

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

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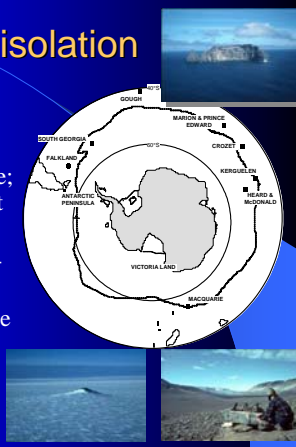


Overview

- Define region under consideration
- (Limits to) natural process of Antarctic colonisation
- Contemporary biodiversity
- Contemporary climate, climate change
- History of human presence in the region
- Presence and impact of non-indigenous species
- Examples of risks and routes of introduction
- The future

Antarctic isolation

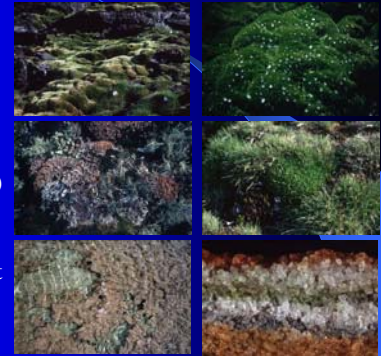
- Antarctic continent isolated by marine and atmospheric barriers
- Marine – Polar Frontal Zone; Atmospheric – cyclonic belt
- These are additional to the “distance factor” of the sub-Antarctic islands
- < 0.5% of Antarctica ice free
- Ecosystems are “islands” isolated by sea or ice



Barnes et al. 2006 Glob. Ecol. Biogeog.

Terrestrial Flora

- Cryptogamic “fellfield” flora
- Dominated by mosses and lichens
- Only two higher plants (Ant. Pen.)
- Predominantly coastal
- Microbial flora at higher latitudes/greater extremes



Terrestrial Fauna

- no vertebrates
- two “higher” insects
- mites and springtails dominate
- few species but high abundance
- microfauna
- very simple food webs, few predators



Contemporary biodiversity

- Low!! – Many taxonomic and functional groups missing, low richness in those present
- Vacant niches?
- Some biota ancient - gondwanan relicts on some continental nunataks
- Natural colonisation currently limited by isolation, ocean and atmosphere circulations, recent deglaciation, severe climate
- Abiotic currently dominate over biotic selective pressures in ecosystems

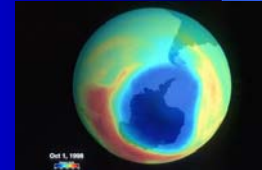
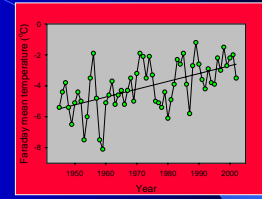
Contemporary Climate

- Low mean temperatures year round (summer means near or below zero, unlike Arctic), very low annual heat budget
- Unpredictable and large short-term microhabitat variation possible (> 30°C daily, > 80°C yearly)
- Low water availability (summer desiccation, winter ice)
- Potentially high (summer) radiative input

Contemporary climate change

Three factors significant to terrestrial environment:

- Parts of the Antarctic face rapid and large temperature increase
- Changed precipitation and glacial melt
- Ozone hole and UV-B climate



Predicted effects of climate change on biodiversity

- Local and exotic colonisation
- Increased biomass and diversity
- Altered/more complex food webs
- Loss of Antarctic species or communities through competition
- Most yet to be seen in the Antarctic, but clear ecological response from indigenous plants, other evidence inferred through manipulations

INCREASE IN TOTAL NUMBER OF *Deschampsia antarctica* AND *Colobanthus quitensis* PLANTS RECORDED OVER 27 YEARS ON THREE OF THE ARGENTINE ISLANDS, ANTARCTIC PENINSULA (65°S)

Year	<i>Deschampsia</i>	<i>Colobanthus</i>
1964	610	62
1990	c. 17,000	377



Fowbert & Smith, 1994, Arct. Alpine Res; Convey, 2003, Antarct. Res. Ser.

Man's presence in Antarctica

- Very recent in biological terms
- C17-19: Early marine explorers, then establishment of sealing, farming operations (mostly sub-Antarctic)
- C20 early-mid: "heroic age" of continental exploration, sub- and maritime Antarctic whaling



Man's presence in Antarctica

- C20 mid-late: IGY and development of national science programmes
- C20 late, C21: further marine exploitation (fisheries), tourism



Occurrence of introduced species

- Approaching 200 known alien plants and animals established
- Most invertebrate groups and locations poorly surveyed
- Virtually no microbial data
- Far greater presence in sub-Antarctic
- Many more species thought to arrive and/or exist synanthropically in stations
- Virtually no evidence of marine introductions to date

	Entire sub-Antarctic	Maritime Antarctic	South Georgia	Marion	Prince Edward	Crozet	Kerguelen	Heard	Mac Donald	Macquarie
Dicoryledons	62	0	17	6	2	40	34	0	0	2
Monocotyledons	45	2	15	7	1	18	34	1	0	1
Phanerogams	1	0	1	0	0	1	1	0	0	0
Total non-indigenous plants	408	2	33	13	3	59	69	1	0	3
Invertebrates	72	2-5	12	18	1	14	30	3	0	28
Vertebrates	16	0	3	1	0	6	12	0	0	6

Frenot et al. 2005 Biol. Rev.

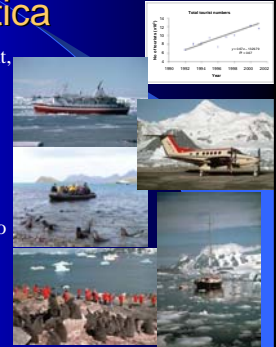
Human impacts on biodiversity

- Human influences on Antarctic ecosystems are both indirect (climate change) and direct (deliberate and accidental transport):
- Deliberate introductions of grazing and predatory vertebrates to most sub-Antarctic islands
- Accidental introduction of rodents and invertebrates to most sub-Antarctic islands
- Deliberate and accidental introductions of higher plants to most sub-Antarctic islands
- But what about the Antarctic continent and peninsula?



Increasing human contact with Antarctica

- c. 5,000 research staff visit continent, and over 30,000 tourists per year (mostly Antarctic Peninsula); up to 11,000 at one site in a season
- Visit successive sites
- Potential to introduce invertebrates, plants, microbial groups,
- Many anecdotal observations, but no concerted monitoring and few data
- Despite concerns, no explicit demonstration of tourism-mediated introduction in region



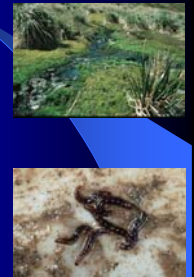
Anthropogenic Transfer

- overcomes natural isolation of the Antarctic and the ecophysiological challenges of long distance dispersal
- Natural processes far outweighed by human assistance, for invertebrates and plants
- Carried on: people themselves, cargo, ships, planes
- Timescales of hours, days to weeks, months



Scientific Introductions

- Feature of research in 1960s/70s
- Experiments to test whether sub-Antarctic, Arctic and temperate plants were pre-adapted to more extreme Antarctic conditions
- Now banned under the Antarctic Treaty
- Range of plants survived and grew on Signy Island, all removed at end of expt
- No effort to monitor invertebrates or microbes
- Subsequently clear that a dipteran and an enchytraeid worm are established and slowly spreading; both detritivorous
- No data on magnitude of impacts, or on presence of alien microbes



Edwards 1980, BAS Bull.; Convey & Block 1996, Eur. J. Entomol.

Accidental transfer - an all too common occurrence

- Transfer of mechanical plant between stations
- South Georgia (sub-Antarctic) to Rothera (maritime Antarctic) (2005/6 season)
- 1 JCB = c. 130 kg of soil, live plants, arthropods, nematodes, viable seeds, microbes
- Some already known (1960s transplants) to have capacity to establish in new region
- Normal feature of logistic (and tourist) operations is successive visits to series of locations, esp. in Scotia Arc region



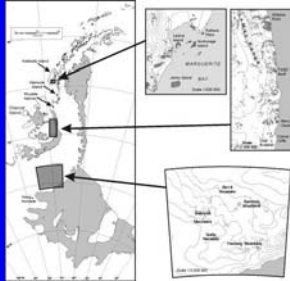
K. Hughes poster

Alien species on stations

- Mouldy fruit and vegetables
- Invertebrates with packaged food
- Slugs on fresh food
- Microbes and invertebrates in soil on root vegetables
- Microbes on uncooked meat
- May establish synanthropically



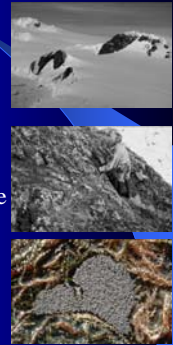
Compromising future research - Antarctic Peninsula biogeography



Convey & Meakes 2005, Ecology, Maslen & Convey in press, Soil Biol. Biochem

Charcot Island – intraregional risks

- Example of a biota missing otherwise ubiquitous functional components of maritime Antarctic ecosystems (springtails)
- Reasonably accessible
- Regional biota already known to be adapted to conditions
- Implications for use as research resource



Convey et al. 2000, Antarct. Sci.

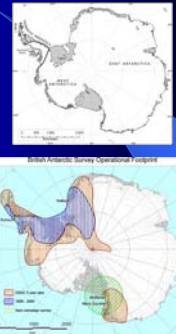
Ellsworth Land – interregional risks

- Simplest known multitrophic terrestrial ecosystems
- Nematodes (and arthropods) absent, leaving tardigrades and rotifers
- Pre-adapted taxa clearly present elsewhere in maritime and continental Antarctic
- At smaller scale, all islands of terrestrial habitat are genetically isolated



Biogeographic boundaries

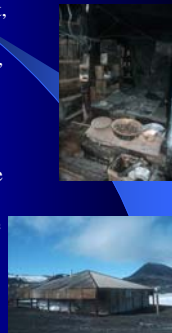
- Risk of transfer across major biogeographic boundary – the “Gressitt Line”
- Logistic operations increasingly widespread
- Breakdown of regional endemism, genetic distinctness, in one of few areas of the planet where this largely still holds
- Microbial endemism remains a “black hole” in knowledge



Lawley et al. 2004 Appl. Environm. Microbiol.; Taton et al. FEMS Microbiol. Ecol. 2006; Chown & Convey in press, Phil. Trans. Roy. Soc.

Microbial introductions

- Arguably the most likely, hardest to detect, impossible to remove
- Inevitable with human presence (e.g. food, wood, sewage), and has already taken place for 100+ years (historic huts)
- Aerobiological and culture studies find taxa “associated” with research stations, and also introductions witnessed to remote nunataks inland; repeat surveys lacking
- Vertebrate disease outbreaks and evidence for exposure reported, though nb sources unproven
- Balance between “global ubiquity” and regional endemism currently unknown



Prevention and mitigation

- Prevention requires clear and robust requirements, along with reliable application
- Baseline data and ongoing monitoring are required to permit detection in the first place; practical challenge for invertebrate and microbial biota
- Mitigation (removal) may be possible in some instances if detected early, but impossible in others (particularly microbial)
- Disease outbreak areas can be quarantined from human contact, but not animal or aerosol dispersal; improved understanding of disease vectors required

Summary (1)

- Small numbers of non-indigenous plants and invertebrates are established at specific maritime Antarctic locations
- Anecdotal evidence of frequent unsuccessful introduction via research stations, and synanthropic presence on stations
- Anthropogenic introduction outweighs natural processes, has occurred over last 100 years at most
- Consequences currently minor, and relate to damage to research resource; some even provide unique research tools
- Native ecosystems may be vulnerable to invading species

Summary (2)

- Large gaps in knowledge for most invertebrates and lower plants; microbes remain largely unknown; little coordinated effort yet devoted to survey or monitoring
- Prevention more practical than mitigation, particularly for invertebrates and microbes
- Regional climate change lowers dispersal and establishment barriers; in concert with human-assisted transfer, predict rapid increase in invasion events, and impacts further south than now, while remaining less frequent than sub-Antarctic
- Any human presence will inevitably lead to some introductions