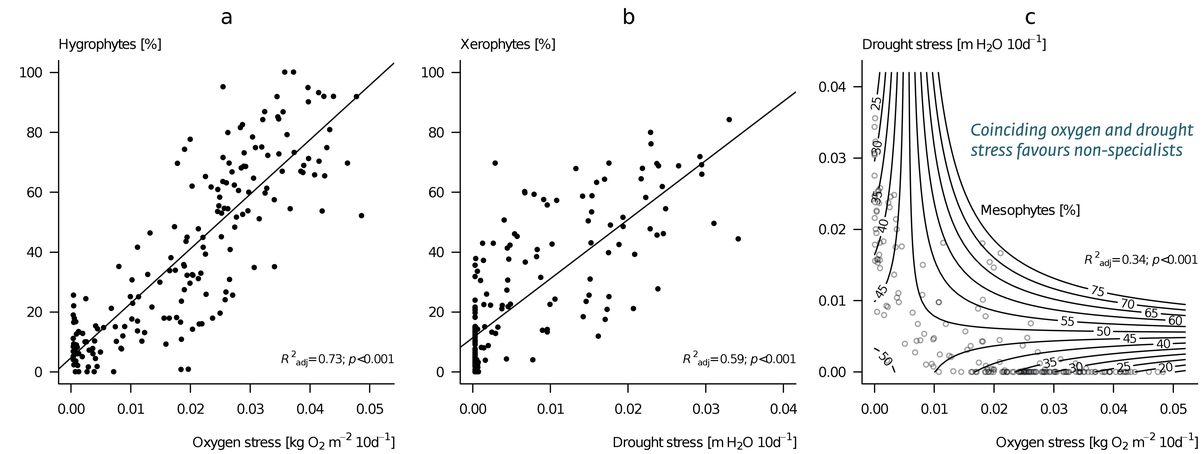


*Figure 1: Percentage hygrophytes (a) and percentage xerophytes (b) as function of oxygen stress and drought stress, respectively, and percentage of mesophytes (c; the isolines represent the percentage of mesophytes) as function of both oxygen and drought stress. Co-occurring oxygen and drought stress reduces the percentage of specialists within a vegetation plot, i.e. either hygrophytes or xerophytes, while increasing the occurrence of mesophytes (Figure 2c). Figure 2c further shows that the percentage of mesophytes within a vegetation plot (i.e. the percentage of non-specialists) decreases significantly with increasing stress as long as only one of the stresses prevails*

## Results & Conclusions

- Process-based measures of oxygen and drought stress are good predictors of vegetation characteristics (Figure 1a,b);
- Co-occurring oxygen and drought stress reduces the percentage of specialists within a vegetation plot, i.e. either hygrophytes or xerophytes, while increasing the occurrence of mesophytes (Figure 1c);
- Under the current climate, variable stress conditions are coupled to a significantly lower potential number of endangered plant species (Figure 2);
- Climate change (IPCC-scenario A2 and A1B) will affect soil moisture conditions and plant oxygen and water demands such, that both oxygen stress and drought stress will intensify and will increasingly coincide (on average with ca. 20% on sites where both stresses occur), causing variable stress conditions (Figure 3);
- This increased coincidence of water-related stresses will negatively affect the future (2050) occurrence of currently endangered plant species (a reduction of 16%), while such a decrease is not apparent for common species.

**Our integrated mechanistic analysis of two stresses combined reveals large impacts of climate change on species extinctions and thereby on biodiversity.**

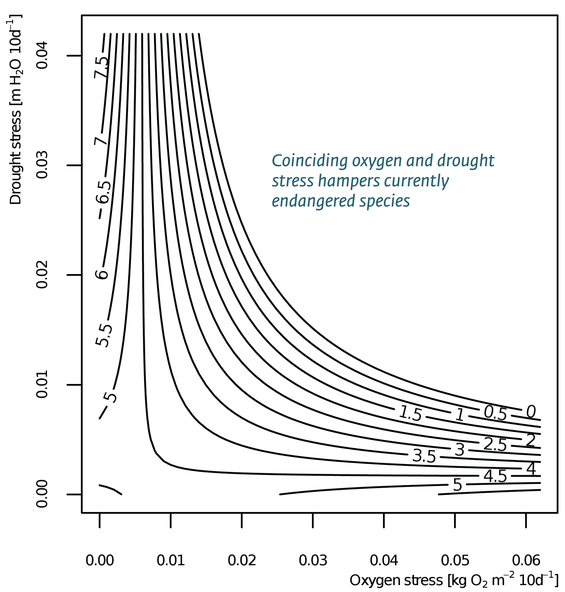


*Figure 2: 95% regression quantile contour plot showing the potential number of currently endangered species within vegetation plots of 4 m² as a function of oxygen and drought stress.*

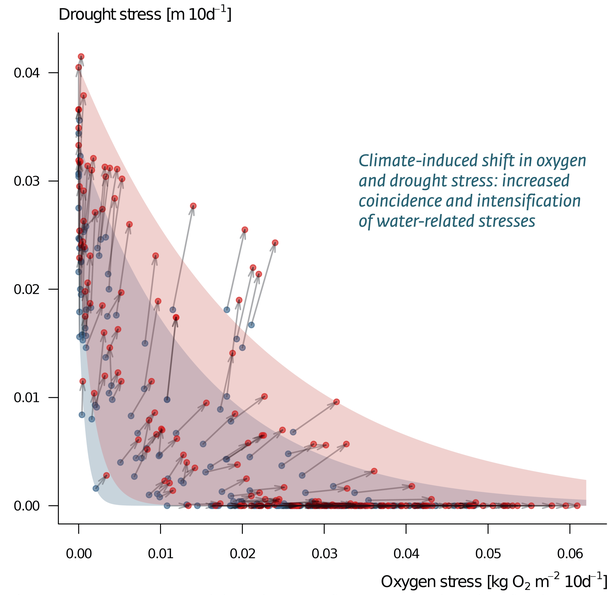


*Figure 3: Oxygen stress and drought stress for 185 vegetation plots for the current (blue) and future climate (red). Arrows indicate the direction of climate-induced shift for each plot. The polygons show the area enclosed by the 5 and 95% regression quantiles, thus encompassing 90% of the data points. Under the future climate, this area represents both an increased coincidence and intensification of oxygen and drought stress.*

References
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