Topic 6: Dealing with invasive species: sharing knowledge and experience

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Invasive species are now widely regarded as the second most important threat to biodiversity, after habitat destruction. The impacts of invasive species are particularly severe on small island ecosystems. This paper briefly reviews the importance of such ecosystems and the threats that they face from invasive species. Some resources available internationally to help in the battle against invasive species (particularly on small islands) are listed, and the outputs of a panel-guided discussion are provided in table form. These draw on the knowledge and experience of conference delegates, under three broad headings: awareness raising, prevention strategies, and control measures.
[Note that some papers relating to this topic occur also earlier in these Proceedings.]

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The importance of island ecosystems

Island ecosystems display many special characteristics (e.g. see Carlquist 1974; Williamson 1981; Whittaker 1998). Many of these result from the relative isolation of islands from other landmasses, and the difficulties that animals and plants experience in dispersing naturally across the sea. Consequently, islands provide remarkable opportunities to study fundamental ecological concepts and processes, including the general rules of biogeography (MacArthur & Wilson 1967), assembly rules for biological communities (e.g. Diamond 1975; Diamond & Gilpin 1982; Gilpin & Diamond 1982) and primary succession (e.g. on Krakatao following volcanic activity there: Whittaker & Bush 1993; Whittaker 1998). Islands can provide also situations in which to study the concepts of minimum viable populations (e.g. Soulé 1987), metapopulation theory (e.g. Levins 1969; Gotelli 1991; Hanski 1996), and the processes of speciation and evolution - it is no coincidence that Charles Darwin and Alfred Russell Wallace both developed their pioneering theories of natural selection based on observations made largely of island communities (Darwin 1859; Wallace 1902).

Island ecosystems tend also to be rich centres of biodiversity. Although they tend to support fewer species per unit area than continental landmasses (Whittaker 1998), islands are often home to disproportionate numbers of endemic taxa. Some of these provide peculiar examples of the evolutionary results of living in great isolation, and/or as part of an ecosystem with relatively few other species. Dispersal ability may be lost, resulting in flightlessness, as seen amongst the birds of New Zealand (e.g. Holdaway 1990), or the endemic beetle fauna of Tristan da Cunha (Elton 1958; Williamson 1981). Nanism or gigantism may occur, producing unusually small- or large-bodied species, respectively. The islands of the Caribbean support the world's smallest species of bird, lizard and snake, but they previously also supported giant tortoises (Case *et al.* 1992), similar to those found on the Galapagos and Aldabra. Spectacular adaptive radiations may occur on islands, resulting in unique suites of closely related but differentially adapted species. Hawaii provides a number of well-cited examples. Here, a single colonist species appears to have given rise to three genera and 54 species of tree crickets (Oecanthinae), representing nearly half of the world's known species (Otte 1989), and drosophilid fruit flies have shown an even greater degree of adaptive radiation, with one or two founder species giving rise to 700-1000 separate species, again accounting for nearly half of the known world fauna (Whittaker 1998).

The island biodiversity crisis

For all of the reasons outlined above, island ecosystems are of enormous conservation value. However, island biodiversity is particularly threatened by the damaging effects of human activities. Available data suggest that a disproportionate number of post-1600 extinctions have involved the loss of island species (Groombridge 1992). Amongst well-researched taxa (mammals, birds and land snails), around 80% of extinctions in this period may have been of island species. There is sub-fossil evidence that human impacts also caused significant extinction of vertebrate island species prior to 1600 (Whittaker 1998). Globally, Case *et al.* (1992) conclude that human activities have raised reptilian extinction rates by an order of magnitude on small islands, and Steadman (1997) estimates that island bird extinction rates increased by some two orders of magnitude as a consequence of human colonisation.

A range of human activities on islands have resulted in rapid species extinctions, notably: direct removal of individuals (hunting, timber extraction, etc.); habitat destruction; and introduction of non-native species (including disease agents). On many islands, introduction of invasive alien species can be regarded as the most important factor in the elimination of indigenous biodiversity, although the above mechanisms often act in combination (Whittaker 1998). Consequently, there is particular interest amongst conservationists in the impacts and management of invasive species on oceanic islands (e.g. Vitousek 1988; Veitch & Clout 2002). It is worth noting that these are not new concerns. Charles Elton devoted a chapter of his seminal 1958 publication *The Ecology of Invasions by Animals and Plants* to remote islands, noting (amongst other things): that New Zealand and Hawaii were particularly affected; that the introduction of rats and grazing animals were particularly damaging to indigenous island biodiversity; that invasive species indirectly (as well as directly) cause extinction of island species; and that some introduced species fail to establish outside human settlements, whilst others spread rapidly through a range of habitats.

Island ecosystems and invasive species

Invasive species and their environmental impacts have attracted much concern in recent years. The Convention on Biological Diversity (CBD) calls for action against invasive species in its Article 8h, and the IUCN (2000) describes their effects on indigenous biodiversity as "immense, insidious and usually irreversible". A number of sources consider in detail the environmental impacts of invasive species (e.g. Vitousek *et al.* 1997; Chapin *et al.* 2000; Mack *et al.* 2000). Globally, invasive species are widely-cited as the second greatest threat to biodiversity after habitat destruction, although figures have been produced which indicate that they represent the *greatest* threat. Hernendez *et al.* (2002) suggest that invasive species are responsible for 39% of all species extinctions since 1600, whilst habitat destruction accounts for 36%. However, as noted above, human-induced extinctions often occur as a consequence of a combination of factors. As well as environmental damage, the huge scale of the economic impacts of species invasions are increasingly recognised (e.g. see Pimentel *et al.* 2000).

Invasive species impacts on indigenous biodiversity can be particularly severe on islands. The introduction of species compromises the all-important isolation of island biotas, the very characteristic that underpins their special patterns of development. Hernendez *et al.* (2002) estimate that 12% of all continental animals (20% of mammals, 5% of birds, 15% of reptiles and 3.3% of amphibians) are threatened by alien invasions. However, the rates of threat increase on islands: 31% of animals (11% of mammals, 38% of birds, 32% of reptiles and 30% of amphibians). Unfortunately, many of the biological characteristics that make islands so special, and of such substantial conservation value, also render them particularly vulnerable to the establishment and impact of invasive species (e.g. see D'Antonio & Dudley 1995; Cronk & Fuller 1995). Such characteristics include the relative paucity of indigenous species (providing for greater vacant niche space and less competition than would be found on the mainland), the small size of island populations (rendering them more prone to extinction), and their evolution in isolation (leading, for example, to loss of defensive behaviours and consequent vulnerability to introduced predators). Other factors that have been cited as increasing the impact of species invasions on islands include the release from natural enemies experienced by introduced species (which often arrive without the predators and competitors that regulate their numbers in continental populations), and patterns of human exploitation of islands (many New World islands were colonised by Europeans before the continental mainland, were important trade centres with substantial international traffic in commodities, and have acquired very high density human populations).

The problem of invasive species impacts on island ecosystems is exacerbated by the fact that a single non-native species can drive numerous indigenous species to extinction, as witnessed by the effects of introduction of the Brown Tree Snake *Boiga irregularis* to Guam, or the invasive shrub *Miconia calvescens* to Tahiti (Whittaker 1998), for example. Such multiple extinctions can result from direct impacts on similar species (e.g. goats overgrazing a range of native plants), or a combination of direct and indirect effects (e.g. the elimination of insect pollinators by an invasive species, leading to plant extinctions, or elimination of plants leading to loss of specialised herbivores).

Coblentz (1998) summarises the impact that an introduced herbivorous mammal, such as the goat or rabbit, can have on an island ecosystem. The initial impact is generally severe over-grazing of local plants, particularly the more palatable species. Over-grazing creates patches of bare ground, which may allow enhanced germination of less palatable plants (which can come to dominate the plant community), or may remain barren. Small populations of plants may survive in inaccessible areas, but these can gradually exhaust their seed supply (as any seed that is dispersed into accessible sites results in seedlings that are quickly eliminated). The death of these relict populations can represent the extinction of the species, and with it any other species (such as insects) that have evolved to depend upon it. The general depletion of the plant community results in loss of habitat for a range of animal species (birds, reptiles, insects), which may also face extinction. The process also exposes soils, promoting erosion (and extinction of the soil biota), and a once vigorous, diverse ecosystem can be replaced by a barren landscape. Omnivorous species, such as pigs, can have all of the impacts of a large introduced herbivore, plus the direct negative effects of feeding on invertebrates and vulnerable stages of vertebrates.

As Coblentz (1998) notes, feral cats and rats on islands are primarily a threat as predators of sea birds and endemic reptiles, and can displace or

extirpate such species very rapidly. It has been suggested that global seabird numbers have been reduced by tens of millions due to predation by rats and cats (Coblentz 1998). Veitch (1998) estimates that 30 of 55 seabird species studied on Pacific islands cannot survive in the presence of rats, which also imperil almost all terrestrial insects larger than 10mm, many reptiles and even certain tree species. Case *et al.* (1992) conclude that introduced predators (dogs, cats, rats, mongooses) have been the main agents of extinction of reptiles on small islands, and that large-bodied reptiles with a long history of island isolation have proved most vulnerable. On the island of Pine Cay (Turks & Caicos Islands), rock iguanas were driven to extinction in just six years by feral cats that originated from pets introduced by resort construction workers (Coblentz 1998).

The process of deliberate or accidental introduction of exotic species to islands involves the same (numerous and diverse) mechanisms that lead to movement of non-native organisms within and between continents. Examples of important pathways (e.g. see Wittenberg & Cock 2001), include:

Deliberate
Plants introduced for agriculture/forestry
Animals introduced as livestock or for sport
Ornamental plants
Other "aesthetic" introductions
Biological control

Accidental
"Contaminants" in traded commodities
"Hitch-hikers" in other consignments
Ballast material from ships
Escaped pets, or other captive species

As in continental systems, whilst most invasive species are exotic, native species can also become invasive in island ecosystems, usually in response human disturbance of habitats. For example, the Bermuda Cedar *Juniperus bermudiana*, an endemic tree, spread across Bermuda after human colonisation, establishing a virtual monoculture in many areas that had previously supported more diverse plant communities (Wingate 2001). Ironically, the Bermuda Cedar was subsequently almost wiped out by an invasive exotic scale insect, and has now largely been displaced in the plant community by non-native *Casuarina*.

Dealing with invasive species

In tackling invasive species problems, it is generally the case that *control* measures (including eradication) are only likely to succeed if they are applied at an early stage, or on sites that can be relatively well-protected against reinvasion. Consequently, *prevention* rather than control is likely to be more cost-efficient and effective as a basis for the management of species invasions. However, islands (by virtue of the strong dispersal barrier that the surrounding ocean represents) are relatively promising sites for attempts at control or eradication of invasive species. Veitch (1998) notes that rat eradication is eminently feasible on islands up to 2000ha in area, or larger in some cases, and that more than 80 islands have been successfully cleared of rodents. Details of many invasive species eradication projects on islands are given in Veitch & Clout (2002).

Although prevention and control measures are clearly critical in the management of invasive species threats, it is invariably the case that efforts to put management strategies in place also require considerable efforts in gathering and managing relevant data (so that informed decisions can be made), and awareness raising across all levels of society (so that the importance of the issue is more widely appreciated, and political will to address it is generated).

Sharing of experience is vital to dealing with invasive species threats, to minimise duplication of effort, enhance co-operation and increase the speed with which effective strategies can be developed and implemented. The following sections provide a summary of some of the resources that are available internationally to assist in understanding and managing invasive species threats (particularly in island situations), and the outputs of a workshop session where conference delegates shared some of their experiences with the invasive species problem.

Available resources on invasive species

International initiatives on invasive species
As awareness of the importance of invasive species issues grows, a number of initiatives are being developed at local and regional scales. These are vital for the development of legal frameworks and practical management strategies. However, co-ordination at a global level is also important, to minimise duplicated effort and maximise exchange

of information and ideas.

GISP – The Global Invasive Species Programme
(http://jasper.stanford.edu/gisp/)
GISP was established in 1997, as a partnership between IUCN (the World Conservation Union), SCOPE (the Scientific Committee on Problems of the Environment) and CABI (CAB International). It has become an international partnership network of governments, institutions and individuals from many disciplines and backgrounds, working towards the GISP mission: To conserve biodiversity and sustain human livelihoods by minimising the spread and impact of invasive alien species. GISP is the main vehicle for tackling invasive species issues under the CBD (Convention on Biological Diversity), and works through: awareness raising, establishment of linkages and networks, co-ordination of workshops, summarising scientific and technical information. GISP's activities focus primarily, but not exclusively, on invasive species issues in developing countries.

ISSG – Invasive Species Specialist Group
(http://www.issg.org/)
The ISSG is part of the Species Survival Commission of the IUCN. It is an international group of 146 scientific and policy experts on invasive species from 41 countries, working towards the ISSG mission: To reduce threats to natural ecosystems and the native species they contain by increasing awareness of invasive alien species, and of ways to prevent, control or eradicate them. ISSG provides advice on threats from invasive species and on control or eradication methods. Its activities focus primarily on invasive species that cause biodiversity loss, with particular attention to those that threaten oceanic islands.

Co-operative Initiative on Island Invasive Alien Species
(http://www.issg.org/islandIAS.html#IslandIAS)
Invasive species problems can be particularly acute on islands (hence the ISSG's particular focus in this area). This ISSG initiative exists to facilitate co-operation in key areas of invasive species management towards the conservation of island biodiversity. The pacific region has provided a particular focus, but the initiative has a global remit.

Communication resources relating to invasive species
Electronic communication allows rapid exchange of information and ideas. General electronic discussion forums, at a local or regional level, such as Caribbean Biodiversity e-mail group (http://groups.yahoo.com/group/caribbean-biodiversity/) often carry information on invasive species issues. However, the following are (respectively) key resources globally, in the Caribbean, and for the UK Overseas Territories, in relation to invasive species specifically.

Aliens-L
The ISSG's Aliens-L listserver is the premier international electronic forum for discussion and information exchange on invasive species. To subscribe, send an email without a subject header to: Aliens-L-join@indaba.iucn.org with the message "subscribe to Aliens-L". For further information, see the ISSG website.

Caribbean Invasive Species Threats
This electronic forum, moderated by CAB International, allows exchange of information and experience in relation to invasive species threats in the Caribbean. To subscribe, send a blank e-mail to carib_ias_threat-subscribe@yahoogroups.com or visit
http://groups.yahoo.com/groups/carib_ias_threat/

A "Breath of Fresh Air" Discussion Forum
(http://www.activeforums.co.uk/Public/)
The UKOTCF (Overseas Territories Conservation Forum) website hosts this electronic forum for discussion of issues relating to the UK Overseas Territories. Invasive species issues have their own discussion group here, for the exchange of views and information.

Publications on invasive species
Aliens Newsletter
(http://www.issg.org/newsletter.html#Aliens)
Produced twice-yearly by the ISSG, this newsletter provides very readable articles, reviews and other information on invasive species issues (particularly in a conservation context).

Biological Invasions
(http://www.kluweronline.com/issn/1387-3547)
An academic journal which provides detailed research and review articles on invasive species issues.

100 of the World's Worst Invasive Alien Species
A booklet published by ISSG – very useful material for environmental education. Available as a pdf file (Adobe Acrobat Reader required for downloading) from the ISSG website at:

http://www.issg.org/booklet.pdf

Turning the Tide: The Eradication of Invasive Species
C.R. Veitch & M.N. Clout (2002). Published by IUCN.
This very recently published book provides the proceedings of an international conference on the eradication of island invasives.
For details see: http://www.issg.org/Eradicat.html

Invasive alien species: A Toolkit of Best Prevention and Management Practices
R. Wittenberg & M.J.W. Cock (2001). Published by CAB International on behalf of GISP.
This book provides practical advice, illustrated with numerous case-studies, on prevention and management practices. Available from CABI (http://www.cabi-publishing.org/) or IUCN (http://www.iucn.org/bookstore/).
Also available as a pdf file (Adobe Acrobat Reader required for downloading) from the GISP website at: http://jasper.stanford.edu/gisp/100Toolkitfin.pdf
Also available in interactive web format at: http://www.cabi-bioscience.ch/wwwgisp/gt1goto.htm

A Guide to Designing Legal and Institutional Frameworks on Alien Invasive Species
C. Shine, N. Williams & L. Gundling (2000). Published by IUCN on behalf of GISP.
Aimed at law and policy-makers, this volume provides guidance on developing or strengthening legal and institutional frameworks for addressing the invasive species problem, in the context of existing international agreements and regional instruments. Available from IUCN (http://www.iucn.org/bookstore/).
Also available as a pdf file (Adobe Acrobat Reader required for downloading) from the CBD website at: http://www.biodiv.org/doc/meetings/sbstta/sbstta-06/information/sbstta-06-inf-08-en.pdf

IUCN Guidelines for the Prevention of Biodiversity Loss Caused by Alien Invasive Species
A set of general guidelines on addressing invasive species issues, prepared by the ISSG in 2000. Available at: http://www.iucn.org/themes/ssc/pubs/policy/invasivesEng.htm

Invasive species in the Pacific: a technical review and draft regional strategy
G. Sherley (ed.) (2000). Published by the South Pacific Regional Environment Programme, Samoa.
This volume collates technical information, and provides a regional strategy for the management of invasive species threats across the islands of the South Pacific. Available as a pdf file at: http://www.hear.org/pier/pdf/invasive_species_technical_review_and_strategy.pdf

Other resources relating to invasive species
Global Invasive Species Database (http://www.issg.org/database/welcome/)
The ISSG is currently expanding this database, which is likely to become one of the most important international reference points for invasive species information. The database can be searched by species name, locality, habitat type and other ecological categories.

Other resources relating to islands
Again, it is worth mentioning resources such as the Caribbean Biodiversity e-mail group (http://groups.yahoo.com/group/caribbean-biodiversity/) which do much to further information exchange and co-operation between island communities at a local or regional scale. However, the following has recently been established, with a global remit.

Global Islands Network (http://www.globalislands.net/)
GIN is a recently established, non-profit organisation with a mission to: Conduct and promote culturally appropriate, ecologically sound, economically sustainable and socially equitable development on islands worldwide. The GIN website provides useful links to a range of resources and information on islands, at a local, regional and global scale.

Dealing with invasive species: sharing knowledge and experience - Workshop output

Rapporteur: Dr Annie Glasspool

Territory	Raising awareness	Invasive control	Invasive prevention
Anguilla	• We need to define who/when we decide a species is invasive, because sometimes it is difficult to determine whether or not a problem species arrived naturally.		• Some species invasive in one area are not necessarily invasive elsewhere which impacts whether or not it becomes a priority. (Casaurina??)
Ascension	• A decision was made to control the feral donkeys – a letter was written to local newspaper asking for public input – no one responded until one week's notice was given that the donkey's were to be castrated – at which point a 300 person petition was presented and the donkeys were left in peace	• Investigate the commercial value for invasives to encourage eradication • Importance for legislation, but needs to be enforced • Lack of enforcement has resulted in import of non-spayed kittens	
Australia	• There is a move to celebrate the 'Easter Bilby' – success story		• Very strict on imports from Malawi
Bahamas	• Working with one Architectural firm to develop of photo series of land they are working on, documenting existing natives, and the difference in care needed for native plots versus plots planted with introduced spp. • Hutia – endangered species is actually destroying the entire ecosystem	• Casaurina's a problem, but something is now starting to kill them • There is a different standard of requirements for foreign versus local development – eg. regulations for local development don't exist and many lots once cleared are left barren for many years	• Container ships are a concern both in terms of checks and contingency planning in the event of an accident

Bermuda	• We need to identify ALL stakeholders • We need to engage and get buy-in from identified stakeholders • There is a lack of guidance/ information about plants being sold in private nurseries (invasives are being sold locally) due to a lack of awareness amongst nursery owners • Awareness was raised during hurricane Emily because native species survived much better than the invasives • Need to promote the existing plant voucher scheme whereby you are given x free plants when you have a planning application • Olivewood is in scale with small lot properties – no leaf problem for home owners – needs to be promoted • Use tourism to highlight natives – ditch the use of invasive species in brochures etc. • Learning through landscapes programme – encourages awareness through native plantings, plus encourage closer interaction with environment and enhance the school environment	• Need to be sure that we can meet demand with replacement species • Currently resources are lacking with regards to meeting demand (money, facilities, skills) • Dept of Planning initiated a programme so that the Cons. Officer can assist local landowners in a woodland management plan for their property – but if it expands, supply may become an issue • Get tourists to come and get involved in culling programmes – eg. through Earthwatch. • Toad exclusion barrier established on Nonsuch as a localized control • Eradication in a localized area can provide data which can be used to promote further eradication	• Some species can be recognised a priori as being invasive • Regulation of pet trade needed but there are no native species to serve as alternatives; pets which cannot survive in the wild should therefore be selected.

	• We gloss over some invasives because of their cultural identity eg. Whistling frog, grass species, Brazil pepper (important for bee keepers) • So, how would people who currently benefit from invasives be compensated? • Could promote use of Casaurina for firewood • Islanders need to accept that some pets are not appropriate on an oceanic island • Cane Toad not flagged as a problem species in Bda but perhaps this reflects lack of information • Highlights power of public awareness – toad has been promoted in the last few years as a flagship for environmental health but that has been misinterpreted as a concern for the Cane toad itself • Shouldn't ignore the value of pets in establishing respect for nature – but it is responsible pet ownership that needs to be promoted		
British Virgin Islands	• Can insist on planting of natives by public institutions • There are high costs associated with contractors working around existing natives so they tend to be removed		

Cayman	• Some invasives are a part of the local culture – meaning that the task in public awareness would be enormous • Promote planting of native species along with promoting the need to eradicate invasives • National Trust is currently working on public awareness. But exotics are produced much more cheaply than natives, making marketing them hard • Education is needed so that when people are clearing land, natives are left in place • Recommendations of how much (minimum) native vegetation should be left was made in the Planning Statement but it has since been removed • Problem with algae being produced for aquarium trade	• It is cheaper for plants to be imported than grown locally • Could the local Government restrict imports or subsidise local production – unless this is done, there is currently no incentive for local production	• Regulation of pet trade needed but no native species as alternatives – but at least select pets that simply cannot exist in the wild in a particular jurisdiction.
Cyprus	• Cannot remove any tree from a property unless it is disrupting the foundations		
Falklands	• Increase in environmental awareness has prompted wider use of biological controls, in the absence of sufficient information	• Reindeer introduced	
Isle of Man	• Need to map data to demonstrate scale of problem in order to secure further support/ justification of resources	• Misidentification of species can be a problem – resources used when not necessary	

Jersey	• Have introduced species which have become flagship spp. Eg the Red squirrel • Need to consider why people adopt such species – get to the root cause • People are confused by the message that is being sent • Reinforce the damage that is being done by a species		
Montserrat	• Still trying to get construction companies to stop clearing areas – to leave natives		
Netherlands Antilles	• Husbandry – eg. Goats • Ballast water	• Husbandry – eg. Goats	
Pitcairn		• Culling of invasives encouraged by promoting use of felled trees for firewood – and natives to replace them	• More imports coming from Polynesia now – concerns for prevention of introduced species associated with this
South Africa	• Declared list of invasive species • Benefit to having demand greater than supply if not excessive and if marketed appropriately		• Fines for having an invasive species on property • Problem with Government personnel 'being allowed' to bring in pets • Don't just focus on invasives – danger of complacency regarding those just considered to be introduced – as oceanic islands we cannot afford to ignore these

St. Helena	• Success story with Ebony	• Value of Opuntia for Vitamin C hadn't been taken into consideration, nor had impact of its removal on hillsides • Can't please everyone – concern at the airport about increasing birds and safety issues	• A problem with diseased lemon segments imported prompted better regulations on importations – phytosanitary certificates etc. – but no one is currently considering wood imports
Turks and Caicos	• A research interest group has held a workshop to raise awareness of the invasives problem • Signage is used to illustrate native species • Plants sales are held to encourage purchase of natives • Award scheme is being implemented to encourage native plantings • Visit schools – requests for labeling of plants to identify natives • Enough information currently exists to demonstrate the threat of cats to iguanas – a great example of where an eradication programme is needed	• Should be conditions attached to planning regulations – when and area is cleared, it must be replaced with natives • Space is being provided in private nursery to Trust to propagate natives • Casaurina's introduced (by Bermudians) are becoming a problem – Bermuda has offered to subsidise some replacement planting with natives • A bush walking crew conducts plant rescue exercises – but only 20 people involved • A flagship spp is the Iguana, but feral cats impacting iguanas	• There is trading with the Dominican Republic for fruit and vegetables – but plants are brought in, unregulated (the same is true with pets – no papers/quarantine are required)

UK	• Need to eliminate the jargon associated with invasives – a problem was identified in trying to raise awareness of the issue in ethnically diverse schools which led to misunderstandings • Talk about species which are destructive and damaging (might include endemics too). This might lead to economic incentives eg. Insurance issues surrounding casuarinas • People are deliberately planting introduced species in nature reserves to 'increase the biodiversity' • Need to come up with costs of dealing with invasives to catch the attention of the politicians • If pet imports are suspended, pet traders refocus on other species which are also problematic • Promote prose, storytelling etc. to tell the knock-on effects – eg. The Lighthouse Keepers Cat	• Cross-departmental control of the issue can mean that decisions don't actually get made – need to have one department in control • Control does involve public awareness	• Imports can be suspended – currently in place for Red-eared Slider terrapin and American Bullfrog • Need to establish a committee to develop a list of potentially invasive species • Establishment of global databases such as GISP will help
US	• Promotion of good practices important – need to work more closely with horticultural industry • "Barking up the wrong tree" -good catch phrase!	• Use of prisoners to work on environmental projects has been successful	

Other	• Must stress the positive element – focus on the fact that a native species will be promoted – not so much the eradication of an invasive species • Let's not forget inorganic invasive species – ie trash • Can't ignore the fact that introduced species are attractive to people – (colourful, cuddly etc)	• Control often takes a long time and ongoing monitoring and funding is essential • How can we make use of our destructive urges constructively – introduce a tally to encourage competitive nature • Danger that an invasive plant might not be recognised if you are recruiting volunteers and the wrong plant may be culled • Marine litter is a major means of dispersal of 'invasive species • FRONTIER – paid customers to 'volunteer' for projects but marketing is not easy – need a very clear idea of what the programme involves – people need a structured programme – not just pulling up trees • Need for pilot projects • Most eradication programmes have been done as a last resort but have lacked the resources for follow-up studies • Spaying and neutering should be a requirement but often not realistic • Water hyacinth considered for brickettes for burning in Malawi	• Need to consider issues of disease when considering reintroducing native species • Need for exchange of information about good practices between territories • Capacity is often lacking at point of import – so certificates can be issued at point of export – but soil for example presents problems • Use of dedicated containers to particular locations

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CAB International and biological control of invasive species (posters)

Oliver D. Cheesman

Cheesman, O.D. 2003. CAB International and biological control of invasive species. pp 273-274 in *A Sense of Direction: a conference on conservation in UK Overseas Territories and other small island communities* (ed. M. Pienkowski). UK Overseas Territories Conservation Forum, www.ukotcf.org

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An introduction to CAB International (CABI) is provided elsewhere in these Proceedings (p.177). One of CABI's major interests throughout its long history has been the use of biological control – the release of natural enemies of weeds or pests, to suppress their populations. For many years, CABI operated a specific body to co-ordinate work in this area (the Commonwealth Institute of Biological Control, later the International Institute of Biological Control). It has published catalogues of biological control agents used against pests in different regions of the world, such as Cock (1985) for the Caribbean and Bermuda, and a global catalogue of weeds and their biological control agents (Julien & Griffiths 1998). CABI continues to research and implement biological control programmes and regularly publishes reference materials (such as *Biocontrol News and Information*).

Agricultural weeds and pests provide some of the most obvious early examples of damaging invasive species. Biological control has been used to counter them for over 100 years. There is an increasing interest in the use of biological control against invasive species in natural as well as agricultural ecosystems. With increasing sensitivity to the negative impacts that alien species can have, it may at first seem counter-intuitive to import deliberately more non-native organisms in attempts to control one that has become invasive. Some examples of "biological control gone wrong" are well known – the Mongoose in the Caribbean, the Cane Toad in Australia. However, these are invariably amongst the earlier attempts at biological control, involving poorly or un- regulated programmes, where the negative impacts could easily have been predicted, if only the underlying ecology of pest and natural enemy had been considered. Although poorly regulated biological control programmes remain a potential danger, international standards have been set for the use of the technique (FAO, 1996). Rigorous screening for potential impacts on non-target organisms is clearly an essential part of any responsible biological control programme (Thomas & Willis 1998).

Biological control is not always appropriate, nor is it always successful. However, in the right situation it can represent an unrivalled technique for the control of invasive species. Alternative techniques, such as chemical and mechanical control, are often damaging to the environment, costly and labour intensive – often needing to be repeated year after year. Such techniques may simply be impractical, because of the topography of the affected area, or because the invasion is too far advanced. For a relatively small initial investment, biological control can provide a self-sustaining solution – using biodiversity to protect biodiversity (Anon. 1994).

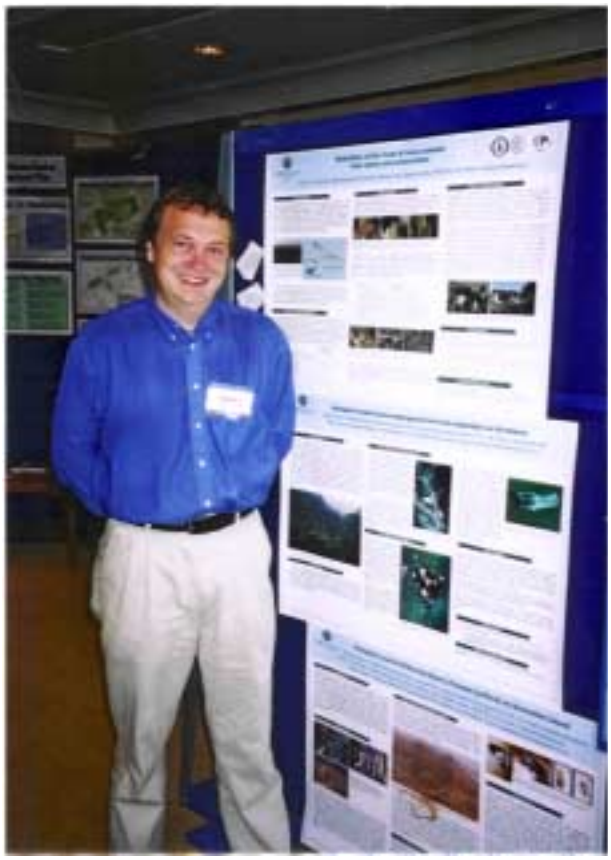
Successful biological control programmes are often forgotten – once a weed or pest problem has been eliminated, it is easy to forget that it ever existed. Nonetheless, spectacular success stories, like the clearance of invasive *Opuntia* cactus in Australia in the 1920s and 30s, are not difficult to find. Although economic analyses are scarce, successful biological control programmes are estimated to have saved millions of dollars (Greathead 1995).

The following poster presentations describe some of CAB International's recent work with biological control in the UK Overseas Territories; not against agricultural pests, but against environmentally damaging invasive species.

The work to protect the endemic Gumwood Tree on St Helena was one of the first examples of biological control being used successfully to save

from extinction a rare species threatened by an invading alien pest. The success of this programme paved the way for the restoration of the Gumwood (the Millennium Forest Project) on St Helena – see Cairns-Wicks & Peters (2001).

Although further effort is needed on Ascension Island, to follow up on initial attempts at biological control of Mexican Thorn, the work conducted there may have contributed to slowing the spread of this pernicious weed. Biological control may provide the only practical solution to the environmental threats posed by this vigorously invasive alien plant on the island, and would complement work undertaken by the RSPB to control cats and rats – see George & White pp.155-160 in these Proceedings.



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The following two posters should be cited as:

Shaw, R. & Fowler, S. 2003. Biological control saves endangered tree from extinction on St Helena. p 275 in *A Sense of Direction: a conference on conservation in UK Overseas Territories and other small island communities* (ed. M. Pienkowski). UK Overseas Territories Conservation Forum, www.ukotcf.org

Djeddour, D., Cheesman, O.D. & Fowler, S. 2003. Biological control of Mexican thorn *Prosopis juliflora* on Ascension Island. p 276 in *A Sense of Direction: a conference on conservation in UK Overseas Territories and other small island communities* (ed. M. Pienkowski). UK Overseas Territories Conservation Forum, www.ukotcf.org

Biological Control saves endangered tree from extinction on St Helena

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Introduction

St Helena, one of the UK's Overseas Territories, is a small volcanic island, approximately 14 million years old. It is situated in the southern mid-Atlantic, around 2000km east of Angola on the western coast of Africa. Despite its diminutive size (122km^2), and the effects of widespread environmental degradation, the island's flora and fauna is of international importance, including 10 endemic genera and 37 endemic species of flowering plants (Ashmole & Ashmole, 2000). Amongst these is the St Helena gumwood *Commidendrum robustum*, a giant member of the daisy family (Compositae). This is the national tree of St Helena, and once formed an extensive forest across parts of the island. However, this special plant is now represented by only 2500 trees at Peak Dale and these were, until recently, under threat of extinction.

Figure 1: Gumwoods on St Helena

The Enemy

In 1991, the scale insect *Orthezia insignis* was identified attacking the remaining gumwood trees. This insect is a common pest in tropical countries and is likely to have been introduced onto St Helena accidentally in the 1970s or 1980s. It proved difficult to control with insecticides because the places where the surviving gumwoods grew were relatively inaccessible.

The Threat to the Gumwood

O. insignis was capable of killing trees partly by its sap-sucking feeding activity, but also because of the sooty mould that grew on the honeydew produced by dense scale infestations. Not only was the gumwood (and the native species associated with it) under threat, but the wide host range of the pest meant that other endemic plants were likely to be attacked as well.

The situation was becoming desperate: between 1991 and 1993 around 100 trees had died, and increasing numbers were becoming heavily infested. CAB *International* (CABI) were approached to investigate alternative methods of pest control.

Figure 2: An infestation of *Orthezia insignis*

The Natural Solution

Fortunately, this particular pest was no stranger to CABI's biological control scientists. Research revealed that between 1908 and 1959 a predatory ladybird beetle, *Hyperaspis pantherina*, had been used to control the scale insect in Hawaii, four African countries and Peru, with substantial success in most cases.

Consequently, the beetle was imported into CABI's UK quarantine facility so that its taxonomy, life history and environmental safety could be studied in detail (Booth *et al.*, 1995).

Figure 3. The specialist predatory ladybird beetle, *Hyperaspis pantherina*

In two years of study, only one egg was laid by this ladybird in the absence of the target pest, indicating a high degree of specificity to this species of prey. Furthermore, all the other scale insects and mealybugs recorded from St Helena were known to be introduced species, and most are pests. As a result of this work, the Government of St Helena gave permission for the release of the predator for the control of *O. insignis*. In May 1993, 80 individual beetles survived a 6 day air and sea journey to the island.

Figure 4. *Orthezia insignis* adult with the oval grey egg of the predator laid on its back (see arrow)

The Results

With an enormous source of prey, a mass-rearing programme initiated on St Helena by local staff allowed continual releases of beetles in 1993, onto gumwood trees infested with *O. insignis*. The programme culminated in the mass release of 5,000 beetles in early 1994. By 1995, the mass rearing programme had to be abandoned, because insufficient prey could be found on the island!

Since 1995, there have been no further problems with *O. insignis* on St Helena, and restoration projects involving extensive tree-plantings are under way to re-establish the gumwood populations.

This project used nature to control nature, and restored the balance which had been upset by human activities. It is fair to say that this little ladybird has saved another species from likely extinction in the wild.

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Biological control of Mexican thorn (*Prosopis juliflora*) on Ascension Island

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Introduction

Ascension Island, one of the UK's Overseas Territories, lies in the equatorial Atlantic Ocean, 1200km northwest of the island of St. Helena and 1700km from the African mainland. A young volcanic island, approximately 1 million years old, it covers 98km^2 and has a naturally dry, barren landscape, largely covered by basalt lava fields and cinder cones. Although Ascension supports relatively few indigenous species, a number of important endemics occur amongst its flora and fauna (Ashmole & Ashmole, 2000). The barren landscape itself represents a rare set of natural habitats, but the island has suffered serious ecological degradation as a result of human exploitation and species introductions.

The Enemy

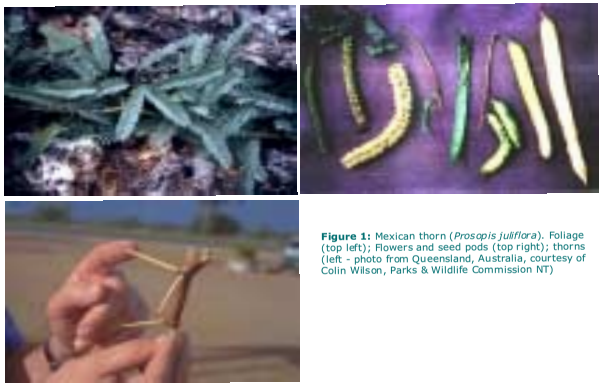

Figure 1: Mexican thorn (*Prosopis juliflora*). Foliage (top left); Flowers and seed pods (top right); thorns (left - photo from Queensland, Australia, courtesy of Colin Wilson, Parks & Wildlife Commission NT)

The Mexican thorn *Prosopis juliflora* is a spiny, leguminous tree which has spread from its native geographical range (centred on Central America) to become a serious invasive alien weed in many parts of the world. *Prosopis* appears to have been accidentally introduced onto Ascension Island in the 1970s or 1980s. The plant grows very rapidly, and trees (which can reach 15m in height) often form dense thickets. On Ascension, the spread of *Prosopis* is assisted by the local population of feral donkeys, which eat the seed pods, and then distribute the seeds in their droppings. The plant represents a serious threat to the indigenous biodiversity of the island, as well as causing serious amenity problems.

The Threat to Ascension Island

Despite being a relatively recent arrival, *Prosopis* has spread very rapidly on Ascension, and is present over approximately 75% of the island. Tracks and paths have become blocked by impenetrable Mexican thorn thickets, and the plant's thorns cause punctures to the tyres of motor vehicles and bicycles. A significant fire risk will also develop as dead wood accumulates, as it burns very easily.

Figure 3: The naturally barren landscape of Ascension Island is now speckled with the green of Mexican thorn bushes (photo taken August 2000 by Nick Jewsbury).

In biodiversity terms, the rapid spread of *Prosopis* threatens to drastically alter the unique landscape of the island and obscure many of its fascinating volcanic features. These barren habitats are home to a small but interesting endemic invertebrate fauna, which could be lost as the Mexican thorn spreads further. In addition, *Prosopis* threatens to suppress important endemic plants such as the rare *Euphorbia origanoides,* and invades the nesting sites of green turtles and sea birds. The Mexican thorn thickets also provide cover for introduced animals, such as rats and cats, which themselves threaten to devastate the island's biodiversity.

The Natural Solution

CAB *International* conducted a study of the potential for biological control of Mexican thorn on Ascension Island during 1996/7 (Fowler, 1998). Although chemical control and mechanical removal of *Prosopis* is possible, this is not a practical solution now that the plant has spread so far. Based on work conducted in South Africa, two species of bruchid beetles (which attack the seeds of the plant) were identified as possible biological control agents: *Algarobius prosopis* and *Neltumius arizonensis*. Releases of adult beetles were conducted on Ascension in May 1997.

Figure 3: Adult *Algarobius prosopis* emerging from a seed pod (left); adult *Neltumius arizonensis* (top centre); *Prosopis* biological control agents featured on Ascension Island stamps (top left)

The Results

Initial observations suggested that both beetles had established populations on Ascension Island. Subsequent work suggests that *Neltumius* may have since died out, but that *Algarobius* has successfully spread through much of the Mexican thorn on Ascension, where it may be destroying around 50% of the seeds produced by the plant (Jewsbury, 2001). Nonetheless, this may be insufficient to halt the spread of *Prosopis*, and additional work may be necessary to control the plant on the island. Fowler (1998) suggested that further biological control agents might be required, acting alongside the two bruchids released in 1997, in order to counter the spread of Mexican Thorn on Ascension Island.

Reports of *Neltumius* and/or *Algarobius* attacking Seed-work Acacia *Leucaena leucocephala* on Ascension are (as expected) incorrect . An entirely different beetle, *Acanthoscelides suramerica*, is responsible for the damage to Acacia (Jewsbury, 2001).

A recent conservation management plan for Ascension Island (Pickup, 1999) recognises Mexican thorn as one of the most important threats to local biodiversity, along with introduced rats and cats. Further funding is required to progress the biological control initiative against Mexican thorn on Ascension Island.

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Mink *Mustela vison* eradication in the Western Isles, Scotland, UK (poster)

Niall Moore and Sugoto Roy, Central Science Laboratory (Defra)

Moore, N. & Roy, S. 2003. Mink *Mustela vison* eradication in the Western Isles, Scotland, UK. p 277 in *A Sense of Direction: a conference on conservation in UK Overseas Territories and other small island communities* (ed. M. Pienkowski). UK Overseas Territories Conservation Forum, www.ukotcf.org

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Invasive non-native species cause the greatest loss of biodiversity on oceanic islands. The American mink *Mustela vison* is a non-native small carnivore which has become established throughout the UK following escapes from fur farms since the 1920s. Farmed mink escaped in the Western Isles (Scotland) and a feral population is now established on 75% of the 2,800 km^2 archipelago.

Mink threaten internationally important ground-nesting bird populations (mainly terns) by predation of eggs and chicks. A five-year eradication scheme is attempting to reduce the impact of mink and assess the feasibility of a pan-archipelago eradication scheme. The project is funded by the EU LIFE-Nature Fund and a consortium of local bodies led by Scottish Natural Heritage, with the work being carried out by staff from Central Science Laboratory.

The main aims of the scheme are to eradicate mink from a 750km^2 trial area of the Western Isles, to collect data for modelling full eradication, and also to remove feral ferrets *Mustela furo*, another alien small carnivore. The main method employed is live-capture cage trapping using 2,500 traps over a five-year trapping campaign. Dogs are used to locate den sites.

The project has just completed its first 16 months of trapping and has achieved over 62,000 trap-nights with 230 mink and 139 feral ferrets caught to date. Mink population densities are substantially lower than previously thought. Most of the mink are confined to the coast with the highest densities on small offshore islands, many close to seabird colonies.

Trapping at den sites has proved highly successful when mink are breeding (a period during which normal line-trapping is unsuccessful). Locating mink dens using dogs has also proved very effective. The use of scent-gland-based lures has improved efficiency, doubling the capture rate. Traps on floating platforms and the use of mirrors are also being investigated.

Tern colonies have been counted and breeding success estimated to compare with future trends. As mink numbers decline, rat *Rattus norvegicus* captures have increased, suggesting possible mesopredator release. Modelling indicates that 80-85% of the mink population must be removed *per annum* to cause extinction in five years.

Mongoose management to protect endangered pink pigeons in Mauritius (poster)

Sugoto Roy, Central Science Laboratory (Defra), Carl Jones, Mauritian Wildlife Foundation and Stephen Harris, University of Bristol

Roy, S., Jones, C. & Harris, S. 2003. Mongoose management to protect endangered pink pigeons in Mauritius. p 278 in *A Sense of Direction: a conference on conservation in UK Overseas Territories and other small island communities* (ed. M. Pienkowski). UK Overseas Territories Conservation Forum, www.ukotcf.org

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The small Indian mongoose *Herpestes javanicus* was introduced to several tropical islands to control rats in the late nineteenth and early twentieth centuries. Seventy five percent of these islands fall within biodiversity hotspots. Its introduction has coincided with the extinction or population demise of several rare and endemic birds and reptiles.

Nineteen mongooses were introduced to Mauritius in 1902, and a century later the species is now widespread. The pink pigeon *Columba mayeri* is a species endemic to Mauritius whose wild population has increased from nine adults in 1990 to over 400 today through long-term intensive management, of which invasive predator management forms an integral component. Mainland populations of pigeons are currently managed at only four sites. These populations stem from a remnant population from which the species has been bred and re-introduced. Pigeons are vulnerable to ground predators such as mongooses, which are controlled using box traps laid out in grid systems. Although successful, the technique is labour intensive and needs to become more efficient to be sustainable in the long-term.

Mongoose ecology was studied to optimise management by targeting the right habitats and spacing traps optimally. Mongooses were trapped, some were radio-tracked, while culled specimens provided data used for population modelling.

Mongooses used riparian, rocky and woodland habitats preferentially within their home ranges. This was partially corroborated by a study which found that traps in forest thickets were most successful. Indirect census data also show that density was higher in degraded woodlands and riparian habitats. The mean home range size (MCP) was 0.77/km^2, and ranged from 0.25-1.1/km^2. Density estimates ranged from 25.6 - 52.4 animals/km^2 (mean 37.3). Home ranges overlap considerably, suggesting that the species is not territorial.

The diet was broad: birds occurred in 6% of mongoose guts (n = 458), predation on pigeons was low (n = 5). However, modelling has shown that low level predation can affect long-term viability of pigeon populations. Mongoose control reduced pigeon mortality rates in the site with the longest history of management.

Control regimes could be improved as follows:

- *Trap siting:* Efforts should be biased towards preferred habitats, i.e. rocky areas, forest thickets and riparian habitats.
- *Trap spacing:* Trap spacing should correspond with home range sizes of mongooses (the smallest was 0.25 km^2). Greater trap densities should improve capture rates.
- *Diet:* Rats are frequently eaten, so controlling mongooses alone may cause future rat problems through meso-predator release. Carrion is consumed frequently, so poisoning is a potential alternative mongoose control method.