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# Guest Editorial

## Pristine Antarctica: threats and protection

Molecular technologies have shown unequivocally that much of Antarctica's biological value and diversity lies in its microbiota. Microbial diversity varies greatly over small spatial scales, and there may be high levels of endemism in some groups. At the 2012 SCAR Open Science Conference, $>70\%$ of scientific presentations by terrestrial biologists concerned microbiology, and the topic features prominently in the newly approved SCAR biology programmes *State of the Antarctic Ecosystem* (AntEco) and *Antarctic Thresholds - Ecosystem Resilience and Adaptation* (AnT-ERA). The future looks bright for Antarctic microbiology - but some significant threats need to be addressed and resolved.

First, terrestrial microbial habitats are vulnerable to microbial and genetic contamination. Wherever humans go, they release non-native microorganisms resident on their bodies, clothing, cargo and food into the environment. Such contamination has been found at supposedly 'pristine' sites in both the Antarctic Peninsula and Ross Sea regions. Modern microbiological techniques have clearly revealed that current field practises can result in microbial contamination. Second, the expanding human footprint in Antarctica may soon make it impossible to find terrestrial microbial habitats that have not been compromised by microbial contamination. Currently, less than 20 $km^2$ of Antarctica is protected within Antarctic Specially Protected Areas (ASPAs) to a degree whereby microbial contamination might be minimised with, for example, the use of protective over-clothing. Even then, arguably, the simple quarantine measures prescribed in these ASPA's management plans may not minimise contamination to a degree adequate for todays - irrespective of tomorrow's - sophisticated molecular biological technologies. We also have little information on the scale and kinetics of transport processes - and to what extent material from a 'heavily contaminated' site may be transported by wind to more pristine sites.

Encouragingly, standards are improving in some instances. Considerable effort, accompanied by intense international scrutiny, has gone into developing guidelines and technologies to prevent microbial contamination during penetration into Antarctica's vast expanse of pristine sub-glacial aquatic environments (covering at least 55 000 $km^2$). Antarctic ice-free ground of $\sim$45 000 $km^2$ is already contaminated by $\sim$95 research stations and 50+ years of intensive science, tourism and exploration. Surely microbial communities in ice-free habitats are entitled to equal or higher biosecurity standards as other communities.

So, where do we go from here? Attention should be focused on safeguarding terrestrial microbial habitats, especially with respect to sites for future microbiological investigations. Unvisited areas containing representative microbial habitats could be set aside as inviolate reference sites for both purposes as is allowed for in the Environmental Protocol (Annex V, Article 3), but a well argued case for this needs to be supported by all the science disciplines if it is to be workable. Biosecurity standards could be agreed for activities within terrestrial areas of microbiological value. Geologists, botanists, chemists and microbiologists must find ways to accommodate these biosecurity standards at unique, but vulnerable locations, such as areas of geo-thermally heated ground, possibly through better use of zoning within protected areas. Cameron *et al*. wrote in 1977 '*Not all sites in Antarctica, although influenced by the presence of man, are perturbed, and it should not be assumed that there are no remaining "pristine" areas…. However, these sites may disappear rapidly as the "Last Frontier" succumbs to planned investigations*'. Thirty-five years on, how many truly 'pristine' areas remain for today's microbiological research, and for that of future generations? Time is rapidly running out if we want to protect this unique resource.

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