Interactive effects of climate and disturbance

on seedling performance in grasslands of Southern Norway

SeedClim
NFR NORKLIMA 2008-2012

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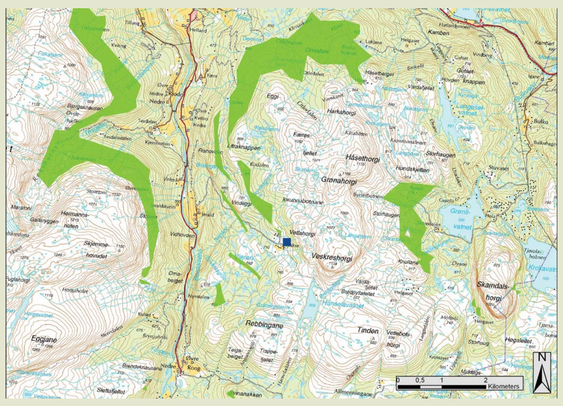
Regeneration from seed is a key event in the life-history of a plant; affecting its ability to disperse, to evolve, and to persist under unfavourable conditions. Consequently, impacts of climate change on the probability of successful recruitment from seed are likely to affect the fate of local populations and communities.

This study is part of a project that integrates observational and experimental approaches across broad-scale climate gradients in Norway, to explore how climate and climate change affect the role of seed recruitment across four levels of organisation - from direct physiological effects via demographic responses to population and community dynamics.



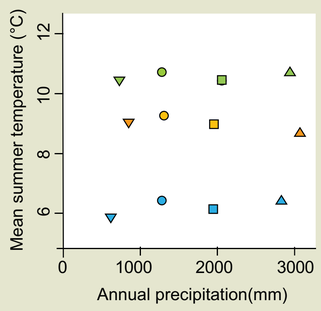
Experiments along natural gradients

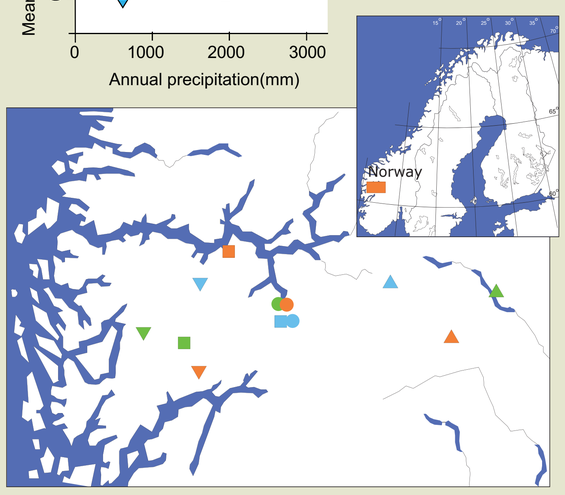
The climate in Norway is predicted to be wetter and warmer (IPPC 2007).

In the fjord landscape, precipitation increases from continental inner fjord to oceanic west coast, and temperature increases from high to low elevations.

We established 12 experimental sites on a climate grid where four levels of annual precipitation (600, 1200, 2000 and 2700 mm) were combined with three levels of mean summer temperatures (7.5, 9.5, and 11.5°C) (keeping all other variables as constant as possible). Within the climate grid, effects of precipitation and temperature can be explored independently.

Data on temperature, precipitation, and bedrock (green colour) overlain onto a topographical map were used to select sites for our grid.





Seedling emergence in intact and disturbed (experimental gaps) vegetation were recorded in the climate grid in August 2009, within 25x25cm subplots. Survival and establishment of the cohort of forb seedlings was monitored over two years (2010-2011).

Plant traits were estimated from field measurements, the LEDA database and the literature. Seed mass was used as a proxy for dispersal and germination ability, and Surface Leaf Area (SLA) as a proxy for relative growth rate.

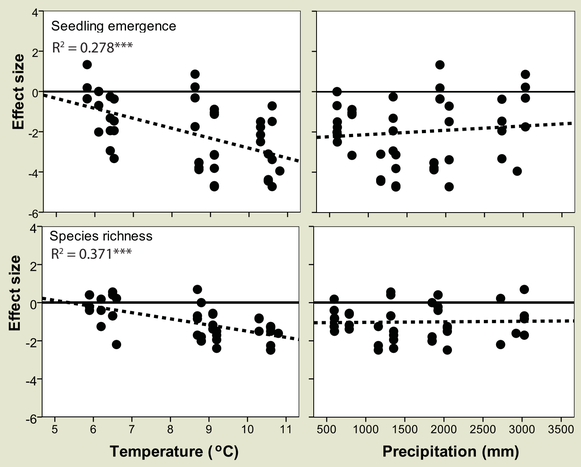
Photos: A. Berge, K. Klanderud, J.L. Guittar, M. Ramírez Boixaderas

Question1.
How do temperature, precipitation and disturbance interact to affect seedling recruitment ?

In undisturbed vegetation, seedling recruitment and establishment do not change along either the temperature or precipitation gradient. Disturbance, however, increases seedling recruitment, species richness of recruits and overall establishment, and has much larger effects in warmer sites.

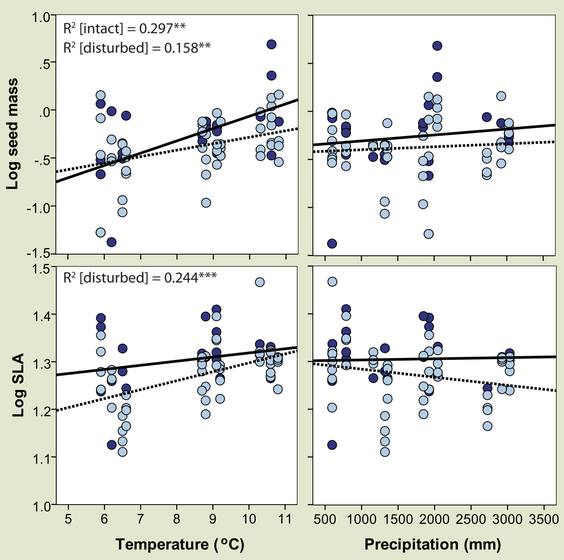
Establishment occurs earlier at the warmest sites (100% within the first year). At the colder sites, seedlings reach adult phase within the second year, and disturbance delays establishment by over a year.

Survival is mostly affected by temperature and its interaction with disturbance; greater survival being observed in warmer disturbed sites.



Effect size of disturbance [ln(intact/disturbed)]: positive values indicate facilitation, negative values indicate competition. Solid line is the zero reference line (no effect), and dotted line is a linear regression of the data.

Question 2.
Can plant-functional traits predict recruitment responses to climate and disturbance?



Seed mass: The mean seed mass of the recruit community increases along the temperature gradient and this trend is stronger in the intact vegetation. Disturbance facilitates the emergence of smaller seeded species at the warmest sites, suggesting competitive interactions. In our study, establishment probability is also greater for small-seeded species.

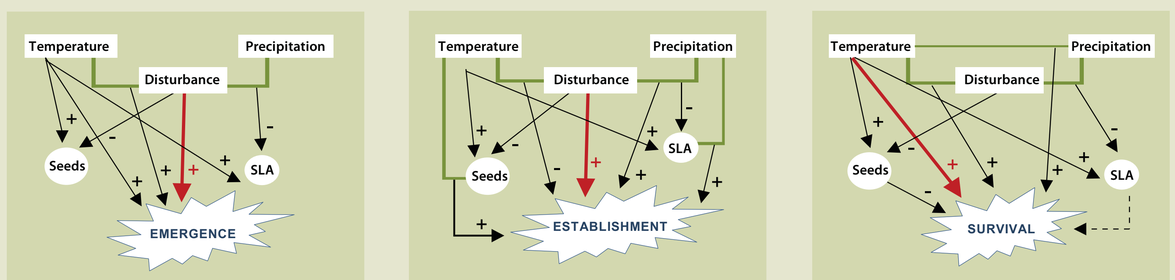
Surface Leaf Area: Disturbance facilitates the emergence of species with smaller SLA at the colder sites. The interactions of SLA with climate influence seedling survival and establishment. Species with faster plant growth strategy (larger SLA) are more likely to survive and establish in warmer sites.

Community-weighted traits of the emerging seedlings in intact (dark blue dots, solid lines) versus disturbed vegetation (light blue dots, dotted lines).

Conclusion: Seedling establishment responds primarily to small-scale disturbance and survival to large-scale variations in temperature.

Species are not all equally affected by disturbance and climate; the temperature-dependent effect of disturbance on recruitment depends on species dispersal and growth strategies.

Processes structuring the seedling community shift along the temperature gradient: from stress-tolerance to competition



Schematic representation of significant interactions (GLMM; p>0.05). Red arrow indicates best model (AIC<2), dotted arrow indicates indirect effect.

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