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DISSOLVED ORGANIC NITROGEN (DON) CYCLING IN THE ANTARCTIC

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Location: Signy Island (South Orkneys)

Rationale:

Antarctic ecosystems such as those at Signy Island are undergoing rapid climatic change. Owing to their simple community structures and intrinsic lack of redundancy in some parts of the food web, climate change can be expected to have profound effects on soil, animal and plant community structure and functioning. Biological responses to climate change are known to be occurring in the Antarctic and one of the most pronounced changes has been the rapid expansion of the two Antarctic vascular plant species *Deschampsia antarctica* and *Colobanthus quitensis*. Populations of both plant species have increased in size in recent years, a response that is correlated with recent anthropogenic climate change and which emphasizes the sensitivity of these communities to climate change. The increased population expansion of both species is apparently not related to the acclimation of photosynthesis to higher temperatures, and we suggest that environmental warming, and higher C throughput to the soil, has resulted in the locking up of ecosystem N in vascular plants, with substantial implications for soil N cycling. Knowledge of the fundamental processes of C and N cycling in Antarctic soils is therefore essential to understanding the responses of these plant species to climate change. We hypothesize that elevated temperatures will significantly alter the patterns of N cycling in Antarctic soils, leading to enhanced NO_3^- production and potentially to selection against species that preferentially use DON or those that rely on rain-fed N. Further, increased concentrations of atmospheric CO_2 will, together with higher temperatures, increase plant production where nutrient status permits, locking up more system N in plant material. The results collected in this proposal will significantly improve our understanding of terrestrial N and C cycling in polar soils and will allow more accurate prediction of polar ecosystem changes using mathematical models.

Highlights:

During the early part of the field season in December 2005 - March 2006 we set up a regular sampling regime of the four major soil types found on Signy: Bare soil at higher elevations, namely Observation Bluff, Factory Bluffs, Jane Col and lower parts of Spindrift Col; Soils from below mosses on the Backslope and on Moss Braes; Soils from below higher plant species at Bernsten point, Factory bluffs, Deschamsia point, Moss Braes and North Point; Orthinogenic soils from around penguin colonies at Gourlay peninsula, Spindrift rocks and North Point and Disturbed soil from around Signy Base itself. To quantify and identify soil N species over a full growth season, small volumes of soil were removed from each sampling site 5 times during the field season and extracted in the laboratory. At the same time, soil pore water was extracted using Rhizon soil water samplers. Soil temperature was monitored at sampling times and ambient air temperature was monitored at each site throughout the field season.

Turnover of DON in soil was determined by the addition of ^{14}C-labelled plant protein (purified from ^{14}C-labelled algal cells) or ^{14}C-labelled glucose to the soil at a range of concentrations reflecting those found in Phase 1, and their turnover (soil label depletion in combination with NH_4^+, NO_3^- and $^{14}CO_2$ production) will be determined when the samples have returned to the UK. This involves the addition of a 1 µM ^{14}C-glucose or plant protein solution to the soil which is rapidly assimilated by the soil microbial community leading to a rapid peak in respiratory $^{14}CO_2$

production which is trapped in NaOH traps. Microbial biomass measurements will be made by standard $CHCl_3$ fumigation-extraction techniques. To assess the degree of functional redundancy in the processing of DON by the soil microbial community, ^{13}C-labelled amino acids were added to the soil and the ^{13}C PLFA signatures of the different microbial groups determined at the NERC SIF facility when samples return.

Gross rates of N mineralization and nitrification were determined using ^{15}N isotope dilution methodology. Soils were labelled with either a $^{15}NH_4$ (98atom% ^{15}N) or $^{15}NO_3$ (98 atom% ^{15}N) solution. The $^{14}NO_3^-$ and $^{14}NH_4^+$ pools will be measured at time zero. The ^{15}N-labelled solution was injected at multiple points into the soil using a 60-mm long hypodermic needle. The soils were destructively sampled 2 h, 48 h and 30 d after ^{15}N label addition. N was extracted with 0.5 M K_2SO_4.

This was a period of intensive sampling, field and laboratory work and virtually all of the laboratory analysis of N speciation and quantification, ^{14}C uptake and respiration, ^{13}C PLFA signatures and ^{15}N analysis still remains to be done when the samples return to the UK.

Although the individual soil samples were small, a full set from a sampling trip weighed a considerable amount. The weather on Signy more often-than-not meant that Skidoo use over the icecap was out of the question. The help of the field assistant and other scientific staff was therefore most appreciated when it was necessary to return with the fruits of a sampling session. Also appreciated were the efforts of the penguins to influence temperature readings; - the data-loggers were regularly found in nests and gave data in excess of 35°C. All sampling and field work around Signy Base Station was closely monitored by the local Skua population and any experiment that did not come up to their high standards was promptly removed.

Figure 1. Orthinogenic inputs into soils at Gourlay peninsula

Figure 2. Soil sampling at Deschampsia point, Signy Island.