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Report on greatest risk of non-native species entering Antarctica, plans of identification and eradication for Postgraduate Certificate in Antarctic Studies.

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Abstract:

The introduction of non-native species is now recognized as one of the most significant threats to biodiversity worldwide, posing both a threat to individual species existence and being responsible for major changes to ecosystem structure and functioning. Antarctic terrestrial

ecosystems are particularly vulnerable to non-native species as generally its own community structures are simple, species richness is low and the native biota have life history strategies that may limit their capacity to compete with introduced species. Assess current response plan for several Antarctic Programmes on scientific basis for the prevention of introduced non-native species compared to that of International Association of Antarctica Tour Operators (IAATO).

With the Antarctic Treaty area is now covered by the Protocol on Environmental Protection to the Antarctic Treaty which came into force in 1998, this report will point out the mixed reviews that this legislation has received.

Table of Contents

Title

Report on greatest risk of non-native species entering Antarctica, plans of identification and eradication for Postgraduate Certificate in Antarctic Studies.

Introduction

Non-native (exotic) species are those that do not naturally occur in an area and have been introduced either intentionally (such as gorse to New Zealand) or unintentionally, that can lead to domination of habitats and alteration to the ecosystems through a decreased abundance of native species and potentially their extinction. It has been discovered that a wide range of non-native species now occur in Antarctica, highlighting the importance of stringent codes of conduct. This report will investigate primarily the modes of transport to Antarctica that pose the greatest threat of introduction of non-native species to the Antarctic and surrounding waters, and how countries, including New Zealand, attempt to prevent such introductions to Antarctica. It also addresses their methods of identification and eradication of these species and the effectiveness of their current codes of conduct.

Background

<u>Terrestrial Native Species of Antarctica</u>

Antarctic terrestrial biological ecosystems comprise primary low biodiversity, which is dominated by lichens, mosses, liverworts, micro-invertebrates, and microorganisms (Hughes et al. 2010b). Antarctic terrestrial ecosystems are particularly vulnerable to non-native species as generally their community structures are simple, species richness is low and the native biota have life history strategies that may limit their capacity to compete with that of introduced biota (Hughes et al. 2010). Such ecosystems are largely found in areas that are ice-free, but which comprise only 0.34% of the Antarctic continent, where trees and most other vascular plant species are absent, with only two flowering plant species; the grass (*Deschampsia antarctica*) and the cushion plant (*Colobanthus quitensis*) present (Hughes & Convey, 2014). Most of the biota of these ice-free areas comprise cryptogams and microscopic life-forms.

Non-Native Species

Invasion and ecological alterations by non-native species are among the primary causes of biodiversity change globally, with the risks being understood in most regions of the world. The greatest risk comes from invasive non-native species which occur in all taxonomic groups where habitats and environments match those in Antarctica (Rogan-Finnemore, 2008), and are similarly thought to be among the most significant conservation threats, especially as climate change proceeds in the region (Committee for Environmental Protection, 2011; Chown et al. 2012; Hughes & Convey, 2010; Hughes & Convey, 2014).

The Sub-Antarctic Islands have already had visible signs of increased numbers of aggressive non-native species colonizing with impacts on their ecosystems (Committee for Environmental Protection, 2011). It is considered that these present a major threat in terms of the native biodiversity in all biomes, and that when non-native species become established, they will displace native species, thus having the potential to change irreversible the existing frail ecosystems, and that this also applies to Antarctica itself (Committee for Environmental Protection, 2011; Hughes et al. 2010b; Hughes & Convey, 2014). Translocation of non-native species by humans has been recognized as an important and significant threat to global biodiversity (Lee & Chown, 2009b).

There is also the risk of genetic contamination of biogeographic zones by cross-contamination between ice-free areas, nunataks, or between different marine areas within the Antarctic Treaty area (Committee for Environmental Protection, 2011). The areas most at risk though human visitation are mainly the northern Antarctic Peninsula and its off shore islands (Hughes & Convey, 2014).

History of Human Interactions with Antarctica

Due to Antarctica's isolation, it wasn't until 7th of February 1821 that the first known landing on the continent by US Capt. John Davis was achieved, leading onto the first scientist; James Eights to visit Antarctica with the pioneering expedition in 1828-1830 led by Benjamin Pendleton (Worldmark Encyclopedia of Nations, 2007).

The International Geophysical Year of 1957-58 saw a major achievement in providing an opportunity for wide scale international co-operation in physical sciences in Antarctica and lead to an international treaty which set aside the continent for peace and science (National Science Foundation, 2009). Articles II and III (Appendix 1) of the Antarctic Treaty System (ATS) (1959) laid out the principles of freedom of scientific investigation, international co-operation and the free availability of results and data, which came into force in 1961 (National Science Foundation, 2009). It was initially seen that many of the participating nations in the ATS validated their presence in Antarctica by taking meteorological measurements as a means to be observed as 'doing science'. As early as 1964 the ATS recognized the importance of non-native species effects in Antarctica's environment, when they implemented the Agreed Measures for the Conservation of Antarctic Fauna and Flora (Rogan-Finnemore, 2008; U.S. Antarctic Program, 2014).

Legal Instrument for the Protection of Antarctica's Environment

The desire to supplement the ATS and provide protection of Antarctic's unique environment within the Antarctic Treaty area is now covered by the Protocol on Environmental Protection to the Antarctic Treaty (commonly referred to Environmental Protocol or Madrid Protocol) which was agreed in 1991 and came into force in 1998 (British Antarctic Survey, 2015). This has become the main legal instrument for the ATS, however with the conditions set out by the ATS, although all Consultative Parties have agreed and it came into force after ratification in 1998, there are still 15 non-consultative Parties of the 21 still to yet to sign it (British Antarctic Survey, 2015).

Guidance Measures Against Non-Native Species in Antarctica

Antarctica New Zealand gives every person prior to leaving New Zealand for Antarctica a pamphlet on 'Environmental code of conduct' (Appendix 2) which stipulates rules to be observed and practiced in Antarctica. Other research stations in Antarctica also provide pamphlets to visitors, for example the U.S. Antarctic Program provides their travel and deployment personnel with a PackaPest brochure outlining the dangers from non-native species and how to prevent them entering Antarctica.

During April 2006, Gateway Antarctica, The Centre for Antarctic Research and Studies at the University of Canterbury held a three-day international workshop to discuss issues surrounding "Non-native Species in the Antarctic Region" (De Poorter et al. 2006). Outcomes from this workshop included the threat to the marine environment globally, the increase in global trade and travel causing exponential increases in the movement of species. For the prevention of the introduction of non-native species to be a priority, surveillance either in a passive way, i.e. waiting for species to appear in the native environment, or targeted, i.e. an active programme of identifying potential non-native species, are used. The key factor, is to rapidly assess the feasibility of eradication of the species, or the use of control and/or containment (De Poorter et al. 2006). Eradication of aggressive non-native species can be extremely expensive, and is often not accomplished once species have become established and spread widely (Hughes et al. 2010). Prevention of incursion is the front line of defence, and is seen to be the most cost effective approach in protecting biodiversity and other values (Rogan-Finnemore, 2008).

The Non-Native Species Manual, 2011 was conceived by the Committee for Environmental Protection (CEP), Secretariat of the Antarctic Treaty to address risks posed by non-native species by accidental or unintentional introductions, under the banner:

> To conserve Antarctic biodiversity and intrinsic values by preventing the unintended introduction to the Antarctic region of species not native to that region, and the movement of species within Antarctica from one biogeographic zone to any other.

This preventing of unintended introductions is seen to be an ambitious goal, even by CEP, and they stress that to be consistent with the principles of Annex 11 to the Protocol, measures should be in place to minimize risk of impacts from non-native species introduced into Antarctica (Committee for Environmental Protection, 2011).

An extract from Committee for Environmental Protection reads;

The 2010 Antarctic Treaty Meeting of Experts on Implications of Climate Change for Antarctic Management emphasised the importance of preventing introductions, identifying species and environments at risk and developing measures to manage the issue (Committee for Environmental Protection, 2011). The meeting:

- Acknowledged that the greatest effort should be placed on preventing the introduction of non-native species, and on minimising the risk of human assisted introductions through national programmes and tourism activities.

It stressed the importance of ensuring comprehensive implementation of new measures to address this risk (Para. 111, Co-chair's report).

- Recommended that the CEP 'consider using established methods of identifying a) Antarctic environments at high risk from establishment by non-natives and b) non-native species that present a high risk of establishment in Antarctica' (Recommendation 22).
- Recommended that Parties be encouraged to comprehensively and consistently implement management measures to respond to the environmental implications of climate change, particularly measures to avoid introduction and translocation of non-native species, and to report on their effectiveness (Recommendation 23).

It is also now seen that data collection to determine a good baseline on native fauna and flora is important to support monitoring effects on non-native species in the Antarctic Treaty area (Committee for Environmental Protection, 2011). Indeed, with many of the life-forms being small or microscopic, there are taxonomic issues that need to be resolved in the form of a catalogue of the Antarctic biota.

Protection of Antarctic Terrestrial Ecosystems from Iter- and Intra-Continental Transfers

Hughes and Convey (2010) state that the Antarctic Treaty Parties have not addressed the redistribution of indigenous Antarctic species between biologically distinct areas within the continent (Hughes & Convey, 2010). Similarly the Protocol on Environmental Protection declares nothing specifically about human-mediated transfer of these native species from one area to another within the Antarctic Treaty area (Hughes & Convey, 2010). Table 1 explains their findings, with support to their claim that there is no effective protection to conserve existing biological assemblages within Antarctica, other than policies.

Table 1: Dispersal of native and non-native species by natural and human-mediated transfer (Hughes & Convey, 2010)

	Species origin and distribution in Antarctica		
	Native Antarctic species—cosmopolitan distribution across Antarctica	Native Antarctic species—restricted distribution within Antarctica	Non-native species—human-mediated initial introduction into Antarctica
Means of species dispersal around Antarctica			
Natural dispersal	Natural increase in genetic variability within the Antarctic population (may be accelerated by climate change)	Natural colonisation process and range expansion (may be accelerated by climate change) E.g. the Antarctic flowering plants, *Deschampsia antarctica and Colobanthus quitensis* have increased in population numbers and extents in the last 40–50 years within the Antarctic Peninsula (Fowbert and Smith, 1994; Grobe et al., 1997)	Expansion in population distribution by natural means (may be accelerated by climate change) E.g. potential expansion in the range of the non-native *Poa annua* grass from Arctowski Station to other parts of King George Island and beyond (Chwedorzewska, 2008)
Human-mediated dispersal	Homogenisation of genetically distinct sub-populations of a native species. E.g. transfer of the alga *Prasiola crispa* from Signy Island to Marguerite Bay on outdoor clothing.	Potentially rapid increase in dispersal range around Antarctic and homogenisation of Antarctic biodiversity. Potentially negative consequences for ecosystem function. E.g. introduction of springtails to Marion Nunataks, Charcot Island, where this faunal group is absent. E.g. accidental transfer of the algae *Stigonema ocellatum* and *Chlorella* cf. *reniformis* from Mt Melbourne to thermally heated ground on Mt Erebus or Deception Island.	Rapid increase in dispersal range around Antarctica E.g. potential accidental transfer of non-native *Eretmoptera murphyi* flightless midge from South Georgia or Signy Island to the Antarctic Peninsula on soil attached to cargo. E.g. potential expansion in the range of the non-native *Poa annua* grass from Arctowski Station to other parts of King George Island on soil attached to footwear.

Determinations of what comprises non-native and native species in Antarctica

Hughes and Convey (2012) state that there is a dilemma for scientists and environmental managers in determining whether a species is of native or non-native status due to a poor baseline knowledge of Antarctic biodiversity, and a newly discovered species which could be either of: (a) a previously undiscovered long-term native species, (b) a recent natural colonist or (c) a human-mediated introduction. The Protocol on Environmental Protection to the Antarctic Treaty dictates noticeably different management responses depending on native/non-native status: native species and recent natural colonists should be protected and conserved, while non-native introductions should be eradicated or controlled, making the correct diagnosis crucial (Hughes & Convey, 2012).

Pathways for Introductions of Non-Native Species to Antarctica

The isolation of Antarctica coupled with its harsh climatic conditions is no longer seen to be enough to protect it from non-native species invasions with visitor numbers from tourists and science personnel, increasing almost exponentially with c. 700,000 person days ashore in the region each year in 2009 reported by Jabour (Hughes et al. 2011). There are now over 75 Antarctic research stations that are generally occupied year-round (Hughes & Convey, 2014). The chosen areas for both tourism and research stations is predominately on ice free ground,

sheltered from strong winds and are coastal, favouring not only human habitation, but also the establishment of non-native species (Hughes et al. 2011).

That coupled with these same areas being affected by rapid climate change, makes establishment of non-native species especially in the northern and western Antarctic Peninsula increasingly likely. With a projected temperature warming of up of 0.5^{o}C per decade (Hughes et al. 2011), the likelihood of successful incursions increases. New local environmental conditions make the establishment of non-native species through both natural and anthropogenic mechanisms even more credible (Hughes et al. 2011). The concern now lies with the combination of accelerating climate change and the rapidly growing scope and extent of scientific and tourist activities leading to substantial environmental degradation on the Antarctic Treaty area (Chown et al. 2012).

The pathways and vectors for introductions are well known now with global experience and involves various direct visitor introductions for terrestrial species, the use of vehicles, research station construction materials, supplies and food (Huiskes et al. 2014)

Food as a Pathway for the Introduction of Non-Native Species

Where humans live or work, food is necessary, and in Antarctica this is often in the form of fresh produce such as fruit and vegetables. These potentially carry a high risk for non-native species introductions to Antarctica.

Hughes et al (date) investigated the risk fresh produce posed on the Antarctic environment by examining research stations located in the Antarctic and sub-Antarctic or at pre-departure ports associated with the UK, Australian, South African, French and Japanese Antarctic research programmes. They found that 12% of all items surveyed contained at least small amounts of soil (Table 2) which could contain over a billion bacteria, more than 56 invertebrates from a range of taxa, including flying insects with fresh food being sent to a British Antarctic Survey's (BAS), Rothera Research Station by either ship or air freight, and that approximately 28% had visible microbial infection. Also, 19 different species of fungi were detected (Hughes et al. 2011).

Table 2: Soil and macro-invertebrate importation into the Antarctic region on fresh foods

Nation	Station	No. of fresh foods types examined	No./weight of food items checked	Soil present on food items			Macro-invertebrates found on checked food items (No. and status) [a]
				No soil (0 g)	Some (c. 0–1 g)	Much (>1 g)	
United Kingdom	Rothera Research Station	37	3608	83.4%	16.6%	0%	Total: 12. Slug (1: alive), earwigs (2: alive), spiders (3: 1 dead, 2 alive), snails (2: alive), weevil (1: dead), flies (2: alive), beetle (1: alive)
South Africa	SANAE IV	19	1430	95.2%	4.5%	0.3%	None recorded
France	Port-aux-Français,	31	1965	88.6%	11.3%	0.1%	Total: 12+. Butterfly (2), caterpillar (3), snails (2), spider (1), slug (1), weevil (1), flies (2: dead), numerous aphids on lettuce, numerous scale insects on pineapples
	Martin de Viviès,	32	2153	85.2%	14.8%	<0.1%	Total: 17+. Earwigs (2: alive), butterfly (1: dead), caterpillars (11: alive), flies (2: dead), fly larva (1), numerous scale insects on pineapples
Australia[b]	All stations	25	2094	89.1%	10.9%	0%	Total: 15. Including: thrips (alive), white flies (2: alive), caterpillar (1)
Japan	Syowa	17	241 kg	85.5%	12.4%	2.1%	None recorded
Mean (±SD)				87.8% (±4.2)	11.8% (±4.2)	0.4% (±0.8)	

These findings lead onto a greater understanding that biosecurity risks posed by the importation of fresh produce, storage, transportation and disposal of fresh food waste in the Antarctic Treaty area are considerable. The greatest concern around the identified fungi that have the potential due to their conidial ascomycetes nature, to liberate air borne asexual spores creating a high probability of subsequent dispersion into the environment (Hughes et al. 2011). A further concern is that with cold storage, the fungi could have arrived in Antarctic 'pre-selected' for low temperature tolerance, and with the microbial strains detected could present an impact on the existing microbial community's structure and may cause disease in Antarctic's own native plants and invertebrates. Another concern with the microbial strains is that lateral gene transfer can lead to 'genetic pollution' of native microbial strains of Antarctica (Hughes et al. 2011).

New Zealand's own Scott Base, has also not been immune to incursions of non-native species, where a species of the Mediterranean Flour Moth (*Ephestia kuehniella*) arrived, necessitating its identification and eradication. That was achieved by moving the contaminated pallet outside, thereby freezing any living moths, the bagging of all flour bags and returning them back to New Zealand for disposal by sterilization and deep burial. Further preventative measures have been put in place with the impending refurbishment of Hillary Field Centre for the storing of dry goods outside over the winter months to reduce the re-infestation of any moth eggs which may have been laid (Antarctica New Zealand, 2015).

<u>Vehicles used for Construction as a Pathway for the Introduction of Non-Native Species</u>

An incident of a significant contravention to BAS operating procedures, the UK Antarctic Act (1994), and the Protocol on Environmental Protection to the Antarctic Treaty (1998), occurred at Rothera Research Station In December 2005 (Hughes et al. 2010b). This incident consisted of contractors importing four contaminated construction vehicles (Figure 1) from the Falkland Islands and South Georgia in the South Atlantic with soil weighing more than 132 kg from these areas being adhered to the wheels, body and tracks on landing in Antarctica (Hughes et al. 2010b).

Figure 1: An example of an imported construction vehicle at Rothera Research Station (Hughes et al. 2010b)

The discovery of this soil (Figure 2) resulted in immediate action to remove it from Antarctica. The soil was examined for micobiological, microarthropods, meiofauna, seeds, moss fragments, and intact plant specimen content, and tested positive for presence of all on disposal. The germination trials under simulated Antarctic temperate conditions for summer resulted in a single grass shoot (*Holcus lanatus*) emerging and seeds estimated to be c. 40,000, with c. 4,500 being viable (Hughes et al. 2010b). Results from these examinations of the soil verified that species from a broad range of biological groups can be readily transported into Antarctica and remain viable in soil (Hughes et al. 2010b).

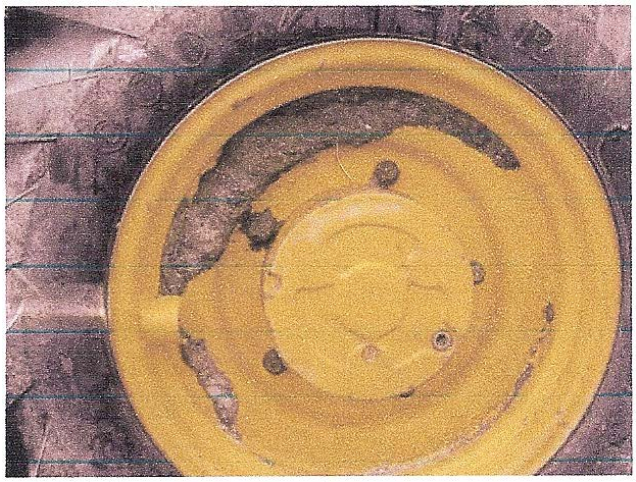

Figure 2: Soil attached to the wheel of construction vehicle (Hughes et al. 2010b)

Shipping Vessels as a Pathway for the Introduction of Non-Native Species

There is also a major threat to biodiversity through the introduction of non-native species into the marine environment via shipping activities by commercial fisheries, research facilities and tourism in the Antarctic Treaty area (Lee & Chown, 2009). Worldwide, the ecological and economic impacts from introduced species via ballast water brought about substantial legislation being used to reduce the flow through exchange between different bodies of sea (Lee & Chown, 2009). This discharge of ballast water is now prevented by the Antarctic Treaty which was updated in the ATCM Resolution 3 in 2006, reducing concern in regard to establishment of non-native species to Antarctica (Lee & Chown, 2009). However, Lee & Chrown (2009) state that there have been several documented cases of species normally found in temperate regions surviving in the colder Antarctic waters.

Hull-fouling is another mechanism which may facilitate the introduction of non-native species into Antarctic waters. Between August 2006 and May 2008, of 12 hull surveys were undertaken using the SA 'Agulhas', a flat-bottomed, ice-strengthened cargo vessel (Lee & Chown, 2009). Initially the most abundant types of biota comprised a fine, filamentous algae (Table 3), and through successional processes by December 2006 these were replaced with macro-algae and macro-fauna. It was noted when the ship passed through sea-ice in December 2007, the stripping of this later successional stage was replaced again with fine filamentous algae, so this in itself presents a biosecurity threat. With the reduction of sea ice in recent years especially in the

northern Antarctic Peninsula the risk of exposing marine communities has increased te chances for establishment of invasive non-native species in that region of Antarctica (Lee & Chown, 2009).

Table 3: Description of fouling classes, with taxa identification on the hull of the SA 'Agulhas' (Lee & Chown, 2009)

Class	Taxa
Biofilms	Slime Fine algae
Filamentous algae	*Ceramium* sp. (Rhodophyta) *Ectocarpus siliculosus* (Phaeophyta)
Macroalgae	*Ulva* sp. (Chlorophyta) *Enteromorpha intestinalis* (Chlorophyta) *Grateloupia filicina* (Rhodophyta)
Macrofauna	*Ciona intestinalis* (Ascidiacea) *Obelia dichotoma* (Hydrozoa) *Lepas* sp. (Cirripedia)

The study by Lee & Chown (2009), indicated that the risk of introducing non-native species could be minimized by having more frequent dry dockings for damaged anti-fouling paint on the hull which lowers the propagule pressure and by changing the dry docking to immediately after ship returns from Antarctica, which will enable a full biosecurity assessment. Another mitigation tacit is the in-water cleaning of ships prior to departure to locations most at risk from introduction of non-native species which not only reduces the biosecurity risk by can also be seen as a cost-effective strategy (Lee & Chown, 2009).

Tourism as a Pathway for the Introduction of Non-Native Species Compared to Science Programmes

In the prevention of tourists (Figure 3) having a negative impact on the environment, Antarctic tour operators established the IAATO (International Association of Antarctica Tour Operators) as early as 1991, where it developed guidelines for the safe and responsible conduct which was latter modified by the Antarctic Treaty Parties, and now provides the "Guidance for Visitors to the Antarctic and the Guidance for Those Organizing and Conducting Tourism and Non-

Governmental Activities in Antarctic." (McGonigal, 2008). This was an important step in the prevention of non-native species incursions in the Antarctic Treaty area.

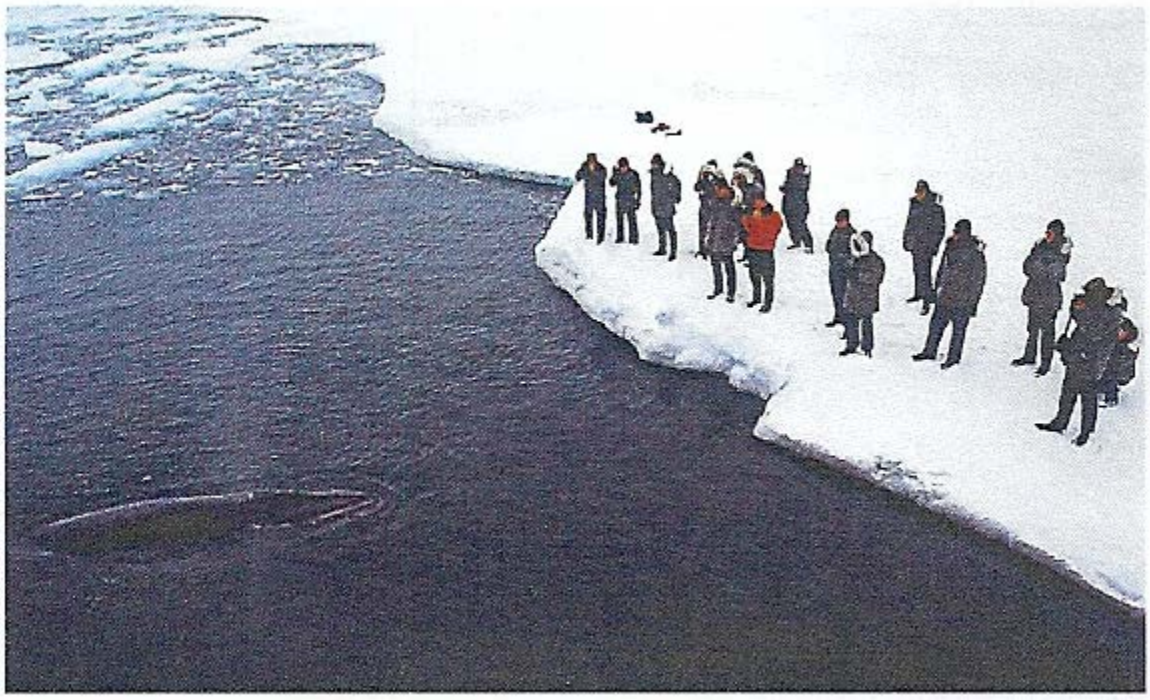

Figure 3: Tourists observing whale (McGonigal, 2008)

A risk assessment was conducted by Chown et al. (2012) in the summer period of 2007-2008 where they examined human, shipping and aircraft traffic with the inadvertent introductions of non-native species to the Antarctic Treaty area. This was evidence that non-native vascular plants and other taxa can successfully colonize both in the maritime and continental Antarctic (Chown et al. 2012). This risk assessment was conducted by checking visitors for the number of seeds on their clothing and bags, these visitors were associated with science programmes, tourist support personnel and tourists themselves, and a questionnaire asking them of their travels in the previous year. Results obtained (Figure 4), clearly shows that tourists present the lowest threat of carrying seeds into Antarctica compared to that of science personnel. Of the 2,686 seeds collected from sampled visitors, 88 per cent were identified to family and 43 per cent to species level. Species-level data showed that these propagules include several species which are known as invaders i.e. aggressive non-native species from the sub-Antarctic or Arctic regions, which exist in similar climatic conditions to parts of the Antarctic (Chown et al. 2012).

As a result of that study, IAATO members are now fully aware of having a great responsibility to ensure that their field staff and Antarctic tourists take inspection and mitigation procedures very seriously when it comes to the inadvertent introduction of non-native species (IAATO, 2012). IAATO explains results (Figure 4) from the study as: “While tourists generally bring new gear to Antarctica and test out clean, the expedition leaders, field staff and Zodiac drivers often use the same boots, outerwear and equipment in other parts of the world.”

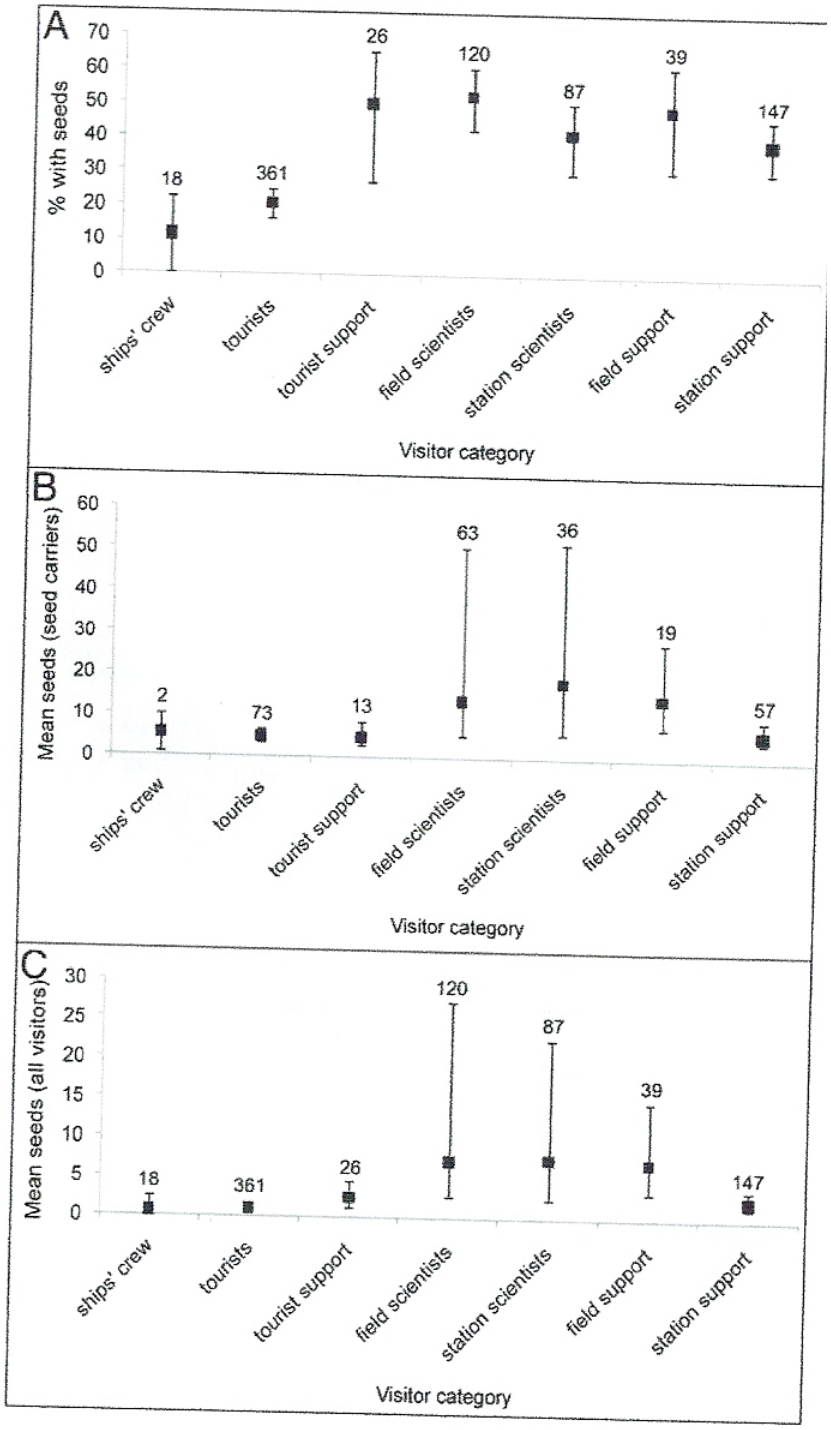

Figure 4: Proportion of visitors carrying seeds, number of seeds per visitor carrying seeds, and number of seeds per visitor across all visitors. (*A*) Proportion of visitors (mean and 95% bootstrapped CI) carrying seeds within each of the visitor categories. (*B*) Mean (and 95% bootstrapped CI) number of seeds per visitor by category for those visitors carrying seeds. (*C*) Mean (and 95% bootstrapped CI) number of seeds per visitor by category for all visitors (i.e., those with and without seed loads). Sample sizes are given above all bars. (Chown et al. 2012)

Effects of Climate Change on the Populations of Non-Native Species

Climate change with temperature increases over the last few decades, combined with introductions of non-native especially aggressive species, will have an particular effect on the Western Antarctic Peninsula coast (Figure 5), and associated islands having the greatest risk for the establishment of non-native species (Chown et al. 2012). This was based upon a risk index, incorporating propagule pressure and origins, and climatic suitability of the ice-free areas of this area of the continent.

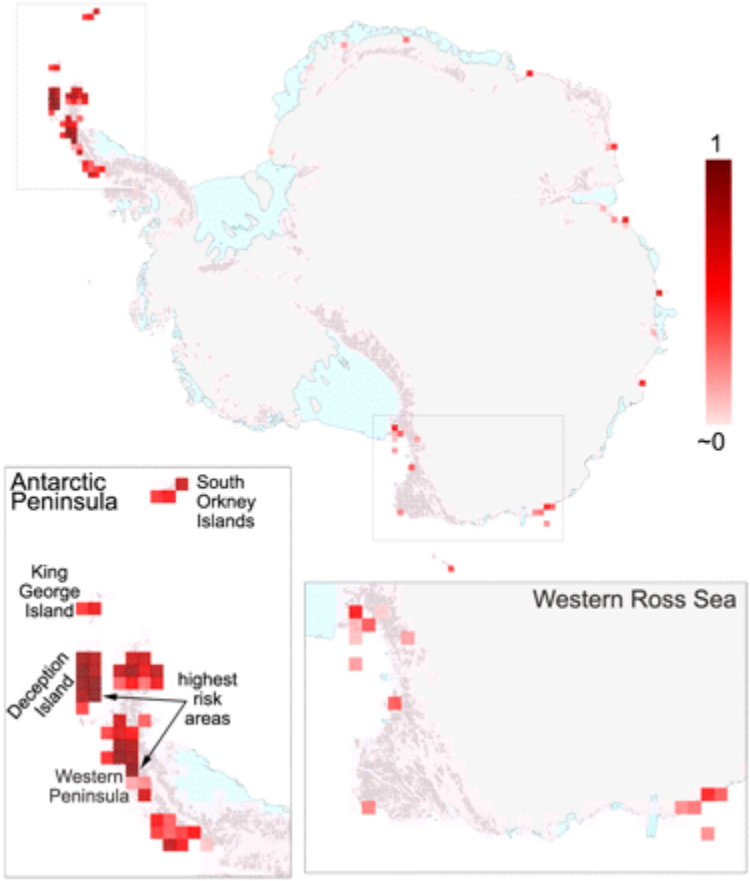

Figure 5: Relative risk of non-native vascular plant species establishing in Antarctica (Chown et al. 2012).

As an example, the invasive grass *Poa annua* is spreading at King George Island from the Arctowski research station to areas much less subject to human traffic which demonstrates that once established, spread does not rely on further human activities. This pattern of dispersal has subsequently been documented at three other research stations.

Conclusion

Non-native species are among the primary causes of biodiversity change globally, with their risks being understood in most regions of the world, with the greatest risk coming from invasive non-native species which occur in all major taxonomic groups affecting all habitats and environments. In Antarctic terrestrial ecosystems are particularly vulnerable to non-native species as their community's structure is simple, and species richness is low. During 1964 the ATS recognized the importance of what non-native species effects are doing in Antarctica's environment, improvements were implemented via the Agreed Measures for the Conservation of Antarctic Fauna and Flora. This was not seen as doing enough to protect Antarctica's environment so in 1998 the Protocol on Environmental Protection to the Antarctic Treaty came into force. Climate change with predicted temperature increases combined with introductions of non-native species especially aggressive ones with increased human traffic will have an effect on particularly the Western Antarctic Peninsula coast having the highest current risk for the establishment of non-native species. Evidence now showing non-native vascular plants and other taxa can successfully colonize both in the maritime and continental Antarctic leads to the question is the Protocol enough to protect the Antarctic Treaty area.

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Appendix

Appendix 1: The Antarctic Treaty (1959) - Full Text

Preamble

The Governments of Argentina, Australia, Belgium, Chile, the French Republic, Japan, New Zealand, Norway, the Union of South Africa, the Union of Soviet Socialist Republics, the United Kingdom of Great Britain and Northern Ireland, and the United States of America,

Recognizing that it is in the interest of all mankind that Antarctica shall continue for ever to be used exclusively for peaceful purposes and shall not become the scene or object of international discord;

Acknowledging the substantial contributions to scientific knowledge resulting from international cooperation in scientific investigation in Antarctica;

Convinced that the establishment of a firm foundation for the continuation and development of such cooperation on the basis of freedom of scientific investigation in Antarctica as applied during the International Geophysical Year accords with the interests of science and the progress of all mankind;

Convinced also that a treaty ensuring the use of Antarctica for peaceful purposes only and the continuance of international harmony in Antarctica will further the purposes and principles embodied in the Charter of the United Nations;

Have agreed as follows:

Article I — Peaceful purposes

1. Antarctica shall be used for peaceful purposes only. There shall be prohibited, *inter alia*, any measure of a military nature, such as the establishment of military bases and fortifications, the carrying out of military manoeuvres, as well as the testing of any type of weapon.
2. The present Treaty shall not prevent the use of military personnel or equipment for scientific research or for any other peaceful purpose.

Article II — Freedom of scientific investiation

Freedom of scientific investigation in Antarctica and cooperation toward that end, as applied during the International Geophysical Year, shall continue, subject to the provisions of the present Treaty.

Article III — International scientific cooperation

1. In order to promote international cooperation in scientific investigation in Antarctica, as provided for in Article II of the present Treaty, the Contracting Parties agree that, to the greatest extent feasible and practicable:
    1. information regarding plans for scientific programs in Antarctica shall be exchanged to permit maximum economy of and efficiency of operations;
    2. scientific personnel shall be exchanged in Antarctica between expeditions and stations;
    3. scientific observations and results from Antarctica shall be exchanged and made freely available.
2. In implementing this Article, every encouragement shall be given to the establishment of cooperative working relations with those Specialized Agencies of the United Nations and other international organizations having a scientific or technical interest in Antarctica.

Article IV — Territorial sovereignty

1. Nothing contained in the present Treaty shall be interpreted as:
    1. a renunciation by any Contracting Party of previously asserted rights of or claims to territorial sovereignty in Antarctica;
    2. a renunciation or diminution by any Contracting Party of any basis of claim to territorial sovereignty in Antarctica which it may have whether as a result of its activities or those of its nationals in Antarctica, or otherwise;
    3. prejudicing the position of any Contracting Party as regards its recognition or non-recognition of any other State,s rights of or claim or basis of claim to territorial sovereignty in Antarctica.
2. No acts or activities taking place while the present Treaty is in force shall constitute a basis for asserting, supporting or denying a claim to territorial sovereignty in Antarctica or create any rights of sovereignty in Antarctica. No new claim, or enlargement of an existing claim, to territorial sovereignty in Antarctica shall be asserted while the present Treaty is in force.

Article V — Nuclear activity

1. Any nuclear explosions in Antarctica and the disposal there of radioactive waste material shall be prohibited.

2. In the event of the conclusion of international agreements concerning the use of nuclear energy, including nuclear explosions and the disposal of radioactive waste material, to which all of the Contracting Parties whose representatives are entitled to participate in the meetings provided for under Article IX are parties, the rules established under such agreements shall apply in Antarctica.

Article VI — Geographical coverage

The provisions of the present Treaty shall apply to the area south of 60° South Latitude, including all ice shelves, but nothing in the present Treaty shall prejudice or in any way affect the rights, or the exercise of the rights, of any State under international law with regard to the high seas within that area.

Article VII — Inspections

1. In order to promote the objectives and ensure the observance of the provisions of the present Treaty, each Contracting Party whose representatives are entitled to participate in the meetings referred to in Article IX of the Treaty shall have the right to designate observers to carry out any inspection provided for by the present Article. Observers shall be nationals of the Contracting Parties which designate them. The names of observers shall be communicated to every other Contracting Party having the right to designate observers, and like notice shall be given of the termination of their appointment.
2. Each observer designated in accordance with the provisions of paragraph 1 of this Article shall have complete freedom of access at any time to any or all areas of Antarctica.
3. All areas of Antarctica, including all stations, installations and equipment within those areas, and all ships and aircraft at points of discharging or embarking cargoes or personnel in Antarctica, shall be open at all times to inspection by any observers designated in accordance with paragraph 1 of this Article.
4. Aerial observation may be carried out at any time over any or all areas of Antarctica by any of the Contracting Parties having the right to designate observers.
5. Each Contracting Party shall, at the time when the present Treaty enters into force for it, inform the other Contracting Parties, and thereafter shall give them notice in advance, of
    1. all expeditions to and within Antarctica, on the part of its ships or nationals, and all expeditions to Antarctica organized in or proceeding from its territory;
    2. all stations in Antarctica occupied by its nationals; and
    3. any military personnel or equipment intended to be introduced by it into Antarctica subject to the conditions prescribed in paragraph 2 of Article I of the present Treaty.

Article VIII — Jurisdiction

1. In order to facilitate the exercise of their functions under the present Treaty, and without prejudice to the respective positions of the Contracting Parties relating to jurisdiction over all other persons in Antarctica, observers designated under paragraph 1 of Article VII and scientific personnel exchanged under sub-paragraph 1(b) of Article III of the Treaty, and members of the staffs accompanying any such persons, shall be subject only to the jurisdiction of the Contracting Party of which they are nationals in respect of all acts or omissions occurring while they are in Antarctica for the purpose of exercising their functions.
2. Without prejudice to the provisions of paragraph 1 of this Article, and pending the adoption of measures in pursuance of subparagraph 1(e) of Article IX, the Contracting Parties concerned in any case of dispute with regard to the exercise of jurisdiction in Antarctica shall immediately consult together with a view to reaching a mutually acceptable solution.

Article IX — Treaty Meetings

1. Representatives of the Contracting Parties named in the preamble to the present Treaty shall meet at the City of Canberra within two months after the date of entry into force of the Treaty, and thereafter at suitable intervals and places, for the purpose of exchanging information, consulting together on matters of common interest pertaining to Antarctica, and formulating and considering, and recommending to their Governments, measures in furtherance of the principles and objectives of the Treaty, including measures regarding:
    1. use of Antarctica for peaceful purposes only;
    2. facilitation of scientific research in Antarctica;
    3. facilitation of international scientific cooperation in Antarctica;
    4. facilitation of the exercise of the rights of inspection provided for in Article VII of the Treaty;
    5. questions relating to the exercise of jurisdiction in Antarctica;
    6. preservation and conservation of living resources in Antarctica.
2. Each Contracting Party which has become a party to the present Treaty by accession under Article XIII shall be entitled to appoint representatives to participate in the meetings referred to in paragraph 1 of the present Article, during such times as that Contracting Party demonstrates its interest in Antarctica by conducting substantial research activity there, such as the establishment of a scientific station or the despatch of a scientific expedition.
3. Reports from the observers referred to in Article VII of the present Treaty shall be transmitted to the representatives of the Contracting Parties participating in the meetings referred to in paragraph 1 of the present Article.
4. The measures referred to in paragraph 1 of this Article shall become effective when approved by all the Contracting Parties whose representatives were entitled to participate in the meetings held to consider those measures.
5. Any or all of the rights established in the present Treaty may be exercised as from the date of entry into force of the Treaty whether or not any measures facilitating the exercise of such rights have been proposed, considered or approved as provided in this Article.

Article X — Activities contrary to Treaty

Each of the Contracting Parties undertakes to exert appropriate efforts, consistent with the Charter of the United Nations, to the end that no one engages in any activity in Antarctica contrary to the principles or purposes of the present Treaty.

Article XI — Disputes between Parties

1. If any dispute arises between two or more of the Contracting Parties concerning the interpretation or application of the present Treaty, those Contracting Parties shall consult among themselves with a view to having the dispute resolved by negotiation, inquiry, mediation, conciliation, arbitration, judicial settlement or other peaceful means of their own choice.
2. Any dispute of this character not so resolved shall, with the consent, in each case, of all parties to the dispute, be referred to the International Court of Justice for settlement; but failure to reach agreement on reference to the International Court shall not absolve parties to the dispute from the responsibility of continuing to seek to resolve it by any of the various peaceful means referred to in paragraph 1 of this Article.

Article XII — Modification and duration

1.
    1. The present Treaty may be modified or amended at any time by unanimous agreement of the Contracting Parties whose representatives are entitled to participate in the meetings provided for under Article IX. Any such modification or amendment shall enter into force when the depositary Government has received notice from all such Contracting Parties that they have ratified it.
    2. Such modification or amendment shall thereafter enter into force as to any other Contracting Party when notice of ratification by it has been received by the depositary Government. Any such Contracting Party from which no notice of ratification is received within a period of two years from the date of entry into force of the modification or amendment in accordance with the provision of subparagraph 1(a) of this Article shall be deemed to have withdrawn from the present Treaty on the date of the expiration of such period.
2.
    1. If after the expiration of thirty years from the date of entry into force of the present Treaty, any of the Contracting Parties whose representatives are entitled to participate in the meetings provided for under Article IX so requests by a communication addressed to the depositary Government, a Conference of all the

Contracting Parties shall be held as soon as practicable to review the operation of the Treaty.

2. Any modification or amendment to the present Treaty which is approved at such a Conference by a majority of the Contracting Parties there represented, including a majority of those whose representatives are entitled to participate in the meetings provided for under Article IX, shall be communicated by the depositary Government to all Contracting Parties immediately after the termination of the Conference and shall enter into force in accordance with the provisions of paragraph 1 of the present Article.
3. If any such modification or amendment has not entered into force in accordance with the provisions of subparagraph 1(a) of this Article within a period of two years after the date of its communication to all the Contracting Parties,any Contracting Party may at any time after the expiration of that period give notice to the depositary Government of its withdrawal from the present Treaty; and such withdrawal shall take effect two years after the receipt of the notice by the depositary Government.

Article XIII — Ratification and entry into force

1. The present Treaty shall be subject to ratification by the signatory States. It shall be open for accession by any State which is a Member of the United Nations, or by any other State which may be invited to accede to the Treaty with the consent of all the Contracting Parties whose representatives are entitled to participate in the meetings provided for under Article IX of the Treaty.
2. Ratification of or accession to the present Treaty shall be effected by each State in accordance with its constitutional processes.
3. Instruments of ratification and instruments of accession shall be deposited with the Government of the United States of America, hereby designated as the depositary Government.
4. The depositary Government shall inform all signatory and acceding States of the date of each deposit of an instrument of ratification or accession, and the date of entry into force of the Treaty and of any modification or amendment thereto.
5. Upon the deposit of instruments of ratification by all the signatory States, the present Treaty shall enter into force for those States and for States which have deposited instruments of accession. Thereafter the Treaty shall enter into force for any acceding State upon the deposit of its instruments of accession.
6. The present Treaty shall be registered by the depositary Government pursuant to Article 102 of the Charter of the United Nations.

Article XIV — Deposition

The present Treaty, done in the English, French, Russian and Spanish languages, each version being equally authentic, shall be deposited in the archives of the Government of the United States of America, which shall transmit duly certified copies thereof to the Governments of the signatory and acceding States.

Appendix 2: Environmental Code of Conduct (Antarctica New Zealand, n.d.)

Antarctica New Zealand
Private Bag 4745
Christchurch
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enviro@antarcticanz.govt.nz

Antarctica New Zealand

environmental code of conduct

MAXIMISE your Antarctic experience with MINIMUM environmental impact

MAXIMISE your Antarctic experience with MINIMUM environmental impact

- **Assess impacts:** Make sure your activities will have minimum impact and are formally approved
- **Protect flora and fauna:** Leave foreign species at home and give wildlife its space
- **Manage waste:** Reduce at source, separate and dispose correctly
- **Respect special areas:** Know where designated areas are and respect their rules
- **Prevent spills:** Avoid sensitive areas, use drip trays and spill kits
- **Keep camps clean:** Reuse past sites, secure gear, leave it as you found it
- **Take only photos:** Don't collect any cultural material without specific approval

Take only photographs

Removal of any natural material, unless it is part of an approved Environmental Evaluation, may be considered a breach of the Antarctica (Environmental Protection) Act.

- Do not remove soil, rocks, minerals, fossils, volcanic bombs or ventifacts unless specifically approved to do so.
- Do not remove feathers, bones, vegetation or other natural materials unless approved to do so.

Field activities

Every effort should be made to minimise the impact of scientific investigations and field activities.

- Where possible, place tents and equipment on snow or previously used campsites.
- Secure rubbish and equipment to prevent it blowing away.
- Keep accurate records of your camp site including location, sites of tents and equipment (such as generators), any grey water and human waste disposal, location and extent of any spills or other incidents and the location of any equipment left at the site. Include this information in the environmental section of your end of season logistics report.
- When leaving a campsite make every effort to return it to its previous state, e.g. replace displaced rocks and flatten snow mounds.
- Never paint or deface rocks or ice-free surfaces.

Mike Mitchell KS-06-0304

Protection of flora and fauna

Wildlife and plants can be very sensitive to disturbance by humans. Unless you have specific approval, disturbance of wildlife may constitute 'harmful interference' which is prohibited under the Act.

- Keep a minimum distance of 10 metres from any animal unless it comes to you. Increase this distance if the animal appears disturbed and take particular care around nesting birds.
- Take special care when photographing and do not walk through bird and seal colonies.
- Keep noise to a minimum in the vicinity of wildlife.
- Wherever it is safe to do so, keep vehicles a minimum of 200 metres away from wildlife.
- Do not walk or drive vehicles on vegetation, including mosses and lichens.
- Removal or disturbance of plants or animals is prohibited except in accordance with a specific permit.
- Introducing non-native species, including pot plants and cut flowers, is prohibited.
- Clean your clothing, boots and equipment before packing them for transport to Antarctica. Pay particular attention to boot treads, velcro fastenings and pockets which could contain soil or seeds.

Environmental impact assessment

Under the Antarctica (Environmental Protection) Act (1994), an Environmental Evaluation detailing potential impacts and how they can be minimised must be completed for all Antarctica New Zealand supported activities. The Evaluation must be approved by the Minister of Foreign Affairs and Trade before the proposed activities can take place.

- Your activities are approved in accordance with an Environmental Evaluation – be familiar with this document and the specific sites and activities your Event is approved for.
- General and special conditions are also attached to the approval. One of the conditions of approval is that activities are reported on at the end of the season. Understand these requirements before you leave.

Fuel spill prevention

The impacts of fuel or other chemical spills on the environment can be significant if appropriate action is not taken quickly. Prevention is the best defence.

- Minimise the handling and storage of fuel in the vicinity of sensitive areas such as freshwater lakes and streams, bird and seal colonies and vegetation.
- Refuel vehicles and other equipment out of the wind and use drip-trays and sorbant mats.
- If a spill does occur, respond quickly using the procedures in your Field Manual.

Brent Sinclair:K1-00:02/03

Waste management

Most activities carried out in Antarctica will produce waste, almost all of which is returned to New Zealand. Many waste products can be harmful to the environment and to human health, so all wastes must be correctly handled, whether in the field or around Scott Base.

- It is your responsibility to separate the waste you produce and dispose of it correctly. Waste streams include Hazardous (e.g. food, medical, chemical), Recyclable (e.g. glass, paper and metal) and General Waste.
- Do not bring PCBs, non-sterile soil, polystyrene beads, chips or similar or pesticides to Antarctica – they are prohibited products.
- Get rid of unnecessary packaging and other potential waste before it comes south and choose reusable packing materials like bubble wrap or paper wherever possible. Vermiculite should only be used for packaging chemicals.
- Waste water and human waste in the field should be collected and returned to Scott Base, unless it can be disposed of directly into the sea. Return all other waste to Scott Base.
- Do not burn any waste.
- Be prepared - carry a personal pee bottle when travelling away from base or camp.
- Read the information displayed around Scott Base and your Field Manual, or consult the Waste Management Handbook for further detail.

Special areas

Certain areas of Antarctica are set aside as Antarctic Specially Protected Areas (ASPAs), Antarctic Specially Managed Areas (ASMAs), or Historic Sites and Monuments (HSMs) to protect the unique natural and physical and heritage values of the sites.

- Be aware of the location of designated areas near your activities. Note that all historic huts in the Ross Sea region are ASPAs and an ASMA covers the Dry Valleys.
- Entry to ASPAs is prohibited except in accordance with a permit, which must be carried.
- Always consult the Management Plan for any ASPA or ASMA you will be in or around.
- If you plan to visit any historic site, consult the Antarctic Heritage Trust's code of conduct. Copies are available at Scott Base.