

**“Non-native Species in the Antarctic”
A Workshop
Held at Gateway Antarctica, University of Canterbury
Christchurch, New Zealand**

10, 11 & 12 April 2006

FINAL REPORT

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The Workshop was made possible due to sponsorship from the following:



Executive summary

The “Non-native Species in the Antarctic” Workshop was hosted by Gateway Antarctica at the University of Canterbury, Christchurch, New Zealand, on 10 – 12 April 2006. The Workshop was co-convened by Dr. Maj De Poorter (University of Auckland), Professor Bryan Storey (University of Canterbury) and Dr. Neil Gilbert (Antarctica New Zealand), with Ms. Michelle Rogan-Finnemore (University of Canterbury) as Workshop project manager.

The workshop highlighted key lessons learned globally and confirmed the significance of non-native species issues in the Antarctic context. Based on the presentations and discussions, participants put forward several conclusions and recommended actions to improve practical measures to address the non-native species issue in the Antarctic context:

- 1) The key lesson from elsewhere in the world is that in view of the complexity of ecological effects, non-native species issues need a preventative and precautionary approach. Prevention of introduction must be a priority and we must consider any species "guilty until proven innocent".
- 2) Whilst Antarctica has natural environmental advantages, these are not enough to stop invasive species, pests and diseases.
- 3) Invasive alien species have already significantly affected the sub-Antarctic islands. There is a strong correlation between introduced species and human activity on the sub-Antarctic islands with most alien species being of European origin.
- 4) Introductions of non-native species into the Antarctic resulting from human activity far outweigh natural dispersal of species.
- 5) While the Antarctic continent itself has, so far, escaped the ravages of biological invasion, non-native organisms, including terrestrial invertebrates and plants, and a marine crustacea have been found in the Antarctic Treaty region
- 6) Increasing travel and transport of goods and people, together with shorter transport times and increasingly direct links between sub-Antarctic and Arctic areas and the Antarctic, increase the likelihood of introductions and risk to Antarctic values.
- 7) Increased human activity on the continent also risks transferring species across natural biogeographic boundaries with the subsequent breakdown of regional endemism, and genetic distinctness. Antarctica is one of the few areas of the planet where such boundaries and regions still hold.
- 8) Human activities will inevitably lead to some introductions, but the aim of management should be to minimise as much as possible the unintentional as well as intentional introductions of any non-native species.
- 9) A changing more benign climate, particularly in the Antarctic Peninsula, is likely to increase the risks of alien species establishing themselves.

10) There is a pressing need for increased and coordinated survey, monitoring and research across the continent and Southern Ocean. Good baseline information should be developed for all taxa and all environments, with special emphasis on closing the gaps in knowledge on microbes and on marine environments. With regards to baseline surveys, however, several marine species that are found in Antarctic waters (notably bryozoans and ascidians) are found elsewhere in the world and it is not appropriate to assume that marine species found in the Antarctic are native.

11) Antarctic Treaty parties have not ignored the issue of non-native species, but provisions, have been largely aimed at intentional introductions of non-native species. The Antarctic Treaty's Committee for Environmental Protection (CEP) is well placed to take action. Consideration could be given to making non-native species issues a separate agenda item.

12) All the values in Article 3 of the Protocol need to be protected from non-native species introductions; the Antarctic requires the highest standard of protection.

13) National Antarctic Programmes have demonstrated a mixed response to the management of non-native species. It will be important to ensure that practical measures are implemented consistently among all operators in the Antarctic. In addition to the consideration of new or additional procedures to address non-native species, existing procedures, such as Environmental Impact Assessment (EIA) and Protected Areas management should incorporate, as appropriate, components to address non-native species concerns. Information sharing should be encouraged and maximised on practices and/or procedures used. Interagency cooperation will be beneficial.

14) The principle components of any management programme are prevention, surveillance and response, with prevention being the most effective means of minimizing any impact.

15) Increasing awareness on the risks posed by non-native species and on the need to prevent their introduction is a key requirement for successful management.

Background and rationale of Workshop

Biological invasions are one of the most significant threats to biological diversity on a global scale (McKinney & Lockwood, 1999; Sala et al., 2000; Courchamp, Chapuis & Pascal, 2003). Worldwide, they have invaded and affected native biota in virtually every ecosystem type on earth. The ecological cost includes the loss of native species and ecosystems, ecosystem services and livelihoods (OTA, 1993; Mack et al., 2000; McNeely et al., 2001). In view of the significance of the threat, several international legal instruments address aspects of alien species introductions and the risks of biological invasion such as, The Convention on Biological Diversity (CBD) 1992, The United Nations Convention on the Law of the Sea (UNCLOS) 1982, and the Ballast Water Convention 2004 (not yet in force).

Native biodiversity on sub-Antarctic islands has been heavily impacted by invasive non-native plants and vertebrates (Bonner, 1984; Cooper, 1995; Chapuis, 1995; Frenot et al., 2005). While the Antarctic continent itself has, so far, escaped the ravages of biological invasion, non-native organisms, including terrestrial invertebrates and plants, and a marine crustacea have been found in the Antarctic Treaty region (Australia, 1995; Japan, 1996; Olech, 1996; Tavares et al., 2004).

The Antarctic Treaty System (ATS) recognised the importance of non-native species as early as 1964 in the Agreed Measures. The Protocol on Environmental Protection to the Antarctic Treaty 1991, (Protocol) has not expanded upon those early provisions, and little has been done to elaborate upon them through practical guidance.

Article 4 of Annex II to the Protocol:

- prohibits the introduction of non-native species except in accordance with a permit;
- places restrictions on what can be permitted;
- provides an exemption for food;
- requires that permitted species must be removed or destroyed;
- requires precautions to be taken to prevent the introduction of microorganisms not present in the native fauna and flora.

Further, the non-native species provisions of the Protocol are largely aimed at intentional introductions of non-native species. The need for parties to address the issue of unintentional introductions is not explicitly stated in the Protocol, though it can be inferred from a number of Articles (e.g. Article 3(2)(b)(iv)).

There is now, however, a heightened interest by the Antarctic Treaty's Committee for Environmental Protection (CEP) of these issues. At CEP VIII, Australia introduced a Working Paper (ATCM XXVIII / WP 28) on *Measures to address the unintentional introduction and spread of non-native biota and disease to the Antarctic Treaty Area*. Australia's paper noted that no formal assessment had been undertaken of the risks associated with non-native species in the Antarctic context, and that increasing visitation and a changing, more benign, climate in certain parts of the Antarctic is likely to be increasing these risks. The CEP discussed the issue in some detail and many members agreed that there were several matters of concern with regard to the broad issues of quarantine and the introduction of non-native species, which warranted further consideration.

New Zealand indicated, during CEP VIII, that it would be prepared to host an intersessional, international workshop on the issue ahead of CEP IX taking account of the matters raised by the Australian Working Paper.

Workshop organisation and outputs

Gateway Antarctica, The Centre for Antarctic Research and Studies at the University of Canterbury, hosted a three-day Workshop on “Non-native Species in the Antarctic Region”, on 10, 11 and 12 April 2006.

The Workshop was jointly convened by Dr. Maj De Poorter (Centre for Biodiversity and Biosecurity, University of Auckland), Dr. Neil Gilbert (Antarctica New Zealand) and Professor Bryan Storey (Gateway Antarctica University of Canterbury), with Ms. Michelle Rogan-Finnemore (Gateway Antarctica, University of Canterbury) as Workshop project manager.

The Workshop was attended by 42 people from six countries: Australia, France, Italy, New Zealand, UK and USA. A full list of participants is included as Appendix I of this report.

The aim of the Workshop was to bring together relevant national and international experts to discuss conservation, management and research issues relating to the introduction of non-native species in the Antarctic in order to foster increased understanding and awareness of:

- The relevance of non-native species introductions to conservation of Antarctic environmental and other values;
- Pathways for intentional and unintentional introductions of non-native species;
- Best practice and management tools (practical as well as legal);
- Identification of gaps (knowledge, methods, regulatory);
- Requirements to address these gaps (including research, implementation, regulatory, awareness-raising).

The geographic focus of the workshop included all habitats in the Antarctic region (below 60° South). This was not meant to exclude the sub-Antarctic region, it was simply a way to focus the discussions to the Antarctic Treaty area. The scope included comprehensive coverage of biota, and the emerging issue of diseases; terrestrial and marine environments; internal (site-to-site) introductions and external (inter-continental) considerations.

Details about the Workshop, including the programme, background material and administrative matters were made available through the CEP website. The conveners are grateful to Australian Antarctic Division for their assistance in posting the information on the website. The workshop was generously sponsored by a number of organisations, especially the makers of the Antarctic movie “Happy Feet”. A full list of sponsor logos are included on the table of contents page of this Final Report.

The programme

The agenda of the Workshop can be found at Appendix II.

The afternoon session of Day 1 and the morning session of Day 2 were an opportunity for presentations to the plenary by international experts. A summary of the key points from each of these presentations can be found in this report and the full PowerPoint presentations, in PDF format, can be viewed or downloaded from www.anta.canterbury.ac.nz/resources.shtml.

The afternoon session of Day 2 and the morning session of Day 3 were dedicated to three concurrent break-out working groups each addressing the same set of questions. The working groups were chaired by Dr. Alan Hemmings, Gateway Antarctica, University of Canterbury, Christchurch, New Zealand; Dr. Tom Maggs, Australian Antarctic Division, Hobart, Tasmania, Australia; and Dr. Polly Penhale, US National Science Foundation, USA. Each group presented the results of their discussions at a final plenary session at the end of the Workshop on Day 3. The full PowerPoint presentation from each working group can be found at: www.anta.canterbury.ac.nz/resources.shtml.

Ahead of the Workshop, a survey was undertaken in an attempt to gauge the extent to which National Antarctic Programmes have assessed and are managing non-native species. The survey, which consisted of six questions, was sent to all CEP contact points in February 2006. Responses from six countries were received. A summary of those responses can be found in Appendix III.

Participants and non-participants alike were invited to present posters which were displayed for the duration of the Workshop. Abstracts from those posters can be found in Appendix IV.

A Working Paper (WP-013) was submitted to the XXIX Antarctic Treaty Consultative Meeting (ATCM), by New Zealand, setting out a number of recommendations for the CEP's consideration based on the outcomes of the Workshop.

Proceedings of the Workshop will be published by the end of the year.

Definition of terms

To aid the discussions the following terms were used, as defined here, during the Workshop:

- ***Non-native species (sometimes called alien species)***: species that have been introduced to an ecosystem either intentionally or unintentionally.
 - ***Introduction*** means the movement, as a direct or indirect result of human activity of species into an area where they are not native.
- ***Transient alien species***: species that have survived in small populations for a short period, but which have either died out naturally or have been removed by human intervention.
- ***Persistent alien species***: species that have survived, established and reproduced for many years in a restricted locality, but which have not expanded their range from a specific location.
- ***Invasive non-native species (sometimes called invasive alien species)***: non-native species whose introduction and/or spread threaten biological diversity.

Presentation summaries

"Invasive species: A global threat to biodiversity."

Dr. Mick Clout & Dr. Maj De Poorter

IUCN (The World Conservation Union) has been engaged in invasive alien species (IAS) work since the early 1990s. The IUCN Invasive Species Specialist Group (ISSG) hosts an international exchange of information and expertise and makes information available via the Global Invasive Species Database (www.issg.org/database & www.invasivespecies.net/database).

Issues

There is a global biodiversity crisis; invasive species contribute to this crisis. An IUCN species assessment shows that 12% of all birds, 23% of mammals and 32% of amphibians are threatened with extinction. For these groups, the third biggest threat is from IAS (excluding disease).

Islands and other isolated ecosystems are especially threatened by IAS, as isolated floras and faunas have high endemism and high vulnerability to invasion. For marine environments, IAS are recognised as the fifth biggest threat to global marine biodiversity. Trade and travel are causing an exponential increase in the movement of species outside their native range.

Dealing with IAS requires prevention, eradication and control. Fighting back is possible, but: Control means ongoing commitment; Eradication is not easy, not cheap and often not feasible; Prevention is by far the most preferred option.

We are getting better at predicting further spread once an alien species has been recognised as invasive in a country, but predicting the likelihood of an alien species becoming invasive in a new environment remains elusive. It is elusive because of the complexity involved, the indirect effects and interactions between species. Yet, understanding this and prediction is critical, because it is the first line of defence.

Antarctica is not safe from effects of IAS. IAS have been introduced into many other isolated ecosystems worldwide. IAS have already established in the sub-Antarctic and have done MAJOR damage. Transport into the Antarctic is increasing, including fishing and polar research vessels from the Arctic. There are magnifying effects because of climate change, which could amplify IAS risks and problems.

Conclusions

1. Although the Antarctic has (so far) escaped the worst effects of alien species, pressures are building; Transport of people and goods is increasing.
2. Alien species (terrestrial & marine) have been found surviving in the Antarctic.
3. Global climate change may heighten the threat.
4. Conservation is not just about avoiding extinction.
5. Protection of wilderness and science values mean that the aim is to avoid any introduction of an alien species (not just those that would be harmful to biodiversity)
6. Need for an interagency, international approach.
7. Need to be pro-active and learn from disasters elsewhere.
8. Need to deal with: All pathways, all taxa, all receiving environments (terrestrial, freshwater, marine), and into/within/from Antarctica.

“Biological invasions in the Antarctic: extent, impacts and implications.”

Dr. Yves Frenot and others

1. At present macro-alien biota is confined to the sub-Antarctic and to a much lesser extent, marine Antarctic.
2. Impacts of alien taxa on indigenous ecosystems range from negligible / transient to significant. These impacts in the Antarctic Treaty area remain low in comparison with the dramatic effects of several introductions in the sub-Antarctic islands.
3. The majority of aliens are representatives of widespread families and/or are European in origin.
4. Major correlates of invasion are human visitor numbers/frequency and temperature.
5. Risks of introductions to region, although lower than elsewhere remain significant.
6. Current climatic trends will further enhance alien invasion.
7. Unless stringent measures are taken to reduce propagule load on humans, their food, cargo, and transport vessels, it is reasonable to predict that, as the number of human vectors visiting Antarctic ice-free areas increases, so will the introduction and establishment of new invasive taxa and, therefore, subsequent modification of ecosystem functioning.
8. There is a clear and urgent need for the establishment of long-term monitoring programmes to identify and assess future invasions, monitor the status of species already established or assess the effectiveness of any mitigation procedures adopted.
9. A range of further measures should be considered and recommended in concert with monitoring to minimise the risk of introduction. Practicable approaches include:
 - a. Cessation of imports of foreign biological material and soil, and on-station cultivation of biological material;
 - b. Stringent measures to ensure rodent-free status of ships and aircraft;
 - c. Logistical planning to minimize the risk of intra-regional and local transfer of propagules to pristine locations;
 - d. Control of visitor numbers and access to more sensitive or pristine sites;
 - e. Cleaning/sterilization of high risk transport locations for aliens, e.g. cargo surfaces, food stuffs and clothing;
 - f. Establish a code of conduct for all visitors in order to assess and to minimise the risk of introduction of new taxa in Antarctic and sub-Antarctic and the risk of accidental transfer of taxa between major ice-free localities.
10. During the next few years, research conducted under the umbrella of the SCAR Programme EBA would be an important tool for understanding the colonization processes and alien species monitoring in Antarctica.

“The state of knowledge: non-native species in the Antarctic marine environment.”

Dr. Chad Hewitt & Mr. Pat Lewis

Marine biological invasions can be either natural dispersal or human-assisted dispersal. Ships are complicated vectors that include ballast water and hull fouling

Challenges

1. Identify current status of invasions.
2. Reduce rate of invasions.
3. Understand and predict new invasions.
4. Control and eradication.

Problems for the Antarctic

1. Systematics of groups are poorly defined.
2. Restricted biogeographical data at the species level.

Issues

1. Remoteness and reduced opportunity for monitoring.
2. High value and high expectations.
3. Limited understanding of unique niche roles.

Way forward

1. Search for suspect species through literature review, identify historic locations and look for species anomalies.
2. Carry out species risk evaluation.
3. Critically evaluate possible transfers, by considering changes in donor regions, changes in transport vectors, and changes in recipient regions including environmental/climatic change.
4. Undertake targeted assessments.
5. Carry out baseline surveys to raise awareness, provide baseline for management, and to identify scale and scope of introduced species in Antarctica.

"Non-native species in the Antarctic terrestrial environment – presence, sources, impacts and predictions."

Dr. Peter Convey

The Antarctic ice-free, terrestrial environment covers less than 0.5% of the continent. The terrestrial ecosystem includes a cryptogamic "fellfield" flora dominated by mosses and lichens. Just two higher plants occur in the Antarctic Peninsula region. At higher latitudes these ice-free environments are dominated by the microbial flora.

The terrestrial fauna includes just two "higher" insects (again on the Peninsula), and is otherwise dominated by microarthropods (mites and springtails). As conditions become more extreme, the role of microfauna (nematodes, tardigrades, rotifers) becomes more important. Faunistically, the terrestrial environment is low in biodiversity though locally it can contain very high abundance. Overall contemporary biodiversity is low with many taxonomic and functional groups missing. In certain isolated areas such as nunataks, certain of the biota are known to be ancient, Gondwanan relicts. This situation has arisen as a result of the isolation of Antarctica and its extreme climatic conditions.

Antarctic terrestrial ecosystems are however experiencing two key pressures: a changing climate and human visitation. A changing Antarctic climate is expected to give rise to significant changes in terrestrial ecosystems including: local and exotic colonization; increased biomass and diversity; altered, more complex food webs; and a loss of Antarctic species or communities through increased competition.

The significance of these impacts is likely to be further influenced by human activity on the continent. Logistical, scientific and tourism activities all carry the potential to introduce new species to Antarctica, and to transfer species between sites within Antarctica. The latter is a very real risk, which also has the potential to compromise future research opportunities. Increased human activity on the continent risks transferring species across natural biogeographic boundaries with the subsequent breakdown of regional endemism, and genetic distinctness. Antarctica is one of the few areas of the planet where such boundaries and regions still hold.

An even bigger unknown is the microbial community. The state of knowledge of the existing microbial community is poor and even less is known about actual or potential microbial introductions, though these are inevitable with human presence on the continent.

Summary of Issues

1. Anthropogenic introductions outweigh natural processes; There have been introduced species, though the consequences to date have been minor.
2. Native ecosystems are vulnerable and there are some key, isolated communities in Antarctica that are particularly vulnerable with high scientific value.
3. Unfortunately there are large gaps in the state of our knowledge for most invertebrates and lower plants; microbes remain largely unknown, and there is little current survey or monitoring being undertaken.
4. Regional climate change is likely to lower dispersal and establishment barriers and increased human activity will inevitably increase the risk of introductions and the movement of taxa between sites.

"Legal tools available for controlling risk and management of non-native species."

Mr. Bill Mansfield

In 1991, with the adoption of the Protocol, the parties committed themselves to the "comprehensive protection of the Antarctic environment, and dependent and associated ecosystems", and designated Antarctica as "a natural reserve devoted to peace and science". The Protocol also states that "the protection of the Antarctic environment and dependent and associated ecosystems....shall be fundamental considerations in the planning and conduct of all activities in the Antarctic Treaty area". As such, the Antarctic Treaty region enjoys an unparalleled level of environmental protection.

The issue of introducing non-native species into the Antarctic was first addressed by the Treaty parties as early as 1964, through the Agreed Measures on the Conservation of Fauna and Flora. The Treaty parties carried over these provisions to the Protocol (Article 4 of Annex II), largely unmodified.

These provisions, however, are largely aimed at intentional introductions of non-native species. The need for Parties to address the issue of unintentional introductions is not explicitly stated in the Protocol, but may be inferred from a number of Articles. For example, Article 3 requires that "activities in the Antarctic Treaty area shall be planned and conducted so as to avoid, *inter alia*, detrimental changes in the distribution, abundance or productivity of species or populations of species of fauna and flora". Annex IV places restrictions on ballast water discharge (though the primary concern is pollutants), and Annex V provides for management plans to specify restrictions on organisms brought into protected areas.

Elsewhere in the ATS, the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) Article II requires its parties to take account of the effects of introduction of alien species, though CCAMLR has yet to give the matter any attention.

Several external international legal instruments have addressed the issue in whole or in part, including the Convention on Biological Diversity (CBD 1992), the UN Convention on the Law of the Sea (UNCLOS 1982), and the Ballast Water Convention (2004, not yet in force). Of these UNCLOS and the Ballast Water Convention apply to Antarctic waters and to vessels operating there. However, despite the fact that the issue is clearly receiving significant international attention it is being dealt with in a highly sectoral way. As a result gaps and inconsistencies exist.

In the Antarctic an opportunity exists to develop a more comprehensive management approach that takes account of both intentional and unintentional introductions, and covers key pathways, species and environments. In this regard the ATS has the advantages of relatively low visitation and vested commercial interests and thus the opportunity to be proactive. The ATS also has decision-making structures in place and the Protocol's high environmental standards. In the first instance effort should be given to developing practical responses, methodologies and guidance. Legal provisions will take time to emerge; though ultimately they will be necessary to demonstrate the serious commitment to the highest environmental standards in the Antarctic.

"Antarctic quarantine management: Australia's framework and practice."

Dr. Tom Maggs and Ms. Sandra Potter

Australian Antarctic Division (AAD) has taken a proactive approach to the issue of quarantine management, and has developed a Quarantine Management System (QMS) that includes the following key components:

1. A "Statement of Principles" underpinned by a certified (ISO 14001) Environmental Management System.
2. An established relationship with national and state quarantine authorities.
3. Legal powers for key personnel and on-site managers.
4. A dedicated cargo facility for loading and unloading vessels.
5. A strong emphasis on training and education.
6. A system of reporting, auditing and review.

The QMS is implemented in a number of ways on key pathways. For ships the system requires:

- Vessel inspections prior to every voyage including: Rat inspections and precautionary baiting; Hull inspections for fouling organisms; and Marine gear and equipment cleaning.
- Ballast water management.

For food the system requires:

- Use of national procedures for the preparation and handling of food.
- A cold chain process.
- Quarantine inspections.
- A ban on high-risk items.
- The use of ozone generators.
- Cleaning of key items in particular potatoes to remove soils.

For general cargo the system requires:

- Adequate cleaning of items.
- Fumigation of dunnage.
- Fumigation of cargo (in particular for Heard and McDonald Island).
- Quarantine inspections.
- Accreditation of the storage yards and buildings.

For personnel and personal cargo the system requires:

- The use of quarantine dogs prior to vessel departure.
- A code of conduct.
- Declarations prior to departure of the vessel.
- Pre-embarkation manual inspections.
- Pre-landing cleaning.

For waste material handling at stations the system requires:

- The treatment of sewage sludge and removal of sludge from Antarctica.
- The incineration of organics and removal of the ash from Antarctica.
- Housekeeping practices such as making food unavailable to local wildlife.
- Restrictions on poultry products away from stations.

AAD also have strict controls in place for their hydroponics unit including annual cleaning procedures, audits and filtering of wastewater. Despite the strict procedures in place AAD have still had several cases of introduced species. In one case, the eradication effort was successful but at a significant cost operationally and financially. AAD's QMS will be further developed to manage the risks associated with inter- and intra-continental flights, and cross-contamination between sites in Antarctica.

"Non-native species in the Antarctic: Tools for risk management and assessment."

Dr. Sue Worner

Risk assessment is based on international standards and a framework that New Zealand follows. The tools developed for risk assessment inform risk management where options for preventing or reducing the risk are considered. There currently exist tools and techniques that enable us to be proactive rather than reactive to alien invasive species. These tools, however, require adequate data.

Tools

1. CLIMEX – *Limitation*: currently does not include Sub-Antarctic Islands nor the area below 60 degrees S, these areas could be added.
2. Principle Component Score Plots – *Limitation*: good weather data and good distributional data required.
3. Other statistical modelling, including CLIMATE, STASH, BIOCLIM, GARP, DOMAIN, HABITAT – *Limitation*: all require sufficient data.
4. Establishment predictions based on ecological informatics and analysis of current global pest species.
5. Geographic Information Systems (GIS) applications.

Issue

All of these tools can be used in the Antarctic context but only when/where there is adequate data available.

“Biosecurity: A New Zealand perspective.”

Mr. Barry O’Neil

Biosecurity: The exclusion, eradication or effective management of risks posed by pests and diseases to the economy, environment and human health.

Biosecurity program has three main components:

1. Prevention, (keeping things out) focuses on pathways involving movement of people, goods and vessels, and natural migration and dispersal.
2. Surveillance, finding things as soon as possible. Surveillance can be Passive (waiting for things to appear) or Targeted (trying to find things as early as possible).
3. Response, Eradication and control. Response options are dependent on feasibility, affordability and desirability.

All parts are underpinned by science, and involve active research programmes, risk analysis, effective regulation, education, audit and enforcement. It is essential to have all three components aligned and working to clear goals.

Antarctica has natural advantage but this won’t be enough to stop invasive species, pests and diseases arriving. Increased human activity equals increased risk.

Way forward

1. Carry out baseline studies.
2. Research is necessary, particularly to develop eradication methods in the marine environment.
3. Identify key risks in advance.
4. Strategic, fully integrated, coordinated approach is needed.

"Non-native species issues challenges of international approach in the Antarctic context."

Dr. Maj De Poorter

All taxonomic groups have produced invasive alien species – and all ecosystems are at risk. Distance and high latitude is not necessarily a barrier or impediment to invasive species and therefore the Antarctic region is not immune.

Increasing human activity in the region increases the risk of unintentional introduction, as does the speed at which we can now travel long distances, including pole-to-pole. Many different actors contribute to the potential pathways and routes – including fisheries, tourism, science, logistics, & recreation.

The vast majority of global alien species do not become invasive, but those that do are one of the main threats to global diversity. It is easier to fight invasiveness if the discovery of the alien species is made early. Therefore, prevention is the key: and if not prevention, early detection and response.

There are numerous *challenges* to preventing introduction of alien species, including:

1. Potential threats not always understood.
2. Size of Antarctic regions (including marine environment).
3. Limited resources.
4. Alien species already in the region.
5. The appropriateness of removal.

Other important considerations include secondary introductions, remembering that the Antarctic region can also be the “donor” region.

Way forward

1. The issue should be considered within the ATS. Antarctic Treaty parties with domestic expertise in alien species issues should continue to lead and set examples.
2. The issue also requires close co-operation with external entities, including, IMO, ICES and the IWC to name a few. The biggest challenge is often one of institutional cooperation.
3. Education that raises awareness. In the context of the ATS, awareness at some levels is growing. Awareness, however, needs to be widespread - all parties within the ATS, other actors and individuals.

The unique values of the Antarctic region require a much lower tolerance for alien species, including those that may not be detrimental to wildlife but may impact other Antarctic values, like intrinsic and scientific value.

Workshop outcomes

Non-native species in the global context

- Invasive alien species (IAS) are contributing significantly to a global biodiversity crisis. For several groups, IAS represent the second or third major threat to their survival.
- In the marine environment, IAS are recognised as the fifth biggest threat to global marine biodiversity.
- Invasive alien species are found in all taxonomic groups, and all ecosystem types are at risk from the impacts of IAS. Isolated and island ecosystems are particularly at risk due to the high degree of endemism found in such communities
- Ongoing increases in global trade and travel are causing an exponential increase in the movement of species outside of their natural range.
- With regards to non-native species, the key lesson from elsewhere in the world is that in view of the complexity of ecological effects, non-native species issues need a preventative and precautionary approach. That is, prevention of introduction must be a priority and we must consider any species "guilty until proven innocent".
- Key components of management are prevention, surveillance and response.
 - **Prevention:** the most effective means of avoiding or minimizing impacts caused by invasive non-native species is to prevent their introduction in the first place.
 - **Surveillance:** this can be passive (i.e. waiting for things to appear in the native environment) or targeted (i.e. an active programme of identifying potential alien species). Good baseline data are required about what is already present in the native fauna and flora.
 - **Response:** the key factor will be to respond quickly and to assess the feasibility, and desirability of eradicating the alien species. If eradication is not an option then control and/or containment needs to be considered.
- To assist with the management of non-native species, a number of risk assessment tools are continuing to be developed. However, such tools require adequate data and are likely to remain inadequate for data poor areas such as the Antarctic.
- A critical component of management is awareness raising at multiple levels to multiple audiences (from decision makers at international and national levels to personnel in the field and crews on ships). This should include awareness raising on the risks posed by non-native species and on the need to prevent their introduction
- No non-native species management programme can be 100% successful. There is a need to focus on the key risks and pathways, to develop a coordinated approach and to ensure adequate research and monitoring is in place.

Non-native species in the Antarctic context

- IAS have already significantly affected the sub-Antarctic islands, with around 200 known alien plants and animals established (Frenot et al., 2005).
- There is a strong correlation between introduced species and human activity on the sub-Antarctic islands with most alien species being of European origin.
- Introductions of non-native species into the Antarctic resulting from human activity far outweigh natural dispersal of species.
- Whilst Antarctica has natural environmental advantages (i.e. remoteness and a harsh climate), these are not enough to stop invasive species, pests and diseases. There are several examples of non-native species occurring in Antarctica. These include:
 - *Poa trivialis* has survived several seasons in Antarctic soils near Syowa station (Japan, 1996);
 - Grasses have been observed in (and removed from) the Larseman Hills (Australia, 1995);
 - The North Atlantic spider crab *Hyas araneus* has been observed in samples taken from the northern Antarctic Peninsula region (Tavares and De Melo, 2004);
 - *Poa annua* has survived several seasons in Antarctic soils and has increased in density around Arctowski station (Olech, 1996).
 - Several invertebrate species survived several seasons in discarded soils in the Schirmacher Oasis (Lewis Smith pers comm.);
- Several marine species that are found in Antarctic waters (notably bryozoans and ascidians) are found elsewhere in the world. It may not be appropriate to assume that marine species found in the Antarctic are native.
- Increased human activity on the continent also risks transferring species across natural biogeographic boundaries with the subsequent breakdown of regional endemism, and genetic distinctness. Antarctica is one of the few areas of the planet where such boundaries and regions still hold. Two examples of high risk areas are:
 - Charcot Island has no springtails (an otherwise ubiquitous species) in its terrestrial ecosystem, which is scientifically highly significant. The introduction of species to Charcot Island would compromise the scientific value of the island.
 - Ellsworth Land nunataks contain the simplest known multitrophic terrestrial ecosystems on the planet comprising only tardigrades and rotifers. The potential for pre-adapted taxa to invade these systems is high with human activity in the region.
- Increased human activity in the Antarctic also means increased ship and aircraft activity. Aircraft pose particular risks by reducing the transport time for alien species from days or weeks to just a few hours (thus increasing the chances of

transport survival). Hull fouling of vessels is likely to be the most significant pathway for marine introductions to the Antarctic.

- Increased links between Antarctica, the Arctic and the sub-Antarctic islands, increases the potential for introductions of species with increased likelihood of survival.
- A changing more benign climate, particularly in the Antarctic Peninsula, is likely to increase the risks of alien species establishing themselves.
- There are significant gaps in our knowledge that will limit our ability to manage the issue in the Antarctic. In the terrestrial environment our understanding is poor for most invertebrates and lower plants, and the microbial community. In the marine environment our understanding of biodiversity and species distribution is extremely patchy.
- There is a pressing need for increased and coordinated survey, monitoring and research across the continent and Southern Ocean.

Practical measures in the Antarctic context: Workshop conclusions & recommended actions

I. Prevention of introductions into the Antarctic (from outside the Antarctic).

- a) Prevention of terrestrial / freshwater introductions of non-native species into the Antarctic area (intentional as well as unintentional):
 - Are there pathways or taxa or situations that are relatively well covered? If yes, what are they?
 - Are there pathways, taxa, situations that are not well covered? If yes, what are they?
 - What are the gaps and how could they be addressed?
 - b) Prevention of marine introductions of non-native species into the Antarctic area (intentional as well as unintentional):
 - Are there pathways or taxa or situations that are relatively well covered? If yes, what are they?
 - Are there pathways, taxa, situations that are not well covered? If yes, what are they?
 - What are the gaps and how could they be addressed?
-
- Priority must be given to prevention of introduction, as it is the first line of defence.
 - Operators show varying levels of recognition and response, and there are wide-ranging differences between the degree of adequacy of coverage for different pathways, different taxa, and different points of origin.
 - Prevention of unintentional introductions of non-native freshwater and terrestrial species is addressed in some programmes, with a focus on boots, clothing, food, cargo, and airplanes as pathways. Other pathways, such as scientific equipment and construction vehicles are much less adequately addressed. Introduction risks associated with micro-organisms are also not very well addressed in general.
 - While hull-fouling, was considered as the most important pathway for marine introductions, ballast water, debris, and waste water (ships or facilities) also have to be considered. In addition, it is likely that there are significant risks of introduction associated with IUU fishing activities.
 - None of the marine pathways are currently adequately addressed. It was recognised that for the marine environment, the state of knowledge on native as well as non-native biodiversity, as well as management options, were several decades "behind" the terrestrial environments. The lack of baseline data is a significant impediment.
 - Introduction risks originating from the Sub-Antarctic are not well addressed in practice, compared to introduction risks from destinations further north.

Recommended actions:

- 1) Encourage universal adoption of best practices and procedures.
- 2) Share information on current practices and procedures, locally and regionally; including sharing of information and cooperation between CEP, CCAMLR, SCAR, COMNAP, IAATO, and others with relevant expertise (e.g. IUCN).
- 3) Increase awareness on the risks posed by non-native species and on the need to prevent their introduction.

II. Prevention of spread within the Antarctic once non-native organisms have arrived.

- a) How can we prevent escape of non-native species out of buildings / other facilities? Is this currently done, or does it need addressing?
 - b) How can we prevent the spread of non-native species already found in the environment? Is this currently done or does it need addressing?
 - c) What should be done if the presence of a non-native species is detected?
 - d) What is the feasibility of early detection & rapid response (removal) of relatively newly arrived non-native organisms, and what are the issues?
- Even in Continental Antarctica non-native organisms have already survived outside buildings and facilities, including invertebrate animals and plants.
 - In practice, prevention of spread is likely to focus on areas in the vicinity of stations/bases and other facilities
 - The lack of baseline data and the lack of expertise in taxonomy make it harder to take appropriate action.

Recommended actions:

- 4) Remove or eradicate non-native species as quickly and effectively as possible; methodologies will be taxa and location specific.
- 5) Consider how the protected areas system can be used as a management tool.
- 6) "Rapid response frameworks" should be compiled and made available: these are collections of reports and expert contacts from programmes and non-Antarctic actors providing ideas on how to respond to an invasion.
- 7) Follow "good neighbour" policies, and share information and feedback with other stations, and regionally.

III. Introduction of species that are native in the Antarctic to other areas in the Antarctic where they are not native.

- a) What are the likely pathways, taxa, situations, geographic areas for such "within Antarctic" introductions?
 - b) How is this currently addressed?
 - c) What are the gaps and how could they be addressed?
- Biogeographic zones within the Antarctic need to be recognised, and cross-contamination between ice free areas including isolated nunataks, or between different marine areas needs to be recognised as a risk to be addressed. Cross contamination can also occur over relatively short distances, for example, between lakes or between wildlife concentrations.
 - Movement of a species that is native in the Antarctic, to another area within the Antarctic where it is not native, is a "non-native species introduction".
 - The major risks occur with any type of human movement. There is a heightened risk with frequent movements, or with successive movements. Pathways of concern include Marine - Circumpolar traffic and transport of simpler life forms via surface traffic and aircraft.

Recommended actions:

- 8) Increase awareness to all operators of the risks of intra-continental movements of species between biogeographic zones in Antarctica and over short distances between, for example, lakes or wildlife concentrations.
- 9) Identify high risk areas for intra-continental introductions so that appropriate management can be developed or consolidated as a priority.
- 10) Require additional types of reporting and information sharing on locations of past and present human activities (especially in isolated areas) and of travel between such areas.
- 11) Consider means to better understand and map vessel movements around Antarctica, such as further development of the vessel monitoring system used by CCAMLR.

IV. Prevention of introduction of Antarctic species into other areas (NORTH of the AT area) where they are not native.

- a) What are the pathways, taxa, situations, geographic areas (marine, terrestrial, freshwater), priorities
 - b) What aspects are addressed by ATS and/or other instruments?
 - c) Are there gaps and how could they be addressed (and what specifically should the ATS do, if anything?)
- Antarctic species may be transported from the Antarctic to the Arctic and other regions outside the Antarctic Treaty Area.
 - Traffic from the Antarctic via the sub-Antarctic may facilitate the transport of sub-Antarctic species to other regions. Moreover, a disease issue on a sub-Antarctic island may impact on the national economy of a country in question.
 - The movement of non-native species from the Antarctic Treaty Area into regions north of the Antarctic Treaty Area is a potential issue for recipient countries rather than the ATS.

Recommended actions:

- 12) Special consideration should be given to potential transfer of species to and from the sub-Antarctic islands and Arctic regions.
- 13) Rapid exchange of information on disease outbreaks or unexplained die-offs must be encouraged.

V. What are the values that require protection?

- a) What are we aiming to achieve? Species extinction, or is there more?
 - b) What is the threat of non-native species to the range of Antarctic values such as ecosystems/communities (as opposed to species level), scientific, intrinsic, wilderness, landscape, spiritual values, other?)
 - c) What are the ramifications of this for prevention and other management?
 - d) How can we increase awareness in decision-makers, scientists, others?
- All introductions of non-native species in the Antarctic, even those that may not be harmful to native biota, detract from Antarctica's scientific and intrinsic values.
 - With regards to Antarctic native biota, protection has to include the preservation of genetic diversity.

Recommended actions:

- 14) Protect, at the highest standard of protection, all the values in Article 3 of the Protocol from non-native species introductions.
- 15) Develop priorities and be pro-active rather than reactive in providing protection.
- 16) Make the highest priority the prevention or minimization of transfer of non-native animals, plants, and micro-organisms associated with human activities.

VI. Legal and institutional issues

- a) How should the legal arm of the ATS address non-native species?
 - b) Are there other international instruments that should/could be applied?
 - c) Because of the cross cutting nature of alien species issues, one of the big challenges globally is interagency co-operation, and cooperation between different international instruments – how would the ATS best do this?
 - d) What aspects of interagency cooperation at national level could be increased (and why)?
 - e) What is the role of NGOs?
- Antarctic Treaty parties have not ignored the issue of non-native species, but provisions, have been largely aimed at intentional introductions of non-native species. The need for parties to address the issue of unintentional introductions is not explicitly stated in the Protocol, though it can be inferred from a number of Articles.
 - CCAMLR requires its parties to take account of the effects of introduction of alien species, though CCAMLR has yet to give the matter any attention.
 - There is a need for understanding of the issues by all stakeholders including policymakers, scientists, tour operators, and national programmes.
 - Management approaches should be adaptive to change and grounded in as much scientific information as available.
 - Formalizing an agreed approach is a progressive, multi-stage process.

Recommended actions:

- 17) Consider making non-native species issues a separate CEP agenda item, as the CEP is well placed to take action and advise on this matter.
- 18) Focus on unintentional introductions.
- 19) Develop new procedures and practices to address the risks associated with non-native species
- 20) Ensure that the issue is adequately addressed through existing procedures and practices as appropriate, e.g. EIA procedures, Protected Area designations and associated management plans.
- 21) Encourage CCAMLR to address the issue in respect of risks associated with fishing vessels and fishing activity.

VII. Science and research

- a) What is the current situation with regards to alien species in Antarctica and monitoring, surveys, research?
 - b) What is the situation with baseline knowledge?
 - c) What do we want to know for “science” purposes?
 - d) What do we want to know for management / conservation purposes?
 - e) Are there priorities for increased efforts? If so, what should they be and who should take responsibility for making it happen?
- There are significant gaps in our knowledge that will limit our ability to manage the issue in the Antarctic. In the terrestrial environment our understanding is poor for most invertebrates and lower plants, and the microbial community. In the marine environment our understanding of biodiversity and species distribution is extremely patchy.
 - Good baseline information should be developed for all taxa and all environments, with special emphasis on closing the gaps in knowledge on microbes and on marine environments. With regards to baseline surveys, however, several marine species that are found in Antarctic waters (notably bryozoans and ascidians) are found elsewhere in the world and it is not appropriate to assume that marine species found in the Antarctic are native.
 - There is a pressing need for increased and coordinated survey, monitoring and research across the continent and Southern Ocean.

Recommended actions:

- 22) Recommend that the following areas be considered research priorities:
 - Sites of high human activity, high value and/or high sensitivity;
 - Pathways, baseline data, and associated risks;
 - Development of taxonomic expertise;
 - Information on micro-organisms (including, but not limited to pathogens);
 - Marine baseline surveys, surveillance, assessment of vectors and pathways.
- 23) Implement increased access to existing information (including "logistics" information).
- 24) Balance research and management requirements.
- 25) Adequately fund the necessary research.

The above recommendations are meant to address issues that are likely to require attention in the very near future, if not presently. However, in the more distant future, it is likely the following considerations will require attention:

- 26) The general increase in human activities in the Antarctic, governmental and non-governmental; including, inter alia, new bases, increasing numbers of tourists, increasing levels of scientific activity and sites, and extension of logistic lines. This increase will most likely be accompanied by new types of technologies which will increase human range across new environments or introduce new threats such as Genetically Modified Organisms (GMOs) and nanoparticles.
- 27) Climate change will increase the number of "colonisation sites" for non-native species.

Conclusion

While the Antarctic continent itself has, so far, escaped the ravages of biological invasion, non-native organisms, including terrestrial invertebrates and plants, and a marine crustacea have been found in the Antarctic Treaty area. Introductions of non-native species into the Antarctic resulting from human activity far outweigh natural dispersal of species.

Increasing travel and transport of goods and people, together with shorter transport times and increasingly direct links between sub-Antarctic and Arctic areas and the Antarctic, increase the likelihood of introductions and risk to Antarctic values. A changing more benign climate, particularly in the Antarctic Peninsula, is likely to exacerbate such risks.

Increased human activity on the continent also risks transferring species across natural biogeographic boundaries with the subsequent breakdown of regional endemism, and genetic distinctness

It is hoped that the outcomes from the Non-native Species in the Antarctic Workshop presented in this Final Report, will contribute to understanding and managing the threat posed by non-native species to the region.

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APPENDIX I: Workshop participants

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APPENDIX II: Workshop agenda

April 10 - Day One: UNDERSTANDING THE THREAT

12:00	Registration\Deposit posters (Commerce Building Foyer)	
12:30	Welcome and introductions (Commerce Building Room 101)	Bryan Storey
12:40	Opening	Hon Jim Anderton, Minister for Biosecurity
12:50	Keynote1: "Invasive species: A global threat to biodiversity."	Mick Clout Chair, IUCN/SSC Invasive Species Specialist Group
1:50	Keynote2: "Biological invasions in the Antarctic: extent, impacts and implications."	Yves Frenot, Deputy Director, IPEV
2.50	Afternoon tea\Posters	
3:15	"The State of Knowledge: non-native species in the Antarctic marine environment."	Chad Hewitt, Macquarie Bank Foundation Chair and Director, National Centre for Marine and Coastal Conservation Australian Maritime College
3:45	"Non-native species in the Antarctic terrestrial environment – presence, sources, impacts and predictions."	Peter Convey, Biological Sciences Division, British Antarctic Survey
4.15	"Legal Tools available for controlling risk and management of non-native species."	Bill Mansfield, Legal consultant
4:45	Discussion	Neil Gilbert (Chair)
5:15	Closing remarks/end of Day 1	Neil Gilbert
5:15- 6:45	Poster session	
7:00	Workshop dinner	

April 11, Day Two: MANAGING THE RISKS & Workgroup Sessions

8:30	Poster Session\coffee & tea	
9:00	Welcome & recap (Commerce Building Room 101)	Bryan Storey
9:10	"Antarctic quarantine management: Australia's framework and practice."	Tom Maggs, Environmental Manager, Australian Antarctic Division
9:40	" Tools for risk management and assessment."	Sue Worner Project Leader, Biosecurity Centre, Lincoln University
10:10	"Biosecurity: A New Zealand Perspective"	Barry O'Neill Biosecurity NZ
10.30	"Non-native Species Issues Challenges of International Approach in the Antarctic context."	Maj de Poorter, Centre for Biodiversity and Biosecurity, University of Auckland
11:00	Instructions for working groups / Key questions	Neil Gilbert
11.15	Working groups	Assigned Facilitators
12:30	LUNCH\posters	
1:30	Working groups	Assigned Facilitators
	Afternoon tea served to working groups/rooms	
5:30	Close	

April 12, Day 3: Workgroups & REPORT BACK

8:30	Working Groups (preparation of reports) (Assigned rooms)	
11.00	Report back from working group 1 (20 minutes + 10 for questions) (Commerce Building, Room 101)	Neil Gilbert
11:30	Report back from working group 2	
12:00	Report back from working group 3	
12.30	Summary of key points from workshop as a whole	
12:40	Closing remarks, where to from here.	Bryan Storey
12:50	End of Workshop	
	Posters available to view until 3pm	

APPENDIX III: Survey responses

The survey consisted of six questions, presented in bold text. Responses were received from six national Antarctic programmes: USA, Peru, Australia, UK, Germany and New Zealand.

- 1. Has your national programme intentionally (i.e. under permit) imported non-native species to Antarctica within the last three to five years? If so, please provide details of the species concerned and the purposes for importing the species.**

Respondents indicated that permitted importations occur for two principle reasons:

- scientific research (e.g. species of phytoplankton, bacteria for food in lab research involving zooplankton or invertebrate larvae and Inactive bacteria fixed on polyester foil for UV-B dosimetry, and Ecoli bacteria for culturing nematodes), and
- food (e.g. various vegetable and herb seeds to be grown hydroponically for food)

- 2. Have you experienced a case where non-permitted, non-native species have been found in Antarctica?**

Responses suggested that there were varying levels of monitoring undertaken in order to identify inadvertent introductions. Some national programmes reported a large number of discoveries others indicated that they had not observed any non-permitted species.

Those programmes that had monitoring in place reported a large number of observed species over several decades of monitoring, including:

- Beetles including *Lathridius nodifer*, *Ptinus tectus*, *Silophilus zeamais*, *Cryphalus* sp., *Rhizophora dominica* and *Aridux nodifer*; mites including *Haemogamasus pontiger*; flies including *Lycoriella ingenua*, *Musca domestica*, *Drosophila* sp., *Megaselia scalaris*; spiders including Amauribidae and *Delina* sp.; springtails including *Lepidocyrtus pallidus*; thrips, *Thrips tabaci*; tramp ants, *Technomyrmex albipes*; weedy herbs, mosses cf. *Funaria hygrometrica* and *Bryum* sp.; and unidentified earwigs, moths, weevils, snails, slugs, bees, wasps, crickets, cockroaches, ants, worms, frogs, ladybirds, fungi, alga and seeds, and butterflies. Most species were found associated with cargo and food supplies.
- Two non-native grass species had been discovered in the vicinity of the Chinese Great Wall Station on King-George Island. These grasses grew at three locations and were already flowering.
- On Deception Island there occur 4 species of marine macro algae which had previously been known to be restricted to the cold-temperate zone (CLAYTON, M.N, &WIENCKE,C. & KLÖSER H. (1997): *New records of temperate and sub-Antarctic marine benthic macroalgae from Antarctica*. - Polar Biology 17: 141-149).

3. Has your national programme undertaken an assessment of the risks posed by the introduction of species through its operations?

Half of the respondents indicated that they had not formally undertaken any form of risk assessment. The remaining half indicated varying degrees of risk assessment focussing on the risk of introduction rather than of possible impacts. Assessments have largely been focussed on specific activities (e.g. hydroponics) and campaigns rather than species, with the exception of one assessment on risks associated with rats.

4. Do you have standard practices in place to guard against the unintentional introduction of non-native species? (e.g. guidelines, code of conduct, etc)

Only one respondent indicated that they currently had no practices in place. Practices in place among the remaining respondents varied from guidance for programme participants through to quite extensive controls, such as: stores procedures, voyage leader briefs, expeditioner handbooks, response plans, inter-agency memoranda, supplier contracts, environmental purchasing instructions, vessel charters, an environmental code of conduct and environmental management system documentation.

One respondent indicated that they had a biosecurity policy in place, though this was largely focussed on poultry products.

One respondent indicated that they had procedures in place to deal with rats and marine organisms in ballast water.

One respondent indicated that they had laws in place to enforce IAATO's Boot and Clothing Decontamination Guidelines and Introduction and Detection of Diseases for their IAATO members.

5. Do you have standard practices in place to respond, if a non-permitted, non-native species is discovered?

Only half of the respondents indicated that they have practices in place to deal with such species, though these varied significantly in how comprehensive they were.

One respondent noted that they have significant practices in place including: a web-interfaced incident reporting system, collection kits provided including preserving agents and bar-coded labels for sample tracking. This programme also indicated that instructions are provided to program personnel on actions to be undertaken if sick or dead animals are discovered in high numbers or with signs that suggest disease.

Another respondent programme indicated that they have a rats contingency plan in place for sub-Antarctic Islands and that further response procedures for other species are under development.

6. Has your national programme conducted (or is it conducting) any research on the issue of introduced species?

Responses indicated varying degrees of research effort from none to intense effort. Australia provided the following list of research projects:

Chief Investigator	Project title (and reference number)
D. Bergstrom	Regional Sensitivity to Climate Change in Antarctic Terrestrial Ecosystems (RiSCC): The Subantarctic Region (1015)
P. Cooper	Introduced collembola from sub Antarctic islands (1043)
G. Copson	The impact of introduced ship rats (<i>Rattus rattus</i>) on burrow-nesting seabirds on sub-Antarctic Macquarie (2281)
C. Crossley	Insect migration and monitoring studies on Macquarie Island (999)
L. Kerry	Indigenous and introduced fungi in the Vestfold Hills region, Antarctica – their physiological and nutritional characteristics and role in the Antarctic ecosystem (377)
M. Lawson	Prevalence of viruses and parasites in populations of house mice on Macquarie Island (1183)
M. Line	Assessment of the potential for microbial contamination of Antarctic terrestrial habitats resulting from human activities (1093/870)
T. McMeekin	Survival of faecal bacteria in the Antarctic environment (134)
A. McMinn	Assessing the hazard of non-indigenous marine species in the subantarctic islands and Antarctica (2356)
A. Richardson	Effect of two introduced invertebrates on litter decomposition rates on Macquarie Island (962)
J. Scott	Effects of feral rabbits, native fauna and humans on vegetation and soil stability, Macquarie Island (76)
G. Shellam	Investigations of bacterial, viral and parasitic infections in Antarctic penguins, and the development of a standardised monitoring scheme (953)
G. Shellam	South polar skuas as vectors of disease (1336)
R. Simpson	Assessment of the impact of human sewage effluent on benthic communities at Macquarie Island (996)
M. Stoddart	The impact of feral house mice on Macquarie Island ecosystems (179)
P. Sunnucks	Introduced invasive terrestrial invertebrates on Macquarie Island (2397/2355)
R. Swain	Population structure, ecological impacts and management of feral rats on Macquarie Island (873)
J. Whinam	The potential and actual threats of introduced organisms to sub-Antarctic islands (1187)

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APPENDIX IV: Poster abstracts

1. Accidental transport of noctuid moths to Southern Ocean islands

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Many islands around or in the Southern Ocean have few or no non-indigenous species (NIS), being protected to some degree by isolation. We report here an instance of noctuid moths being carried accidentally on a research vessel from Montevideo (Uruguay) first to the Falkland Islands and, eventually, to Signy Island in the Scotia Arc (maritime Antarctic). In late October 2004 we found 38 specimens (of which eight were alive) of *Pseudaletia adultera* Schaus around an external light source when the vessel arrived in the Falkland Islands. There were also three dead individuals of a second noctuid, *Peridroma saucia* (Hübner). We can assume that the moths were attracted to the ship's lights when in the port of Montevideo, as neither species occurs naturally in the Falkland Islands and both are well-known agricultural pest species in Argentina and Uruguay. Five *P. adultera* individuals survived throughout the 4 day period of the ship being in the Falkland Islands, and one then survived a further 4 day Antarctic voyage to Signy Island before expiring.

There are many potential natural and anthropogenic vectors for the import of alien species into the Antarctic, amongst which shipping is amongst the most influential, and a number of reports have highlighted the threat and vulnerability of Southern Ocean islands to NIS invasion. Unlike elsewhere in the world, Antarctic shipping movements are increasing and, with this, the threat of introductions. Our observations highlight the urgent need for measures to be adopted to reduce risks of NIS spread.

2. Decontaminating Boots of Visitors to the Antarctic

C Curry, L Gillespie, J McCarthy, H Darragh, R Wake, R Todhunter, J Terris, S Churchill, A Robins, & R Lowen

Introduction: A study undertaken on two tourist visits to penguin colonies in the Ross Sea in 2001 demonstrated that practices for cleaning boots of visitors to Antarctic wildlife colonies may not be sufficient to prevent the transmission of pathogens. A better method of decontamination was required (1). Studies undertaken in 2002 and 2004 demonstrated the effectiveness of a disinfectant (Virkon® S, Dupont/Antec). It was recommended that disinfection be included in cleaning boots of visitors to wildlife sites (2).

Objective: This third investigation assessed the effectiveness of boot disinfection by tourists visiting sub-Antarctic and Antarctic penguin colonies under the standard operating procedures of a tourist ship, which involved a boot wash in disinfectant alone.

Method: Boots of visitors to Macquarie Island Nature Reserve and to Cape Adare were swabbed after a seawater wash or a disinfectant wash (Virkon® S). Swabs were cultured for potentially pathogenic bacteria and viruses previously associated with Antarctic penguins.

Results: Growths of bacteria were substantially greater from Macquarie Island compared to the Antarctic continent. The disinfectant wash reduced growth significantly but there remained substantial contamination. From Cape Adare bacterial growth was less and the effect of the disinfectant reduced. No pathogens were identified.

Conclusion: While washing in disinfectant alone reduces the risk of biological translocations, decontamination is incomplete, particularly where contamination is heavy. Tour operators need to use a more rigorous procedure in which boots are scrubbed clean before they are disinfected.

1. *J Travel Med* 2002; 9: 190-193.
2. *Polar Record* 2005; 41(216): 39-45

3. Unintentional transfer of alien soil species into Antarctica on construction vehicles

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Soil contaminated construction vehicles were transported to Rothera Research Station (Antarctic Peninsula). A diverse range of non-native species were unintentionally introduced with the soil, many in a viable state. Steps have been taken to reduce the likelihood of this reoccurring.

4. Aliens on ice: marine biosecurity in the Southern Ocean

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Invasive species are recognised as one of the primary threats to global biodiversity. Even the remote islands of the Southern Ocean now play host to over 200 species of alien plants and animals. Despite the efforts aimed at managing terrestrial introductions in this region, this study represents the first investigation into the extent to which marine environments are also affected by alien species. To describe this hazard I have explored a number of stages in a successful introduction pathway. Hull fouling is identified as the highest risk vector for the transport of marine organisms and fouling communities are shown to be capable of surviving voyages within the Southern Hemisphere. Future trends in global warming, and an increase in human traffic to the region are likely to result in an accelerating risk of non-native species introductions in high-latitude coastlines.

5. Quarantine Facility Processes

Australian Antarctic Division

Sound housekeeping practices, staff training, and a third-party inspection program by a recognised quarantine service are integral to Australia's efforts to prevent or minimise introductions to Antarctica associated with the delivery of materials in support of Australia's Antarctic program. The Australian Antarctic Division's cargo facility is located at Macquarie No. 4 Wharf in Hobart, Tasmania. The site is accredited by Australia's national quarantine authority, the Australian Quarantine and Inspection Service, and audited against prescribed sanitary, administration and security standards. Cargo handling, inspections and cleaning processes are outlined.

6. Australian Antarctic Division Quarantine Management

Australian Antarctic Division

The movement of aircraft, vessels, personnel, support cargo and research equipment between Australia, Antarctica, the sub-Antarctic and Southern Ocean creates a risk of transferring animals, plants, micro-organisms and materials of quarantine concern. The Australian Antarctic Division is committed to conducting and administering activities in a way that will prevent or minimise such risks, consistent with the environmental principles of the Protocol on Environmental Protection to the Antarctic Treaty. The quarantine management principles underpinning Australia's efforts to prevent or minimise introductions are outlined.

7. Operation Fly Eradication

Australian Antarctic Division

A small mushroom gnat, *Lycoriella ingenua*, established a population at the Australian Antarctic station Casey, for at least six years. The flies probably arrived at Casey in 1998 as eggs or larvae on vegetable produce, and were washed down the kitchen sink into the waste water holding tanks where they set up home. The eradication of the flies was a major station activity. The processes involved are outlined.

8. Quarantine Incident Response

Australian Antarctic Division

The Australian Antarctic Division has developed (i) alien invertebrate collection kits for the opportunistic collection of introduced species, and (ii) unusual animal mortality response kits containing the equipment necessary to record an event, undertake post-mortem examination and prepare samples for transport and subsequent analysis. The contents of the kits are outlined.

9. No Unwanted Passengers

Australian Antarctic Division

The Australia-Antarctic Airlink will provide intercontinental services between Hobart and Antarctica and intra-continental flights linking each Australian Antarctic station and remote field locations. Existing quarantine measures will be applied to the air transport system. However, some specific measures will need to be developed and incorporated into an environmental management plan for all aircraft operations within Australian Antarctic Territory.