Competitive interactions of *Calluna vulgaris* and *Deschampsia flexuosa* in dry heathlands

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Evidence for competitive interactions in plant communities

How often has the competitive interactions in a plant community been measured in a realistic setting compared to the times competition has been postulated to be an important ecological mechanisms?

1/1000 is certainly too high

1/1000,000?

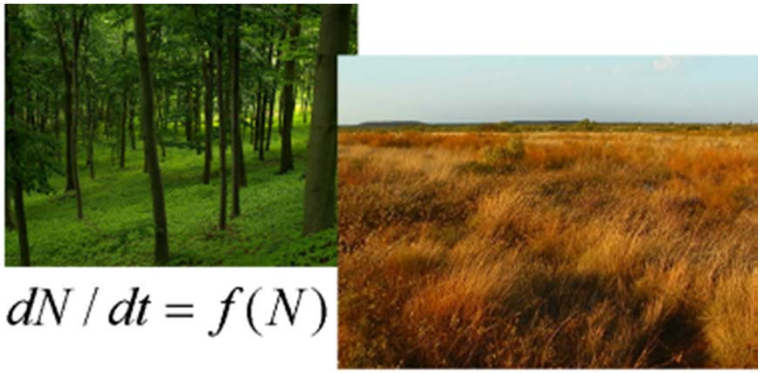
Measuring ecological success

$$dN/dt = f(N)$$

$$N = ?$$

Measuring ecological success

Natural plant communities are dominated by spatially structured perennial species with variable life histories



$dN/dt = f(N)$

$N = ?$

Often difficult to count individual plants and large size variation among individuals of the same species.

The ecological success may instead be assessed from cover (= relative area that the species cover) and vertical density (= 3D space occupancy, which is correlated to biomass, plant volume, or LAI)

The pin-point (point-intercept) method

Method for measuring:

- i) cover
- ii) vertical density

Place a frame with a grid pattern

A pin is inserted vertically through one of the grid points into the vegetation

The pin will typically touch a number of plants and the different species are recorded (to determine cover)

The number of times the pin hits the same species is also recorded (to determine vertical density)

This procedure is repeated for each grid point

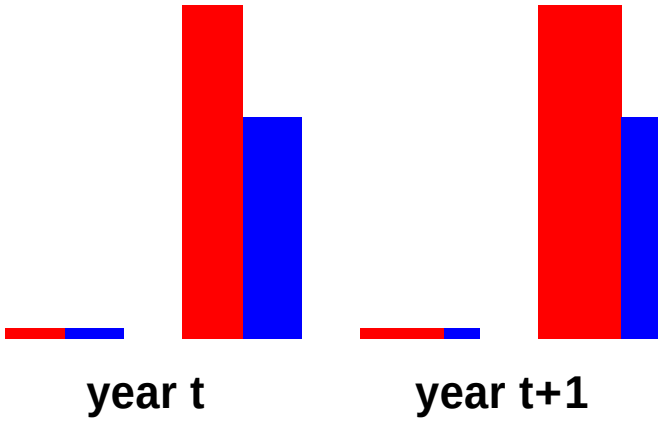
Plant cover and vertical density – assumptions

i) Plant cover and vertical density measure ecological success

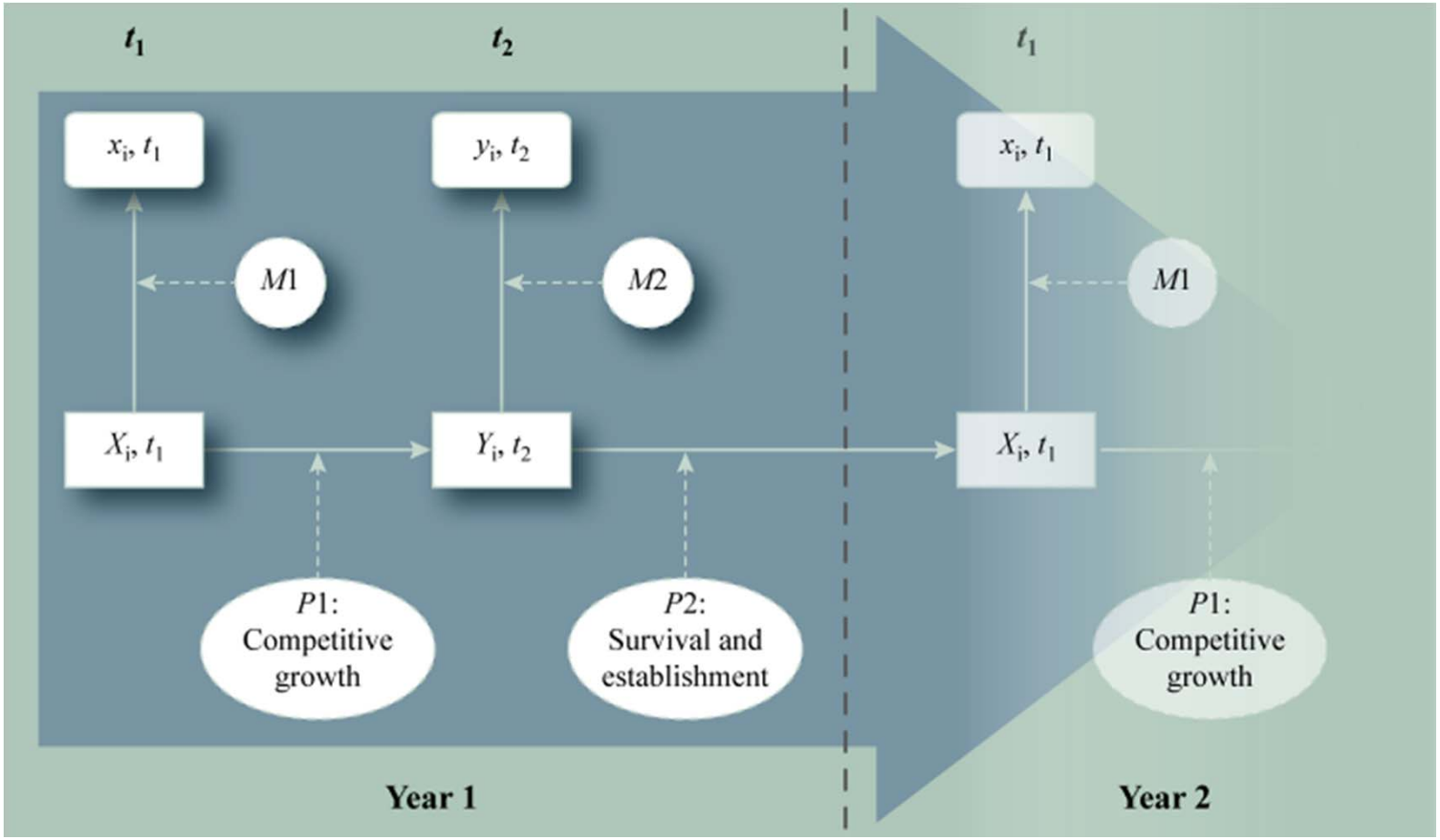
ii) Due to the growth form of most plant species, the vertical density will increase relatively faster than plant cover during the growing season

iii) Species with a high cover in spring will have relatively high vertical density at the end of the growing season, however, the vertical density is reduced by the cover of other species due to competition

iv) A plant species that grows to a relatively high vertical density has a relatively high cover the following year, i.e., plants allocate resources into occupying resource space the following year



Plant cover and vertical density – model



Plant cover and vertical density – model

Competitive growth (P1):

$$Y_{i,t2,y,r} = a_i \, X_{i,t1,y,r}{}^{b_i} \cdot \exp(-c_{ij} X_{j,t1,y,r}{}^{d_j}) \cdot \exp(-c_{ik} X_{k,t1,y,r}{}^{d_k}) + \varepsilon_{P1,i,y,r}$$

Survival and establishment (P2):

$$\text{logit}(X_{i,t1,y+1,r}) = \text{logit}(a_i \, Y_{i,t2,y,r}{}^{b_i} \cdot \exp(-c_{ij} Y_{j,t2,y,r}{}^{d_j}) \cdot \exp(-c_{ik} Y_{k,t2,y,r}{}^{d_k})) + \varepsilon_{P2,i,y,r}$$

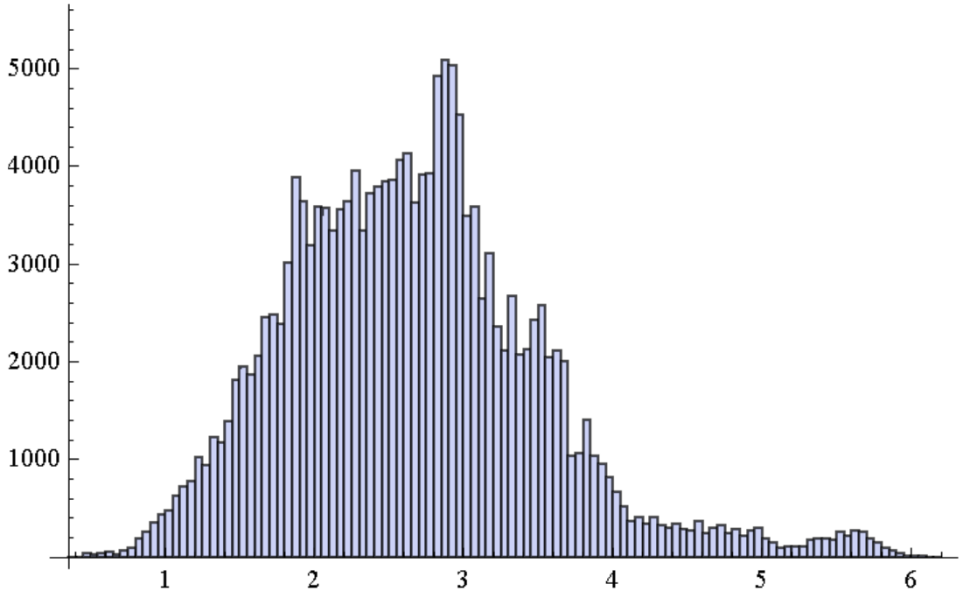

Case study: dry heathlands
Ambient treatments in the CLIMAITE experiment
Calluna vulgaris and *Deschampsia flexuosa* are the dominating species and are expected to compete for resources


Pin-point data from fixed positions has been collected in two consecutive years and fitted to the state-space competition model

Significant competitive interactions between *C. vulgaris* and *D. flexuosa*

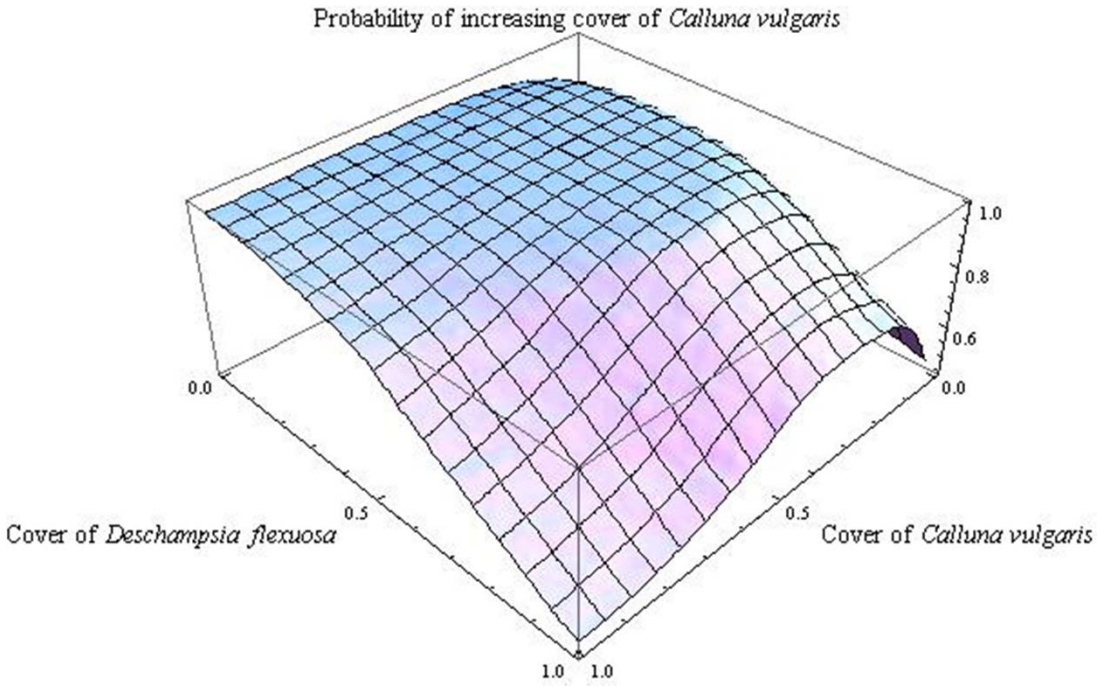
Bayesian posterior distribution of the parameter that measures the competitive effect of *C. vulgaris* on *D. flexuosa* within growing seasons

MCMC – 100.000 iterations



Predicted change in plant cover

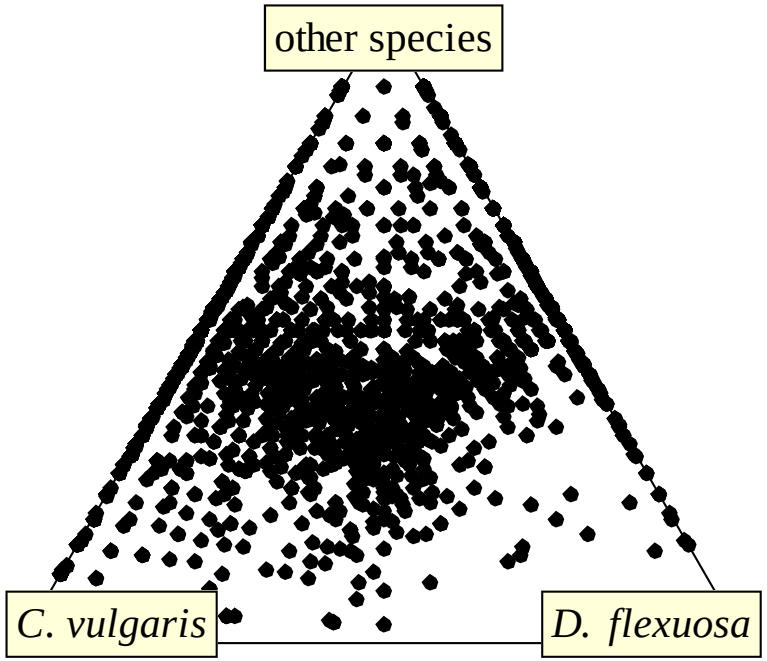
Assuming that the measured competitive interactions were unaltered *C. vulgaris* was predicted to outcompete *D. flexuosa*

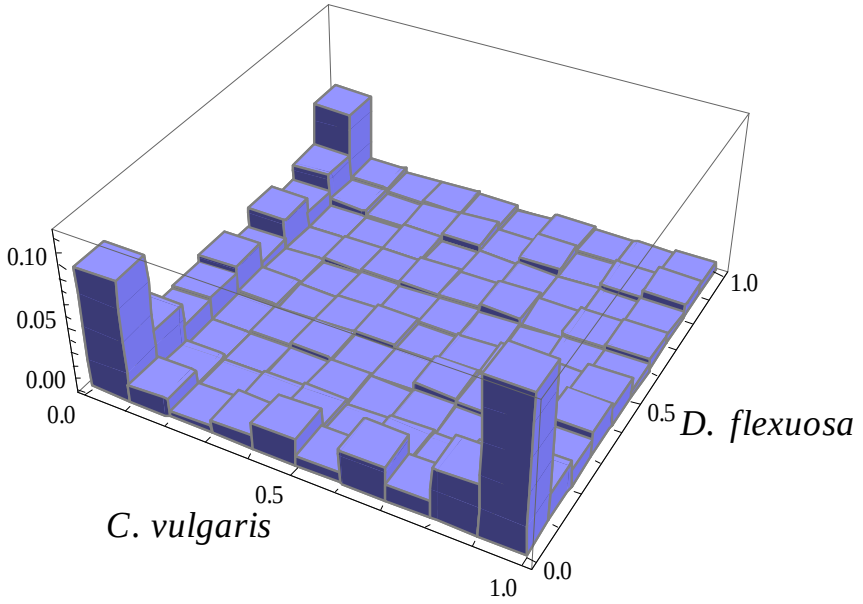


However, individuals of *C. vulgaris* becomes senescent after about 30 years

What is the distribution of *C. vulgaris* and *D. flexuosa* in 5000 Danish dry heathland plots?

Pin-point cover data (16 pins 10 cm apart)

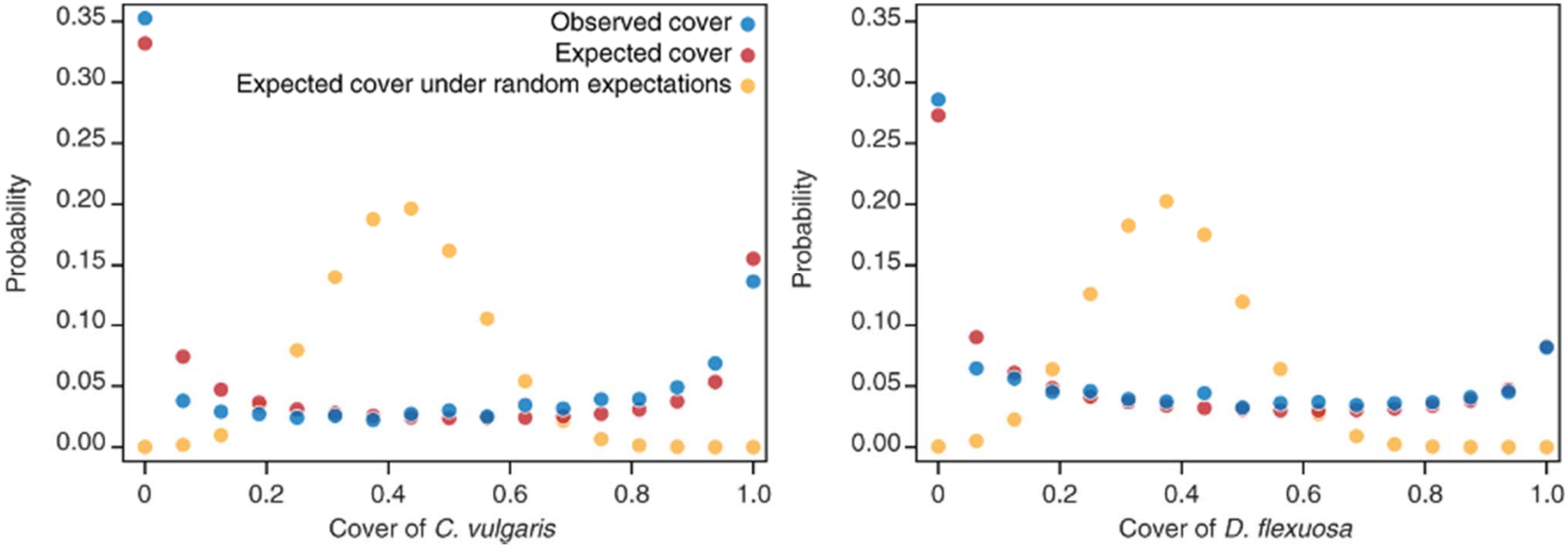




What is the distribution of *C. vulgaris* and *D. flexuosa* in 5000 Danish dry heathland plots?

Both species have highly significant intra-plot correlation compared to random expectations, this may be due to either

- **large individuals or/and**
- **spatial aggregation of individual plants**



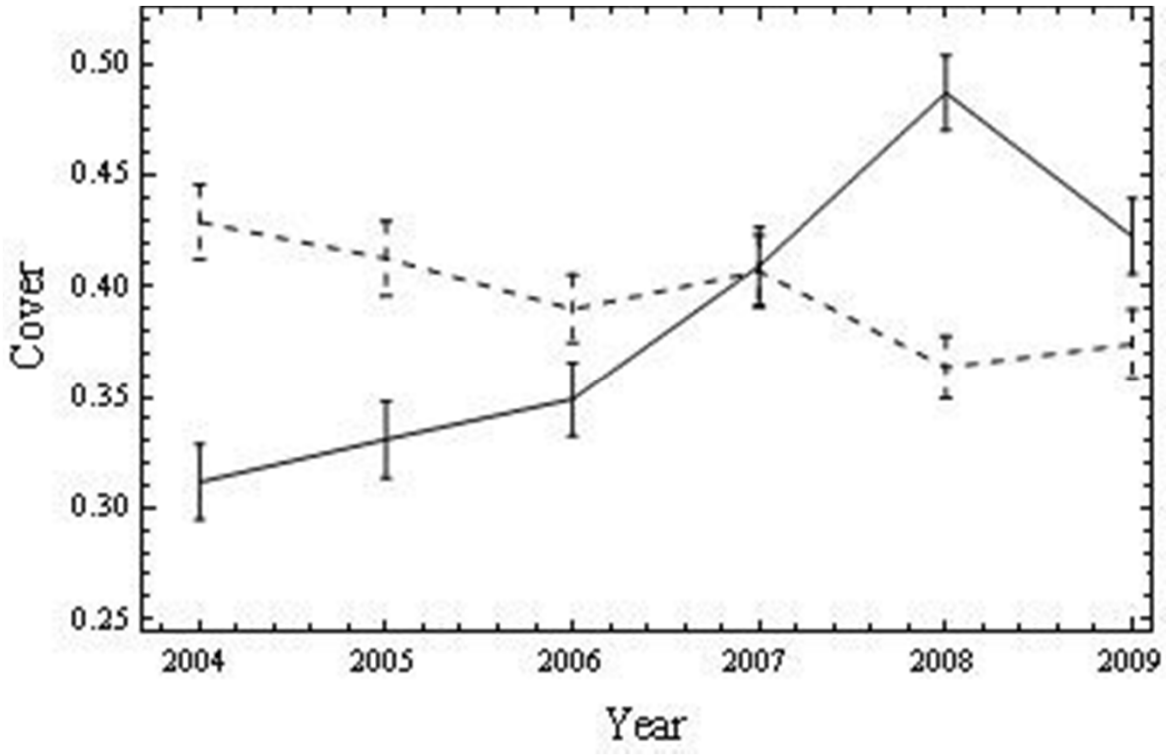
What is the distribution of *C. vulgaris* and *D. flexuosa* in 5000 Danish dry heathland plots?

Presence-absence data in 5 m circles:

No significant deviation from random expectations (P = 0.74)

		D. flexuosa		
		absent	present	total
C. vulgaris	absent	25	291	316
	present	393	4257	4650
	total	418	4548	4966

Trends in plant cover at 20 Danish sites



Solid line: *C. vulgaris* (P = 0.06)

Dashed line: *D. flexuosa* (P = 0.77)

Cyclical succession of *C. vulgaris* and *D. flexuosa*

Combining the results of

i) significant competitive interactions

ii) local patchiness

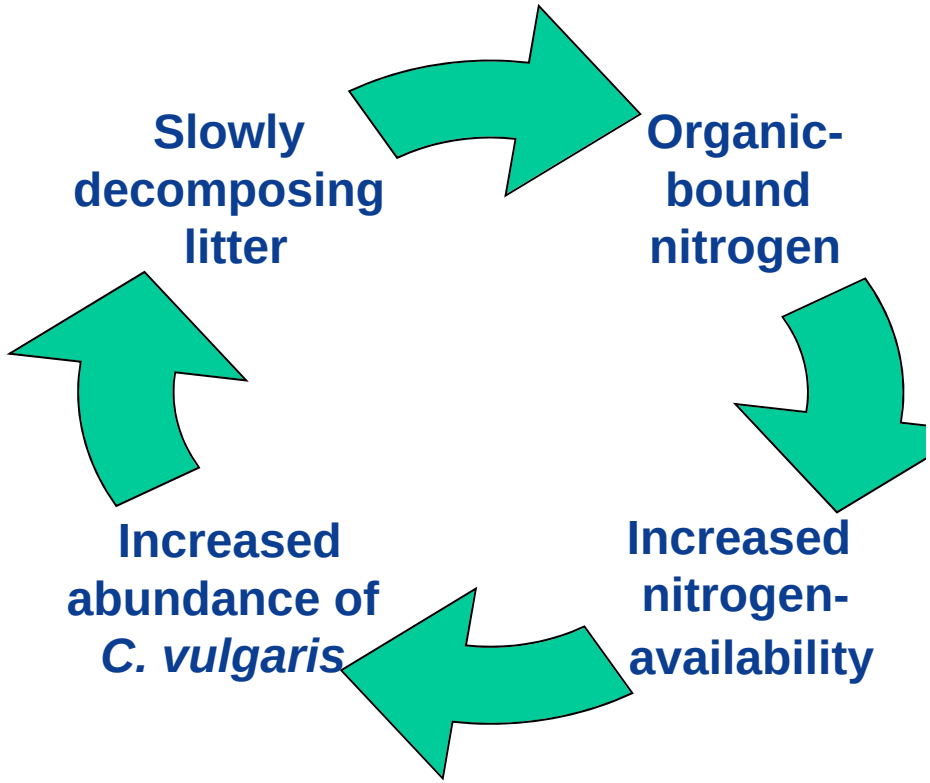
it is suggested that *C. vulgaris* and *D. flexuosa* has an unstable equilibrium of "coexistence" on dry heathlands, where *C. vulgaris* locally outcompetes *D. flexuosa* but that the system is regularly perturbed towards the presence of *D. flexuosa* due to the senescence of *C. vulgaris* and effects of the heather beetle

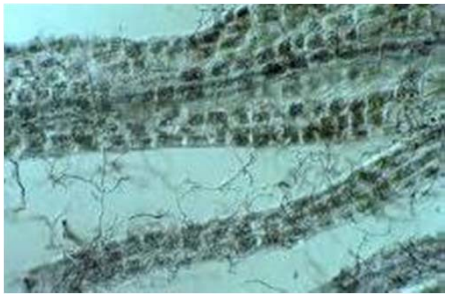
Alternative hypothesis – soil feed back process

A possible mechanism for the observed patchiness is a positive nitrogen-availability feedback cycle in the soil (Aerts 1999)**, where *C. vulgaris* monopolizes nitrogen by**

i) producing slowly decomposing litter, and

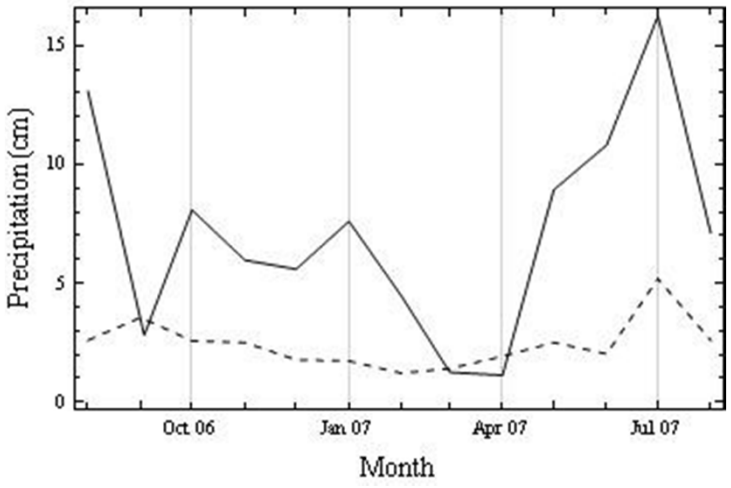
ii) forming associations with ericoid mycorrhiza that utilise the organically bound nitrogen



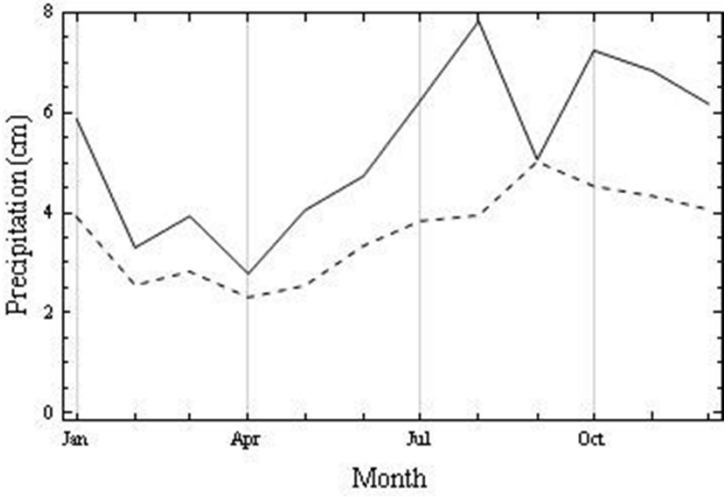


Is the observed increase in *Calluna* due to increased precipitation?

Experimental site



All heathland sites



Competitive interactions between *C. vulgaris* and *D. flexuosa* - summary

***C. vulgaris* and *D. flexuosa* compete in dry heathlands!**

In most 5 m circles (86 %) both *C. vulgaris* and *D. flexuosa* are present

- **indicate that the dynamics of the expected competitive interactions are slow**

Since both species are locally present we expect that *dry heathlands respond to altered competitive interactions on a large spatial scale relatively quickly*

For example, if the competitive exclusion of *C. vulgaris* becomes more likely, as a consequence of a climatic change or increased nitrogen deposition, then *D. flexuosa* quickly may become the sole dominating species on dry heathlands

Competitive interactions between *C. vulgaris* and *D. flexuosa* – in the future?

The competitive interactions between *C. vulgaris* and *D. flexuosa* under a climate change scenario is currently being investigated

Manipulations: Temperature, drought, CO_2 (www.climaite.dk)