Prescribed burning of northern heathlands: *Calluna Vulgaris* and germination cues

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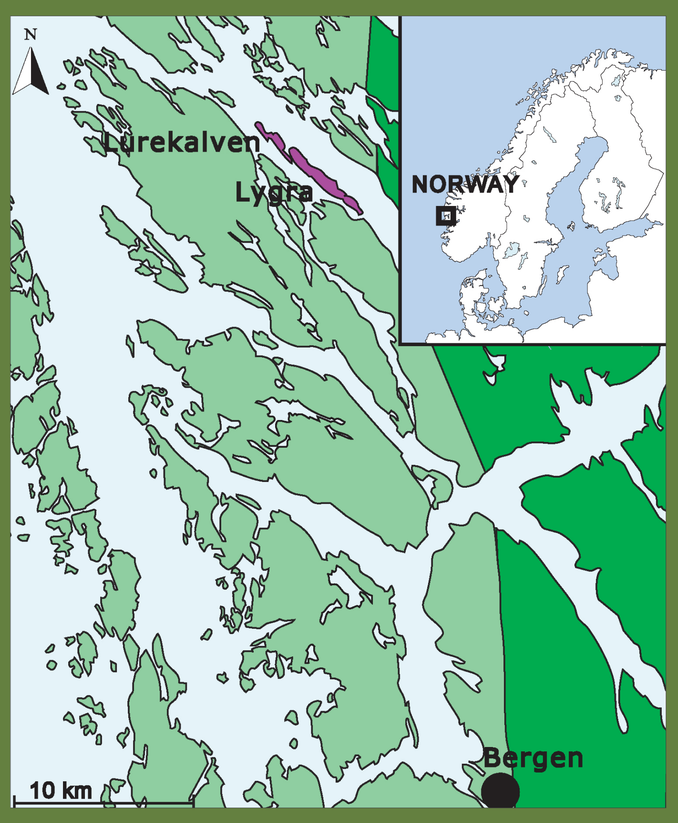
Background

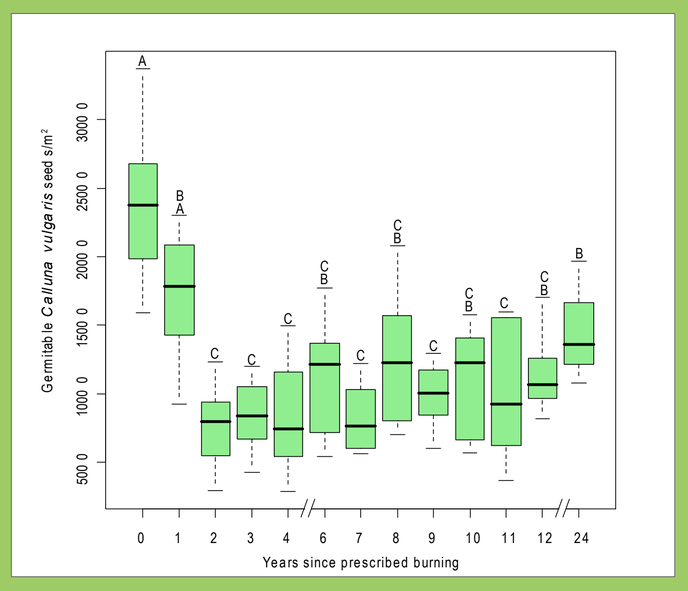
Fire is a disturbance influencing plant communities in many parts of the world. However, fire differs from many other disturbances in the way that it "consumes" complex organic molecules and it has been argued that fire is more analogous to herbivory than to other abiotic disturbances.

Anthropogenic use of fire, often in conjunction with grazing, is contributing to the creation and maintenance of semi-natural ecosystems on marginal lands world-wide. In natural systems the effects of fire on germination responses are often explained by adaptation to fire over extended periods of time (for example as a smoke response; butenolide, a derivate from the combustion of cellulose).

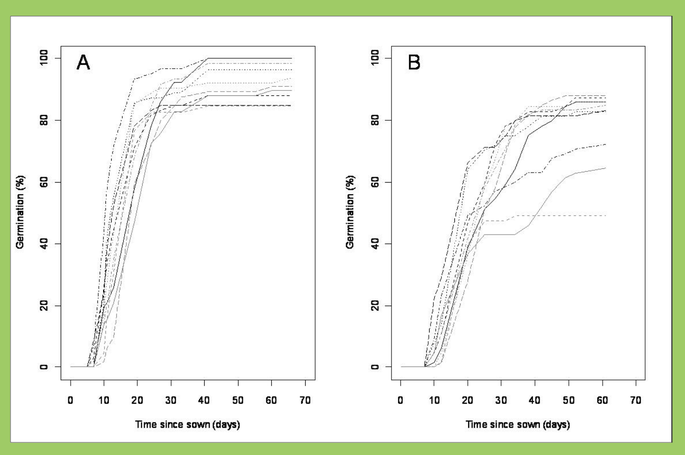
The European coastal heathlands are important habitats for international conservation. Today, these low-intensity farming systems are threatened by the cessation of traditional management regimes managed by grazing and prescribed burning, with a fire history reaching back 1000-6000 years in time.

We investigated if and how the keystone species *Calluna vulgaris* in this anthropogenic "fire-prone" coastal heathland system responds to prescribed burning.



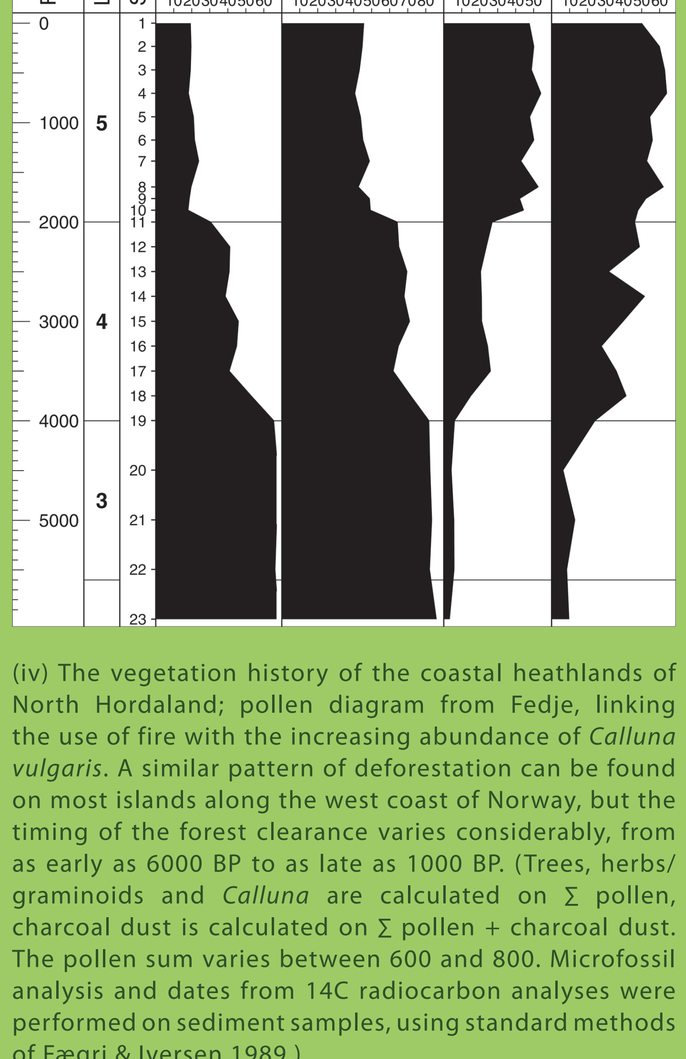


(i) *Calluna* germinating from the seed bank over a post-fire succession (0-24 years since last fire) showed a pronounced peak right after fire. Equal letters indicate years not significantly different (0.05 level; Turkey HSD multiple comparisons test). After the two first years, densities of *Calluna* seeds increased linearly with time; y = 455.5 x + 7123.3 ($F_{1,108} = 17.64$, $p < 0.0001$), over the remaining course of the succession.



(ii) Freshly collected *Calluna* seeds and the response to aqueous smoke solution (1:1000 dilution) of 10 ind. in two treatments; aqueous plant derived smoke solution (A) and distilled water control (B). Seeds in (A) germinated faster and to a higher final germination percentage than in (B). Final germination values pr ind; 74–94% (smoke trt) and 40–85% (controls). Mean time to germination; 14–23 days (smoke trt) and 20–28 days (controls). An ecosphysiological response to smoke presents a potential explanation.

(iii) *Calluna* seed densities in seed bank experiments of mature heath and newly burnt heath with four treatments: control, ash, smoke, and ash and smoke combined. Smoke and ash treatments increased seedling emergence from seed banks of mature heath (20%), whereas there was no effect on the emergence from the newly-burnt seed banks. We managed to recreate the germination pattern of (i) experimentally by using an aqueous plant-derived smoke solution.



(iv) The vegetation history of the coastal heathlands of North Hordaland; pollen diagram from Fedje, linking the use of fire with the increasing abundance of *Calluna vulgaris*. A similar pattern of deforestation can be found on most islands along the west coast of Norway, but the timing of the forest clearance varies considerably, from as early as 6000 BP to as late as 1000 BP. (Trees, herbs/graminoids and *Calluna* are calculated on ∑ pollen, charcoal dust is calculated on ∑ pollen + charcoal dust. The pollen sum varies between 600 and 800. Microfossil analysis and dates from 14C radiocarbon analyses were performed on sediment samples, using standard methods of Fægri & Iversen 1989.)

Implications for conservation

- The large soil stored seed banks of the heathland ecosystem bridge the temporal gap between seed production and seed germination. The widespread occurrence of smoke-induced germination in a variety of phylogenetically distant families supports the hypothesis that smoke-induced germination is the result of convergent evolution.
- Species comprising this semi-natural heathland habitat have probably not evolved in this system, but have greatly increased in distribution and abundance due to the management practices of grazing and burning. The palaeoecological data shows this to be the case for *Calluna*; we document the historic use of fire in the region.
- We demonstrate that the observed peak in germination of *Calluna* from soil-stored seeds directly following prescribed burning of mature heath can be attributed to the fire-related germination cues. The heathland keystone species *Calluna vulgaris* is adapted to take advantage of the post-fire environment.
- Management by heather burning is important in order to conserve the heathlands of northern Europe.

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