Master project

TransPlant: Linking plant and microbial climate change responses to ecosystem function and adaptability

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TransPlant will integrate gradient and experimental approaches in a comparative study of climate change effects across organism groups. This study will have three unique features: (1) our observational and experimental studies will compare climate responses of plant and microbial populations and communities (2) we will investigate consequences in terms of functional responses and biogeochemical cycles such as carbon and nitrogen fluxes, allowing us to evaluate how population-level plant and microbial effects scale up to ecosystems, and (3) we use the strong climate gradients in western Norway to integrate gradients and experimental approaches along regional-scale climatic gradients. The results will be of interest for microbiologists, plant ecologists and climate scientists, and they will have implications for ecological theory, nature conservation and for down-scaling meteorological data and forecasting.

Climate has an overriding effect on species diversity on a global scale, and for most life forms, biodiversity decreases with increased latitudes. Microbial communities of high latitude ecosystems are expected to experience rapid changes over time due to climate warming and increased deposition of nutrients. Microorganisms carry out key processes in soil development and underpin the major biogeochemical cycles. Therefore they are important for ecosystem functioning and stability (Torsvik et al 2002). Considering the critical role microorganisms play in climate-related ecosystem processes, including both N- and C-turnover, it is surprising how little is known about their composition and distribution. Soils harbor some of the most complex microbial communities on Earth, and total cell counts using epifluorescence microscopy and fluorescent dyes range from 10^8 to 10^{10} cells per gram, indicating high biomass. Not all organisms are expected to be equally well adapted to a changing environment, and we will first gain an overview of the major groups of soil microorganisms in the study area and then link their distribution and abundance to the climate grid as well as to soil physical and chemical parameters. Microorganism responses to changes in temperature and precipitation and other physical and chemical parameters will determine their response to climate change.

Alpine ecosystems are predicted to be particularly vulnerable to climate change. The western Norwegian fjord landscapes provide a unique possibility to set up a grid of study sites along two major climate gradients, temperature and precipitation, enabling studies of the unique and combined effects of the two climatic factors. In an ongoing project, we have set up 12 experimental sites in a climate grid where four levels of annual precipitation (600, 1200, 2000 and 2700 millimetres) are combined with three levels of mean summer temperatures (7.5, 9.5, and 11.5°C) while keeping all other variables as constant as possible (Figure 1).

In this climatic grid, we transplant intact ecosystems of plants and soils, as well as focal plant populations, from cold and/or dry conditions towards warmer and/or wetter conditions, paralleling the projections for future climate change (IPPC 2007). We also measure relevant climatic variables. TransPlant will explore microbial community responses and nutrient cycling processes and link the understanding of changes in population and community dynamics with climate with changes in microbial communities and ecosystem function.

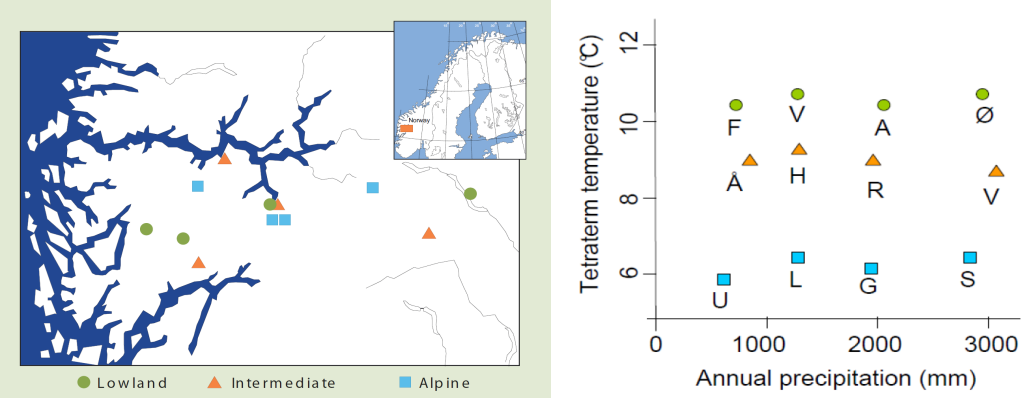

Figure 1. *Location of TransPlant sites in Norway. (left) and the climatic grid (right). Climate data refer to the 1960 – 1990 normal period provided by met.no. Capital letters refer to site names.*

Research program:

Microbial community composition (leader Lise Øvreås)

We will assess the microbial community composition along the climate gradients to provide a comprehensive picture of microbial community structure under the different geographic and physical settings. The microbial community structure will be analysed across the climate grid using high throughput sequencing technology for deep sequencing of microbial small subunit ribosomal RNA sequence tags. PCR products will be obtained from DNA and from reversely transcribed 16S rRNA. PCR products (from the V3 or V6 hyper variable regions of rRNA) will be pooled prior to sequencing and individual sequences from the different samples will be subsequently binned based on artificial, sample-specific bar code sequences. A limited number of samples will be prioritized for a novel metatranscriptomic technology that will be used to obtain an in-depth quantitative profile of the microbial community composition. This approach provides a holistic community profile of all three domains of life (bacteria, archaea and eukaryotes [e.g. fungi, protozoans, collembola, nematodes]) in the soil.

Microbial function (leader VigdisTorsvik)

We will study the microbial process and microbial community composition in all the transplant experiments to provide a mechanistic understanding of the changes observed at the population and community levels and to dissect the dominant groups involved in nitrogen cycling. Functional information in the form of expressed messenger RNAs will also be obtained. Several 1000 mRNA tags will provide an initial picture of the activity state of the communities and can be related to process measurements and geochemical analyses. Based on results obtained from these descriptive analyses in all of the transplant experiments some key features will be studied in more detail. Important functional groups are those with key functions in the nitrogen cycle. Ammonia oxidizers play a key role in nitrification, a rate limiting step in the nitrogen cycle. To get information about this soil function, primers to target specific the α-subunit of ammonia monooxygenase gene (amoA) will be used as biomarker for both ammonia oxidizing bacteria and archaea in the microtransplant and litter transplant experiments. The N dynamics of soil and soil microbial biomass will be examined in soil samples from the microtransplants. Soil CO2 emission and soil respiration rate will be measured in extant and transplanted plots in all sites. Soil nitrogen mineralization and nitrification will be determined by culturing in situ. The measurements will be used to estimate potential effects of climate change on biogeochemical cycles.