SVALBARDS MILJØVERNFOND

Measuring and managing the potential for visitors to Svalbard to introduce non-indigenous organisms

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Summary

Recent awareness of the potential for human activities to inadvertently mediate the introduction of non-indigenous species to new environments has motivated research concerned with better understanding and managing patterns of species transfer. Substantial headway has been made in the Antarctic in this regard, and more recently in the Arctic. As a result, management measures have been implemented in both regions. This project assessed the efficacy of new biosecurity procedures trialled by Arctic Expedition Cruise Operators (AECO) ships, and further examined the difference in threat posed by different pathways of species introduction (passengers travelling on large cruise-ship, scientific visitors, cargo items). We undertook this work with the overall aim of improving the biosecurity management undertaken in Svalbard.

Results showed that efforts to reduce propagule loads (plant seeds, bryophytes fragments, microorganisms) carried on passengers' outwear and personal equipment were effective, while efforts to disinfect footwear when evaluated on board a single ship were largely ineffective. Despite the success in the former case, most ships found it unpractical to allocate time to this procedure within the tight schedules operated to during an expedition. Given this, the receptiveness of an alternate management strategy of 'self-assessment' was investigated, and subsequently employed. This manifested as a 'biosecurity guideline' developed in cooperation with AECO staff (available on the AECO website), and is now distributed to all AECO member passengers prior to their travel to Svalbard. Means to improve the effectiveness of footwear disinfection were communicated to AECO members by way of a standardised protocol based on our own research, and work undertaken elsewhere.

Work evaluating differential risks of species introduction posed by different visitation categories considered cruise ship tourists, expedition ship tourists, and scientific researchers. Contrary to research undertaken elsewhere, our data showed that there were no significant differences in the numbers of propagules transported among the three categories, although the sample size of scientific researchers was small. Further, preliminary data suggests that cargo items are not heavily contaminated with seeds or invertebrates (though again the sample size was small). Cargo items inspected included those stored in the local warehouse prior to their distribution; we note that we did not have the possibility to inspect and sample vehicles or machinery which we believe would present the greater biosecurity risk.

Together, our results build on previous work demonstrating that all visitor categories pose a risk of species introduction. Management practices employed by expedition ships need improvement and also need to move towards passenger self-assessment. We believe this practice could be employed by all visitation groups to Svalbard, and extended to the import of target cargo items.

CONTENTS

1. BACKGROUND

Until recently in polar regions, two processes have maintained ecological integrity: low frequency of human-mediated dispersal, and the prevailing climate, both of which are rapidly changing (Convey et al. 2006; Elven et al. 2011). Seed dispersal by humans and cargo is to some degree documented for the Antarctic (Whinam et al. 2005; Lee and Chown 2009; Chown et al. 2012), and has been the subject of management development by the Antarctic Treaty Parties (Australia and SCAR 2007). In contrast, no such quantification exists for the Arctic, where few biosecurity measures are currently employed.

To date, the only attempts to quantify the significance of a total pathway of species introduction to the Arctic focused on ship mediated introductions (Alaska –Ruiz and Hines 1997; Canada – Chan et al. 2012; Svalbard – Ware et al. 2013). Human activity in the Arctic has, however, rapidly increased over the past 40 years (Kaltenborn 2000; Forbes et al. 2004). Between 1995 and 2004, for example, there was a 255% increase in the number of tourists visiting Svalbard (Governor of Svalbard 2006). Other activities are increasing similarly, such as scientific research and construction, both of which entail increased visitation and import of materials.

Strategies used to reduce the risk of human-mediated non-indigenous species (NIS) introductions are typically inexpensive and rapid, and are designed to both clean and disinfect. Empirical evaluations have been undertaken in controlled settings to determine processes under which efficacious outcomes can be achieved (Amass et al. 2001, 2005, Curry et al. 2005, Lee and Chown 2009). As a result, best-practice or evidence-based cleaning strategies have been incorporated into public (PAWS 2013) or industry-based guidelines (IAATO 2013), and state-based regulations (USDA 2013) in efforts to minimize NIS transmission.

One industry to adopt guidelines to reduce NIS transmission is the polar tourism industry. Concern exists that disease transmission to, and between, wildlife populations might occur at high latitudes (Curry et al. 2005, Kerry and Riddle 2009), as might the introduction of pathogens (Cowan et al. 2011, Hughes et al. 2011), invertebrates (Hughes et al. 2011), and invasive plants (Chown et al. 2012, Ware et al. 2012). The consequences of such introductions are as yet, largely unknown, but are likely to impact on existing community structure and functioning (Litchman 2010), and may cause disease to both fauna and flora (Kerry and Riddle 2009, Hughes et al. 2011).

In 2012, The Association of Arctic Expedition Cruise Operators (AECO) trialed voluntary biosecurity measures aimed at reducing the risk of NIS introduction mediated by tourists and ship-crews. One measure aims to prevent the transmission of microorganisms to the natural environment through footwear disinfection, while another aims to reduce the introduction of non-indigenous plant and insect propagules through the cleaning of all personal outerwear and equipment.

The objectives of this project were two-fold:

1. To evaluate the efficacy of biosecurity measures practiced by expedition companies operating ship-based tourism ventures in the Arctic.
2. To sample the propagule loads carried by a wider range of visitation categories to Svalbard than performed previously (cruise ship passengers, scientists, and cargo).

The latter compliments previous and ongoing research we have undertaken investigating the propagule loads associated with shipping pathways to Svalbard, and also carried on the footwear of visitors arriving to Svalbard through the Longyearbyen airport. We undertake these additional analyses so as we can provide a preliminary assessment of the differences in introduction risks posed by various pathways of introduction.

2. AECO BIOSECURITY MEASURES

Annually up to 20 expedition ships operate around Svalbard between the months of June and September. These ships take between 5-220 passengers and carry nearly 10,000 passengers collectively during a season (Governor of Svalbard 2012). Landings are carried out multiple times per cruise at nearly 180 different sites (Governor of Svalbard 2012). Opportunities for NIS dispersal may occur upon landing in Svalbard, through the introduction of NIS following a landing around the archipelago, or through the translocation of NIS between Svalbard locations.

Biosecurity measures were trialed by six ships during the 2012 tourist season. These involved the vacuuming of all passenger outwear and personal equipment (e.g. outer jackets and pants, warm hats, gloves, footwear, backpacks, camera cases, and walking poles) to remove any propagules prior to the first landing, and the disinfection of shoes both before and between landings. For the former, ship crews would collect passengers' personal equipment and vacuum clean these, while the latter was conducted at the gangway of ships.

2.1 DATA COLLECTION

To evaluate the effectiveness of vacuum cleaning personal outerwear and equipment to remove any propagules, ship crews were requested to insert a (stocking) filter into the nozzle of the vacuum cleaner; any material was collected in the filter, and we were able to later inspect these for propagules. Questionnaires completed by passengers indicated whether each item cleaned had been used previously. Methods used here are similar to those performed in the Antarctic as part of large international study *Aliens in Antarctica* (Chown et al. 2012, Huiskes et al. 2014). A further questionnaire documented passengers' attitudes towards, and knowledge of, cleaning personal outwear and equipment for biosecurity purposes.

To evaluate the efficacy of footwear disinfection, we sampled the sole of passengers' footwear prior to, and following, footwear disinfection using contact plates (55mm with Columbia 5% sheep blood agar base, Oxoid) (Fig 1). Participating expedition cruise ships used baths of Virkon S® (DuPont, America) to disinfect footwear. Tests were carried out on board a single ship during the shipping season. Owing to variation in procedures used as reported by ships, we evaluated the effect of disinfection under two scenarios. The first (Test 1) tested the immediate effect of footwear disinfection on microbial removal without the complete drying of disinfectant. The second procedure evaluated (Test 2) tested the effect of microbial reduction following disinfectant drying (1 hour).

Contact plates were stored in a drying oven at 37° C for 48 hours following sampling. Growth on the contact plates was scored at 24 and 48 hours, following the method of Curry et al. (2005) using the categories in Table 1. Differences in growth on pre- and post-treatment contact plates were calculated using the Wilcoxen signed rank test for paired samples. As we were focused on evaluating the effect of treatment, we did not attempt to identify any organisms collected from footwear.

Table 1. Descriptions used to score growths on sample contact plates. CFUs = colony forming units (*sensu* Curry et al. 2005).

Growth score	*Growth descriptor*
1	No growth
2	Scanty growth (5-10 CFUs visible)
3	Moderate growth (> 10 CFUs but none extending beyond a single grid square)
4	Heavy growth (CFUs extending beyond a single grid square)
5	Profuse growth (CFUs extending beyond two grid squares)

2.2 RESULTS

From 76 samples of expedition ship passengers' clothing, equipment, and footwear collected by crews of five separate ships (ship six did not return any samples), and 134 items cleaned, we found 374 seeds in addition to a number of bryophyte fragments and live invertebrates. For plant seeds, this constitutes an average of 4.5 propagules per passenger. Just over half of the sampled items contained propagules (seed, bryophyte, or invertebrate). We found a number of non-indigenous species in the samples.

Passengers reported a low cleaning rate: just 20% of all items sampled had been cleaned prior to the expedition. However, the effect of cleaning seemed to be beneficial in lowering propagule numbers: from the previously cleaned items, just 10 plant seeds were recovered, whereas 364 seeds were recovered from previously un-cleaned items.

One vessel was unable to collect any samples, while three of the remaining four reported that it was difficult or not practical to accomplish the vacuum cleaning of passengers' outwear and equipment prior to the first landing.

Surveys of passengers' knowledge of, and attitudes towards, biosecurity cleaning were collected during one expedition. A total of 65 questionnaires were completed. These demonstrated that half of the passengers had previously been requested to clean personal items for biosecurity purposes elsewhere, a quarter had received some form of information related to biosecurity previous to the expedition, and nearly all indicated that they would in future be willing to undertake some form of biosecurity cleaning – or 'self-assessment' – at home prior to their travels.

For the footwear disinfection, pre-disinfection samples produced microbial growth on all contact plates, generally with heavy-to-profuse growth (growth score 4-5: 75 % for Test 1; 80 % for Test 2). In Test 1, only 17 of 60 samples (28%) exhibited a reduction in microbial growth compared to pre-disinfection samples after 48 hours (Fig. 2), demonstrating a non-significant effect of disinfection (Wilcox test: $p = 0.69$). Microbial colonies often 'carpeted' the contact plate, and appeared morphologically similar to that on pre-disinfection plates. Thus, there was no significant effect of disinfection on preventing microbial load on footwear immediately following disinfection.

The effect of disinfection was more pronounced in Test 2. In this test, 23 of the 35 post-disinfection samples (66%) showed reduced growth compared to pre-disinfection samples, demonstrating a significant effect of reducing (but not completely removing) microbial load (Wilcox test: $p = < 0.001$) (Fig. 2). Considering only the instances where growth was reduced, growth was either scanty or moderate in 87 % of the samples after 48 hours.

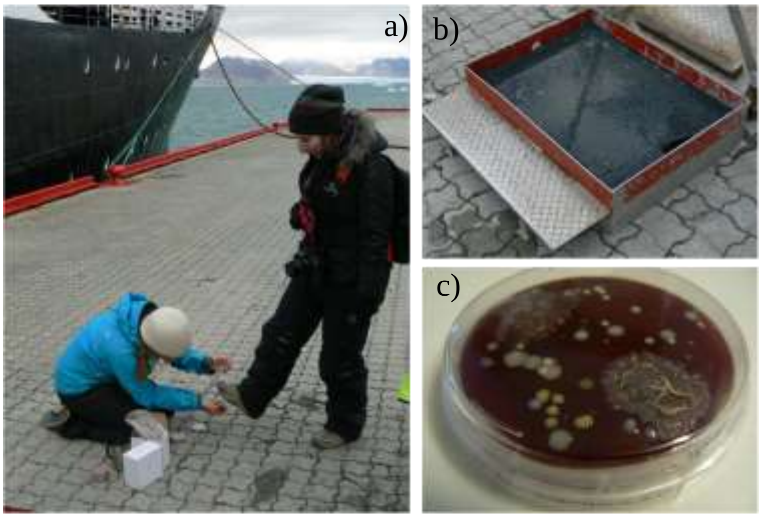

Figure 1. a) Using contact plates to swab footwear soles prior to disinfection; b) a typical footwear disinfection bath used on board vessels and prior to re-embarkation in between landings; c) microbial growth on a contact plate after incubation. Photo: Chris Ware.

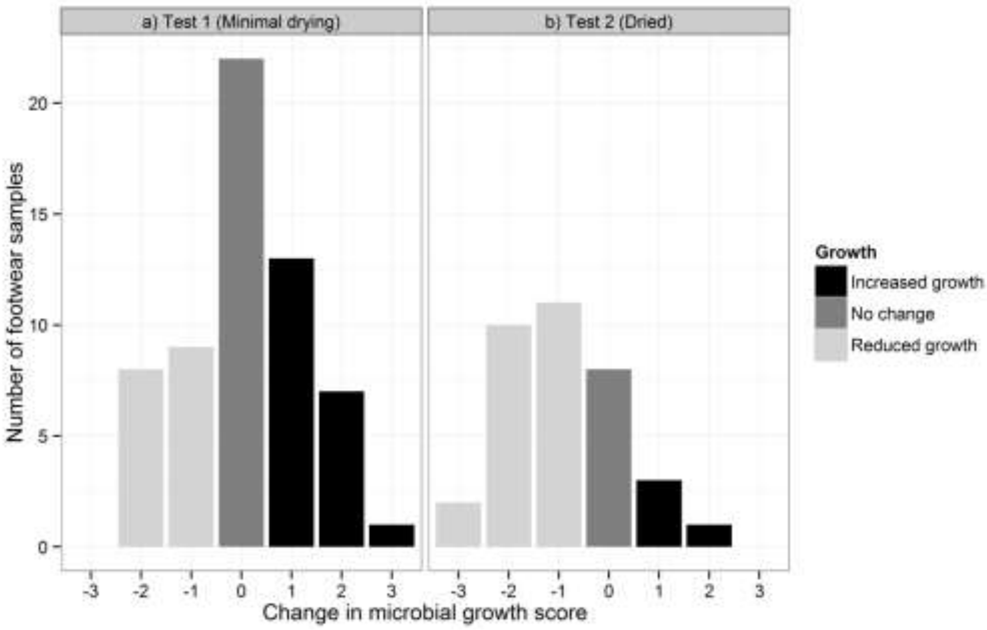

Figure 2. Change in growth on contact plates used to sample the microbial content on disinfected footwear of expedition ship passengers. Panel a) samples collected prior to a landing (at the gangway permitting only minimal drying time) and in panel b) following a landing (whereby footwear was allowed to dry completely before contact plate sampling). Change in growth score indicates the number of categories that growth reduced (-) or increase d (+) on samples according to the categories in Table 1. In Test 1, reduced growth was evident in 28% of the samples (panel a); in Test 2, reduced growth was evident in 66% of the samples (panel b).

3. RELATIVE PATHWAY RISKS

Differences in the relative risks of propagule transport have been demonstrated elsewhere. For example, in the Antarctic, scientists were more likely to be carrying a higher number of propagules than tourists (Chown et al. 2012), while in a preliminary study, differences in propagule loads existed between tourists travelling on cruise ships and those travelling on smaller expedition ships (Ware et al. 2012). In addition, cargo items and machinery have also been found to transport large numbers of non-indigenous propagules to new regions (Whinam et al. 2005, Hughes et al. 2010). These may also pose different levels of species introduction risks.

3.1 DATA COLLECTION

During the 2012 summer, we collected samples from two visitation categories (cruise ship passengers and scientists), and cargo being delivered to Svalbard. Samples were collected from the footwear of 160 cruise ship passengers from three different vessels as they made their first landing in Svalbard at Longyearbyen, while samples were collected from eight scientists. Samples collected from cruise ship passengers' footwear was collected in the same manner as outlined in our previous work (Ware et al. 2012) to permit comparisons, while sampling scientists was done similarly to that described above for tourists' outwear and personal equipment. Finally, cargo items were inspected for any propagules as they were delivered into a storage shed following transport to Svalbard by ship. Cargo items shipping to Svalbard includes a wide variety of items (container, car, building materials etc). Any newly arrived was target and inspections made for bryophyte fragments, plant seeds, and invertebrates. We hypothesised that cruise ship passengers would carry smaller propagule loads on their footwear than other visitors, and did not represent the same threat, while we expected scientists to carry more propagules. We expected a greater number of invertebrates to be transported with cargo.

3.2 RESULTS

Mean seeds carried per cruise ship passenger was lower (mean: 2.7±0.7 SE seeds) but not significantly different to the wider population (mean: 3.8±0.8 SE seeds) sampled at the airport during 2012 (t-test p=0.31, df=366), while seeds carried with scientists was far smaller (mean: 3.6±1.6 SE seeds) compared to that carried by expedition ship tourists (mean: 9.2±3.1 SE seeds) (t-test p=0.1, df=58). Here we note that only eight scientists had their clothing and equipment sampled compared to 41 expedition ship passenger. Furthermore, from one expedition ship passenger, 111 seeds were recovered heavily inflating the mean. Few propagules were collected from cargo items, though a small number of live invertebrates were collected. Identification of these is underway to determine whether they are non-indigenous to Svalbard.

Seeds collected from the footwear of cruise ship passengers were of similar taxonomic composition to that collected from visitors to Svalbard arriving through the airport, and were again dominated by grass seeds (Poaceae) including many known invasive species (e.g. *Poa annua*, *Taraxacum* sp.). Of note, we found a high number of *Empetrum* leaves in the samples. Considering Longyearbyen (where sampling took place) was the first landing passengers made since the cruise ship travelled from northern Norway (where *Empetrum* is found), this is indicative of the capacity for plant propagule transport to occur, and the greater threat posed by visitors arriving directly from another Arctic or high latitude natural setting.

Fig 3. Example of seeds recovered from the footwear of cruise ship passengers. This sample includes > 30 seeds of the invasive grass *Poa annua.* Photo: Chris Ware.

4. OUTCOMES

The efficacy of biosecurity measures practiced by expedition companies operating ship-based tourism ventures in the Arctic

Results of this research further demonstrate the capacity of visitors to Svalbard and associated activities to mediate non-indigenous species introduction. Importantly, mitigation measures are now being trialled, these being shown to have mixed effect. The process of vacuum cleaning the outerwear and personal equipment of expedition ship passengers is highly effective. From one passenger a substantial load (111) seeds was recovered. Non-indigenous species may stand a greater chance of establishing if introduced in large numbers. Overall, the number of propagules recovered in these samples was similar to that recovered in comparable samples (Husikes et al. 2014) supporting the conclusion that it is a successful measure; yet it is time consuming, and unpractical to carry out during an expedition cruise. Therefore, self-assessment is seen as a viable alternative. The majority of questionnaire respondents reported that they would be willing to undertake such pre-cleaning if given instruction. The biosecurity guideline developed to meet this need is attached in Appendix 1. The resulting success of this guideline (in the absence of other measures) lies in the vigilance of tour operators to disseminate and communicate the requirements effectively.

While the results of our disinfection trial were limited to one ship, practices employed by this ship are similar to many across the AECO expedition fleet. Means to improve the disinfection of footwear employed on expedition cruise ships were discussed with tour operators and AECO staff. This resulted in the development of a 'best practice' protocol for conducting disinfection, underpinned by our results and research into disinfection efficacy carried out elsewhere. Several operators are already conducing footwear disinfection in a manner consistent with this protocol.

The propagule loads carried by a wider range of visitation categories to Svalbard than performed previously (cruise ship passengers, scientists, and cargo).

Results demonstrating the similar propagule loads carried on the footwear of cruise ship passengers indicates that this visitor type poses a threat consistent with others. Given many cruise ships arrive directly from other Subarcic or Arctic regions (typically northern Norway, or Iceland) our data underscore the potential for cold-climate adapted non-indigenous propagules to be transferred to Svalbard. The number of samples collected from the outwear and personal equipment of scientists was low, and therefore conclusions must be viewed in light of this. Nonetheless, the number of near-pristine field locations scientists commonly visit, in addition to their propensity to work in other polar environments, means they may also be likely to introducing cold-climate adapted species, and also deliver these directly to viable habitat. Samples collected from cargo items must be considered preliminary as we were not able to inspect a wide range of items due to access limitations. Generally, however, items were not heavily contaminated with seeds or invertebrates. Cargo items likely to pose the greatest risk (as demonstrated elsewhere) include cars, building supplies, and packing cases stored in natural settings.

We believe similarity of risk posed by visitation pathways, and the identification of management deficiencies and opportunities more broadly across pathways of species introduction to Svalbard (Ware et al. 2012; 2013, Ware et al. in prep, Alsos et al. 2014), suggests the need for a Svalbard wide approach to preventing species introduction.

REFERENCES

Alsos, IG, Ware, C, Elven, R (2014) Past Arctic aliens past away, current ones may stay. In Ware, C: Measuring and managing invasive species threats in the Arctic. PhD thesis, University of Tasmania.

Amass SF, Ragland D, Spicer P (2001) Evaluation of the efficacy of a peroxygen compound, Virkon1S, as a boot bath disinfectant. Journal of Swine Health and Production 9: 121–123.

Amass SF, Schneider JL, Gaul AM (2005) Evaluation of current and novel protocols for disinfection of airplane passenger footwear under simulated conditions. Preventative Veterinary Medicine 71: 127-134.

Australia and SCAR (Scientific Committee on Antarctic Research) (2007) IPY Aliens in Antarctica. Information paper presented by the Government of Australia and the Scientific Committee on Antarctica Research: information paper 49. Antarctic Treaty Consultative Meeting (ATCM XXX), New Dehli.

Chan, F. T., Bailey, S. A., Wiley, C. J., & MacIsaac, H. J. (2013). Relative risk assessment for ballast-mediated invasions at Canadian Arctic ports. Biological invasions, 15(2), 295-308.

Chown SL, Huiskes AHL, Gremmen NJM, Lee JE, Terauds A, Crosbie K, Frenot Y, Hughes KA, Imurag S, Kiefer K, Lebouvier M, Raymond B, Tsujimotoi M, Ware C, de Vijverk BV, Bergstrom DM (2012) Continent-wide risk assessment for the establishment of nonindigenous species in Antarctica. Proceedings of the National Academy of Sciences 4938-4943. DOI:10.1073/pnas.1119787109.

Curry CH, McCarthy JS, Darragh HM, Wake RA, Churchill SE, Robins AM, Lowen RJ (2005) Identification of an agent suitable for disinfecting boots of visitors to the Antarctic. Polar Record 41: 39-45.

Convey P, Frenot Y, Gremmen N, Bergstrom DM (2006) Biological invasions. In: Bergstrom DM, Convey P, Huskies AHL (eds) Trends in Antarctic terrestrial and limnetic ecosystems: Antarctica as a global indicator. Springer, The Netherlands, pp 194–220.

Elven R, Murray DF, Razzhivin V, Yurtsev BA (2011) Checklist of the panarctic flora (PAF). CAFF/University of Oslo, Oslo. http://gbif.no/paf. Accessed 20 Aug 2013.

Governor of Svalbard (2006) Report on tourism statistics from Svalbard 1997–2006. Svalbard Sysselmannen. http://www.sysselmannen.no/hovedEnkel.aspx?m=45275. Accessed 10 Aug 2013.

Governor of Svalbard (2012) Governor of Svalbard. (2012) Reiselivsstatistikk for Svalbard. http://www.sysselmannen.no/Annet/Rapporter/.

Huiskes, A. H., Gremmen, N. J., Bergstrom, D. M., Frenot, Y., Hughes, K. A., Imura, S., ... & Chown, S. L. (2014). Aliens in Antarctica: Assessing transfer of plant propagules by human visitors to reduce invasion risk. Biological Conservation, 171, 278-284.

Hughes K, Lee J, Ware C, Kiefer K, Bergstrom D (2010) Impact of anthropogenic transportation to Antarctica on alien seed viability. Polar Biology 33:1125–1130. doi:10.1007/s00300-010-0801-4.

Hughes KA, Lee JE, Tsujimoto M, Imura S, Bergstrom DM, Ware C, Lebouvier M, Huiskes AHL, Gremmen NJM, Frenot Y, Bridge PD, Chown SL (2011). Food for thought: risks of non-native species transport to the Antarctic region associated with fresh produce. Biological Conservation 144: 1682-1689.

IAATO (International Association of Antarctica Tour Operators) (2013) Boot, clothing and equipment decontamination guidelines for small boat operators. IAATO. http:// www.iaato.org/guidelines.html.

Kaltenborn BP (2000) Arctic-alpine environments and tourism: can sustainability be planned? lessons learned on Svalbard. Mt Res Dev 20:28–31.

Kerry KR, Riddle M (2009) Health of Antarctic wildlife: a challenge for science and policy. Springer 2009, pp 1-10.

Lee JE, Chown SL (2009a) Breaching the dispersal barrier to invasion: quantification and management. Ecol Appl 19:1944–1959. doi:10.1890/08-2157.1.

PAWS (Parks and Wildlife Service Tasmania) 2013 Phytophthora root rot: managing Phytophthora. http://www.parks.tas.gov.au/index.aspx?base=12813.

Ruiz, G.M. and A.H. Hines. 1997. Patterns of nonindigenous species transfer and invasion in Prince William Sound, Alaska: Pilot Study. Report Submitted to the Prince William Sound Citizens' Advisory Council. 80pp.

SCAR (Scientific Committee on Antarctic Research) (2010) Preliminary results from the International Polar Year Program: Aliens in Antarctica. Working paper 4 presented to the Committee on Environmental Protection. Antarctic Treaty Consultative Meeting XXXIII, Punta del Este, Uruguay.

(USDA APHIS) United States Department of Agriculture: Animal and plant health inspection services (2013) Import and export. http://www.aphis.usda.gov/import_export/plants/manuals/online_manuals.shtml.

Ware C, Bergstrom DM, Müller E, Alsos IG (2012) Humans introduce viable seeds to the Arctic on footwear. Biological Invasions 14: 567–577.

Ware, C., Berge, J., Sundet, J. H., Kirkpatrick, J. B., Coutts, A. D., Jelmert, A., Olsen, S.T., Floerl, O., Wisz, M.S. & Alsos, I. G. (2013). Climate change, non-indigenous species and shipping: assessing the risk of species introduction to a high- Arctic archipelago. Diversity and Distributions, 20(1), 10-19.

Whinam J, Chilcott N, Bergstrom DM (2005) Subantarctic hitchhikers: expeditioners as vectors for the introduction of alien organisms. Biological Conservation 121:207–219.

APPENDIX 1

Biosecurity guidelines

for visitors to the Arctic

Photo: Visitgreenland

Help protect the Arctic Environment

The Arctic remains one of the most pristine natural environments in the world. AECO's biosecurity guidelines aim to minimize the risk of future introductions of non-native species to the Arctic.

Photo: Bjørn Erik Sandbakk

Non-native species can spread to the Arctic through our activities there. By following a few simple steps in these guidelines you can help prevent this (see opposite page).

Photo: Robert Lubas / The Nature Conservancy

If you notice organic matter on boots, clothing or gear, make sure to clean it off.

Be a responsible visitor

One of the main ways non-native species can spread to the Arctic is by our activities there. Seeds, micro-organisms, and even insects can hitchhike to the Arctic on footwear, attached to clothing, or in bags that have been used in the outdoors previously. By following a few simple steps, you can ensure that your visit won't lead to non-native species being introduced to the Arctic.

Before leaving home

Examine and clean clothes, footwear, and bags thoroughly
Examine and clean all clothing, including pockets, seams, Velcro fasteners, and footwear soles for dirt and organic material. Use a vacuum cleaner, brushes, and water where necessary to ensure all seeds and dirt have been removed. This is especially important if you have used your clothing and equipment previously in parklands or rural settings, or other polar regions.

Photo: Dana Bergstrom – Australian Antarctic Division

Upon arrival

Be biosecurity aware

1. Follow the biosecurity procedures on your expedition. This is especially important if you are moving between distinct geographic regions (e.g. between eastern and western Svalbard, Svalbard and Greenland or Greenland and Canada) but also when moving between distinct landing sites.
2. Watch your step. If you notice organic matter on boots, clothing or gear, make sure to clean it off before leaving a site and use the disinfectant wash between visits. Leave disinfectant to dry between landings.
3. Spread the word. Share this information with others and help protect the Arctic environment.

Photo: IAATO.org

Non-native species – a potential threat to the Arctic environment

Non-native species represent a threat to biodiversity globally as they can cause serious negative impacts to the natural environment. These are species that are introduced to regions where they are not normally found as a result of human activity. Increasing visitation in the Arctic means a greater chance of more non-native species introductions.

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