

Report on Antarctic Gradients Invited Workshop
Under SCAR's EBA Scientific Research Programme
19-21 May 2008, British Antarctic Survey, UK



Workshop Context

Changes to Antarctic ecosystems are occurring due to global climate variability and change, as well as increased tourism and fishing. Global climate models suggest that parts of Antarctica will change at a more rapid pace in the next 30 years and that this change will be unevenly spread across the continent. One prediction is that while the Antarctic Peninsula and Weddell Sea will continue to warm, with significant losses of sea ice and glacier ice, the Ross Sea area will not change, and may even continue to slightly cool. These changes are likely to occur over timescales within the working life span of environmental scientists, and thus provide a platform for hypothesis driven research that may firstly allow for predictions of change and secondly, testing of those predictions.

Antarctica is the only continent where the global science community is sufficiently well aligned (through SCAR), and where large and small nations can link and have a voice in science. As a result, an internationally coordinated long-term observational and predictive science study could be established under a hypothesis-driven framework to look into the current changes. Ecosystem change/response is already being studied at local scales by individual researchers carrying out experiments supported by their own national programmes, and/or by integrated studies that look at change at regional and continental scales simultaneously.

There is now an opportunity to bring these various studies together from across the continent, to compare and contrast results and begin a continental scale study to understand a global scale problem.

In the Ross Sea area there are already two major research initiatives that look at regional-scale change, the US-led Dry Valleys Long Term Ecological Research project (MCM-LTER; www.mcmlter.org), now in its 15th year, and the New Zealand-led Latitudinal Gradient Project (LGP; www.lgp.aq). In the Peninsula area there are the US-led Palmer Station LTER project (<http://pal.lternet.edu/>), the long-term environmental data sets of the British Antarctic Survey at Signy Island and more lately at Rothera Point, and several other national projects that are currently investigating ecosystem change (e.g., led by Argentina, Chile, Spain, Poland and The Netherlands).

The outcome of an International LGP workshop held at the SCAR Open Science Conference in Hobart in July 2006, was an agreement that it would be of great value to compare the findings of ecosystems research along latitudinal and other environmental gradients within different areas of Antarctica (i.e. in particular the Victoria Land coast and the Antarctic Peninsula). The importance of such comparisons has also been demonstrated by an LTER workshop held in September 2006 where Palmer and McMurdo Dry Valley LTER researchers compared results on observed responses to climate change.

This concept of making such comparisons in a formal sense was proposed to SCAR's Evolution and Biodiversity in Antarctica (EBA; www.eba.aq) programme by the NZ-LGP science community, and EBA are keen to support this however they can.

LGP-associated research in Victoria Land addresses a general hypothesis and eight key questions (see below), which were initially formulated at the SCAR Biology Symposium in Amsterdam in 2001 to address various aspects of ecosystems research along this latitudinal gradient. It has been proposed that the LGP general hypothesis and eight key questions can also form the basis of comparisons between Victoria Land coast and Antarctica Peninsula ecosystems (marine, terrestrial and aquatic).

Workshop Purpose

EBA facilitated a small invited workshop to bring together key terrestrial, inland aquatic and near-shore coastal marine biologists whose research focuses on the Victoria Land coast and the Antarctic Peninsula. The workshop explored the issues associated with a "Trans-Antarctic" approach to the study of environmental gradients in the current context of global change and in the context of EBA's research plan.

The aims of the workshop were grouped into two broad areas:

A. Directed goals for the short to middle term (1-3 yr):

1. Decide on the feasibility of comparative studies of the areas encompassed by the latitudinal gradients along the Antarctic Peninsula and the Victoria Land coast;
2. Agree on a common general hypothesis and key questions to help guide this comparative study (using the LGP general hypothesis and key questions as a starting framework – see below);
3. Gain an understanding of the various applicable studies that are currently going on and how information from these can be used for this comparative study;
4. Present and discuss data that are useful indicators of the effects of climate change and environmental variability;
5. Record practicalities and challenges of how comparisons between the areas can be made;
6. Identify common ground that participants can actively use at the workshop towards the goal of pulling together a synthetic/comparative output;
7. Resulting from the above points, start to generate a 'state of play' review paper to form an integrated synthesis outlining what current gradient-based Antarctic research has actually achieved so far, and what the next logical steps in this area are.
8. Decide on how to present and progress this work at the EBA workshop at St Petersburg.

B. Longer term strategy (3-10 yr):

1. Show how an Antarctic Gradients project under EBA can be combined with research from the SCAR programmes *Antarctica and the Global Climate System* (AGCS) and *Antarctic Climate Evolution* (ACE), and propose the way forward for this;
2. Propose a vision of where this study should be in 2018 (including how to encourage more nations to contribute to the proposed framework);
3. Outline a strategy for publication of these comparative studies.

Resources

Prior to the workshop attendees were:

- Sent an overview document of the structure of the LGP framework and the work that has been undertaken by the LGP to date – as background reading to exemplify the type of coordinated research that is being undertaken in Victoria Land.
- Given a specific research area to look into, so that they can bring with them to the workshop information relating to points A3 and A4 above.

Workshop Outcomes

1. An ‘immediate’ document presenting the above discussions that will be edited for presentation at the EBA workshop in St Petersburg in July 2008, and used as the basis for this workshop developing the international perspective and contribution;
2. Poster prepared for presentation at the SCAR/IASC conference in St Petersburg entitled ‘Antarctic Gradients’ – outlining the key points that came out of the workshop.
3. A ‘state of play’ review outlining what current gradient-based Antarctic research has actually achieved so far, and what the next logical steps in this area are. Participants agreed to submit this review paper to *Ecological Monographs* which is a high impact journal that reaches Antarctic and non-Antarctic communities. Submission will be made within a year of the workshop to provide a benchmark in Antarctic gradient studies.

Timeline for review paper submission

Action	Responsibility	Due Date
Send rough draft of document outline to all	Shulamit	25 May
Send meeting notes to Pete	Shulamit	30 May
Case studies of topics highlighted in yellow to be completed as an example of how others should be done and sent to Shul	Allan, Diana, Berry, Ad, Andrew, Vonda, Andy, Jo	23 June
Compile case studies and send to Pete	Shulamit	24 June
Submit to Editor of <i>Ecological Monographs</i> a proposal for submitting the review paper	Diana	24 June
Send to all a structured framework of the paper especially showing the context of where the case studies fit. Include examples of case studies so all can have a model of how these should be done.	Pete	2 July
Submit case studies for each topic highlighted to Shul	ALL	1 October
Bring paper together with support from other authors as needed	Pete	1 October- 22 December
Submit paper	Pete	22 December

Key points arising from the workshop

- **Why are gradients important?**
 - Gradients drive diversity
 - Gradients are needed for understanding change
 - Gradients are used in space-time substitutions
 - Gradients are useful for long-term projection of change

- Latitude is assumed to be a significant gradient, but in the Antarctic context we believe that this is overridden by gradients in other directions.

- **What other gradients can be identified in marine, terrestrial and inland water ecosystems?**
 - **Geographic Gradients:**
 - Altitude/depth
 - Distance from sea/land
 - Soil type/substrate type
 - Distance from the supply source of organisms
 - Isolation
 - Topography
 - Barriers
 - **Physical Gradients:**
 - Shelter
 - Salinity
 - Disturbance
 - Ice (marine only)
 - By animals (including humans)
 - Extreme events (flooding, high winds, heavy snowfall)
 - Nutrients/micro nutrients
 - History Ice cover
 - Precipitation
 - Solar Radiation [PAR]
 - UVB/UVR
 - Windiness
 - Cloudiness
 - Tides
 - Temperature
 - Mean annual temperature
 - Degree days
 - Diurnal variability
 - Seasonal Variability
 - Water availability (terrestrial only)
 - Mid-summer zero degree isotherm distribution (terrestrial only)
 - Soil moisture (terrestrial only)
 - Current/fronts/water masses (marine only)
 - Calcium carbonate solubility (Marine only)

- **Biological variables that respond to these physical and geographic gradients:**
 - Evolutionary rates
 - Species distribution (rate of change, Dispersal mechanisms and Gene flow rates, endemism)
 - Trophic complexity – Mixotrophy
 - Morphological and physiological adaptations
 - Metabolic function
 - Survival (Insistence)
 - Legacy
 - Productivity
 - Richness/diversity
 - Community stability

- **The influence of these gradients occur at different temporal scales:**
 - **Seasonal scale** (*melt, importance of early and late season conditions, sea ice*)
 - **Decadal scale** (*warm/cool events, storms e.g. SAM, ENSO, iceberg scour, sea ice*)
 - **Century scale** (*extreme storms; ecosystem subsidies (e.g. legacy carbon), iceberg scour*)
 - **Millennia scale** (*glacial cycles, refugia recovery, isostatic rebound, ecosystem subsidies (e.g. legacy carbon)*)

- **Gradients are evident at different spatial scales → What is an ideal spatial framework to address these gradients?**
 - a. Large scale framework - large scale comparisons of the Antarctic Peninsula, Victoria Land and East Antarctica on both sides of the Amery Ice Shelf
 - b. Intermediate scale: Landscape Units – (rather than an ecosystem approach?) – but marine equivalents of landscape scales are hard to identify.
 - c. Small scale

- **These gradients are underlain by:**
 - Stochastic factors
 - Extreme events
 - Metabolic agility of organisms adapted to extreme conditions

- **What data do we have to address these gradient studies?**
 - a. Geographic and bathymetric/altitude spread;
 - b. Long term time-series records to define inter-annual variability and trends;
 - c. Spot records to show long-term change.

Workshop Participants

1. Dave Barnes - British Antarctic Survey, UK
2. Andy Clarke - British Antarctic Survey, UK
3. Pete Convey – British Antarctic Survey, UK
4. Hugh Ducklow – The Ecosystems Centre, USA
5. Vonda Cummings - National Institute for Water and Atmospheric Research, New Zealand
6. Francesco Frati – University of Siena, Italy
7. Allan Green - University of Waikato, New Zealand
8. Shulamit Gordon – Antarctica New Zealand, New Zealand (EBA Secretary)
9. Clive Howard-Williams – National Institute for Water and Atmospheric Research, New Zealand
10. Ad Huiskes - Netherlands Institute of Ecology, The Netherlands
11. Johanna Laybourn-Parry, University of Tasmania, Australia
12. Berry Lyons – Ohio State University, USA
13. Andrew McMinn – University of Tasmania, Australia
14. Antonio Quesada - Universidad Autonoma de Madrid
15. Stefano Schiaparelli - Università di Genova, Italy
16. Diana Wall – Colorado State University, USA (absent with apology)