Effects of global warming on Antarctic soil microorganisms and associated functions

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Summary

Soil microorganisms are involved in all the major global biogeochemical cycles, but consequences of ongoing climate changes on these organisms and associated functions are mostly unknown. Antarctic terrestrial habitats are ideal testing grounds for the impacts of perturbation on soil microbes, and the ecosystem functions for which they are responsible. Indeed, the unusually harsh environmental conditions of terrestrial Antarctic habitats result in ecosystems with simplified trophic structures, where microbial processes are especially dominant as drivers of soil-borne nutrient cycling. The Antarctic Peninsula is one of the most rapidly warming regions in the world, yet few studies have addressed the potential impacts of global warming on soil microbes and associated nutrient-cycling functions inhabiting these simple and vulnerable environments.

The main objective of this thesis is to assess the effects of global warming on Antarctic soil-borne microorganisms and associated functions. This objective was pursued via three complementary experimental approaches:

1. A detailed description of the microbial communities, and their associated functions, inhabiting Antarctic terrestrial habitats along a latitudinal transect, as a proxy for long-term, large-scale climatic changes (Chapters 2–5).
2. A study of the short-term responses of soil microorganisms and associated functions to increasing temperature and altered freeze-thaw cycle frequency in controlled microcosm experiments (Chapter 6).
3. An assessment of the responses of soil microbial communities and functions in a field manipulation experiment involving three years of artificial enhancement of soil temperature warming using open-top chambers at three field locations (Chapter 7).

Such an integrated approach is thought to help overcome methodological, spatial and temporal limitations and to help discriminate between general and context-dependant responses of ecosystems to global warming.

Results from the latitudinal gradient studies revealed that the large differences in climatic conditions at the different sites sampled exerted strong influence on microbial community structure, diversity, abundance and functions. In addition, vegetation cover was observed to also exert a strong effect, indicating that indirect effects of global warming through vegetation expansion may lead to large ecosystem responses. Microcosm studies highlighted that fungi and bacteria respond differently to increasing temperature and changes in freeze-thaw cycle frequency. These experiments also showed that several functional genes involved in the N-cycle were more sensitive to changes in freeze-thaw cycle frequency than to increases in temperature. Field warming experiments showed that the short-term responses of soil organisms and associated functions to warming of a few degrees were highly dependent on local environmental condition. Large responses were only recorded in moist, nutrient-rich Antarctic environments, while few responses were observed in nutrient- or water-limited environments and the more temperate soils.

Taken together, the results presented in this thesis suggest that global warming will have profound effects on Antarctic soil microorganisms and associated functions. The short-term effects will be highly variable and shaped by local environmental conditions, while in the longer-term, global warming will strongly affect soil microorganisms and nutrient-cycling functions, both directly and indirectly.