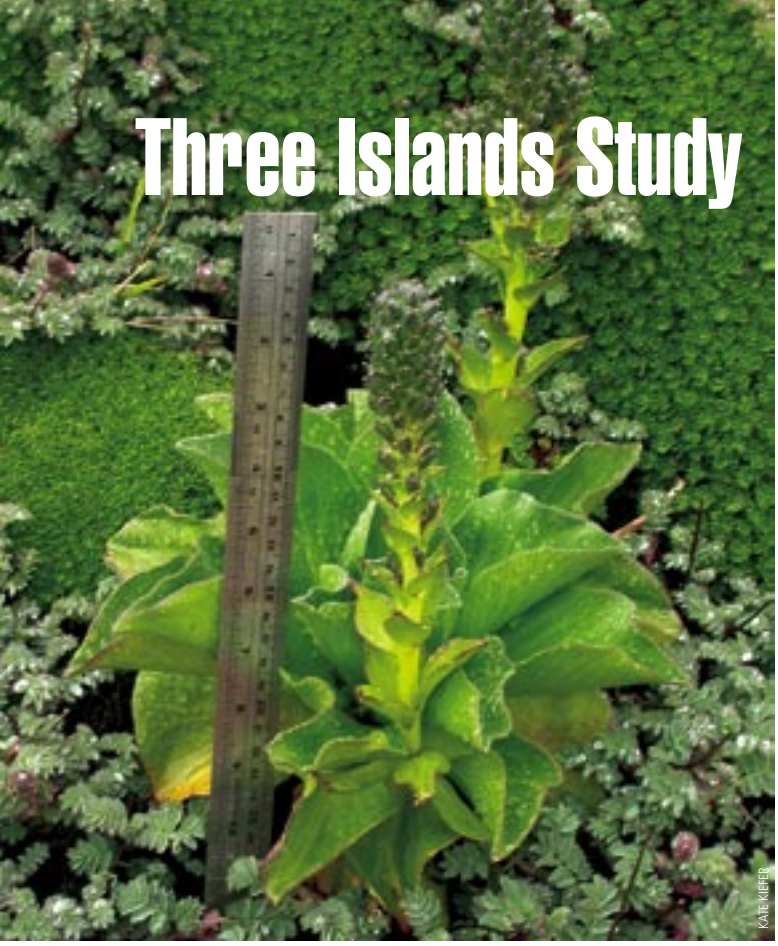
Three Islands Study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A multinational study spanning three subantarctic islands, has given us an insight into the effects of climate change on subantarctic plant species.

The three islands in the study – Marion Island, Iles Kerguelen and Heard Island – lie north, within and south of the Antarctic Polar Frontal Zone (APFZ), respectively. This zone, on the edge of the Antarctic region, is both an oceanic and climatic boundary, with warmer seas and air temperatures to the north and colder temperatures to the south. The three islands therefore provide a latitudinal temperature gradient and a fabulous suite of natural laboratories to explore the impact of temperature on species' performance and ecosystem structure.

There is about a 2°C jump in average air temperature between each island, starting with Heard in the south at about 1.5°C; 3.5°C on Kerguelen; and 5.5 °C on Marion. This natural temperature gradient provides a useful analogy for the impact of climate change, with the warmer islands being models of what the cooler islands will be like in the future.

To overcome problems with year-to-year variations in seasonal temperatures – a hot summer one year and a cold summer the next, for example – we deployed teams on the three islands simultaneously over the 2003–04 summer. Logistical support was provided by Australia, France and South Africa, while scientists from eight nations were involved, either in the field or patiently awaiting samples.

There were many components to the three islands study, but one of the main ones involved examining the differences in the progression of flowering and seed development in four important plant species that occur on all three islands. These were the Kerguelen cabbage, *Pringlea antiscorbutica*, which is endemic to these islands as well as Iles Crozet; the cushion plant, *Azorella selago*; a subantarctic tussock grass, *Poa cookii*; and a creeping, wiry subantarctic herb from the rose family, *Acaena magellanica*. We had sites established along altitudinal gradients on all islands and these sites were visited every five days, weather permitting. Plants, identified by temporary markers, were monitored throughout the summer.

Our preliminary analysis has shown that not all species perform in the same way across the temperature gradient between the islands. This is important because it give us clues as to whether or not there will be winners and losers in a climate change scenario. Although we expected a lag in flowering development on the colder islands, compared to the warmer islands, in the case of *Acaena magellanica*, development differed by more than one month between Kerguelen and Heard islands. Such a lag time was surprising. Furthermore, coastal *Acaena* on Kerguelen had three flushes of flowers, compared to only one on Heard. The end result of this behaviour was substantially more seed production on Iles Kerguelen compared with Heard Island by the end of summer, so that *Acaena* may be more competitive under warmer conditions.

The three islands study was part of an international Scientific Committee on Antarctic Research program called RiSCC (Regional Sensitivity to Climate change in Antarctica) and took advantage of the opportunity that co-operation between nations in the Antarctic offers. Support for the visit to Kerguelen came from both the French Antarctic program and the French Embassy in Australia.

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Far left: Three of the four target plant species: The Kerguelen cabbage, *Pringlea antiscorbutica* (centre), the green-grey foliage of the subantarctic herb *Acaena magellanica* or buzzy (bottom) and the cushion forming species *Azorella selago* (top).

Top left: Dr Dana Bergstrom downloads data from an automatic weather station on Iles Kerguelen using a satellite telephone and laptop computer.

Left: Aerial shot of Marion Island, showing the lush coastal vegetation typical of this warmer island. The persistent ice cap, which covers only one percent of the island, can be seen on the higher peaks in the background.

Above: The higher snow covered peaks of Mt Ross, Iles Kerguelen's highest peak, dominate the skyline. Low herbaceous vegetation, typical of Iles Kerguelen can be seen in the foreground.

Measuring the response of Heard Island plants to global warming

As the effects of global warming intensify, plants that have evolved in the cool environment of Heard Island must cope with rising temperatures. The amount of carbon plants acquire from the air by photosynthesis, or lose to the atmosphere by respiration, strongly affects their growth. Both processes are temperature-dependent and their balance is likely to change in a warming environment.

We can measure the response to an instantaneous change in temperature, but this does not tell us whether and how organisms might acclimate to a long-term, sustained temperature change. If you live in Darwin, for example, you will likely perceive and physiologically react to a cold day differently than someone living in Hobart. If you move from Darwin to Hobart and still freeze after 20 years, it's probably because there are limits to how well you can acclimate. These limits vary between people, and vary between plant species.

On Heard Island, we need to know whether plants in a future, warmer environment will have an altered physiology compared to those growing today. But how do we compare the plants of today and tomorrow? Over the 2003-04 summer on Heard Island, our approach was to treat the island as a natural laboratory, and to study the amount of carbon gained and lost by plants grown at different altitudes.

The theory is that plants growing at an altitude of say 200 m, currently experience temperatures that coastal plants would have experienced 50 years ago. In our natural laboratory, we worked on a transect from sea level, at Skua Beach, to the escarpment of Scarlet Hill, at an altitude of more than 200 m. Our 'guinea pig' was the Kerguelen cabbage, *Pringlea antiscorbutica*. By measuring the amount of carbon gained and lost through photo-synthesis and respiration, we now know that acclimation to warmer temperatures does occur, but that the delicate balance between carbon gain and loss in *Pringlea* is upset on days warmer than 10-12°C. This likely results in slower growth.

Pringlea and other 'guinea pigs' are currently under close observation in Canberra, where they are being treated with cool and warm days in different walk-in growth chambers.

Below: Marcus Schortemeyer measures photosynthesis in Kerguelen cabbage (*Pringlea antiscorbutica*) on Scarlet Hill, Heard Island, using a LiCor 6400 Portable Photosynthesis System. His research will help him understand how plants on the island respond to rising temperatures.

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