

Proposal 8*Submitted by:*Thomas Bjørneboe G. Berg tbb@dmu.dk

Frederiksborgvej 399, DMU - Arktisk Miljø, 4000 Roskilde

Ecosystem processes across climatic gradients

Recommendations by the Commission for Scientific Research in Greenland stress the need for research on biodiversity, population dynamics, trophic interactions and ecosystem functioning (carbon and nutrient cycling) along climatic gradients in both terrestrial, freshwater and marine ecosystems [1, 2]

In the Northern Hemisphere, the North Atlantic Oscillation (NAO) is the most prominent and recurrent pattern of large-scale atmospheric circulation variability, and it has a strong impact on the local winter conditions in the Arctic [3]. Uniquely for the Northern Hemisphere, the NAO is pivotal for dividing Greenland into different local winter weather regimes displaying distinct dichotomous dynamics [4, 5]. In particular, high NAO years are associated with warm and snow winters in East Greenland but cold and dry winters in West Greenland. Also associated with NAO is a meridional gradient in winter climate [4].

The wide range of climatic regimes available in Greenland offers a unique possibility for studying ecological processes across regional climatic gradients. To obtain knowledge of such processes is crucial for predicting ecological effects of global change. Considering the complexity of an ecosystem with its inter-trophic dynamics, large-scale manipulation is a true bottleneck in our options for analysing the cascading effects of temperature and precipitation across trophic levels. Effects of increased temperature on plant phenology are well documented by for instance the International Tundra Experiment (ITEX) [6] but effects on higher trophic levels (as indirect effects) are still poorly understood. In aquatic systems in polar regions global warming is expected to affect the rate of ice-melting and thereby light availability. On a regional scale the annual mean temperature decreases linearly from Ammassalik towards Station Nord, while the ice-free period and the annual precipitation decrease exponentially along the same gradient.

The use of large-scale gradients enables us to develop tools for building scenarios reflecting the ecosystem response to predicted climate change scenarios developed by the Hadley Centre forecasting a temperature increase of 2-10°C in Greenland (most pronounced in the High Arctic region). This will move the High Arctic biome out into the Arctic Ocean and change the present High Arctic into a middle or even sub-Arctic climate with dramatic consequences for biodiversity and trophic interactions due to immigration of new species. Along with this temperature rise, precipitation will change dramatically, affecting breeding phenology for high arctic waders and survival of herbivores and moulting geese populations and hence also the predators. One third of the world's carbon pool is bound in the Arctic soils [7, 8]. Carbon flux is strongly linked with temperature and plant species composition and is thus an important parameter for describing the rate of change in the soil-vegetation interaction.

Terrestrial part

Main focuses along the gradients will be on biodiversity, population density, genetic diversity within populations, plant phenology, spatial habitat

use by animals, CO₂ flux of selected vegetation types, climatic variables and NDVI and snow analyses of satellite images. We propose a two-legged concerted project to be carried out simultaneously along two different gradient regimes: a coast-- inland regime that represents a latitudinally fixed (equal day length) gradient of temperature (increasing towards the inland) and precipitation (decreasing towards the inland), and a north – south gradient with increasing temperature and precipitation. Both legs should be represented on both the East coast and the West coast. This leads to two coast-inland transects, each with four sites: Sisimiut – Kangerlussuaq on the West coast and Daneborg – Krumme Langsø on the East coast. The North – South gradient on the East coast goes from sites at: Brønlundhus – Zackenberg – Coloradodal – Sermilik, while on the West coast from sites at: Hall Land – Kangerlussuaq – Ivitut. All sites are chosen according to scientific background data and accessibility. Zackenberg and Kangerlussuaq will be the two main sites. The long-term monitoring programmes at Zackenberg and Daneborg have documented the linkage between local climate and biological variables at a local scale in the terrestrial [9-11] and in the marine environment [12-15]. For historic climate records, dendrochronological analyses of tree-like species and sediment cores from lakes provide important time series on climatic conditions, plant and insect composition, and physical–chemical parameters of climatic relevance [16-22], which should be linked to both the coast – inland and north-south gradients.

Aquatic part

The marine component of the proposed programme will build on existing methods used within the CAMP programme [23] and will follow and describe the carbon and nutrient budget in the water column and sediment cores at multiple sites along the north-south gradient documenting the responses of production, consumption, and degradation in Arctic coastal marine ecosystems to future changes in temperature and sea ice-cover. The aim is to study the regulation of primary production and the effects of alterations in primary production on secondary production and bacterial recycling of nutrients.

The freshwater component aims to investigate ten lakes at each site visited along the north-south gradient and coast-inland described in the terrestrial part and builds on cross-system analysis of the variation in biological structure and dynamics of lakes related to variations and changes in climate in order to elucidate how variation and changes in climate influence physico-chemical variables, biological communities, trophic interactions and biodiversity [22,24]. In addition, stable isotopes ($\delta^{13}\text{C}$ and $\delta^{15}\text{N}$) will be used to elucidate changes in food-web interactions [25, 26] in the lakes and analyses of biological remains in the sediment will be applied to evaluate changes in biological communities and physico-chemical variables in the past [19-21, 27].

References

- [1] KVUG 2003. Forskningsstrategi for Nationalparken i Nord- og Østgrønland. Kommissionen for Videnskabelige Undersøgelser i Grønland. 21pp. [2] KVUG 2003. Strategi for dansk-grønlandsk polarforskning 2003-2007. Kommissionen for Videnskabelige Undersøgelser i Grønland. 30pp. [3] Hurrell JW et al. (eds) 2003. North Atlantic Oscillation – Climatic

Significance and environmental impact. Geophysical Monograph no. 134. 279 pp. [4] Forchhammer MC et al. 2002 *Population ecology* 44 (2): 113-120 [5] Post E, and Forchhammer MC 2002 *NATURE* 420 (6912): 168-171 [6] Henry G (ed.) 1997. *Global Change Biology*, Special volume [7] Nordstroem C et al. 2001 *Theoretical and applied climatology* 70 (1-4): 149-166 [8] Parkin TB and Kaspar TC 2003 *Soil science society of america journal* 67 (6): 1763-1772 [9] Forchhammer MC, 2001. *Terrestrial Ecological Responses to Climate Change in the Northern Hemisphere*. In: Jørgensen AMK et al. (eds.) *Climate Change Research – Danish Research*. Danish Climate Centre. DMI, Ministry of Transport. 408 pp. [10] Meltofte H. (red.) 2002. *Sne, is og 35 graders kulde. Hvad er effekterne af klimaændringer i Nordøstgrønland?* DMU-Tema rapport no. 41. 88pp. [11] Caning K and Rasch M (eds.) (2003). *Zackenbergs Ecological Research Operations, 8th Annual Report, 2002*. Copenhagen, Danish Polar Center, Ministry of Science, Technology and Innovation. [12] Glud RN et al. 2000. *Marine Ecology Progress Series* 206: 59-71. [13] Glud RN et al., 2002. *Marine Ecology Progress Series* 238: 15-29. [14] Rysgaard S et al. 2001. *Marine Ecology Progress Series* 223: 15-26. [15] Sejr MK et al. 2002. *Marine Ecology Progress Series* 244: 163-169. [16] Fredskild B, 1973 *Meddr. Grønland* 198(4): 245 pp. [17] Fredskild B et al. 1975. *Meddr Grønland* 198(5): 44 pp. [18] Böcher J, 1988. *Meddr. Grønland, Biosci.* 26: 100 pp. [19] Røen U, 1988. *Ver. Int. Verein. Limnol.* 32: 845-847. [20] Bennike O 1999. *Polar Record.* 35: 232-336. [21] Bennike O et al. 2003 *Aquainver* (in press). [22] Jeppesen E et al. 2001. *Trends. Ecol. Evol.* 16: 191-198. [23] CAMP see <http://www.dmu.dk/lakeandestaurineecology/camp> [24] Jeppesen, E. et al. 2003. *Ecosystems* 6: 313-325. [25] Vander Zanden M.J. and Vadebonceur, Y., 2002. *Ecology* 83: 2151-2161. [26] Jeppesen, E. et al. 2003. *Limnol. Oceanogr.* 48: 1346-1349. [27] Jeppesen, E. et al. 2003. – *Hydrobiologia* 491: 321-330.