Climate change and its ecological consequences at Marion and Prince Edward Islands

V R Smith

Department of Botany and Genetics
University of the OFS
9301 BLOEMFONTEIN
South Africa

Annual mean surface air temperature at Marion Island has increased on average by 0,04 °C per year since the late 1960s. This was associated with corresponding changes in sea surface temperature and with a general trend of decreasing annual totals of precipitation. Changing sea level (atmospheric and oceanic) circulation patterns in the region are suggested to underlie these changes and similar ones have probably occurred at nearby Prince Edward Island.

The International Geosphere-Biosphere Programme (IGBP) has identified sub-Antarctic islands, along with Antarctica and the Southern Ocean, as critical areas for the study of global change. In particular, the relatively simple ecosystems of sub-Antarctic islands are ecologically very sensitive and offer ideal opportunities for studying the responses of ecological processes to changing climate or other perturbations.

It was against this background that the South African Committee for Antarctic Research recently initiated a multidisciplinary project focussed on the biological and ecological consequences of climate change at Marion and Prince Edward Islands. Based on the results of previous bioenergetic and nutrient-cycling studies a possible scenario of these consequences was proposed, which is serving as a set of working hypotheses for the current project. Briefly, the scenario is as follows:

Primary production on the islands is high and consequently the vegetation has a large annual requirement for nutrients. There are no macroherbivores and even the insects play only a small role as herbivores. Therefore, most of the energy and nutrients incorporated in primary production go through a detritus rather than grazing cycle. Ameliorating temperatures and increasing CO_2 levels are expected to increase productivity and nutrient demand even further. However, most of the plant communities occur on soils which have especially low plant-available levels of nutrients, and nutrient mineralisation from organic reserves is the main bottleneck in nutrient-cycling and limitation on primary production.

Increasing temperatures will not significantly enhance microbially mediated mineralisation rates, since soil microbiological processes on the islands are limited by waterlogging rather than by temperature. The islands support large numbers of soil macroinvertebrates which are responsible for most of the nutrient release from peat and litter. The activities of these animals are strongly temperature-dependent and warming will result in enhanced nutrient availability, allowing the potential for increased primary production due to elevated temperature and CO_2 levels to be realised.

However, house-mice occur on Marion Island and have an important influence on the ecosystem, mainly by feeding on soil invertebrates.The mouse population is increasing, possibly as a result of ameliorating temperatures and decreasing numbers of feral cats that are being hunted out. An increasing mouse population, through enhanced predation pressure on soil invertebrates, will decrease overall rates of nutrient-cycling and aggravate the imbalance between primary production and decomposition. This, along with more direct effects of mice (e g granivory), has important implications for vegetation succession and ecosystem structure and functioning on the island. Some of these are already apparent from comparisons with nearby Prince Edward Island where mice do not occur.

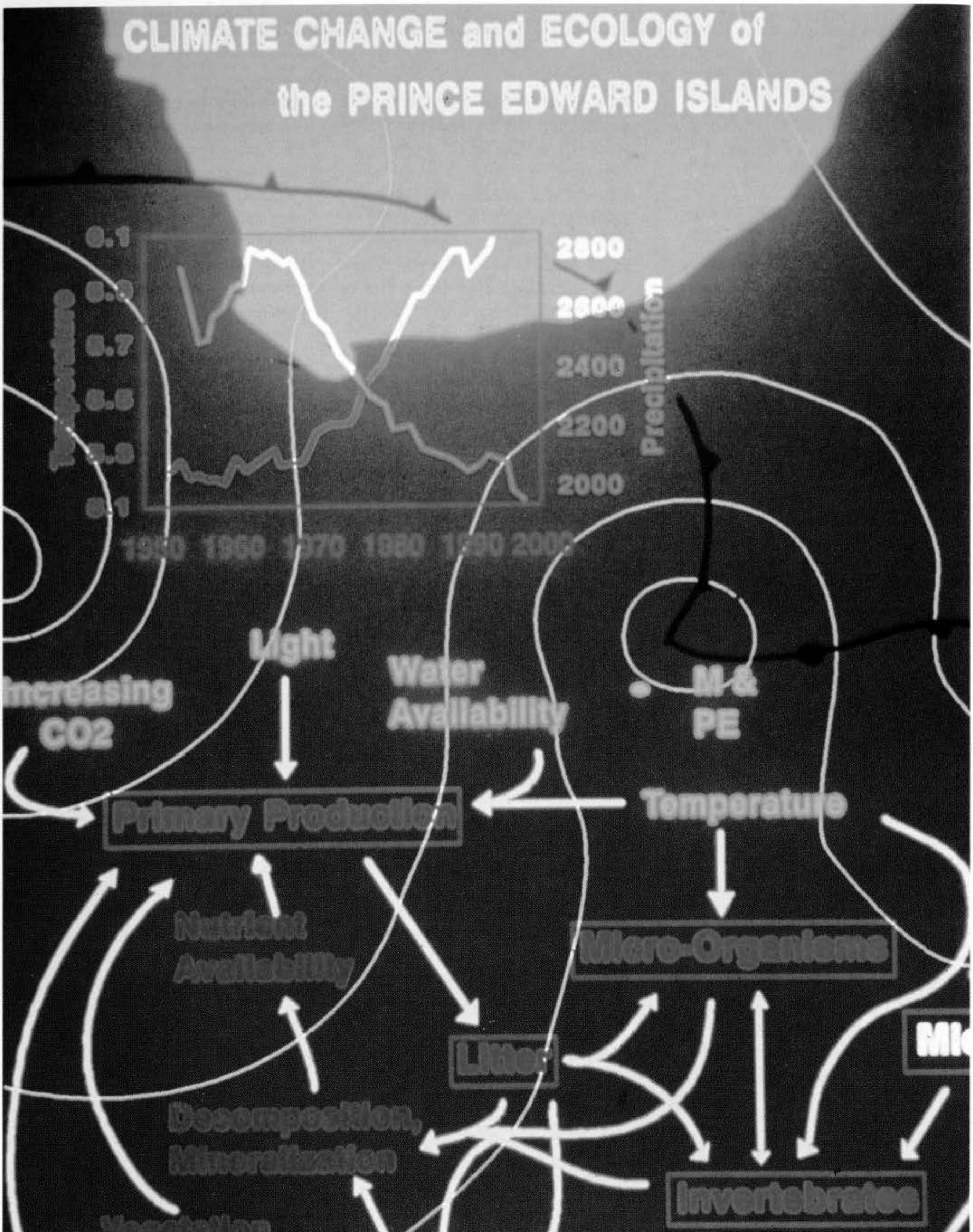
Climatic variation will also influence other components of the islands' biota and ecology. For instance, approximately one million pairs of burrowing petrels and prions occur on Marion Island and possibly even more on Prince Edward Island. They are an important source of marine-derived nutrients and energy for many of the islands' communities and form a major driving force in vegetation succession. The birds use atmospheric frontal systems to move between the islands and their feeding areas, which may be several hundred kilometres distant, in the surrounding ocean. If the changes in temperature, precipitation and radiation being experienced at the islands are due to changing atmospheric circulation patterns, then the birds may not be able to reach their usual feeding grounds. Alternatively associated changes in oceanic circulation may move the feeding grounds to other localities. Thus, changing sea level circulation patterns may be expected to influence the breeding success and population densities of these animals, with obvious implication for nutrient-cycling and vegetation succession on the island. Similar considerations possibly apply to the islands' populations of seals, penguins and albatrosses.

Changes in atmospheric circulation patterns may also provide opportunities for new organisms to colonise the island and there are botanical and entomological suggestions that this is already occurring. As has been the case with house-mice, recent establishments of invasive plants and insects on Marion Island have demonstrated the dramatic effects that invasive organisms may have on structure and functioning of the island ecosystem. Thus, through allowing opportunities for colonisation by new biota, changing sea level circulation patterns may have an even more important influence on terrestrial ecosystems of the sub-Antarctic than might be suggested merely on the basis of associated changes in temperature or precipitation.

The project should contribute significantly to an understanding of the functional responses of organisms, populations and ecosystems to abiotic and biotic perturbations. It will also enable rational conservation and management criteria to be identified once statutory protection is finally afforded to Marion and Prince Edward Islands.

Caption of photograph on page 224:

Climate change and ecology of the Prince Edward Islands


CLIMATE CHANGE and ECOLOGY of
the PRINCE EDWARD ISLANDS
Temperature
Precipitation
2800
2600
2400
2200
2000
Light
ncreasing
CO2
Water
Availability
M &
PE
Primary Production
Temperature
Nutrient
Availability
Micro-Organisms
Litter
Decomposition,
Mineralization
Invertebrates
Vegetation
Succession
Peat