SPATIO-TEMPORAL STRUCTURAL EQUATION MODEL

Ecology of wet heathlands

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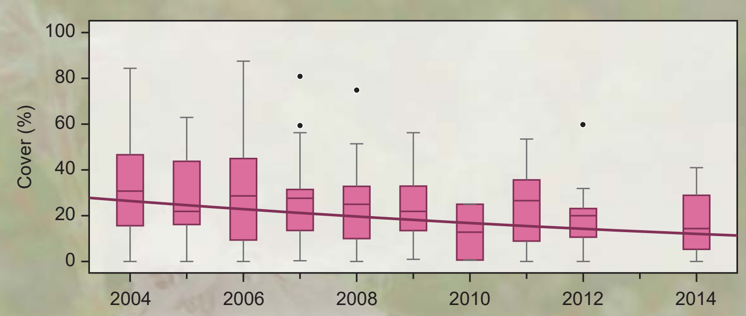
Erica tetralix is decreasing on Danish wet heathlands

- Characteristic species of wet heathlands
- What is the cause?
- What management actions may reverse the trend?

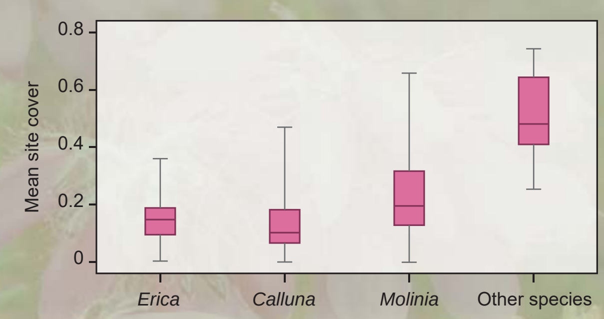


Wet heathland vegetation data

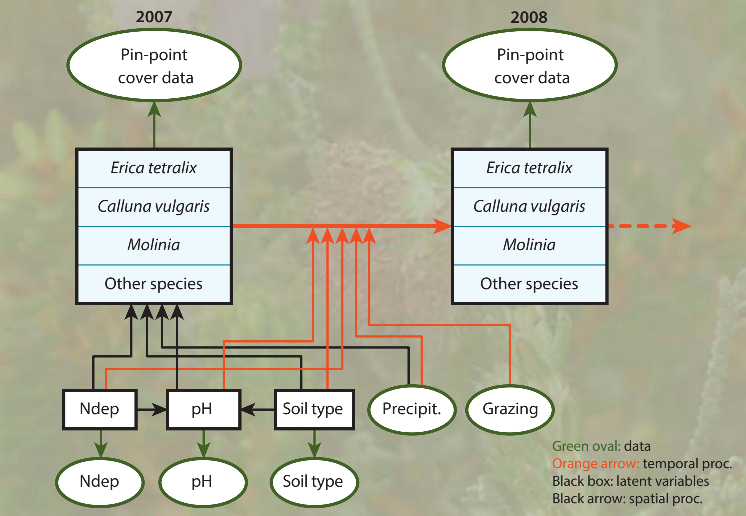
The cover of the three dominating species on wet heathlands, *Erica tetralix*, *Calluna vulgaris* and *Molinia caerulea*, as well as all other higher plant species was determined by the pin-point method.

Time series data (2007–2014) from 39 sites with a total of 1322 plots.

Pin-point cover data allows the aggregation of species.



Spatial and temporal model (SEM)



Joint distribution of cover data

The Dirichlet-multinomial distribution models pin-point cover data of n species – accounts for spatial aggregation.

y_i: pin-point hits of species i; $\sum_n y_i \geq$ # of grid points

p_i: relative cover of species i; $\sum_n p_i = 1$

$$Y \sim Mn\left(\textstyle\sum_n y_i, (p_1, \ldots, p_{n-1}, 1 - p_l - \cdots - p_{n-1})\right)$$

$$\Lambda(p_1, \ldots, p_{n-1}) \sim Dir\left(\frac{q_1 - q_1\delta}{\delta}, \ldots, \frac{q_{n-1} - q_{n-1}\delta}{\delta}, \frac{1-\delta}{\delta} - \frac{q_1 - q_1\delta}{\delta} - \cdots - \frac{q_{n-1} - q_{n-1}\delta}{\delta}\right)$$

$$E(p_1, \ldots, p_{n-1}) = (q_1, \ldots, q_{n-1})$$

δ: intra-plot correlation due to spatial aggregation.

Spatial process (2007)

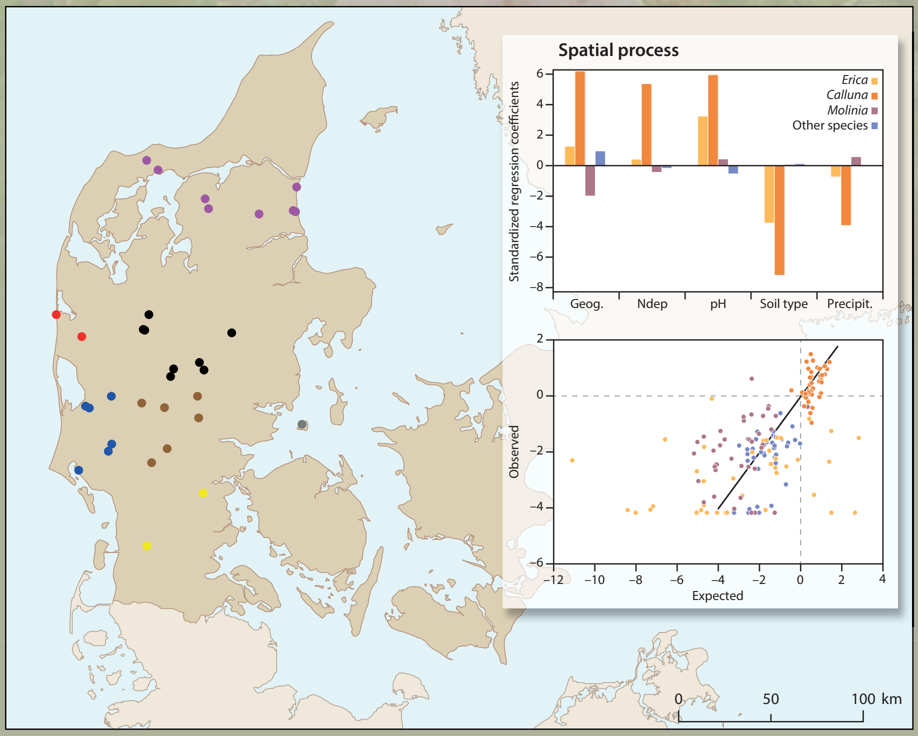
- Large uncertainty
- Regional geographic variation (50 km scale)
- South Jutland behave qualitatively different (yellow)
- Information may be used to generate new hypotheses

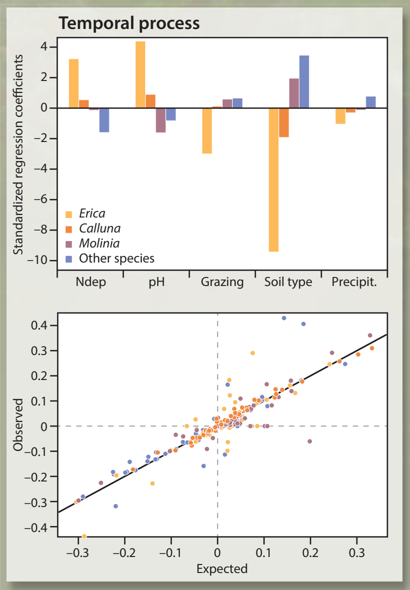
Temporal process (2007–2014)

Good fit!

Dwarf shrubs (*Erica* and *Calluna*) have same qualitative response, and opposite to *Molinia* and other plants.

Positive effects of nitrogen deposition, pH, sandy soils, and low precipitation on dwarf shrubs. Negative effect of grazing on *Erica*.





Application: local prediction

- Collect data from 20 to 40 plots
- Only temporal process is relevant (good model fit)
- Prediction of the effect of local management actions
- Set-up of an adaptive management plan

Conclusions

- Important to take local spatial aggregation of plant abundance into account
- Important to separate measurement errors from structural uncertainty when making predictions
- Ecological processes are best studied using time-series data