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Prevention and Management of Invasive Alien Species

Proceedings of a Workshop on Forging Cooperation throughout Southern Africa

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*Edited by Ian A.W. Macdonald, Jamie K. Reaser, Chris Bright, Laurie E.
Neville, Geoffrey W. Howard, Sean T. Murphy, and Guy Preston*

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The workshop was co-chaired by the Governments of the Republic of Zambia and the United States of America, and by the Global Invasive Species Programme. Members of the Steering Committee included: Mr Lubinda Aongola (Ministry of Tourism, Environment and Natural Resources, Zambia), Mr Troy Fitrell (U.S. Embassy - Lusaka, Zambia), Mr Geoffrey W. Howard (GISP Executive Board, IUCN Regional Office for Eastern Africa), Ms Eileen Imbwa (Permanent Secretary, Ministry of Tourism, Environment and Natural Resources, Zambia), Mr Mario Merida (U.S. Embassy - Gaborone, Botswana), Ms Margaret Mweene (IUCN Zambia Office), Dr Sean J. Murphy (GISP Executive Board, CAB International), Dr Laurie E. Neville (GISP Programme Coordinator), Dr Guy Preston (GISP Executive Board, Working for Water Programme, South Africa), Mr Dennis Rangi (CABI Africa Regional Centre, Kenya), Dr Jamie K. Reaser (GISP Executive Board, U.S. National Invasive Species Council), Ms Gabriella Richardson-Temm (IUCN Zambia Office), Dr Dana Roth (U.S. Department of State), and Dr. Jeffrey Waage (Chair, GISP Executive Board and Imperial College, Wye).

The organizers wish to thank all participants for their valuable contributions during and after the workshop. A list of the participants is provided in Appendix 2.

The views expressed in this publication are those of the authors and do not necessarily reflect the positions of any government or other body represented in the meeting, nor its sponsors.

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Contact: Global Invasive Species Programme
National Botanical Institute, Kirstenbosch Gardens
Private Bag X7, Claremont 7735
Cape Town, South Africa
Tel: +27 21 799 8800
Fax: +27 21 797 1561
gisp@nbi.ac.za
www.gisp.org

Southern African Recommendations:

Steps for Implementation of a Regional Approach to Address Invasive Alien Species in Southern Africa

Prevention and Management of Invasive Alien Species: Forging Cooperation throughout Southern Africa

June 2002, Lusaka, Zambia

The delegates to the Southern Africa regional workshop on *Prevention and Management of Invasive Alien Species: Forging Cooperation throughout Southern Africa*, co-chaired by the Government of Zambia (Ministry of Tourism, Environment and Natural Resources) in collaboration with the Government of the United States of America, and the Global Invasive Species Programme (GISP); noting key participation by governmental and non-governmental representatives of Botswana, Malaŵi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania, and Zimbabwe; and with representatives of the Food and Agriculture Organization (FAO), International Plant Protection Council (FAO-IPPC), the International Maritime Organization (IMO), the World Conservation Union (IUCN), and Centre for Agriculture and Biosciences International (CABI), recommend the following initial steps be taken:

Recognizing that: Invasive alien species (IAS) cause substantial economic and environmental impacts in both developed and developing countries, and that countries have varying levels of awareness of the crisis, priorities for addressing the crisis, practical experience in managing IAS, and resources to address the issues raised by IAS;

With the objective of: Promoting regional collaboration and activities with tangible outputs that will reduce the threat posed by IAS¹. Each country represented at the regional workshop, *Prevention and Management of Invasive Alien Species: Forging Cooperation throughout Southern Africa*, should elect one representative who should:

Step 1: Convene a first meeting of a working group on IAS issues in their country within the year 2002;

Step 2: Identify national focal points, establish national working groups, together with the appointment of a GISP National Coordinator, for each country, and begin the process of establishing effective collaboration between the various national institutions with a responsibility for IAS. The working group should include representatives of all stakeholder sectors². National Coordinators should report through the CBD focal point in countries where the latter is active;

Step 3: Establish a SADC working group from representatives attending the regional workshop, *Prevention and Management of Invasive Alien Species: Forging Cooperation throughout Southern Africa* and identify a SADC focal point for IAS issues, or establish one if it does not already exist. Where possible, this should be done through the Regional Biodiversity Support

¹ National activities are implied within this, but what is being sought is a not the sum total of national activities, but rather the initiation of a regional strategy to address IAS. The implication of this is that we should seek to define key issues that can form the platform upon which a major regional process can be undertaken that will lead to a comprehensive regional strategy.

² Potential representatives/sectors include: Environment; Tourism; Forestry; Agriculture; Convention on Biological Diversity (CBD); Marine Systems; Fresh Water Aquatic Systems; Academic and Research Institutions; Non-Governmental Organizations; and the private sector.

Programme, attempt to link IAS issues into National Biodiversity Strategy and Action Plans (NBSAPs), and be funded initially through GISP (with support from Working for Water/IUCN/CABI), under the auspices of SADC and NEPAD;

Step 4: Through the national working groups, identify priority areas for each country and develop IAS inventories, as well as control and prevention projects through NEPAD (if possible, with GEF funding which could be linked to collateral funding available from Working for Water and other existing leverage projects, as well as with other sources of funding). The action plans should draw up that promote collaborative be regional management of IAS and circulated among member countries so that the regional working group can set regional priorities;

Step 5: Raise awareness of the IAS issue among decision-makers, through the compilation of a report on the current and future impacts of IAS, meetings with decision-makers, brochures, the provision of a web page and other information-disseminating services on IAS for SADC countries, and, where possible, through the national focal points;

Step 6: Using pilot projects³, focus on national capacity building as the first major activity. Capacity building should be considered the key issue for immediate attention once substantial support and resources have been obtained;

Step 7: Build upon (and develop where necessary) policies, strategies, and plans for effective national prevention and control of IAS, and link these through the SADC coordinating unit on biological diversity;

Step 8: Where appropriate, appoint SADC representatives as co-chairs (2-3) of IAS regional working groups. These regional working groups should strive to mainstream IAS issues in SADC by engaging with the relevant economic sectors, i.e., trade and commerce. GISP and other partners can be approached to assist with organizing workshops;

Step 9: Develop national and regional policies (in consultation with GISP and FAO) through SADC for the creation of legislation and trade frameworks through capacity building, to lead into prevention and control projects on a regional level; and

Step 10: Develop Programs of Research and Development and Monitoring and Evaluation in the prevention and management of IAS in Southern Africa.

³ Examples of pilot projects include: *Malawi/Tanzania*: Invasive waterweeds on Shire River, Lakes Malawi and Victoria; *Mauritius*: forest restoration projects; *Seychelles*: invasive alien vertebrates; *South Africa*: Working for Water and GEF GloBallast project; *Zambia*: Pan African invasive plant prevention and management project (GEF funding available) and invasive waterweeds on the Kafue River; *Zimbabwe*: FAO project on invasive alien tree species in South Africa, Zambia, and Zimbabwe.

Southern Africa



Map of Africa, showing the southern African region from Angola, Zambia and Tanzania southwards. Credits: U.S. Central Intelligence Agency map database © 2003

***Prevention and Management of Invasive Alien Species:
Proceedings of a Workshop on Forging Cooperation
throughout Southern Africa***

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1. Background

1.1 Rationale for strengthening cooperation in southern Africa

"Each Contracting Party shall, as far as possible and appropriate: Prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species."

- *Convention on Biological Diversity, Article 8 (h)*

Invasive Alien Species (IAS) are non-native organisms that cause, or have the potential to cause, harm to the environment, economies, or human health. They are now regarded as one of the most severe threats to biodiversity, and one of the most significant drivers of environmental change worldwide -- consequently placing constraints on environmental conservation, economic growth, and sustainable development. The globalisation of trade, travel, and transport is greatly increasing the rate at which IAS are moving around the world, as well as the diversity and number of species being moved. At the same time, changes in land use and climate are rendering some habitats more susceptible to biological invasions.

Southern Africa is one of the landscapes or palettes upon which the European era of exploration, colonization and trade has been painted. It is also a region with an ancient and recent history of migration, exploration, turbulence and trade – all of which have helped shape its current environments, political economies and biodiversity. The countries of southern Africa are united by many common cultural, social, ecological, economic, and political features that define the essence of "Africa." However, this region also encompasses a wide diversity of cultures, economies, and ways of life. Its major ecosystems include deserts, mountains, tropical moist and dry forests, grasslands, precious riverine and delta systems, fresh and brackish water systems, and marine environments. All of these ecosystems are threatened by habitat loss, degradation, climate change, pollution, and the invasion of IAS.

The issue of preservation of the natural environment is one of the key unifying problems that draws the countries of southern Africa together. Of these problems, the issue of IAS requires the greatest cooperation among governments and across sectors. With the exception of countries that have very large land masses or scattered territories where biological invasions may be between ecosystems of the same country, most biological invasions occur across national borders, from one geographic region to another.

The problems posed by IAS in Africa and the rest of the world are not new. Societies have suffered from the impacts of IAS as long as humans have intentionally and unintentionally moved organisms around the world. Clearly, it is a problem that will have to be managed in perpetuity. What is relatively new, however, is the scale of the problem and its impacts -- at no time in history has the diversity and volume of IAS, and the rate at which IAS are spreading around the world been greater. Since most of the countries of southern Africa are particularly water-stressed, with arid and semi-arid environments and burgeoning human populations, IAS that threaten watersheds, agriculture, human, and animal health have become particularly significant problems. The island nations of the region, such as Mauritius, additionally suffer from the trade-related and 'development'-related IAS issues common to most small island states.

Article 8(h) of the Convention on Biological Diversity (CBD) calls on member governments to "as far as possible and appropriate, prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species." However, national and international responses to the IAS problem have so far been insufficient to counter their increasing toll on natural resources and society. One of the most significant barriers to policy development and

implementation has been a lack of awareness of the causes and consequences of biological invasion.

The governments of southern Africa have already taken some steps towards mitigating the impacts from IAS to biodiversity (see national reports in Macdonald et al. 2003⁴). These include efforts to address IAS within their National Biodiversity Strategies and Action Plans (NBSAPs) and national level meetings to assess the status of IAS, and develop national plans to address them. Because national efforts alone are inadequate to manage problems that transcend jurisdictional borders, the countries of southern Africa have also started to engage in international IAS activities. For example, SAFRINET (see Eardley, this volume) is the Southern African Development Community (SADC) network chartered to build organism identification capacity for the SADC Food, Agriculture, and Natural Resources (FANR) sectors. Therefore, SAFRINET is developing an IAS information hub that will include effective, user-friendly identification tools (e.g. electronic keys and computer automated image recognition). Other initiatives are underway to build international collaboration in terrestrial and marine environments (see papers by Nyoka and Awad, this volume). Also, at the 6th meeting of the CBD's Subsidiary Body on Scientific, Technical, and Technological Advice, SBSTTA (Montreal, March, 2001), governments from southern Africa joined with other Parties to address IAS as a cross-cutting theme in the CBD.

Overall, national and international responses to the challenges posed by IAS are insufficient to counter their increasing toll on natural resources and society. Although it has become increasingly clear that IAS pose a major threat to biodiversity, economies, and human health throughout the world, the capacity of most countries in Africa to address this threat has remained quite limited. In particular, it is evident that many tools and strategies adopted for prevention, eradication, and control of IAS, and the large body of scientific and technical information relating to IAS in other parts of the world, are not readily available in many parts of southern Africa. While there is much to be gained globally from the lessons learned by some countries in combatting IAS, for example Mauritius, South Africa and Zimbabwe, this opportunity remains largely untapped.

The efforts of most governments to limit the spread of IAS are so poorly coordinated that neighboring countries, trading partners, and even ministries within a single government are often unaware of each others' policies and programs. Non-governmental and intergovernmental organizations face similar challenges, and have few mechanisms to develop a holistic approach. However, the revealing and innovative experiences in several southern African countries provide excellent models for adaptation elsewhere.

Southern Africa is experiencing an increase in economic activity within the region, and between it and other parts of the world. Adoption of increasingly liberal trade policies (e.g. emergence of preferential trade agreements) and higher volumes of tourism will undoubtedly facilitate more biological invasions. The risk that these alien species will cause significant harm is exacerbated by a considerable lack of awareness of the severity of the IAS problem (especially among policy makers), as well as seriously inadequate technical support in most countries.

1.2 Workshop design and approach

It was within this context that the southern African workshop, *Prevention and Management of Invasive Alien Species: Forging Cooperation throughout Southern Africa*, was organised by the Global Invasive Species Programme (GISP) and its partners from 10-12 June 2002 in Lusaka, Zambia. This meeting was one of seven regional IAS workshops held in 2001-2004 by GISP and

⁴ Macdonald, I.A.W., J.K. Reaser, C. Bright, L.E. Neville, G.W. Howard, S.T. Murphy & G. Preston. 2003. Invasive alien species in southern Africa: national reports and directory of resources. Global Invasive Species Programme, Cape Town, South Africa.

its partners, IUCN and CABI, with the kind support of the U.S. Government and contributing organizations. The other workshops included: the Baltic/Nordic region (May 2001), Meso-America (June 2001), South America (October 2001), South and Southeast Asia (August 2002), the Austral Pacific region (October 2002), and West Africa (postponed to March 2004). Each meeting has resulted in a regional statement, meeting report (including draft regional action plans), and development or strengthening of regional directories of information resources on IAS.

Representatives of the Southern African countries (including several small island States of the southwestern Indian Ocean) were invited to participate in the regional workshop in Zambia, together with a group of international IAS experts. The workshop was designed to meet three primary objectives, to:

1. Raise awareness of the IAS problem and opportunities to manage it;
2. Forge cooperation between nations and between economic and policy sectors (especially agriculture and environmental protection); and
3. Lay the groundwork for the development of a regional southern African IAS strategy.

Forty-five people attended the meeting, which was co-chaired by the Governments of Zambia (Ministry of Tourism, Environment and Natural Resources) and the United States of America (which acted as a sponsor and observer), and the Global Invasive Species Programme (GISP). The key participants came from governmental and non-governmental organizations in Botswana, Malaŵi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, Swaziland, Tanzania, and Zimbabwe. They were assisted in their deliberations by representatives of the Food and Agriculture Organization, International Plant Protection Council (FAO-IPPC), the International Maritime Organization (IMO), the World Conservation Union (IUCN), Centre for Agriculture and Biosciences International (CABI), and the Global Invasive Species Programme (GISP).

On Day 1 (agenda in Appendix 1), technical experts provided an overview of the IAS issue from both global and regional perspectives. They defined the problem, as well as its consequences for the environment, economies, and human health. They also identified opportunities to minimize the spread and impact of IAS through scientific, technical, and political means. The regional relevance of these points was underscored through the presentation of selected case studies from southern Africa. Country representatives were given the opportunity to present a brief statement on the status of the issue within their countries, with regard to both the main challenges and mechanisms for addressing them. Participants were also invited to present initial ideas on the possibilities for improving regional collaboration.

On Days 2 and 3, participants were divided into two working groups in which they addressed a series of questions designed to help determine regional goals for addressing the IAS problem, as well as the overall strategies and first steps for achieving their goals. Task teams helped the working groups to summarize their deliberations and produce recommendations.

The participants produced a statement of objectives for improving the prevention and management of IAS within the region, as well as the core elements of a regional IAS action plan (see Table 1, sections 2.2 and 2.3 of this volume). The companion volume (Macdonald et al., 2003, op cit.) represents a directory of information resources on IAS, for selected countries within the region.⁵ This "Regional Resources Directory" includes information on relevant people, projects, policies, and other resources, and is the first of its kind for southern Africa.

⁵ All countries were invited to contribute, but not all of them were able to do so.

2. Summary of recommendations from the workshop sessions

2.1 Challenges and opportunities for achieving regional collaboration in southern Africa

Representatives from national delegations who chose to do so addressed the following two questions:

- A. What are the main challenges and mechanisms for addressing the problems posed by IAS within your country?
- B. How do you perceive the needs and opportunities for co-operation on IAS issues throughout southern Africa?

2.1.1 The situation in *Botswana* was presented by *Innocent Tyolo*

Mr. Tyolo emphasized that the invasive alien plants currently pose the greatest invasive alien species (IAS) problems in Botswana. Examples include: 1) kariba weed (*Salvinia molesta*), which was first recorded in the Zambezi River in 1948 and is a major problem, 2) water lettuce (*Pistia stratiotes*), which is currently not considered a very serious problem, and 3) water hyacinth (*Eichhornia crassipes*), which is only an incipient problem in Botswana. The mechanisms for addressing the problem to date have been legislative measures aimed at trying to limit the spread of these plant species by boats (e.g. the 'Aquatic Weeds Control Act' of 1971), herbicide spraying programmes (which have proven too expensive as re-infestation invariably occurs), biological control (e.g. using the weevil *Cyrtobagous salviniae* on *S. molesta*), and mechanical control (e.g. *S. molesta* is being removed monthly from the Okavango Delta in an effort to clear boatways and to reduce the rate of spread).

Water lettuce is currently only found in a single ephemeral waterbody which dries up each year in the dry season. Work to eradicate the infestation is being performed by manually removing all the plants before they flower. The hope is that eventually this approach will lead to the exhaustion of the *P. stratiotes* seedbank. *E. crassipes* has not yet been recorded invading natural waterbodies anywhere in the country; however, pre-emptive control was taken when it was learned that people were keeping this plant in their private gardens. These plants were located, removed, and destroyed. The government is now trying to raise public awareness on the dangers of IAS such as *E. crassipes* through radio campaigns and other means. A major challenge in Botswana is the lack of trained experts in IAS, including invasive alien aquatic plant management.

The need for regional cooperation in the control of these species is clear, as many of the invaded waterbodies in Botswana are part of international river basins (e.g. the Okavango Basin, shared with Namibia, Angola, and Zambia). Cooperative control programmes have already been launched between Botswana and Namibia for *S. molesta*. *E. crassipes* is present in rivers in Namibia just outside Botswana's border, making co-operation with this country essential if this species is to be prevented from invading the inland waterways of Botswana. Botswana is already participating in a SADC Working Group on Aquatic Weeds where experiences with these IAS are shared. It was through this forum that the country learned of the existence of *E. crassipes* just outside its border. Another area of fruitful cooperation is in the international sharing of control expertise (e.g. biocontrol agents for *S. molesta* have been obtained from Australia's CSIRO).

2.1.2 The situation in *Malawi* was presented by *John Saka*

Mr. Saka identified two main groups of IAS that required major management efforts in Malawi. The first of these were invasive alien plants, in particular several problematic aquatic plant species: water hyacinth *Eichhornia crassipes*, water lettuce *Pistia stratiotes*, Kariba weed *Salvinia molesta* and red water fern *Azolla filiculoides*. Important terrestrial invasive alien plants include lantana *Lantana camara*, Mexican sunflower *Tithonia diversifolia* and mesquite (*Prosopis* spp.). The major impacts of these alien plants are loss of biodiversity and increased wetland management costs. For example, the current campaign to control *E. crassipes* costs US \$400,000 per annum. The second group of IAS warranting concern at this stage is alien invertebrate pests of crop species, e.g. woolly whitefly *Aleurothrixus floccosus*, larger grain borer *Prostephanus truncatus*, cassava green mite *Mononychellus tanajoa*, and red spider mite, all of which reduce crop yields. The only potentially invasive alien fish species mentioned was the mirror carp *Ctenopharyngodon idellus*, currently considered to be under control in southern Malawi.

Malawi faces heightened invasion pressures as a result of increasing globalisation, greater freedom/democratisation (and the resulting increased movement of people across borders), food insecurity (and the resultant aid shipments), and climate change effects (including more frequent/more severe droughts and floods). At a human management level, the major challenges faced are a widespread lack of knowledge and awareness of the IAS problem and the inadequate human resources available to manage these invasions. This capacity problem is exacerbated by the effects of the HIV/AIDS pandemic.

The three major institutions currently addressing the IAS problem within Malawi are the Ministry of Environment, the Ministry of Agriculture, and the University of Malawi. The main mechanisms for addressing the problem within the country are Public Awareness (e.g. posters, newsletters, radio and TV advertisements, and community mobilisation both through formal training programmes and awareness workshops), Strengthening Research (e.g. review and update of information on IAS in the country and initiation of research into sustainable IAS management strategies), and Enhanced Networking (between the following bodies, all of whom should become involved in IAS management: the ministries of Environment Affairs, Agriculture Research, Fisheries, Water Resources, Forestry, Energy and Justice, as well as the NRCM, NEC/Justice, NHBGM, Investment Partners, NGOs/ Faith Groups, the Electricity Supply Corporation, Water Boards, NAREC, the Bunda College of Agriculture and the Pesticide Control Board). The impetus to improve the prevention and management of IAS in Malawi should come from a team effort of the three lead institutions: the Natural Resources and Environment Centre at the University of Malawi (NAREC), the Department of Agricultural Research and Technical Services, and the Environmental Affairs Department (EAD) within the Ministry of Natural Resources and Environmental Affairs.

The major needs and opportunities that Malawi sees in the field of regional cooperation are the initiation of forums to promote cooperation between agencies involved in IAS prevention and management in SADC countries. This cooperation should include the routine exchange of information on IAS, the holding of study tours, reciprocal training schemes, and possibly the sharing of scarce resources including specialised equipment.

2.1.3 The situation in *Mauritius* was presented by *Neeta Leckraz, Manikchand Putto, and John Mauremootoo*

Mauritius is very prone to invasion from IAS because it is a small island nation. Since the island's first colonization in 1598 to the first enacted IAS legislation in 1976, there were no restrictions on the flow of alien species into these islands, and the results have been predictable.

One of the main IAS challenges currently faced in the country is a lack of capacity to address the problem. In particular, Mauritius lacks a rapid response capability if new species are found to be invading. Another major challenge is the lack of awareness about IAS in the general public and amongst the current policy/decision makers.

There are several groups of IAS currently posing a challenge in Mauritius. The first of these are invasive insects (e.g. the cycas pest (*Chilades pandava*), the cypress pest (*Cinara cupressivora*), woolly whitefly (*Aleurothrixus floccosus*), rhinoceros beetle (*Oryctes rhinoceros*), fruit fly (*Ceratitis rosa*) and spiralling whitefly (*Aleurodicus dispersus*). These are all pests of economically-important introduced crop plants (e.g. sugarcane). The main mechanisms for addressing the problem of introduced insect pests are proscribed under the 'Plant Act,' introduced in 1976. The mechanisms include an awareness campaign (including placement of posters at airports) and deployment of officers at all ports of entry who carry out strict inspection procedures, question all arriving passengers about the IAS risk they pose, and carry out standard preventative treatments (e.g. the fumigation of all shipped consignments of wood such as those of wooden furniture from Pakistan). Specific prevention measures have been implemented to prevent the accidental introduction of the sugarcane white grub (*Phyllophaga smithi*) via planes and ships from Reunion, where it has devastated the sugarcane industry. Mauritius signed a protocol with Reunion which includes regulating the time of day at which planes may enter Mauritius from Reunion; no flights are allowed between 18h00 and 22h00 during the relevant months of the year. The authorities have also implemented biosecurity measures to prevent, for example, any outbreak of Foot and Mouth Disease and the introduction of pests that could threaten the lucrative Anthirrium industry. All refuse from incoming aeroplane flights is now incinerated. Additionally, officers in the Ministry of Agriculture are currently working on Integrated Pest Management strategies for the major pest species. Mauritius also has a wide range of introduced alien invasive plant species, covered in the regional case study presented later in the workshop by John Mauremootoo. Finally, the Indian house crow *Corvus splendens* is problematic in Mauritius.

Although there is plenty of information on IAS on a regional basis, this information is not being shared well between countries and institutions. There is a need for enhanced networking and the harmonisation of practices (e.g. those relating to the regional movement of goods). A role for regional cooperation in the area of lobbying policy makers was also recognized.

2.1.4 The situation in *Mozambique* was presented by *Abú Jone*

The two major groups of IAS posing a challenge in Mozambique are invasive alien plants (in particular water hyacinth *Eichhornia crassipes*, especially on the Cabora Bassa Dam on the Zambezi River, and kariba weed *Salvinia molesta*) and invasive alien invertebrate pests of economic crops (e.g. various stem borers such as the larger grain borer *Prostephanus truncatus*, various pests of sugarcane, the cassava green mite *Mononychellus tanajoa* for which there is an active management programme, and the cassava mealy bug *Phenacoccus manihoti* which is now considered to be under control). Amongst the few invasive alien birds in the country, the Indian house crow (*Corvus splendens*) is considered to pose the greatest challenge. Only recently introduced via ships, the crows have multiplied to the extent that they have become a serious nuisance, particularly on the offshore island of Inhaca. The crows rapidly replace other bird species, spread rubbish and disease, and pilfer items from houses. A programme of physical removal is being attempted, but does not appear to be succeeding.

The major challenge Mozambique faces in controlling these IAS is a lack of local expertise. The country's top priority in the field of IAS is the establishment of a policy of prevention and containment, to be achieved through stricter quarantine measures backed up by a major public awareness campaign on the IAS issue. Currently there is an informal network of collaborators on the IAS issue within the country, which includes staff from the Ministry of Agriculture, the Ministry of Environment, and the national university. However, there is a need for enhanced cooperation between all the relevant organisations.

In terms of the needs and opportunities for more regional cooperation, Mozambique favours more international collaboration on control programmes. The country is currently collaborating with South Africa's Plant Protection Research Institute and with the International Institute for Tropical Agriculture, but needs to increase efforts in this area. International co-operation is undoubtedly essential in the control of alien aquatic plants; Mozambique's major river systems all rise in neighbouring countries. A specific IAS which has given rise to a major exercise in international collaboration is the recent introduction of the larger grain borer into southern Africa. There is currently a concerted quarantine and monitoring process at all main points of entry into Mozambique, along the country's northern border with Malaŵi and Zambia, and along the southern borders with Zimbabwe and South Africa.

2.1.5 The situation in *Namibia* was presented by *George Rhodes*

In introducing the Namibian situation, Mr. Rhodes stated that not much has been done on the IAS issue in the country. However, the national IAS working group (set up under the Namibian National Biodiversity Task Force) held a recent national workshop with the following objectives:

- (1) create an inventory of established IAS in Namibia;
- (2) list potential IAS not yet established in the country; and
- (3) set up a national policy and strategy for IAS.

The two key outputs of the workshop were a plan of long-term activities, and a poster depicting the "Nasty Nine" IAS in Namibia to create public awareness of this issue. A challenge faced in Namibia is developing objective criteria to determine which IAS pose the greatest threats. However, the Namibian National Biodiversity Strategy and Action Plan (NBSAP), which emphasizes the link between biodiversity and national development, includes an IAS action plan for improving management, including policy and legislation. The overall goals of this plan include improving human livelihood/wellbeing in the country and reducing the threat posed by IAS to the nation's biodiversity. Plan implementation will result in conducting a national inventory of IAS with the aim of producing an IAS atlas and database, assessing the invasive potential of certain alien species, establishing an IAS policy and the relevant legislation and regulatory capacity, conducting an awareness campaign, and initiating low-cost control programmes.

2.1.6 The situation in *South Africa* was presented by *Christo Marais*

In South Africa, 198 plant species have been declared invasive in three categories. There are 58 alien aquatic animal species (mainly fish) that have become invasive in South Africa, 33 introduced from outside the country's borders and 25 the result of inter-basin transfers within the country. Regarding mammals, the major challenge is that of intentional internal translocations of native species outside their original distribution ranges, resulting in hybridization with congeneric species. In general, invasive reptiles are not a problem, although at least one species of freshwater turtle is invading. Molluscs are more of a problem; at least 25 IAS in this group are known to be present in South Africa. The situation with insects and spiders requires more study; however, it is known that 24 spider species commonly found in and around human habitations are introduced, and about 225 alien insect species have been intentionally introduced for biological control of 50 insect pests.

Existing national legislation can be used to address the IAS problem in South Africa (e.g. the Conservation of Agricultural Resources Act, the Agricultural Pest Act, the Mountain Catchment Areas Act., the National Water Act, the Forest Act and the National Biodiversity Bill). Several different arms of government are currently charged with implementing IAS legislation, including three national departments (Water Affairs and Forestry, Environmental Affairs and Tourism and Agriculture) and nine provincial departments responsible for environmental affairs within the country's nine provinces. This plethora of legislation and responsible bodies has resulted in a

certain amount of confusion, limited integration between agencies, and unnecessary duplication. Resolving this confusion is a major challenge facing improved IAS management in the country.

Notwithstanding, the *Working for Water Programme* is considered an innovative approach to invasive alien plant management. This huge national programme combines labour-intensive mechanical and chemical clearing of IAS from entire catchments, supplemented by an extensive biological control programme. This program creates IAS awareness through education and training. In addition, there is a major effort to promote secondary industries based on the cleared material, e.g. furniture, firewood and charcoal production. This programme has been so successful that Professor Hal Mooney, founding Chair of the Global Invasive Species Programme (GISP), has said that *Working for Water* provides a model for the world of an innovative way to deal with the invasive species problem.

As far as South Africa is concerned, the major opportunities for regional cooperation within SADC are as follows: collaboration in the field of IAS data management - protocol, support and resources; negotiation of SADC agreements on ports of entry; compilation of protocols for all intentional alien introductions including for state-supported research programmes; sharing of information on IAS; and the improvement of inter-country communication on this issue.

Dr Marais was questioned on whether promoting the commercial utilisation of invasive alien plants would not create an incentive for people to actively spread IAS. He replied that it was important to view an IAS as a "mine," recommending simultaneous control and utilisation of the resource, whilst continuing the search for alternatives, employing the dual approach of seeking to biologically control the IAS to reduce its invasiveness, and looking for alternative species to replace the IAS as a natural resource which could still be utilised.

2.1.7 The situation in the *Seychelles* was presented by *Selby Remie*

Species in numerous taxonomic groups have invaded the Seychelles both intentionally and accidentally. For example, camphor trees (*Cinnamomum camphora*) and goats are present on the islands as a result of intentional introductions, and both have become highly invasive there. In contrast, the invasive common mynahs (*Acridotheres tristis*) were accidentally introduced.

The problems created by IAS in the Seychelles are diverse. Some IAS out-compete native species (e.g. goat browsing now threatens the giant tortoises on Aldabra). Some IAS affect native species through direct predation (e.g. cats and rats kill native seabirds). Other IAS become agricultural pests, such as rats, common mynahs, and the ringnecked parakeet *Psittacula krameri* which has only recently been introduced. Still other IAS give rise to genetic contamination of native species (e.g. the introduced Madagascar dove has hybridized with the endemic Seychelles dove).

Various taxonomic groups of IAS present great challenges on the Seychelles. Several alien mammals have proven highly problematic (e.g. rats, cats, dogs, goats and pigs). Although a few alien reptiles have been observed, these have not yet become established. Several fish are beginning to invade the island's rivers (e.g. guppies and tilapia are now found in the lower portions of most rivers), and a few snails have invaded successfully. Many invasive alien plant species pose a threat (including invasive creepers), as do invasive alien insects such as the crazy ant (*Anoplolepis longipes*).

Most of the current work on animal invaders is carried out by the Conservation Section of the Ministry of the Environment, in coordination with NGOs and other organisations with the aim of conserving the islands' native biodiversity. Most of the work on alien plant invaders is carried out by the Forestry Department. Strict legislation aimed at preventing the intentional introduction of further animal species exists – for example, few birds and no reptiles may be imported. The bounty system is currently used to control certain invasive birds. For example, a bounty of US\$100 is paid for each Indian house crow (*Corvus splendens*), and is proving successful in

controlling this species. The bounty system is less successful in the case of the introduced barn owl (*Tyto alba*). Total eradication of rats has been attempted on three small islands and was successful in one case. Feral cat populations have been successfully eradicated on some islands. Pilot projects on the control of invasive alien plants have been initiated. In some of these, contractors have been employed to remove alien creepers seen to be strangling native forest species. These pilot projects are being monitored to assess levels of competition between native and alien plant species.

The Seychelles currently have an aggressive IAS awareness campaign, with a “green line” phone number which members of the public are encouraged to call to report sightings. This is proving highly successful in the case of the Indian house crow. An inventory of IAS is being prepared. Private owners of smaller islands in the group are being educated on the benefits of controlling IAS, and some are responding positively, even to the extent of being prepared to fund the eradication of rats on their island.

Recently, a few new species of birds have been intentionally introduced, despite the ban on such introductions. All imported birds must now be authorised by the Ministry of Environment. A potential new threat is posed by the recent craze for the importation of tropical marine fish. A new policy is being drafted to control this source of IAS. However, the major challenges faced in the Seychelles at the moment are the lack of capacity and funds to implement IAS prevention and control measures. There is also a desperate need for better information on marine invasions.

Major advances in regional co-operation could be made in the exchange of information and expertise, in seeking funding as a region (e.g. for training programmes), and in improving coordination with regards to pathway management (e.g. standardising protocols for preventing accidental introductions through shipping).

2.1.8 The situation in *Swaziland* was presented by *Similo Mavimbela* and *Lungile Magagula*

Swaziland’s economy is based on agriculture. Invasive alien plants are considered to pose a threat to agriculture, both on grazing lands and on cropping lands, and they are considered an economic threat affecting the wellbeing of the Swazi people. IAS also pose a threat to the nation’s biodiversity and water resources. Some 90 alien plant species have been recorded, in different categories of invasiveness. The four considered most important are: triffid weed *Chromolaena odorata* which is undoubtedly the most serious IAS in the country and which has brought the whole matter of biological invasions to the attention of the people and the government, lantana *Lantana camara*, bugweed *Solanum mauritianum*, and parthenium *Parthenium hysterophorus*.

Currently the following stakeholders are involved in the IAS issue in Swaziland: 1) the Ministry of Agriculture and Cooperatives (MOAC), in particular its animal production, research and extension sections, 2) the Ministry of Tourism, Environment and Communication (MTEC), in particular the Swaziland Environmental Authority (SEA) and Swaziland National Trust Commission (SNTC), 3) NGOs such as Yonge Nawe, 4) the University of Swaziland, and 5) private farmers. Currently the only existing invasive alien plant management programmes are those being conducted by the SNTC, by private nature and game reserves, and by private farms. The Plant Control Act, which covers issues relating to alien plants, has been promulgated but has not yet been effectively implemented. Animal importation is covered by the Veterinary Services.

The priorities for future work on the IAS issue in Swaziland are

- (1) to carry out a national inventory;
- (2) to run a national awareness campaign for the public and government, perhaps with *Chromolaena odorata* as the focal species;
- (3) to initiate integrated pest management for the priority species; and
- (4) to develop legislation to deal with IAS.

The work on IAS should be spearheaded by the Ministry of Agriculture and Cooperatives and the Ministry of Tourism, Environment and Communication. In the short term they should organise a national workshop on IAS involving all these stakeholders.

2.1.9 The situation in *Tanzania* was presented by *Francisca Katagira*

Tanzania shares many of the region's IAS problems. Some of the most important IAS are crop pests, including grey leaf spot *Cercospora zea-maydis* and larger grain borer *Prostephanus truncatus*, the latter having been introduced to the country in an aid shipment. Other major pests include the cassava mealy bug *Phenacoccus manihot*, cassava green mite *Mononychellus tanajoa*, woolly whitefly *Aleurothrixus floccosus*, coffee wilt disease *Colletotrichum coffeanum*, coffee berry disease *Colletotrichum* sp., banana weevil *Cosmopolite* sp., stem borer *Chilo partellus*, and sugarcane white grub *Phyllophaga smithi*. Leucaena psyllid *Heteropsylla cubana* is a pest of the introduced agroforestry tree, leucaena *Leucaena leucocephala*. Among vertebrates, the Indian house crow *Corvus splendens* is possibly the most important IAS present in Tanzania. Among invasive alien terrestrial plants, the Mexican poppy *Argemone mexicana* is considered important.

Undoubtedly the most important invasive alien plant in Tanzania is the water hyacinth *Eichhornia crassipes*. Water hyacinth first appeared in the country in 1986, invading from Rwanda and Burundi. In 1987 it was first recorded in the Tanzanian section of Lake Victoria and was soon so dense in some areas that it prevented boats from passing through it and made fishing impossible. By 1995, 700 ha were densely infested within the lake's Tanzanian sector, and by 1998 this had increased to 2000 ha. In 1997 a programme of integrated pest management was initiated. This involved the mass rearing and release of a biocontrol agent, a weevil, from 12 rearing units, nine of which were run by local fishing communities. The programme involved NGOs, Community Based Organisations (CBOs), and the affected local communities. It was a great success, with the extent of infestation within Tanzanian waters reduced by 78% to date. However, there now appears to be a resurgence of *E. crassipes*, apparently from the seed bank, which is giving rise to a new infestation of about 53 ha annually. Annual reinvasion also occurs down the rivers from Rwanda into the lake. The biocontrol agents apparently do not establish well under riverine conditions. A study trip to Papua New Guinea has recently been undertaken to learn how that country controls this species in their rivers. Hopefully, application of the learned control systems will finally bring *E. crassipes* under full control in Tanzania.

Regional co-operation would be helpful in improving Tanzania's ability to manage IAS. This should include collaborative research, capacity building, and technology sharing and transfer. The countries in the region need to join forces in order to prevent new invasions and more effectively contain established IAS.

2.1.10 The situation in *Zimbabwe* was presented by *Simon Sithole*

In opening his presentation, Mr. Sithole stated that it was crucially important to have an enabling political environment if one was to effectively manage the IAS situation. It is important to have IAS policy, to have the appropriate IAS legislation in place, and to implement this legislation effectively. In Zimbabwe there are sanitary, zoosanitary, and phytosanitary mechanisms which are currently working to control IAS, but the country appreciates the need to work closely with its neighbours to ensure that this situation continues into the future.

Zimbabwe's "Number One IAS Problem" is undoubtedly water hyacinth *Eichhornia crassipes*. A national committee has been established specifically to address the control of this species. This committee is made up of various institutes from a range of different ministries, and the biggest problem it faces is coordination between the various institutes. A lead institution is needed to spearhead this coordination. Water hyacinth affects agriculture by clogging irrigation pipes and affects fisheries by preventing fish farming through the clogging of fish ponds. A programme of biocontrol using weevils introduced from Australia is working, but in the future an integrated

strategy will be required. There is an existing cooperative programme within SADC for the control of *E. crassipes*; Zimbabwe is already cooperating with Botswana and Zambia, and there is undoubtedly a need for a regional approach for the management of this species, which is found all the way from the Cape to Cairo.

Other aquatic weeds causing problems in Zimbabwe include Kariba weed *Salvinia molesta* (in the past an introduced grasshopper was used to successfully control *S. molesta*, but for unknown reasons this biocontrol agent has recently disappeared), the red water fern *Azolla filiculoides* (successfully biocontrolled using a weevil), and water lettuce *Pistia stratiotes*.

One IAS causing problems in Zimbabwe is lantana *Lantana camara* (locally known as "bad bush"), which contains alkaloids hazardous to livestock. Lantana is being controlled with some success using biocontrol in South Africa, and there is a need to collaborate regionally on this species. Some useful species such as guava *Psidium guajava* and donkeys are considered to be IAS by some sectors in the country. Among insects, introduced crop pests such as the larger grain borer *Prostephanus truncatus* are definitely problematic. The cape honeybee *Apis mellifera* is apparently causing problems for the apiculture industry in the northern parts of South Africa to where it has been introduced, and it is apparently moving towards Zimbabwe. There is a definite need to control the movement of hives internationally, and Zimbabwe is already discussing this with South Africa and Botswana. As far as introduced pathogens are concerned, an important species is grey leaf spot (*Cercospora zae-maydis*) on maize, which is now present in most SADC countries and is being successfully controlled in places through efforts of CAB International and others. Kernel bunt is another invasive pathogen in Zimbabwe.

Regarding regional cooperation, Zimbabwe thinks there is a need for improved international coordination and harmonisation of sanitary and phytosanitary measures. The Southern Africa Development Community Network of BioNET International (SAFRINET) initiative should be expanded to assist member countries with IAS identification. There is also a need to develop risk assessment procedures for the region. "Centres of Excellence" should be identified in the region which would take the lead in particular fields of the prevention and management of IAS.

2.2 Designing a strategy for southern Africa

In the morning of Day 2, all the workshop participants were divided into two working groups, with the representatives of multi-person national delegations split between the two groups. These two groups then independently addressed a further four questions (see 2.1):

- C. What do we want the region to achieve collectively?
- D. What are the challenges to achieving regional cooperation?
- E. What are the necessary elements for a strategy to facilitate regional cooperation?
- F. How can we promote collaboration and cooperation within existing frameworks?

The results of these two groups' deliberations are summarised below.

Question C. What do we want the region to achieve collectively?

The first working group addressed this question at varying hierarchical levels. At the Highest Level, they agreed that the goal of this collective endeavour should be to **minimise the deleterious impacts of IAS in the region** (including the reduction of future threats of IAS to all sectors, including agriculture, biodiversity, trade and health) through the development of a common stand on this problem (possibly through the development of a **regional Memorandum of Understanding on the prevention and management of IAS** to be drawn up with the assistance of GISP).

At the Intermediate Level, the collective objective should be to **actively prevent the introduction of new IAS** into the region, to **control the spread of established IAS** (through coordinated management and monitoring programmes) and even to **eradicate certain IAS** from the region where feasible.

At the Lowest Level, efforts should be aimed primarily at **building the necessary capacity** within the region to control, prevent and manage IAS. This capacity building should be achieved through **improved networking**, including the development of a regionally accessible information system on IAS, and the formation of **GISP regional working groups** on specific topics that should aim to share information on IAS issues, specifically best practices. It should also include **training**, and build expertise in the fields of institutional arrangements, policy development, legal measures, research and development, etc. This working group also prioritized the setting up of **regional inventories of IAS**, the **creation of a risk assessment centre** for new alien introductions to service the whole of SADC, the **standardisation of legislation** controlling the entry of new alien species into any country in SADC, the **identification of introduction pathways** for new IAS into the region, and the **development of quick response mechanisms** to combat new invasions (possibly through the creation of new units set up purely to combat invasions at the earliest possible stage). It felt that a **dedicated secretariat** would be needed to achieve this collaboration.

The second working group addressed the question according to the areas in which **regional cooperation** would be most useful. Cooperation would be most important in:

- Developing the necessary **institutional arrangements** to meet IAS prevention and management challenges in the region (e.g. the establishment of focused regional task forces and regional advisory bodies, and of a regional centre for dealing with IAS issues).
- Creating the necessary **policy environment** (by setting up a regional policy framework, and by enabling collaboration both in the enforcement of IAS regulations and in the active management of established IAS).
- Improving **information sharing and expertise** (e.g. through the sharing of lessons in IAS management - failures and successes, through standardization of protocols, methodologies and databases and through the development of a directory of regional expertise).
- Increasing **IAS management capacity** (through regional training and other capacity building programmes).
- Raising the **awareness** of IAS as an issue (in particular among the region's top-level decision makers and by continually emphasizing to target audiences the importance of biodiversity resources to the region and the enormous threat IAS pose).
- Helping secure **funding and other resources** for regional prevention and management programmes (for regionally significant IAS such as water hyacinth and triffid weed, possibly with international funding under NEPAD).

Question D. What are the challenges to achieving regional cooperation?

Working group 1 considered the lack of political commitment by decision makers in the SADC region to be the most important challenge that will have to be overcome if this regional cooperation on IAS issues is to be achieved.

Other challenges are the practical difficulties inherent in achieving this collaboration. For example, how would this be integrated into existing SADC programmes, which regional body would coordinate this collaboration, how could we achieve harmonisation across the region of differing national priorities and policies, remembering that SADC states are at different stages of development, how could we agree on the priority IAS for the region when the region is so diverse, and how could we overcome the existing weaknesses in the region's communications networks? The currently low levels of financial and human resources available to address the IAS issue in this region also constitute major challenges to achieving a cooperative effort: Even building the necessary capacity would be difficult, as there are few suitable training institutions.

Group 2 traced the major challenges for regional collaboration primarily to the lack of capacity to address regional IAS issues - including inadequate resources including funds, equipment, staff, institutional capacity, and the existing knowledge base on IAS in certain countries. This is exacerbated by major inequalities in the distribution of capacity between the different countries in the region.

Group 2 also saw significant challenges in creating the necessary enabling policy environment at a regional level that would allow this cooperation to flourish. These challenges had their roots in political differences between SADC countries, in a general lack of political commitment to environmental management amongst the region's policy makers, in a virtual absence of political champions for this cause, and as a consequence of the above, in a general absence of clear supportive policies in which such a collaboration could be grounded. The allied challenge lay in the general lack of awareness of the IAS problem within the region: the first challenge would be to create a political awareness of the serious implications of IAS among current decision makers.

Other challenges identified by Group 2 included strategic considerations, such as differing IAS priorities between countries in the region, conflicts of interest where one country viewed a species as an IAS and another viewed it as a useful natural resource, and the current absence of any overall strategic plan for IAS in the region. There was agreement that currently the IAS issue was inadequately focused within the region and there were not yet enough successful pilot projects on IAS in the region on which a regional collaboration could be built. There was uncertainty as to what was actually needed at a regional level: should we be aiming at establishing an IAS early warning system, more effective systems for sharing IAS information, or regional action plans for combating specific IAS? There was also a need for a clarification of institutional roles in this field – currently the situation was described as chaotic in at least some of the participating countries. Unless these institutional responsibilities were sorted out at the national level, there was little hope of establishing effective regional cooperative programmes in this field.

Question E. What are the necessary elements for a strategy to facilitate regional cooperation?

Group 1 concluded that the most essential element for achieving regional cooperation on IAS issues was efficient coordination. This could only be carried out by a body specifically charged with this function. The appropriate regional structure would need to be identified and agreed upon by all affected parties. This coordination should include establishing agreed formal linkages on IAS matters at national and regional levels, if necessary, the identification/creation of a regional focal point (body) to coordinate national focal points and to promote regional communication and information dissemination. In the longer term, such a body should coordinate the agreed programme of regional IAS activities, including the establishment of pilot projects and the replication of good practice.

The next most essential element would be political commitment – at both national and regional levels - to resolving the IAS issue at a regional scale. This would initially hinge on all countries recognising that we share a common problem with IAS, and would eventually give rise to an agreement on an appropriate legislative mechanism to address IAS at a regional level.

Another essential element would be obtaining consensus at a regional level of the main aims and priorities for a collaborative initiative on IAS. A framework for such an IAS programme would then have to be developed, e.g. preventing unintentional introductions, risk assessment of intentional introductions, management, monitoring, and so on.

Group 2 concluded that the most essential element for the establishment of this regional strategy would be the creation of the necessary capacity, expertise and financial resources. The next most important requirement would be creation of the necessary enabling environment through awareness programmes aimed at politicians, so as to get the necessary political support. The suggestion was made that to create this enabling environment, a regional forum should be

convened of leaders from all the relevant sectors, e.g. agriculture, wildlife conservation, water supply, fisheries, forestry and trade. Another requirement was that all the players must be committed to sharing information. One participant was convinced that open communication was the key to establishing this regional cooperation.

Following from this theme of close networking, it was agreed that another key element would be the fostering of a strong ethos of cooperation, to the extent that participants would develop a shared vision of this regional cooperation. Finally, it was agreed that an essential element would be to have clearly articulated deliverables which should be well focused, achievable, and deliver tangible benefits to all the participants in the strategy.

Question F. How can we promote collaboration and cooperation within existing frameworks?

Group 1 felt that the most important method of promoting regional collaboration would be through improved information exchange. As a first step in this improvement, we should make all the existing frameworks known to all the relevant parties, as these are not well known throughout the entire region. Other suggestions were to enhance existing communication networks, organise national and regional workshops and study tours to exchange notes, possibly initiate a series of regular meetings on IAS between member countries, set up regional exchange programmes, and possibly even set up an international 0800 telephone line to share information and best practices from pilot projects. Finally, the point was made that we should attempt to build partnerships with other frameworks by initiating a dialogue with such frameworks.

The next most important method proposed by Group 1 was through the identification of centres of excellence among the existing regional institutions for different areas of the prevention and management of IAS. These centres should become the focal points or enquiry points for the entire region on their particular specialised area of expertise. This approach would prevent unnecessary duplication within the region.

Finally, promotion of regional cooperation in this sphere required increased funding for existing frameworks and coordinating bodies to carry out this task. If new funding was not available, it was suggested that the sharing of existing financial resources within the region might be enough to get this regional cooperation on IAS issues going.

Group 2 proposed that the initial step for promoting this collaboration through existing frameworks was to carry out a formal assessment of the opportunities that such frameworks provided for new work on IAS. The next step would be to share the collaborative vision with the existing frameworks identified in this assessment. One would next have to create the necessary enabling environment by lobbying the relevant politicians and then identifying and involving "champions" for this cause. Having secured the necessary political support, one should set up a formal regional agreement on IAS as rapidly as possible.

The practical steps required to set up regional collaboration using existing frameworks, according to Group 2, also included enhanced information exchange, particularly through promotion of regional success stories on IAS prevention and management. Collaboration would also require building capacity in IAS prevention and management, using existing regional training and exchange programmes. Finally, it would require enhanced access to regional or global funding.

The existing frameworks that could be used were identified by Group 2 as:

- (i) existing regional biodiversity conservation programmes, e.g. Southern Africa Biodiversity Support Programme (SABSP), SAFRINET and SABONET;

- (ii) international groups already involved in the IAS issue, e.g. Global Invasive Species Programme (GISP), World Conservation Union (IUCN), CAB International (CABI), International Plant Protection Commission (IPPC), Ramsar Convention, and the Indian Ocean Commission;
- (iii) all relevant sectoral programmes of the Southern African Development Community (SADC), or possibly a new desk for IAS in SADC,
- (iv) existing funded programmes on IAS management, e.g. those already funded by the Global Environment Facility (GEF), and possibly the clearinghouse mechanisms of the Convention on Biological Diversity (CBD), e.g. the biosafety clearinghouse;
- (v) other possibilities identified were COMESA, the United Nations Convention to Combat Desertification (CCD), and the Protocol on Shared Water Basins (PSWB).

The soon-to-be-launched New Partnership for African Development (NEPAD) was said to make extensive provision for cooperative work on IAS within its draft programme on biodiversity conservation.

In the afternoon, the two groups addressed three further questions:

- G. What are the existing resources that can be utilized to achieve regional cooperation?
- H. What additional resources are needed?
- I. Who needs to be involved? When and where?

The results of these two groups' deliberations on these three questions were then presented in plenary to all the workshop participants. Following this, the results of the two groups' independent deliberations were integrated by a small task group. Their integration is presented below.

It was agreed that the overall goal of the current workshop was "Developing Regional Activities with Tangible Outputs." National activities are implied within this, but what is sought is a not the sum total of national activities, but rather the beginnings of a regional strategy to address IAS. We should therefore define key issues to form a platform upon which we can have a major regional process (including a high-level workshop) that will lead to a comprehensive regional strategy. That will take time, and our focus here is to prioritize activities to kick-start the process.

The following activities (Table 1) have been identified by delegates in answering the questions posed in the workshop sessions. What is now being sought is whether the synthesis team has done justice to the workshop outputs, in putting forward these priorities in terms of a joint commitment to regional activities with tangible outputs.

Table 1. Elements of a regional strategy to address IAS throughout southern Africa

Key activity / issue	Suggestions
Establish national focal points	Use existing CBD focal points in the interim
Establish regional focal point	Use Southern African Biodiversity Support Programme (SABSP) Project Implementation Unit (PIU) and GISP in the interim
Raise awareness / advocacy	PIU/GISP report on current and future impacts of IAS in SADC, as advocacy aimed at decision-makers Aim to create enabling environment for optimal regional IAS interventions
Capacity	Ensure availability of necessary expertise, experience and infrastructure at national level Train for requisite capacity, including empowerment of marginalized groups
Inventories	All national inventories undertaken by achievable date GISP expertise to assist individual countries GISP to assist in understanding vulnerability to trans-boundary invasions from non-SADC areas (including marine) Synthesis of work in countries done by achievable date

Funding	National funding strategies developed and implemented International funding strategies sought for regional work, including NEPAD projects, regional GEF-funded projects linked to collateral funding possible through <i>Working for Water's</i> existing budgets, EU, FAO, USAID, etc.
Institutional arrangements	National integration of IAS work through implementation agencies / capacities ("one-stop shop") Regional "secretariat" to oversee IAS work in the region Formal links to GISP and FAO
Prevention projects	Risk assessment capacity developed at national level Regional risk assessment profile done at PIU/GISP level Import/export control through regional role models, application of WTO agreements at national level
Control projects	Integrated IAS management through role-model projects, both those driven within countries and regional show-case initiatives (possibly through NEPAD / GEF, and with a strong developmental basis where practicable)
Policy/ strategy/ planning	Need to develop timeframe for national and regional outputs
Legislative frameworks	Develop comprehensive, enforced national legislation that compliments control and educational efforts Develop regional legislation for enactment within SADC
Research and development	ID key areas of research
Monitoring and evaluation	Ensure optimal returns on investment at national and regional levels
Develop networks and communication links	Networking, linking, channelling of information and co-operation

2.3 Steps toward achieving regional collaboration through establishment of a regional southern African IAS strategy

At the start of the day, workshop participants met in plenary and amended and subsequently agreed upon a summary of the previous day's deliberations produced by a small task team the previous evening. The remainder of the morning was spent addressing the two last questions:

- J. What are the steps required to establish regional collaboration and promote action?
- K. What are the steps that can be taken immediately and who should take them?

The results of these deliberations were condensed into the workshop's recommendations of the ten initial steps required for effective regional IAS management (pp. 4-5). In addition, participants rated the priority of the different key issues as summarized below.

Priority	
1	Raise awareness/advocate policy changes
2	Establish national focal points Establish regional focal points Undertake IAS inventories Secure funding Identify and establish institutional arrangements
3	Undertake IAS prevention projects Undertake IAS control projects Develop networks and communication links
4	Build capacity Strengthen policy/strategy/planning frameworks
5	Strengthen legislative frameworks Carry out research and development Undertake monitoring and evaluation

3. Background papers

Invasive alien species: problem definition, causes, and consequences

Dr. Jamie K. Reaser⁶

U.S. Office of the Global Invasive Species Programme
c/o The Smithsonian Institution
NMNH MRC 105
Washington, D.C. 20019
sprgpeeper@aol.com

Dr. Geoffrey W. Howard

IUCN - the World Conservation Union
Eastern Africa Regional Office
P.O. Box 68200, Nairobi, Kenya
gwh@iucnearo.org

Abstract

Invasive alien species (IAS) are one of the most significant consequences of globalization. Alien species are moved intentionally and unintentionally. Those that establish and spread into new ecosystems can have serious implications for people and the natural resources that they depend upon. In this paper we introduce some of the terms used in the study and management of invasive alien species and provide an overview of the impacts and costs of invasive alien species to people and ecosystems. The causes and consequences of biological invasions are described, and goals and processes for minimizing the spread and impact of invasive alien species are outlined. The chapter concludes with a discussion of the challenges to the prevention and management of invasive alien species, as well as suggestions for overcoming these challenges.

Problem definition

No country is self-sustaining. Globalization has created a situation in which even the most prosperous countries in the world are now economically dependent on the goods and services provided by other countries (Levintin & McMahon, 1996, Bright, 1999). Increasingly these global markets are not only driven by needs, but also by desires for "more" and things that are "new," "better," "different," or "exotic." Nearly every imaginable good and service is now traded internationally.

While globalization has brought social and economic benefits to many people, it has also brought new challenges, and IAS are among the most significant. At no time in history has the rate of biological invasion, nor diversity and volume of invaders been so high and the consequences so great (Bright, 1998, McNeely et al., 2001).

Under the Convention on Biological Diversity (CBD, 2002), *invasive alien species* "means an alien species whose introduction and/or spread threaten biological diversity." Like most definitions of IAS, this one is context-specific. Other definitions (e.g. National Invasive Species Council 2001; <http://www.invasivespecies.gov>) also address impacts to economic and human health sectors. An *alien species* "refers to a species, subspecies or lower taxon, introduced outside its natural past or present distribution; includes any part, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce" (CBD, 2002). These organisms are sometimes called "exotic," "non-native," or "non-indigenous species." *Vectors* (or modes) are the

⁶ Current address: President, Ecos Systems Institute, 6210 Julian Street, Springfield, VA 22150, USA.

means by which IAS are relocated. Some vectors consist of equipment specifically designed for trade and transport – cargo containers, for example. Other vectors are not so obvious. For instance, seeds might be translocated when they adhere to the bottom of a suitcase. *Pathways* are routes by which IAS are moved from one location to another. Because they follow the patterns and trends of globalization, pathways are ever expanding and changing.

In most cases, the translocation of biological organisms does not present a problem; either the organisms do not survive in their new conditions without deliberate care, or their populations are small and easily managed (Mack et al., 2000, Mack et al., 2001). However, about 1 of every 1000 organisms is introduced into a new environment where it thrives and becomes invasive (Williamson & Brown, 1986, Williamson, 1996). *Intentional introductions* of IAS occur when alien organisms are introduced into the natural environment for specific purposes (e.g. agriculture, aquaculture, forestry, recreational fishing, gardening) or released with the intent to do good or relieve care-givers of responsibility (i.e. freeing former pets, research subjects, etc.) and later cause harm. *Unintentional introductions* take place when harmful alien species are imported as "hitchhikers" on people and products and disperse into the environment (e.g. insects infesting wood packaging materials) or when they escape from captivity (McNeely, 2001).

While there is no perfect science to predict which introduced species will become invasive, there are a few broadly-defined characteristics that are likely to give an organism an advantage. Examples include: rapid growth rate, strong dispersal capabilities, large reproductive output, and broad tolerance for such environmental conditions as moisture, temperature, and acidity. Numerous researchers have attempted to determine the specific characteristics that contributed to the success of invaders and develop tools to predict invasions (Kolar & Lodge, 2002, Rejmanek & Richardson, 2002). Parties to the CBD (CBD, 2002) and other international (McNeely et al., 2001) and national (National Invasive Species Council, 2001) bodies have recognized the urgent need for risk analysis frameworks that will better enable prevention and management of IAS. However, due to the nascence of the issue and the numerous biological and socio-economic variables involved, the capabilities of predictive models and the risk assessment frameworks based on them remain poor (National Research Council, 2002). One thing is certain: if the spread of IAS is not stemmed, there will be a gradual "sameness" around the world as places with similar environmental conditions become occupied by the same types of IAS and the local, native diversity of species is subsumed.

Causes

International trade, travel, tourism, and transport - The 4 Ts - are the major drivers of biological invasion (McNeely et al., 2001). Every country contributes to the problem: some request goods and services from afar, while others supply products to meet these demands. "More – Faster – Further" have become the slogans of economic growth. In 2001, world import and export markets were valued at US\$6270 billion and US\$6155 billion, respectively (World Trade Organization, 2002). People also increasingly travel the world for business and pleasure. Commercial services (including travel, transport, and other services) totalled US\$1443 billion in imports and US\$1458 billion in exports worldwide in 2001 (World Trade Organization, 2002). Despite good intentions, developed countries occasionally facilitate the introduction of IAS to other countries through development assistance programs, military operations, famine relief projects, and international financing (McNeely et al., 2001, Reaser et al., 2003). Land-use and climate change can also facilitate invasion by making habitats more challenging for native species and more hospitable to IAS (Mooney & Hobbs, 2001). Because disturbed habitats often favor rapid colonizers, they are particularly vulnerable to the invasion of alien species (Mooney & Hobbs, 2000). From the perspective of the IAS, it does not matter whether the environmental changes are natural or human induced.

Consequences

Every country has been invaded by IAS and society is paying the consequences. The costs of biological invasion are measured not just in currency, but also unemployment, damaged goods and equipment, power failures, food and water shortages, environmental degradation, loss of biodiversity, increased rates and severity of natural disasters, disease epidemics, and lost lives (Bright, 1998, McNeely et al., 2001). Not only do IAS have obvious immediate and long-term impacts, effectively addressing the problem can require natural resource managers to invest substantial time and finances in management operations and work to restore ecosystems in order to re-produce their goods and services.

While the impacts of IAS are typically classified as environmental, economic, and human health-related, these categories should not be regarded as mutually exclusive. IAS often have synergistic and cascading impacts, influencing numerous aspects of environmental and human well-being over long periods of time.

Environmental

IAS are one of the most significant drivers of environmental change globally (Sala et al., 2000, McNeely, 2001, McNeely et al., 2001). In the United States, IAS now rank second to habitat conversion as a cause of species endangerment and extinction (Wilcove et al., 1998). Even the most well protected natural areas are not immune to IAS (Chapin, 2000, Simberloff, 2000, Simonson et al., 2001, Parkes et al., 2002, Tye et al., 2002, O'Dowd et al., 2003).

The decimation of native species by the brown tree snake (*Boiga irregularis*) illustrates the potential for a single IAS to cause significant and permanent losses to biodiversity in a relatively short time frame. The snake, which is native to northern Australia, Papua New Guinea, and the Solomon Islands, was accidentally introduced to the Pacific island of Guam in the 1940s, probably in military transports. Within sixty years it spread throughout the island, reaching numbers as high as 12,000 per square mile in some forests. It has eliminated nine of the island's eleven native land bird species, adversely impacting other fauna, such as native lizards (Savidge, 1987, Fritts, 2001).

A single ecosystem can suffer numerous invasions, with resultant changes in its structure, function, and ability to provide natural resources. Much of the developing world is just beginning to observe significant impacts of IAS in their ecosystems. In contrast, some ecosystems in the developed world, such as the eastern forests of the United States, have been suffering losses from IAS for centuries (e.g. near-extinction of American chestnut, *Castanea dentata*, as a result of root rot, *Phytophthora cinnamomi*, and blight, *Cryphonectria parasitica*). This is due in large part to the long history of trade and transport between regions with similar climate – between the eastern U.S. and Europe, for example (Bright, 1999, Baskin, 2002).

Economic

IAS can also take a heavy financial toll on governments, industries, and private citizens. A recent study estimates that IAS cost the U.S. more than \$100 billion a year (Pimentel et al., 2000) and at least this much in six other countries combined (Pimentel et al., 2001, Pimentel, 2002). There are, however, remarkably few quantitative studies of the socio-economic impacts (Perrings et al., 2000, but see Pimentel, 2002 for case studies of costs internationally). Worldwide, the losses to agriculture have been estimated to be between \$55 billion and nearly \$248 billion annually (Bright, 1999). The impact and management costs of a single species can carry a price tag in the millions. For example, the golden apple snail (*Pomacea canaliculata*), introduced from Latin America as a high protein food source, caused losses to Philippine rice crops during the 1980s of approximately US\$1 billion (Naylor, 1996). The formosan subterranean termite (*Coptotermes formosanus*) introduced from East Asia costs an estimated US\$1 billion annually in property

damage, repairs, and control measures in the southeastern United States (Suszkiw, 1998). The European gypsy moth (*Lymantria dispar*) was introduced into North Carolina in 1993 and eradicated four years later at a cost of approximately US\$19 million (U.S. Army Corps of Engineers, personal communication). The U.S. Department of State contributes more than US\$10 million annually to control the sea lamprey (*Petromyzon marinus*) in the Great Lakes shared by the U.S. and Canada (U.S. Department of State, personal communication).

Costs from IAS are also incurred when specific commodities or transport systems are affected. Because trade disputes may arise over pest risks (Jenkins, 1996), the spread of IAS increases the probability that countries will not be able to:

- Sell certain food products because their trade and transport may spread destructive pests and highly infectious diseases that kill agricultural crops, livestock, or people;
- Sell certain types of other commodities (e.g. horticultural products, seeds, and pets) because countries fear they will escape into the environment, causing irreversible harm and requiring expensive, long-term control; or
- Use certain types of shipping containers because their trading partners fear that, upon arrival, they will inadvertently release pests that will destroy agricultural, forestry, or fisheries systems or the natural environment.

Health

IAS can impact the health of humans, plants, and animals. Pathogens and parasites may themselves be IAS or may be introduced by invasive vectors (e.g. mosquitoes such as *Aedes aegypti*; Bryan, 1996, Bright, 1998, Meyerson & Reaser, 2003). Plague *Yersinia pestis*, particularly that known as the bubonic plague, provides a well known historical example. The pathogen, native to parts of Asia, Africa, and the Middle East, spread into Europe and other areas along with alien rats (*Rattus* sp.) and other animals harboring infected fleas, which might also be alien (e.g. *Xenopsylla cheopis*, Oriental rat flea). "Black Death" is reported to have claimed more than 130 million lives (Butler, 1983, Thomas, 1997). The karnal bunt fungus (*Tilletia indica*) that infects wheat crops and the viral foot-and-mouth disease (FMD), a pathogen of cattle and other ungulates, are of recent concern to agriculture and livestock industries (Enserink, 2001, Meyerson & Reaser, 2002). Cholera (*Vibrio cholerae*) and some of the microorganisms that can cause harmful algal blooms are relocated and released in the ballast water carried by large ships (Wilson, 1995). Other high-profile diseases caused by invasive pathogens include malaria (*Plasmodium* spp., parasites), dengue fever (*Flavivirus* sp., virus), and the human immunodeficiency viruses that cause Acquired Immune Deficiency Syndrome (AIDS).

Food and water shortages induced by IAS can have negative consequences for all living organisms, but are particularly problematic in the developing world (McNeely et al., 2001). Invasive floating water weeds take enormous toll on human livelihoods, water supply, and biodiversity of Africa where the biocontrol option is preferable but slow compared to risky herbicides (Howard & Harley, 1998, Hill et al., 1999). When certain pesticides are used to eradicate or control IAS, people, and the ecosystems on which they depend can often be placed at risk (Parker, 2001).

Addressing the problem

Approaches for preventing and managing the spread of IAS are discussed in other chapters and approximately 100 case studies can be found in the Global Invasive Species Programme's "Toolkit" (Wittenberg & Cock, 2001). Here we define the goals and outline the general processes.

Goals for addressing the problem of IAS include:

Prevention: Keeping an IAS from being introduced into a new ecosystem. Ideally, this usually means keeping alien organisms from entering a new country.

Early detection: Locating IAS before they have a chance to establish and spread. This usually requires effective, site-based inventory and monitoring programs.

Eradication: Killing the entire population of IAS. Typically, this can only be accomplished when the organisms are detected early.

Control: The process of long-term management of the IAS' population size and distribution when eradication is no longer feasible.

Control and eradication methods can take one or more of three forms (see below). Integrated pest management (IPM) is their combined application:

- ⇒ Mechanical control: The physical removal of organisms – pulling weeds, for example. The process requires a long-term investment of human resources.
- ⇒ Chemical control: Using chemicals to kill organisms – poisons for wildlife and herbicides for plants, for example. The processes can be quite costly and typically requires repeated applications.
- ⇒ Biological control: The introduction of a highly specific predator, parasite or pathogen that will attack the IAS. This process is not likely to result in eradication of the organism but often can reduce the population of the IAS to tolerable levels. The initial costs associated with research and development may be high, but the long-term costs once applied are low and relatively little maintenance is required.

Restoration: The process of re-establishing natural populations and ecosystem functions. In theory, this increases the ecosystem's resistance to future invasions (Mueller-Dombois 1981).

These goals are best accomplished through a strategic, holistic approach that incorporates the following processes:

- Risk assessment and risk management
- Research
- Inventory and monitoring
- Education and outreach
- Policy and regulation
- Information management
- International cooperation and capacity building

International cooperation and capacity building are crucial, as IAS are typically an international problem by their very definition (see Macdonald, this volume). However, these processes are probably the weakest link in any country's efforts to minimize the spread of IAS.

Challenges

The prevention, eradication, and control of IAS presents scientific, political, and ethical challenges (McNeely, 2001). The process of invasion is often complex, resulting in considerable scientific uncertainty (Bright, 1998, Mooney & Hobbs, 2000, Mack et al., 2001). Implementing effective prevention, eradication, and control measures can be costly and require new policy approaches, as well as significant advances in ecological knowledge and natural resource management (Shine et al., 2000, McNeely et al., 2001, Wittenberg & Cock, 2001).

Scientific

Biological invasion can involve any number of individual organisms from any taxonomic group, any ecosystem, and numerous pathways and vectors (McNeely et al., 2001). There is considerable uncertainty in both the process and the outcome. Typically, scientists do not have an adequate ability to determine which species will become invasive under what circumstances and the interactions among species are often unpredictable. Alien species thought to be benign have on occasion suddenly become invasive, even after a significant amount of time since their introduction – known as the time lag phenomenon (National Research Council, 2002).

Political

IAS are not only moved, they move themselves. They can walk, run, hop, fly, or swim across jurisdictional boundaries or be borne there by wind and water currents. Thus, once IAS become established within one country, they pose a threat to an entire region, as well as trading partners and every country along a trading pathway (McNeely et al., 2001).

There are more than 40 international agreements, as well as numerous codes of conduct that directly address IAS (Shine et al., 2000). However, few countries consider IAS a top priority and have invested in the development of well-coordinated policies and programs to address the problem. Developing countries that recognize the gravity of the situation and want to take immediate action are hampered by a lack of scientific, technological, and financial resources. Efforts of most governments to address IAS problems are poorly coordinated. Neighboring countries are often unaware of each other's policies and practices (National Invasive Species Council, 2001, Reaser et al., 2003).

Ethical

Efforts to manage IAS have been hindered, and in some cases halted, on ethical grounds. Many animal rights groups oppose the eradication and control of IAS, especially large mammals (Low, 1999, Genovesi & Bertolino, 2001). Human health concerns arise over the application of certain pesticides, such as the use of DDT to control introduced species of mosquitoes in malaria-infested regions (Bright, 1998, Parker, 2001). Some scientists and environmental groups believe that potential biological control agents pose risks of invasion that may exceed those of the IAS already in place (Ouder, 1996, Strong & Pemberton, 2000). There are also instances where different sectors of society place different values on alien species. What some people see as beneficial, others might view as undesirable. Such conflicts of interest are not uncommon and are often associated with intentional introductions (Hattingh, 2001, Reaser, 2001).

Opportunities

*"...what I choose to do shapes a little bit of the world,
and the ripples sent out by the actions of us all change
the whole world for better or for worse."*

- Philip Stewart, botanist

Human health, food and water security, social stability, and long-term economic gains all depend upon a healthy environment at local, regional, and global levels. IAS are thus a problem facing the developed and developing worlds. Because every country is an exporter and importer of goods and services, every country is also a facilitator and victim of the invasion of alien species. The patterns and trends of invasion will continue to follow the patterns and trends of international commerce and the movement of people. Every country, even the most economically wealthy, needs to raise their capacity to minimize the spread and impact of IAS.

Although the prevention and control of IAS present scientific, political, and ethical challenges, the problem can be dramatically reduced through concerted action. Stakeholders need to be made aware of the problem and motivated to address it. Scientifically-based information and effective tools need to be provided to policy makers and resource managers so that well-informed decisions can be enacted. Co-operative programmes need to be forged among governments and other institutions to enable the problem to be addressed in a strategic, holistic, and timely manner.

No programme to minimize the spread and impact of IAS will be successful, however, unless it effectively addresses the factors that ultimately drive invasions. IAS are a by-product of human values, beliefs, and behaviours. They are a symptom of a society that is choosing immediate gains over long-term, irreconcilable losses. We must recognize that the way in which we choose to conduct business and live our daily lives will either magnify or minimize the problem (Reaser, 2001).

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Overview of international instruments addressing IAS issues

Mr. David Nowell

Food and Agriculture Organisation
Agricultural Officer (Plant Protection)
Room B-661, Viale delle Terme di Caralla-00100
Rome, Italy
E-mail: dave.nowell@fao.org
Internet: <http://www.fao.org>, <http://www.ippc.int>

Ms. Clare Shine

Legal Consultant, Environmental Law and Policy
37 Rue Erlanger, 75016, Paris, France,
(IUCN-Environmental Law Centre affiliate)
E-mail: clare.shine@noos.fr

This paper provides a brief overview of international instruments relevant to IAS and outlines:

- ⇒ the rationale for international action on IAS;
- ⇒ the scope of existing treaties and guidelines that address IAS in the context of biodiversity, aquatic ecosystems, plant, animal and human health, transport, and international trade;
- ⇒ constraints in existing frameworks and recent policy developments; and
- ⇒ frameworks for regional and subregional cooperation in the southern African region.

Why are IAS an international legal issue?

The causes and impacts of biological invasions are often international by definition. Through trade and transport pathways, countries both send and receive non-native species. Species may also be translocated within countries to areas or islands where they are not currently present and become invasive in this new location. For these reasons, unilateral action by a few States can never be enough to prevent unwanted introductions. Cooperation is essential at all jurisdictional levels.

Policy, legal, and technical tools need to address the range of pathways through which non-native species are moved (see Box 1).

How does the international regulatory framework address IAS issues?

Nearly fifty internationally-agreed legal instruments or guidelines deal with some aspect of the introduction, control, and eradication of IAS. These instruments set out the policy or technical norms that should form the baseline for national legal frameworks. They fall into three broad categories:

- ⇒ the longest-established agreements focus on controlling the introduction and spread of pests (some of which are IAS, others are not) and diseases to protect human, animal, and plant health through the establishment of quarantine systems. A series of quarantine agreements now mandate and govern sanitary (human health), zoosanitary (animal health), and phytosanitary (plant health) measures to control introductions for such purposes.

Box 1. Examples of pathways for intentional or unintentional introductions of non-native species

- trade and movement of goods (non-native species translocated in containers, planting media, untreated wood packaging, some food products)
- movement of people, including for tourism, through air, road, rail and sea transport
- shipping and boating (ballast water, sediment, hull fouling, anchors)
- aviation (in cargo and on and in the aircraft itself)
- postal and courier services (including biological material purchased via the internet)
- mariculture and aquaculture (fish, molluscs, and crustaceans introduced for production)
- food fish (release on non-natives)
- agriculture (crops and livestock) (direct introductions)
- hunting and fishing (game species and live fish and bait introduced for sport and restocking, movement of equipment)
- aquaria (deliberate discards, discharge of organisms with waste water)
- release of pets or other domestic animals
- horticulture and gardening (dispersal of material from gardens, ponds etc.)
- habitat restoration and landscaping (use of non-native genotypes of native plants, escapes)
- waste disposal and overflow (discharges of untreated effluent to aquatic systems)
- infrastructure development, interbasin transfers of water (dam removal, canals)
- movements of vehicles/equipment during development, famine relief, and military operations
- note: non-native species may be carrying pathogens and parasites.

⇒ biodiversity-related treaties are concerned with IAS for their possible impacts on native species and ecosystems. Some focus specifically on marine and/or inland water ecosystems;

⇒ most recently, technical guidelines and codes of conduct aim to minimize risks associated with a limited number of transport and trade-related pathways.

Existing instruments have been developed by different multilateral bodies at different times with different objectives, for implementation by different national agencies and sectoral stakeholders. This affects how they refer to IAS, down to the terms, definitions, and procedures used. Most national systems reflect these sectoral differences and have overlaps, gaps, and result in little contact between IAS specialists in different departments and agencies.

Conservation and sustainable use of biological diversity

The Convention on Biological Diversity (CBD) is the only global instrument to provide a comprehensive basis for measures to protect all components of biodiversity against those non-native species that are invasive. Article 8(h) requires Parties “as far as possible and as appropriate, (to) prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species.”

Other CBD provisions that should be taken into account when implementing IAS measures relate to strategic and cross-sectoral planning, regulation, and management of potentially damaging processes and activities, involvement of local populations and the private sector, incentives, environmental impact assessment, transboundary notification, and emergency planning.⁷

CBD institutions have prioritized IAS issues in recent policy-making. In 1998, recognizing the problems IAS pose to indigenous and local communities and their negative effects on local and national economies, the Conference of the Parties (COP) designated non-native species as a cross-cutting issue to be taken into account in each thematic work program and identified geographically and evolutionarily isolated ecosystems, including islands, as needing special attention because of their vulnerability to biological invasion.

⁷ Respectively Art.6(a) and (b), Art.8(l), Art.10, Art.11 and Art.14 of the CBD.

Box 2. Resolution VIII/18 (Invasive Species and Wetlands) urges Ramsar Parties to:

- address the problems posed by IAS in wetland ecosystems in a decisive and holistic manner, making use as appropriate of the tools and guidance developed by various institutions and processes, including relevant guidelines or guiding principles adopted under other conventions;
- undertake risk assessments of alien species which may pose a threat to the ecological character of wetlands, taking into account the potential changes to ecosystems from the effects of global climate change, and applying the guidance available in Ramsar's *Risk Assessment Framework*;
- identify the presence of IAS in Ramsar sites and other wetlands; the threats they pose to these sites' ecological character, including the risk of invasions by such species not yet present within each site; and the actions underway or planned for their prevention, eradication or control;
- when developing and implementing national IAS strategies and responses, recognise that terrestrial IAS can threaten and affect ecological character of wetlands (e.g., lowering of water tables, alteration of water flow patterns) and ensure that appropriate measures to prevent or control such invasions are in place;
- prior to moving water between river basins, examine carefully the potential environmental impacts due to invasive species;
- work closely with their counterpart national focal points for CBD, U.N. Convention to Combat Desertification, UNESCO Man and the Biosphere Program, International Maritime Organization and others in developing and implementing national IAS policies, strategies and management responses
- ensure that IAS prevention, eradication and control are fully incorporated in national legislation and national wetland and biodiversity policies, strategies and action plans, applying the Ramsar *Guidelines for reviewing laws and institutions to promote the conservation and wise use of wetlands* (Ramsar Handbook 3) and *Guidelines for developing and implementing National Wetland Policies* (Ramsar Handbook 2).

In 2002, after extensive preliminary work, the sixth meeting of the COP adopted Decision VI/23 on *Alien species that threaten ecosystems, habitats and species*. This decision:

- ⇒ reaffirms the importance of national and regional IAS strategies and sets out detailed recommendations for the content of national strategies and action plans;
- ⇒ urges closer international and regional cooperation and specific measures for capacity building, assessment, information and tools;
- ⇒ urges Parties, other governments, and relevant organizations to promote and implement the *Guiding Principles for the Prevention, Introduction and Mitigation of Impacts of Alien Species that Threaten Ecosystems, Habitats or Species* annexed to the decision.

Information on other biodiversity instruments (including CMS and CITES is available in the *Guide to designing legal and institutional frameworks on alien invasive species* (see references).

Aquatic and marine ecosystems and resources

The emphasis on prevention is particularly important in aquatic and marine systems because IAS can be particularly hard to detect and can disperse rapidly, making eradication or control extremely difficult. Introductions of non-native species to marine ecosystems are covered in a general way by:

- ⇒ the United Nations Convention on the Law of the Sea (UNCLOS). Parties should take all measures necessary to “prevent, reduce, or control pollution of the marine environment resulting from the intentional or accidental introduction of non-native or new species to a particular part of the marine environment, which may cause significant and harmful changes thereto” (Article 196);
- ⇒ instruments developed under the United Nations Environment Programme (UNEP) Regional Seas Programme, e.g. the Nairobi Convention and Abidjan Convention.

IAS in coastal and inland wetlands were addressed by the Conference of the Parties to the Ramsar Convention on Wetlands in November 2002 (see Box 2).

Introductions of IAS into inland water systems have very little coverage under binding instruments, except for the 1997 Convention on the Law of Non-navigational Uses of International Watercourses (not in force). Most existing bi- and multilateral watercourse treaties do not reference this risk.

Instruments for the protection of plant, animal and human health

International instruments and institutions for the protection of plant, animal, and human health are an important part of the international regulatory framework, because the interests they protect may be adversely affected by non-native animals, plants, and micro-organisms (e.g. viruses, bacteria, and fungi) that become invasive.

Plant health

The International Plant Protection Convention⁸ (IPPC) provides a framework for international cooperation to prevent the introduction of pests of plants and plant products and to promote appropriate measures for their control. It deals with the spread of pests between countries and phytosanitary measures within a country (see the International Phytosanitary Portal (IPP) at <http://www.ippc.int> for further information). It is not explicitly a trade or environmental treaty, but is directly relevant to IAS issues that fall within its scope.

The IPPC defines "pest" as "any species, strain or biotype, animal life or any pathogenic agent injurious or potentially injurious to plants or plant products," e.g. fungi, bacteria, phytoplasmas, viruses and invasive plants. It covers both direct and indirect damage by pests to plants, defined broadly to include natural flora as well as cultivated plants. Alien organisms that meet the definition of "pest" are covered, as are biological control agents used to control pests in this broad context. Official IPPC definitions can be found in the International Standard for Phytosanitary Terms (ISPM) # 5 "Glossary of Phytosanitary Terms," which is revised annually.

Until the 1990s, the IPPC mainly focused on phytosanitary certification with an almost exclusively agricultural focus. In 1997, it was revised to provide for the development of international phytosanitary standards (ISPMs) recognised within the multilateral trading system. ISPMs are not binding *per se* on World Trade Organization (WTO) members, but Members that do not comply with available standards must base national measures on risk assessment. Existing ISPMs cover matters such as pest risk analysis, import and release of exotic biological control agents, guidelines for the establishment of pest free areas and guidelines for pest eradication programmes. The most recent standards⁹ are beginning to take greater account of environmental implications, which could provide an important bridge with the work carried out under the CBD.

⁸ 1951, revised in 1979 and 1997 (latest revision not yet in force, but countries have agreed to starting implementation due to its imminent acceptance).

⁹ In 2003, the IPPC's Interim Commission on Phytosanitary Measures (ICPM) approved standards on the analysis of environmental risks and the coverage of taxa that impact unmanaged as well as agricultural systems: see Supplement on

The IPPC provides for national mechanisms that are well-suited to prevention, early detection, and control of IAS. Each IPPC party is required to:

- ⇒ establish a National Plant Protection Organization (NPPO);
- ⇒ adopt legislative, technical and administrative measures to prevent introduction/spread of pests;
- ⇒ establish a single official contact point to facilitate the exchange of official information;
- ⇒ undertake pest risk analysis, in the absence of an ISPM, to provide technical justification for a national phytosanitary measure;
- ⇒ carry out surveillance of growing plants, including both areas under cultivation (e.g. fields, plantations, nurseries, gardens, greenhouses and laboratories) and wild flora, and of plants and plant products in storage or in transportation, particularly with the object of reporting the occurrence, outbreak and spread of pests, and of controlling those pests;
- ⇒ provide for the protection of endangered areas and the designation, maintenance and surveillance of pest free areas and areas of low pest prevalence;
- ⇒ establish export certification systems to ensure that exported products comply with the import requirements of trading partners;
- ⇒ establish inspection procedures and treatments (when appropriate), and
- ⇒ establish an official process for the implementation of the ISPMs.

Implementation is facilitated by nine regional plant protection organisations (RPPOs). RPPOs are beginning to develop regional phytosanitary standards to facilitate regional harmonization of trade-related measures consistent with the WTO-SPS Agreement.

Animal health

Animal health issues are addressed by the Office International des Epizooties (OIE), which develops standards and guidance on pests and diseases of animals (but not on animals themselves as pests). The International Animal Health Code for Mammals, Birds, and Bees and the International Aquatic Animal Health Code set out standards on import risk analysis and risk management measures for specific diseases and are updated annually. The OIE has an Ad Hoc Working Group on risk analysis for aquatic animal diseases and a long-established Working Group on Wildlife: this addresses wildlife management and reintroduction issues that have an animal disease dimension, but has not covered related habitat and ecosystem issues.

Analysis of environmental risks to ISPM No.11 (Pest risk analysis for quarantine pests, 2001) and IPPC Supplement No. 2 on Guidelines on the understanding of 'Potential Economic Importance' and related terms including reference to environmental considerations to ISPM No.5 (Glossary of Phytosanitary Terms). ISPM 3 (Code of Conduct for the Import and Release of Exotic Biological Control Measures, 1996) is currently being revised. Proposals for consideration include its expansion to better address intentional introductions of biopesticides, soil enhancers, pollinators and sterile insects for purposes of pest control and the enhancement of its RA component.

Human health

Human health can be affected by alien species providing hosts for diseases. One example is the West Nile virus apparently introduced to New York, U.S. via an imported alien bird and then transmitted to local mosquitoes. Because the virus can decimate bird populations and affect other species including humans, it is a serious concern for many countries represented at this Workshop.

The World Health Organization (WHO) has developed International Health Regulations¹⁰ to prevent the international spread of human infectious diseases, which are currently being updated due to changes in disease epidemiology and the increase in international traffic. Codex Alimentarius (a joint FAO/WHO initiative) deals with food safety and is responsible for international standard setting in this regard.

Technical guidance for certain transport sectors

There is a growing emphasis on the need for technical guidelines or codes of conduct to address specific pathways in a more detailed and practical way than treaty negotiation permits.

The International Maritime Organization (IMO), through its Maritime Environmental Protection Committee (MEPC), has focused on prevention efforts to minimise IAS introductions via ships' ballast water. It supports the development of a mandatory legal regime to avoid unilateral responses by individual states in such an international industry, but began by adopting voluntary *Guidelines for the control and management of ships' ballast water to minimize the transfer of harmful aquatic organisms and pathogens*¹¹ to assist governments, ships' masters, operators and owners, and port authorities to establish common procedures to minimize the risk of introducing harmful aquatic organisms and pathogens from ships' ballast water and associated sediments.¹² The MEPC has also approved a technical circular on design measures for ballast water and sediment options in new ships (MEPC 47th session, London 4-8 March 2002). The IMO Council¹³ has now convened a Diplomatic Conference for early 2004 to finalise the the draft IMO *International Convention for the Control and Management of Ships' Ballast Water and Sediments*.

The IMO, Global Environmental Facility (GEF), and U.N. Development Programme (UNDP) have jointly developed the GloBallast Programme¹⁴, a global technical cooperation programme to assist developing countries to tackle the transfer of harmful aquatic organisms in ships' ballast water and to prepare for the implementation of the future convention. This Programme ran from 2000-3 and has been extended until 2004. A favourable mid-term evaluation¹⁵ found that stakeholder participation and support has been impressive and that the project has created a solid foundation of support for the future IMO Convention.

There are no internationally-agreed prevention measures for hull-fouling as an IAS vector, although CBD Decision VI/23 §7 called on the IMO to develop mechanisms to minimise this as a matter of urgency.¹⁶ The IMO International Convention on the Control of Harmful Anti-Fouling Systems on Ships (2001) provides for the global phase-out of tributyl tin (TBT) in paints, but this

¹⁰ Geneva, 1969; amended in 1982.

¹¹ Annex to Resolution A.868 (20), 20th IMO Assembly, 1997.

¹² At least seven countries and three ports have now enacted legislation requiring ships calling at their ports to comply with the Guidelines, e.g. Australia, Canada, Chile, Israel, New Zealand, Portugal, the USA, some States within the USA and some ports around the world, such as Buenos Aires (Argentina), Scapa Flow (Scotland) and Vancouver (Canada).

¹³ 89th session, 25-29 November 2002.

¹⁴ The GEF/UNDP/IMO *Global Ballast Water Management Programme for the Removal of Barriers to the Effective Implementation of Ballast Water Control and Management Measures in Developing Countries*.

¹⁵ Vousden, D. & B. Okamura. 2003. *GloBallast Project Independent Mid Term Evaluation: Final Report* (31 March 2003).

¹⁶ Note that IMO, the International Council for the Exploration of the Sea (ICES) and the International Oceans Commission have recently established a Study Group on Ballast and other Ship Vectors (first meeting in Vancouver, 24-25 March 2003).

ban is designed to reduce chemical pollution of the marine environment and could even lead to a significant increase in the number of introductions of invasive fouling species such as ascidians.¹⁷

The International Civil Aviation Organization (ICAO) recognises that civil air transportation represents a potential pathway for IAS introduction (e.g. the brown tree snake, *Boiga irregularis*, to Guam). Contracting States have been urged to take mutually supportive efforts to reduce the risk of introducing potential IAS via this pathway to areas outside their natural range.¹⁸ In 2002, the ICAO surveyed 188 States to gather data for an assessment of whether civil aviation is a "significant"/"high-risk" pathway for unintentional introductions. The questionnaire covered possible vectors (aircraft structure, cargo, passengers, baggage, packaging, mail) and control measures based on education (brochures, airport notices, quarantine declaration on arrival cards), physical intervention (detector dogs, disinfection of aircraft, searches of passengers, baggage and/or cargo), enforcement and surveillance. The Secretariat's preliminary analysis of the 47 responses shows that about half of the States aware of IAS problems in their respective countries consider that air transport is a contributing factor (the other half lacked the data to respond). The detailed analysis will also cover species-specific information provided by States. The ICAO Council will then determine whether an ICAO prevention strategy is necessary: the matter will be considered by the ICAO Assembly in 2004.

Technical guidance for fisheries and aquaculture

Aquaculture and mariculture operations present a known risk of unwanted introductions (escapes, parasites, and disease). Some technical guidance has been adopted to establish principles and standards and provide best practice guidance for this rapidly growing industry.

Through the Food and Agriculture Organization (FAO), the Code of Conduct for Responsible Fisheries was adopted in 1995.¹⁹ The Code provides guidelines for the responsible introduction, production and management of fish species under managed conditions. It urges States to adopt measures to prevent or minimize harmful effects of introducing non-native species or genetically altered stocks used for aquaculture into waters.

The 1994 Code of Practice on the Introductions and Transfers of Marine Organisms was issued by the International Council for the Exploration of the Sea and the FAO's European Inland Fisheries Advisory Commission. It establishes procedures and practices to diminish the risk from intentional introductions of marine alien species into marine and freshwater ecosystems.

Relationship of existing instruments with the multilateral trading system

Alien species are introduced through trade intentionally (imported products) or unintentionally (e.g. as by-products, parasites and pathogens of traded products, hitchhikers and stowaways in vessels, vehicles, or containers that deliver products or services). National measures to minimize unwanted introductions - quarantine and border controls on live species, commodities, packaging and other vectors - therefore have a direct interface with the multilateral trading system and need to be consistent with applicable rules and disciplines adopted within the WTO framework.

Multilateral environmental agreements do not directly address international trade aspects of alien species control, except CITES - to a limited extent. The non-binding FAO Code of Conduct for

¹⁷ These are also found in submerged man-made structures in ports, harbours and marinas with appropriate salinity and can tolerate high levels of pollution and considerable variations in temperature (*Ballast Water News* Issue 12 Jan-March 2003).

¹⁸ ICAO General Assembly Resolution A33-18, adopted at the 33rd Session, Montreal 2001.

¹⁹ Guidance developed under this Code includes *Precautionary approach to capture fisheries and species introductions and Aquaculture Development* (FAO Technical Guidelines for Responsible Fisheries 2/1996 and 5/1997).

Responsible Fisheries recommends that States develop international agreements for trade in live specimens where there is a risk of environmental damage *inter alia* in importing States.²⁰

In contrast, the IPPC, OIE, and Codex Alimentarius have a formal relationship with the multilateral trading system, following the conclusion in 1995 of the WTO Agreement on the Application of Sanitary and Phytosanitary Measures (WTO-SPS Agreement). The SPS Agreement provides:

- ⇒ that a WTO Member may adopt national measures to protect human, animal, or plant health/life from risks arising from the entry, establishment or spread of pests, diseases, or disease-causing organisms and to “prevent or limit other damage” within its territory from these causes.²¹
- ⇒ for the use of international standards as a basis for national protection measures that affect trade. The aim is ensure that national measures have a scientific basis and are not used as unjustified barriers to international trade. The Agreement recognises standards set by three organisations: IPPC (pests of plants and plant health); OIE (pests and diseases of animals and zoonoses); and Codex Alimentarius Commission (food safety and human health).
- ⇒ for key principles (reflected in the revised 1997 IPPC Agreement) that include consistency in the application of appropriate levels of protection, least trade restrictive alternatives, acceptance of equivalent but different SPS measures and transparency through advance notification of measures.

Consistent with these principles:

- ⇒ countries may take action when necessary to protect plant/animal health by preventing introduction or carrying out eradication/containment;
- ⇒ such action should be based on the appropriate level of protection for that country;
- ⇒ pest risk analysis is to be used in the development of measures;
- ⇒ countries should base national measures on international standards where available. Where no international standard exists or a higher protection level is sought, the State concerned must justify a national measure through scientifically-based risk assessment; and
- ⇒ emergency (or provisional) measures are permissible without such analysis, when situations require urgent action or there is insufficient information on which to base action. However, such measures must be reviewed for their scientific justification and modified as appropriate.

Progress and remaining constraints

Terminology

Many different terms are used for alien species generally (non-indigenous, alien, exotic, foreign, new), the subset that cause damage (pest, weed, harmful, injurious, invasive, environmentally dangerous) and the concept of "introduction." The need to clarify concepts and terms is widely acknowledged, internationally and nationally. Biodiversity-related instruments prior to the CBD Guiding Principles contain few definitions of key terms and concepts. In contrast, the FAO/IPPC Glossary of Phytosanitary Terms provides for standardized use of terms at

²⁰ Section 11.2.10.

²¹ Abridged from Annex A, Definitions.

international, regional and national level and is updated annually. Some key IPPC terms (e.g. "quarantine pest") are roughly comparable but not identical to IAS in the CBD sense. In 2003, the ICPM adopted guidance²² on the interpretation of the term "economic importance" in the IPPC and ISPMs. This notes that the IPPC has historically maintained that the adverse consequences of plant pests, including those concerning uncultivated/unmanaged plants and wild flora, are measured in economic terms, but recognises that the term "economic" has resulted in some misunderstanding of IPPC's focus. The new Guidelines clarify that pest risk analysis can account for environmental concerns in economic terms using monetary or non-monetary values;

⇒ market impacts are not the sole indicator of pest consequences; and

⇒ members have the right to adopt phytosanitary measures with respect to pests for which the economic damage caused to plants, plant products or ecosystems within an area cannot be easily quantified.

⇒ for a plant pest to have "potential economic importance," it must have a potential for introduction in the area subject to pest risk analysis, the potential to spread after establishment, and a potential harmful impact on plants (e.g. loss of crop yield or quality, damage to ecosystems, habitats or species, or some other specified value such as recreation, tourism or aesthetics).

At the operational level, it is very important for quarantine and environmental personnel to develop a common approach to terms used in these sectors.

Taxonomic coverage

Biological invasions may be generated by all taxonomic groups at all taxonomic levels. Internationally, only the CBD covers IAS in relation to all levels of the biodiversity hierarchy. Nationally, biodiversity laws that regulate introductions tend to be limited to higher taxa of non-native animals and plants and rarely go below the species level.

Sanitary and phytosanitary instruments potentially cover all taxonomic groups and lower taxonomic categories, but only to the extent that these are injurious to plant or animal health as defined by the IPPC or OIE. The IPPC's trigger for pest classification is "injurious to plants or plant products." This covers alien organisms that could damage wild plants, but not explicitly those that may harm ecosystem function or plant genetic diversity.

Ecosystem/biome coverage

Invasion processes affect all ecosystems, but the impact of particularly aggressive species is especially severe on the structure and function of vulnerable and isolated ecosystems, including small islands, certain lakes, and mountain areas. Guidance is needed to assist countries and regions to develop appropriate frameworks for vulnerable ecosystems.

Coverage of pathways and vectors

Many pathways and vectors are still not covered by international rules or guidance. For transport, only one shipping-related vector (ballast water) has been addressed: equivalent measures to minimize hull fouling are urgently needed. Aviation-related guidance is voluntary and is limited to civil aviation. Land transport is not formally regulated to minimize transfer risks. For inland waterways, there seems to be no guidance on water-borne transport or risks associated with dam removal or canal linkages connecting drainage basins or coasts.

²² Supplement No. 2 on *Guidelines on the understanding of 'Potential Economic Importance' and related terms including reference to environmental considerations* to ISPM 5 (*Glossary of Phytosanitary Terms*).

Material moving outside conventional trade pathways (e.g. in development assistance, humanitarian programmes, military operations) falls outside the regulatory framework. A preliminary report on *International Assistance Programmes as pathways for the introduction of invasive alien species*²³ found that serious and under-documented IAS problems still result from such programmes. More concerted work is needed in international funding and technical agencies to assess the nature and severity of associated IAS risks and to support development of better prevention methods and stronger national and international quarantine systems.²⁴

Quarantine systems are theoretically broad enough to cover all introductions that can involve the transfer of pests (e.g. passengers, mail, Internet transactions, means of transport). However, national systems vary widely in capacity and resources (inspection facilities, taxonomic capacity, access to information). Many smaller nations lack the resources to operate comprehensive quarantine and risk assessment systems. Moreover, national systems mainly focus on international boundaries and rarely cover movements between regions of the same country except for high-risk agricultural and forestry pests. This is a very serious deficit.

Prevention, eradication and control

All existing instruments mandate prevention, recognizing the technical difficulties and costs of detecting, eradicating, or containing introduced species after they have become invasive. However, frameworks tend to be weaker on monitoring, eradication, and control for IAS that impact biodiversity, when compared with those that affect agriculture and forestry.

Internationally and nationally, the use of import and export controls to prevent introduction of pests is long established. National plant and animal health services and Customs play a key role in establishing and implementing border controls, import restrictions, and other quarantine measures. However, some developing nations lack the technical capacity or resources for adequate quarantine systems and may not be able to meet the standards and requirements of agreements within the multilateral trading system. There are wide variations in the national capacity levels and assessment and control procedures of different trading partners within Africa. This can place countries at risk from others in the same region that do not apply such stringent measures. This is another reason why regional technical support is particularly important for the southern African region.

Effective prevention also requires the restriction of further imports and internal movements of IAS. This is important to cut off supply, support containment strategies, and prevent spread to other areas. Measures of this kind are often restricted to agricultural and forestry pests.

Institutional coordination and synergy

Cooperation between key organisations has expanded significantly over the last five years. The CBD has endorsed closer cooperation with the FAO, WHO, IMO, OIE, Codex Alimentarius, UNESCO and relevant treaty secretariats. The 3rd Joint CBD-Ramsar Work Plan (2002-2006) provides for collaborative actions with GISP, IUCN, and the World Conservation Monitoring Centre (WCMC) to increase the availability of information and guidance on aquatic IAS. In February 2003, the CBD and IPPC Secretariats agreed a Memorandum of Understanding that recognises their overlapping objectives, calls for strengthened cooperation between secretariats and identifies areas for collaboration. There is no equivalent mechanism between the CBD and the OIE, but the OIE has expressed support for the development of closer cooperation (B. Vallat, pers.comm.).

²³ Source: unpublished report by CABI Bioscience compiled on behalf of GISP.

²⁴ Decision V/25 (Biological diversity and tourism) includes as some of the potential impacts of nature-based tourism the increased risk of introduction of alien species by tourists and tourist transportation and the spread of pathogens from humans or companion animals to wild species.

Increased engagement of non-State actors

There is growing acceptance of the need to engage trade, transport, and other stakeholders in IAS prevention and management, and to harness their ingenuity in finding solutions and alternatives. The development of codes of conduct and of best practice should be promoted, although voluntary measures of this kind will not necessarily be enough to tackle difficult IAS issues.

In the marine sector, the shipping industry contributes through the International Chamber of Shipping and the International Association of Independent Tanker Owners to the *GloBallast* Global Ballast Water Management Programme which gives practical guidance for the implementation of the IMO voluntary guidelines on board ships.

In the pet and ornamental fish sector, some trade associations participate actively in CBD and CITES discussions relevant to IAS. A small number of trade organisations have developed voluntary codes of conduct for national application, usually directed at the point of retail (e.g. pet shops, garden centres).

Conclusion: key steps for regional and national cooperation

The existing instruments summarised above give rise to significant national obligations and commitments. Effective and practical institutional and legal frameworks are needed as well as a stronger political commitment for regional coordination and cooperation on IAS.

The following are priority issues *at regional and sub-regional levels* :

⇒ *develop a holistic focus on pathways as well as intentional introductions*

Pathways and pathway actors need to be identified as part of integrated pathway management. The expertise of relevant trade and industry sectors should be harnessed through stronger contacts with vector-responsible groups, such as timber and plant traders, aquarium and sport fish traders, transporters and so on. The region/sub-region is a good level to develop contacts with target groups.

⇒ *promote stakeholder and community participation*

Stakeholders involved in or affected by alien species-related activities need to be engaged and, where appropriate, made accountable. Appropriate education and communication strategies need to be developed, tailored to different target audiences and groups, including enforcement personnel. For socio-cultural reasons, it is particularly important to strengthen the role of local authorities, local communities and indigenous peoples in IAS detection and management.

⇒ *collect, share and manage information to support early warning and rapid response*

⇒ *develop regional dialogue and strengthen institutions*

Broad-based coordination means building links with counterparts across borders, throughout the region and with trading partners. The need for a sound ecological approach to IAS that includes agriculture justifies increased cooperation between regulatory agencies and key sectors. Regionally-agreed negotiating positions, measures and standards may carry greater weight in global fora than unilateral measures.

At the *national* level:

- decisions should be taken at the right level by the right body, taking into account the affected communities of interest;
- there should be clear lines of authority and appropriate associated accountabilities;
- there should be appropriate public input into decisions but this should be designed to ensure it does not impose unreasonable costs or prevent effective action;
- there needs to be the ability to take rapid decisions in emergencies;
- the responsible institution should have adequate stability of function and resources to enable long-term programmes to be run.

⇒ *review and develop strategy and tools*

A review of existing policy, legal and institutional arrangements makes it possible to identify gaps and inconsistencies and any necessary improvements. The review process may be an integral part of developing an national IAS strategy or action plan.

Sectoral agencies whose programmes and projects have IAS implications should assess these implications in consultation with affected stakeholders. Strategic environmental assessment of policies, programmes and projects that may provide new IAS pathways – e.g. transport infrastructure, inter-basin hydrological links and new trade agreements and practices - is central to prevention.²⁵ Such approaches can make it easier to identify some types of risk and take avoidance or mitigation measures early on.

⇒ *make better use of existing measures and expertise*

Environmental impact assessment (EIA) regulations and criteria may need to be expanded to cover activities and processes involving IAS. Operating licence requirements should apply to premises where potential IAS are held in containment or captivity, to minimise the risks of escapes.

There may be scope to streamline regulatory procedures, so that permit applicants do not have to make multiple applications to different regulatory authorities. Complex systems tend to be less transparent and can deter compliance.

Existing tools may be under-used, e.g. competent authorities often have powers under quarantine/ agricultural legislation to require land owners to control noxious weeds or nuisance species, but these species lists may not be regularly updated.

⇒ *Develop incentives and funding tools*

Research carried out by GISP found that there are few deterrents to the export, import or use of IAS (i.e. traders and users are often not the ones affected by the consequences of a harmful introduction). There are also few incentives for importers and other users to use locally-available native species or to manage land to prevent biological invasions.

Few countries have mechanisms to generate sustainable funding for public investment in IAS prevention and control programmes. This is a serious deficit, particularly for developing countries, and calls for priority research into innovative new approaches.

²⁵ The CBD COP has called for use of impact assessment and strategic environmental assessment in the alien species context (Decisions V/18 and VI/23).

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Detailed technical and advisory material is available from international organisations, governments, and specialist bodies working on IAS issues, including IUCN, GISP and the FAO which has legal and technical expertise with regard to IAS in agriculture, forestry and fisheries. A list of key websites is given in Appendix 3.1.

Overview of the Global Invasive Species Programme (GISP) and the Global Strategy on Invasive Alien Species

Dr. Guy Preston

Working for Water Programme

Private Bag X4390

Cape Town 8000

South Africa

gpreston@mweb.co.za

Abstract

The Global Invasive Species Programme (GISP) emerged out of a meeting of concerned organizations and individuals in 1996. It was designed to foster collaboration and action to address the ecological, economic, and social harm caused by invasive alien species. The first phase of GISP (1997-2000) focused on building a knowledge base on the issue of invasive alien species. This phase was driven by an international consortium of experts working as volunteers. Among the significant outputs were *A Global Strategy on Invasive Alien Species* (McNeely et al., 2001) and *Invasive Alien Species: a Toolkit of Best Prevention and Management Practices* (Wittenberg & Cock, 2001). The second phase of GISP (2000 - present) is designed to build upon the products of Phase I and foster greater international awareness of the problems caused by IAS. In Phase II, GISP will work with nations and regions on appropriate, cooperative measures for preventing, controlling, or eradicating IAS through six working groups, organized around the following topics:

1. National and regional facilitation and cooperation
2. Communication, education and outreach
3. Global information management
4. Pathway management
5. Evaluation and assessment
6. Law and policy

Phase II operates through an Executive Board, Advisory Panel of IAS experts, a formal Secretariat with paid staff (based in South Africa), and partnerships among countries and international organizations. GISP is prepared to play a pivotal role in building the global capacity to implement the goals of the Convention on Biological Diversity²⁶ as they relate to IAS.

Background on GISP

In 1996, 80 governments and numerous organizations came together at Norway/UN Conference on Alien Species in Trondheim, Norway (Sandlund et al., 1996). The results of this meeting inspired the Scientific Committee for Problems of the Environment (SCOPE), the World Conservation Union (IUCN), and CAB International (CABI) to launch the Global Invasive Species Programme (GISP) a year later. Funding for GISP has come from a variety of sources, with the Global Environment Facility (GEF) and the United Nations Environment Programme (UNEP) playing particularly important roles in GISP's first phase of operations.

GISP Phase I

GISP Phase I, which ran from 1997 to 2000, was aimed at building a knowledge base on IAS. This phase engaged an international consortium of experts. Ten working groups were established, each covering one of the following topics: ecology of IAS, human dimensions of the problem,

²⁶ <http://www.biodiv.org>

IAS and global change, prevention and management, pathways of invasion, early warning systems, risk analysis, legal instruments, the economics of invasions, and education. Phase I concluded with the GISP Phase I Synthesis Conference held in Cape Town in 2000, and the subsequent publication of the major written products of this phase (Table 2).

Table 2. Products from GISP Phase I.

<i>Biological and socioeconomic syntheses</i>	<i>Policy and management synthesis</i>	<i>Other products</i>
<i>Invasive Species in a Changing World.</i> 2000. H.A. Mooney, R. J. Hobbs (eds.) Island Press, Washington, D.C.	<i>A Guide to Designing Legal and Institutional Frameworks on Alien Invasive Species.</i> Shine, C., N. Williams, L. Gundling. 2000. IUCN Environmental Law Centre.	<i>Global Invasive Species Database</i> http://issg.appfa.auckland.ac.nz/database (Coordinated by IUCN/ISSG)
<i>The Great Reshuffling: Human Dimensions of Invasive Alien Species.</i> McNeely, J.A. (ed.). 2001. IUCN, Gland, Switzerland and Cambridge, UK.	<i>A Global Strategy on Invasive Alien Species.</i> McNeely, J.A., H.A. Mooney, L.E. Neville, P. Schei, J.K. Waage (eds.). 2001. IUCN, Gland, Switzerland and Cambridge, UK. www.gisp.org	<i>100 of the World's Worst Invasive Alien Species - a selection from the Global Invasive Species Database.</i> Lowe, S. et al. http://issg.appfa.auckland.ac.nz/database/species/search.asp?st=100ss&fr=1&sts (IUCN/ISSG)
<i>The Economics of Biological Invasions.</i> 2000. C. Perrings, M. Williamson, S. Dalmazzone (eds). Edward Elgar Publishers.	<i>Invasive Alien Species: A Toolkit of Best Prevention and Management Practices.</i> Wittenberg, R., M.J.W. Cock. 2001. CAB International, Wallingford, Oxon, UK. www.gisp.org	
<i>A Plague of Rats and Rubbervines: The Growing Threat of Species Invasions.</i> Baskin, Y. 2002. Island Press, Washington, D.C.	<i>Invasive Species: Vectors and Management Strategies.</i> 2003. Ruiz, G.M. and J. T. Carlton, (eds). Island Press, Washington, D.C.	
<i>Invasive Alien Species: a New Synthesis.</i> Mooney, H.A., J. McNeely, L. E. Neville, P.J. Schei, J.K. Waage (eds). Island Press, Washington, D.C. (in press)		

GISP Phase II

GISP Phase II is derived from the *Global Strategy on Invasive Alien Species*, a product of Phase I, which encompasses ten strategic elements:

1. Building national management capacity
2. Building scientific, social, and economic research capacity
3. Promoting the sharing of information
4. Developing economic policies and tools
5. Strengthening national, regional, and international legal and institutional frameworks
6. Instituting a system of environmental risk analysis
7. Building public awareness and engagement

8. Preparing national strategies and plans
9. Building IAS issues into global change initiatives
10. Promoting international cooperation

GISP's second phase of operations was launched at the GISP Synthesis Conference in Cape Town in September, 2000, where representatives of 42 countries and 30 international organizations met to review the findings of Phase I and discuss the way forward in the prevention and management of IAS. A more formal operational structure for GISP was agreed upon, in which GISP would have an Executive Board and an Advisory Panel, with a full-time Secretariat and six Working Groups to manage the key issues that emerged from Phase I and that require further analysis or immediate implementation. It was also agreed that GISP would need substantial, secure funding if it is to realize its potential. In designing Phase II, GISP focused on thematic areas and activities that could be effectively addressed through its unique Partnership Network. The Phase II Working Groups are as follows:

1. National and Regional Facilitation and Cooperation

Development of national and regional frameworks, the development of pertinent toolkits, taxonomic capacity (in collaboration with BioNET International), the establishment of regional centers and pilot projects.

2. Communication, Education and Outreach

Awareness raising, education, and information dissemination through the production of various print and on-line materials, training programs, international conferences, and workshops.

3. Global Information Management

Development of the Global Invasive Species Information Network, a distributed network of data-bases that will enhance the capacity for prediction and early warning of invasions.

4. Pathway Management

Analyze the major IAS pathways (for example, horticulture, and international aid and trade) and minimize the spread of IAS through development of voluntary codes of conduct and other appropriate measures (for example, insurance).

5. Evaluation and Assessment

Assess the impact of IAS on various ecosystems, promote research (biological and socio-economic) on factors controlling biological invasion and forge collaboration between the agriculture and fisheries sectors.

6. Law and Policy

Review national-level laws and policies with a view to defining gaps in the legal coverage and promote standards that can lead to efficient, sustainable, and coherent management of IAS.

Through these Working Groups, GISP undertakes catalytic projects to minimize the impact of IAS on biodiversity and human livelihoods, with a particular emphasis on the needs of developing countries. GISP thereby enables donors to apply their financial resources to address the most pressing IAS problems while facilitating capacity building throughout the world. Furthermore, because GISP's work is undertaken collaboratively, it can leverage financial and technical resources to achieve outcomes that are beyond the capacity of any one institution.

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The Global Invasive Species Information Network and SAFRINET'S work on IAS

Dr. Connal Eardley

Agricultural Research Council
Plant Protection Research Institute
Private Bag X134
Pretoria 0001
South Africa
vrehcde@plant5.agric.za

Abstract

To prevent the spread of invasive alien species (IAS), potentially harmful alien organisms must first be identified promptly at ports of entry. SAFRINET is the Southern African Development Community (SADC) network chartered to build organism identification capacity for Food, Agriculture, and Natural Resources (FANR). Locating and identifying new IAS requires an adequate number of appropriately trained people to perform the relevant tasks in a timely manner. The process for identifying IAS must be easy, and access to relevant information quick. Therefore, SAFRINET is developing an IAS information hub that will include effective, user-friendly identification tools (e.g. electronic keys and computer automated image recognition). These tools are much easier to use than conventional guides, and more accurate. SAFRINET's initial focus will be on developing capacity for quarantine services, but the hub will be available to everyone.

Introduction

SAFRINET is a Southern African Development Community (SADC) project, and the southern African network of BioNET-International. Its purpose is to build capacity for the provision of taxonomic services, i.e. the identification of, and provision of information on, organisms.

This capacity is *inter alia* essential for:

- curbing the spread of IAS, including pests and disease
- food security
- eliminating poverty, especially among rural people
- enhancing international trade in agricultural and horticultural products
- conserving biological diversity and preventing the loss of natural ecosystems.

For agricultural and horticultural quarantine services, a taxonomist can only be expected to identify a small proportion of the potentially harmful species that may move through any port of importation or exportation. Therefore, using current methods for organism identification, a cadre of taxonomists is needed for effective identification services, and each requires considerable training and years of experience. Building taxonomic capacity that depends on human expertise is, therefore, a long-term, costly exercise. The need, however, is vital, urgent, and massive. It is unrealistic to expect that a sufficient number of competent taxonomists will be trained within the foreseeable future, so new, cost- and time-effective mechanisms for providing identification services must be implemented.

Invasive alien species information hub

IAS are a major threat *inter alia* to:

- agriculture, including international trade in agricultural products
- food security
- maintenance / protection of natural habitat
- conservation of biological diversity.

The United States of America - Geological Survey (USGS) and the Global Invasive Species Programme (GISP) are fostering the development of a Global Invasive Species Information Network comprising regional hubs and concerned with:

- taxonomy, distribution, ecology and impacts of IAS
- management tools and practices for IAS prevention, eradication and control
- alerts for recent IAS invasions, with pathway of introduction
- patterns, trends and pathways of IAS dispersal, and projected patterns and trends of IAS distribution. SAFRINET has agreed to join USGS and GISP in developing a hub in SADC.

SAFRINET's role as an IAS information hub

SADC, to better protect itself against IAS, requires better organism identification facilities at its ports of importation. To contribute to the prevention of the spread of IAS to other parts of the world and enhance international trade, it must also provide an effective identification service for exports. SADC is acutely aware of this need.

Although it is unlikely that an effective regional organism identification services based on human expertise alone will be developed in SADC within the foreseeable future, SADC can use existing technology to develop capacity for improved identification services, and thus provide better taxonomic services.

The technologies current available within SADC include:

- electronic keys
- computer-based image recognition
- molecular procedures
- biochemical tests.

Tools, custom designed for specific IAS needs, must still be developed. However, it has been demonstrated that the technology provides accurate identification, is easy to implement and use, and a worthwhile investment when the cost of building centres of taxonomic expertise, eradication/control of IAS, and lost trade opportunities are considered.

Technological support in inspection of traded goods

The purpose of developing identification tools for non-native species is to facilitate efficiency and self-sufficiency among the users of taxonomic services. For the initial phase of the IAS Information Hub, phytosanitary services have expressed an interest in capacity building for their inspectors, who need it for the:

- recognition of potentially harmful species among transported goods
- distribution of diagnostic information, for problematic cases, to taxonomic centres for quick, authoritative identifications
- quick access to relevant, credible information.

The advantages of these tools over traditional mechanisms (i.e. using trained taxonomists) for phytosanitary services are *inter alia*:

- quick development of the identification and information tools
- quick, inexpensive training in the use of the tools
- quick, accurate identification of intercepted organisms
- more thorough inspection due to easy access to information on signs and symptoms, and the identification of organisms
- expansion of the organism groups an inspector can consider
- quick access to applicable information for the treatment of intercepted organisms and/or infested goods
- quick identification and communication with taxonomists, and other experts
- dispatch of quality information, e.g. electronic images and test results, to specialists
- enabling taxonomists to undertake more taxonomic revisions and to develop new, better identification and information products.

After initial investment in the development of these tools, it is reasonable to suggest that:

- routine identifications will take place at the ports of importation or exportation
- services at small regional border posts will be dramatically improved
- support services from taxonomic organizations will be improved.

A levy on government supplied taxonomic services for imported and exported agricultural and horticultural products could enable continued delivery of the service, and contribute to improvements and new products after the initial investment is exhausted.

Conclusions

For the implementation of this new technology a small subset of the ultimate envisaged user community is required to test it. In other words, as a pilot project, SADC national phytosanitary services organizations have:

- asked SAFRINET to develop the taxonomic capacity they require for their daily activity
- agreed that the use of organism identification tools is the preferred mechanism
- agreed to implement the use of these tools as a pilot project
- asked SAFRINET to develop tools for their specific needs
- recommended that SADC's documented trade priorities be given priority, but understanding that taxonomic information and expertise for each activity must first be available
- agreed for this exercise to become a pilot project for wider quarantine services.

This has been endorsed by the SAFRINET Coordinating Committee. SAFRINET, through the BioNET-International philosophy of regional and international co-operation, is interested in developing partnerships for the development and implementation of this exercise. The products, with minor adjustment, will be globally useful.

Overview of opportunities and options for addressing IAS: a toolkit of best prevention and management practices

Dr. Sean T. Murphy

CAB International
Silwood Park,
Ascot, Berkshire SL5 7TA
United Kingdom
s.murphy@cabi.org

Introduction

Many tools and technologies are available for the management of invasive alien species (IAS). The application of these tools is very patchy on a global basis, but overall, successes in management are significant and provide a good platform on which to build future efforts. Practical and viable solutions need to be available to countries that frequently do not have the resources or infrastructure to prevent or deal with severe invasive species problems.

In this context, the Global Invasive Species Programme (GISP) has produced a book entitled *Invasive alien species: a toolkit of best prevention and management practices* (Wittenberg & Cock 2001; hereafter Toolkit). The Toolkit provides a review of concepts, techniques, and best practices relevant to the prevention, eradication, and control of IAS. It includes 102 case studies and numerous linkages to other information sources. It is a product of GISP Phase I and was developed by 26 international experts at a GISP workshop held in Kuala Lumpur in 1999.

National plan development

An assessment of the status and trends of bioinvasion in a given area is fundamental first step in the development of a national plan for dealing with IAS issues. The Plan itself should include a strategy to build institutional support and engage all important stakeholders in the effort, particularly local communities. This national strategy will be needed to make a national commitment operational. Goals and objectives for a national plan need to be shared across sectors and the strategy needs to be integrated into larger national plans for conservation and agricultural development. For invasions in natural environments, the goals will ideally include the preservation or restoration of that environment; the control of a IAS is only the first step in this process. Existing legal and institutional frameworks also need to be assessed and reviewed as these are key to the sustainability of any national effort to address the problems. There is also need to have concerted bilateral, regional and sometimes global actions based on common objectives. Finally, basic biological knowledge (e.g. taxonomy) must be combined with evolving technologies and tools for management. These tools rely heavily on the existence of reliable and taxonomically comprehensive data.

Broadly speaking, any national plan should comprehensively address the four categories of tools and processes for IAS management: prevention, early detection, eradication, and control. The following section provides a brief summary of these issues. Detailed descriptions and case studies for the examples mentioned below can be found in the Toolkit.

Prevention

Species introductions are either deliberate (e.g. crops, ornamentals) or accidental. The latter has included contaminants in introduced germplasm and in ships' ballast water. Prevention is the first line of defense against IAS and, all being equal, is the most cost-effective approach. However, although quarantine is now a common feature of many countries' import systems, implementation

is frequently hindered by factors such as inadequate institutional capabilities and existing infrastructures.

Historically, prevention measures have been developed by the agriculture/forestry sector for economic pests and these methods have mostly relied on exclusion methods. There are three types of exclusion methods: interception, treatment, and prohibition. Interception relies on risk assessments and the effective implementation of national regulations at the borders of a country. Treatment has involved, for example, the application of chemicals such as methyl bromide (MB) for the fumigation of many agricultural and forest products. Due to concerns for environmental health, MB is being phased out in some cases (by 2005) so alternative fumigation procedures are being investigated, such as irradiation and hot water treatment.

Additional measures for prevention, such as biological risk assessment and analysis, are also under development. These measures are aimed at predicting whether or not a species is likely to become established and invasive. In theory, risk analyses can be applied to entire pathways (e.g., shipping) for the movement of species. The International Plant Protection Convention (IPPC) provides details for the analysis risks to cultivated plants (see International Standard for Phytosanitary Measures – ISPM No. 11²⁷). However, recently, the IPPC has started to consider the analysis of risks of plant pests to the environment and biological diversity (plant related). Indeed, more generally, the challenge ahead is adaptation of appropriate prevention measures to cover environmental as well as agricultural concerns

Early detection

Should prevention measures fail in any particular case, then early detection, locating the organisms before they have a chance to establish and spread, is the key to successful eradication. However, this is one of the least developed of the general groups of IAS measures. Nonetheless, successful national programmes do exist, such as some of those developed for monitoring crop pests. For marine pests, a few countries (e.g. Australia, UK) have set up port biota surveys. The CBD has encouraged countries to conduct monitoring of ecosystems of biodiversity value and developed guiding principles that address early detection and rapid response measures, as well as prevention, eradication, and control of IAS.

The IPPC has produced guidelines on surveillance (ISPM 6). A number of methods have been used for detection. General surveillance or collation of information (e.g., site specific surveys) has been used for sites of conservation value. Traps and lures are used in agricultural and forestry systems to detect insect pests.

In some regions, identification manuals have been produced which assist with the diagnosis of probable IAS. For example, the European Plant Protection Organisation (EPPO), in conjunction with CAB International, has produced guidelines and data sheets on quarantine pests of Europe.

Eradication

Eradication, elimination of the entire population of IAS, is most feasible for invasions over a small area and when action is taken early in the establishment process. There are now many successful eradication programmes which have been conducted against weeds, animal pathogens, insects, and mammals. The following factors are thought to contribute to the success of eradication programmes (Mack et al., 2000):

- biology of the target species suggested that the eradication techniques would be effective
- sufficient resources were devoted for a long enough time;

²⁷ <http://www.ippc.org>

- widespread support from both the relevant agencies and the public;
- clear lines of authority;
- re-invasion was prevented;
- species were detectable at relatively low densities; and
- restoration or management of the community or ecosystem was considered.

Several of guidelines have been produced for eradication programmes, including those of IUCN in 2000 (Guidelines for the prevention of biodiversity loss caused by alien invasive species²⁸) and the IPPC (Guidelines for pest eradication programmes – ISPM No. 9²⁹).

A number of tools have been employed for IAS eradication. Invasive plants are generally eradicated by the use of herbicides and by mechanical or hand-pulling techniques. Insecticides have been used for insects in crop systems, but male sterile release has also been used for fruit flies of economic importance. The eradication of some mammals (e.g., goats, cats and rats) using poisons and/or shooting has been possible on islands and localised regions of mainlands. There are some examples of eradication with chemicals in marine and freshwater systems where the population of the IAS was very localised (e.g. the Caribbean black-striped mussel, *Mytilopsis sallei*, in Australia).

Control

Most IAS become established before any action is taken and thus control tools are the most researched and commonly used measures for IAS management. The principal aim of control programmes is to reduce the density and abundance of the IAS to or below acceptable and agreed thresholds. There are many successful examples of control of a wide range of taxa from the agriculture and forestry sectors. Important first steps in control programmes includes: deciding on the goal of the control programme, the extent and nature of the area that needs to covered, and the native species being threatened. Control (and eradication) needs to be evaluated on the basis of likelihood of success, cost effectiveness, and any likely detrimental impacts.

Control tools for either containment or suppression can be divided into the following broad categories:

- Physical or mechanical (e.g. mechanical harvesters, hunting, trapping)
- Chemical (e.g. herbicides, insecticides)
- Biological (this includes a number of tools: the introduction, conservation or augmentation of natural enemies, the application of microorganisms as a biopesticide, host plant resistance (HPR), and other tools such as behaviour modifying chemicals (e.g. pheromones), male sterile release and fertility control)
- Habitat management (e.g. crop rotation, nutrient management)
- Integrated pest management, utilising combinations of the above four main measures.

For each of these measures, a number of tools have been developed and used in specific environmental circumstances. One feature of all control measures, with the exception of introduction (or classical) biological control, which is self-sustaining, require long-term funding and commitment.

Physical control and habitat management measures frequently require high levels of input but nonetheless can form an important part of IPM programmes; physical control measures are particularly appropriate for isolated populations of invasive species.

²⁸ <http://www.issg.org>
²⁹ <http://www.ippc.org>

Frequently action against invasive species needs to be immediate, therefore pesticide use has an important role for the eradication (see above) or control of some taxa. This should be on a rational basis that maximises impact while minimising use. Institutions are more likely to achieve this working from contingency plans developed in advance than from a reactive stance at the time of an emergency.

Long term sustainable solutions, such as biological control measures, frequently require a long research period before implementation can begin and are sometimes expensive to develop. In some methods of biological control, workers studying different taxa are now sharing common experiences. For example, in the introduction approach, more attention is being paid to possible non-target effects of introduced agents because of mistakes made in the past.

Although some measures, such as the introduction approach in biological control, can by themselves provide solutions, it is more often the case that a combination of measures (e.g. pesticides, biological control, physical control) is needed to satisfactorily solve invasive species problems on a long-term sustainable basis. This implies a complexity in the solutions that will require greater capacity in design, management and evaluation of future programmes. Components should be environmentally benign. This will require co-operation among funding agencies and researchers to set environmental quality as a priority. For the purpose of control, integrated pest management (IPM) needs to be developed in the context of the biology of the taxa rather than on any single paradigm.

Conclusions

Environmental and agricultural/forestry/livestock sectors need to take advantage of each other's expertise by forming stronger partnerships. Some tools can benefit from exchange between terrestrial and aquatic based research and implementation experiences. Measures such as pathway analysis, prediction of spread of an invasion, or the introduction approach in biological control stand to have significant impact as they are particularly appropriate for invasive species problems. However, progress in such areas would benefit from greater interaction between workers dealing with different taxa.

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Restoring paradise: alien species management for the restoration of terrestrial ecosystems in Mauritius and Rodrigues

Mr. J.R. Mauremootoo^a and Ms. C.V. Towner-Mauremootoo^b

^a Mauritian Wildlife Foundation
Avenue Bois des Billes, La Preneuse,
Mauritius
cjmaure@intnet.mu

^b Mauritian Wildlife Foundation,
Port Louis Office, Ken Lee Building, Port Louis
Mauritius

Abstract

The globally significant and highly threatened native terrestrial biodiversity of the Republic of Mauritius has been the focus of concerted conservation efforts over the last 25 years. Many of these efforts have centered on the management of invasive alien species, which currently pose the greatest threat to Mauritian biodiversity. Conservation in Mauritius can be divided into four categories. First, species recovery programs have helped save some highly endangered bird species and become global success stories in the process. There are also recovery programs for some endangered plants. Second, weeded and fenced "conservation management areas" are helping parts of Mauritian native forest to regenerate and in many cases, benefiting the associated fauna. Third, "active restoration" - the clearing of alien plants and the restoration of native pioneer species has significantly increased native forest area in parts of Mauritius. Fourth, islet restoration is conserving precious biodiversity that has been lost from the Mauritian mainland. These achievements have been considerable, but the areas currently managed are too small to be stable without regular intervention. The current challenge is to scale up the restoration in a way that is technically and financially sustainable. This cannot be done by simply expanding current approaches because these would be too expensive on a large scale. Hand weeding, for example, is already the major cost in the current restoration program. We review several approaches that would complement the current labour-intensive techniques of alien plant management. These approaches involve the use of grazing, fire, and biological control. Activities that would help finance new restoration activities are also considered. Potential avenues for financing include a tourist tax, ecotourism, revenue generation through watershed restoration, and social welfare programs for the unemployed. We argue that these integrated approaches will ensure a sustainable future for the archipelago's remaining native biota.

An area of globally significant and highly threatened biodiversity

The Republic of Mauritius comprises the two major Indian Ocean islands, Mauritius (1865 km²) and Rodrigues (109 km²), 67 associated islets, and several other small islands. Mauritius lies about 900 km east of Madagascar, and Rodrigues is 600 km east of Mauritius. Mauritius and Rodrigues are part of the Mascarene Archipelago, which also includes La Réunion, a French territory.

Concerted conservation efforts began in Mauritius about 25 years ago with intensive species recovery programs for several bird species on the brink of extinction. Efforts in Rodrigues began in the early 1980s with a rare plant recovery program. These endeavors have since expanded to include other endangered vertebrate and plant species recovery programs, as well as intensive restoration efforts for mainland and islet sites of key biodiversity importance. The methods and impressive achievements of these programs are summarized below. The next step is to scale up conservation efforts while consolidating the gains made to date. This will require a strategy for

dealing with invasive alien species (IAS), especially plants. A range of management and financing options are discussed below.

The Mascarenes rank with the Galapagos, New Zealand, and Hawaii as archipelagos that, by virtue of their relative isolation, possess a high degree of endemism (Table 3). Because of their high levels of endemism and species diversity per unit area, the islands have been classified as a Center of Plant Diversity (CPD Site 102) by the IUCN (Strahm, 1994a) and included within the Madagascar and Indian Ocean islands biodiversity hotspot (Myers et al., 2000).

Table 3. Level of endemism in selected elements of the Mauritian native biota (figures include species thought to be extinct)

	Flowering plants	Birds	Reptiles
Total native taxa	685	28	19
Strict endemics	311 (45%)	15 (54 %)	17 (89 %)
Mascarene endemics	459 (67%)	19 (68 %)	17 (89 %)

On Mauritius, only about 2 percent of the original native forest remains and this is rapidly degrading. Of the 11 surviving land bird species, 9 are endangered, and 105 flowering plant species are critically endangered (*sensu* IUCN, 1994). On Rodrigues the losses are even greater. No contiguous areas of native forest remain, 14 of 17 original vertebrate species are extinct, and 35 of the remaining 37 endemic plant species are endangered. These dramatic statistics are a consequence of a range of anthropogenic stresses, which began with the colonization of the islands just 400 years ago. Three primary factors are involved.

Habitat destruction

Rapid habitat destruction, chiefly for agriculture and settlement, has occurred on both Mauritius and Rodrigues. On Mauritius, 45 percent the land is under intensive cultivation, and with nearly 1.2 million people living in its small area, Mauritius is one of the world's most densely populated countries. Major forest clearing ceased in the 1970s, with the end of a large-scale scheme to replace native forests with pine plantations (Anon, in press). On Rodrigues, almost all the land, including the major watersheds, has been cleared for agriculture at one time or another (Gade 1985). Over the past 30 years, watersheds on Rodrigues have been reforested with alien plantation species, many of which are invasive or highly water-demanding.

On Mauritius, the remaining native forests are highly fragmented. Most of the fragments are in the 6,574-hectare Black River Gorges National Park, which lies in the southwestern uplands. Smaller remnants, which still contain a high level of biodiversity are found in the southeastern and the northern mountains. There are also many small forest fragments that are important for particular rare plants and animals, but only a few of these are in managed reserves. All of the unmanaged native forest areas on Mauritius are invaded to some extent by alien woody plants.

The situation is even more extreme on Rodrigues, where there is no surviving contiguous native forest canopy. Patches of endangered native flora are scattered across the island, but three areas are of particular importance. The Mourouk Valley has the largest area of surviving native plant diversity. The Grande Montagne Nature Reserve contains a number of key critically endangered plants. The Anse Quitor Nature Reserve contains a range of critically endangered lowland plant species not represented in Mourouk or Grande Montagne. Although they contain some of the "best" remaining native vegetation on the island, all three areas are dominated by invasive alien woody plants.

A significant amount of native biodiversity still remains on the islets off Mauritius. Lack of settlement and, in many cases, limited introductions of invasive alien species have spared these islets much of the destruction that has affected equivalent areas on the main islands. Round Island, a 169-hectare islet about 20 km north of Mauritius contains at least four species of reptile found

nowhere else on earth (and possibly a fifth species as well: the burrowing boa (*Bolyeria multicaerinata*), was last seen in 1975). These species were spared extinction because rats have never colonized the island (Bullock 1986). Round Island also contains the last remnants of the palm-rich forest that once covered much of northern Mauritius. Ile aux Aigrettes, a 26-hectare islet less than 1 kilometer southeast of Mauritius, contains the best remaining remnant of coastal ebony forest—the type of forest that used to surround much of Mauritius itself. Like the main island forest remnants, all of the unmanaged islets are badly invaded by alien plants. Round Island is the only islet that has escaped this form of disturbance.

Direct exploitation

Direct exploitation of certain species has pushed them towards extinction. Mauritius was originally settled for its highly-prized hardwood timber. Many of these timber species are now extremely rare. Most of the Mauritian and Rodriguan palm species were probably exploited for their edible hearts and at least one was tapped for its sap, which was fermented to make an alcoholic drink. All are now threatened (Maunder et al., 2002). The five endemic species of Mascarene giant tortoises (two species each on Mauritius and Rodrigues and one species on La Réunion) are all extinct after being exploited for their highly palatable meat (Cheke, 1987). Direct exploitation of most species has now largely ceased although certain plants are still harvested from the wild in large quantities for medicinal purposes, especially on Rodrigues, and endemic reptiles continue to be caught illegally for the international pet trade.

Invasive alien species

An estimated 40 mammal, reptile, and bird species have invaded Mauritius, and 18 alien plant species have been identified as particularly aggressive invaders (Strahm, 1999). Mammals such as Javan deer (*Cervus timorensis*), introduced to Mauritius in 1639, browse native seedlings and spread alien seed. Feral pigs (*Sus scrofa*), introduced in 1606, also spread alien seed and disturb the soil. The pigs caused another form of disturbance as well: their egg predation was probably a factor in the extinction of several ground-nesting reptiles and birds, notably the dodo (*Raphus cucullatus*) and two species of giant tortoise (*Cylindropsis inepta* and *C. triserrata*). Feral pigs may also adversely affect ground-dwelling invertebrates. Javanese macaques (*Macaca fascicularis*), introduced at the turn of the 17th century, damage native fruits before maturation and eat the eggs and chicks of native birds (Carter & Bright, in press). Rats (*Rattus rattus* and *R. norvegicus*), possibly introduced before settlement, also eat native bird eggs and chicks (Safford and Jones 1998), as well as invertebrates and the seeds of native plants (Cuddihy & Stone, 1990). The lesser Indian mongoose (*Herpestes javanicus*), introduced to Mauritius in the early 20th century to control rats, preys on native birds (Roy, 2001). The 17 invasive alien vertebrates on Rodrigues are a subset of those on Mauritius; only three mammals are represented: the two rat species and the Indian house shrew (*Suncus murinus*).

All of the vegetation zones of Mauritius and Rodrigues, apart from those areas that are undergoing restoration, are highly invaded by alien plants, which are becoming dominant wherever they are not managed. Chinese guava (*Psidium cattleianum*) and privet (*Ligustrum robustum*) are good examples of the problem. Chinese guava, first recorded on Mauritius in 1763 (Rouillard & Guého, 2000), is spread by both native and alien birds and by alien mammals such as wild pigs and macaques (Strahm, 1999). Privet, first cultivated in plantations in 1902 (Rouillard & Guého, 2000), is also spread by birds. Both plants are capable of establishing under deep shade and have relatively rapid growth rates, prolific fruit production, and long fruiting seasons (Smith, 1985, Laverne et al., 1999). All unmanaged areas of native upland forest on Mauritius are highly invaded by these two species. A recent survey of such forest, which had originally been surveyed 60 years earlier, showed that only 29 percent of the native trees and shrubs remain; many large trees and almost the entire forest understory have been lost (Motala, 1999). Native upland forest is rapidly being strangled by alien plants.

Terrestrial conservation on Mauritius and Rodrigues

The wide range of activities that make up the conservation program on Mauritius and Rodrigues can be classified under four headings:

1. species recovery programmes
2. weeded and fenced conservation management areas
3. active restoration of degraded areas by weeding and planting
4. islet restoration.

This section reviews the methods used in each category and the resulting achievements to date.

Species recovery programmes

In recent years Mauritius has had the dubious distinction of being home to the world's most endangered raptor, pigeon, and parrot: the Mauritius kestrel *Falco punctatus*, down to a single known pair in 1973; the pink pigeon *Columba mayeri*, down to 10 known birds in the wild in 1990; and the echo parakeet *Psittacula eques echo*, down to 12 known birds in the wild in 1986. Concerted conservation work in Mauritius began with a recovery program for the Mauritius kestrel in the early 1970s (Jones & Hartley, 1995) along with preliminary conservation work on the pink pigeon and echo parakeet. Rare plant species recovery work began in the early 1980s.

The recovery programs are designed to expend as much effort as is practical to ensure the survival of each individual of the species in question. There are several reasons for this rationale:

- Because these species are so rare, every individual is precious;
- Each individual (at least in the founder population) should have a chance to reproduce, to maximize genetic variability in the recovered populations;
- A rapid reproductive rate improves the chances of emerging from a genetic bottleneck with a high degree of population heterozygosity (Frankel & Soulé, 1981); and
- The threats that initially caused population declines probably still exist, so a recovery program is unlikely to succeed if these threats are not managed.

Bird conservation techniques include: harvesting wild eggs to encourage extra production in the wild and for captive rearing; placement of chicks with wild or captive pairs without offspring (or in captivity with related species where appropriate); predator control around nests and in feeding areas; provision of artificial nest boxes; supplementary feeding of released birds; and veterinary intervention where necessary. The use of these methods on Mauritius has been documented in detail elsewhere (Jones et al., 1991, Jones et al., 1998, Swinnerton, 2002).

The plant species recovery programs on Mauritius and Rodrigues include population surveys and intensive efforts to propagate rare species in nurseries from seed or vegetatively. Propagators have experimented with the growing media, seed treatment, nursery pest management, and planting practices. The resulting plants are not necessarily returned to the area of the parent stock origin, due to difficulties in managing the threats in these locations. Instead, many plants are reintroduced to appropriate locations in managed nature reserves, Conservation Management Areas, and intensively managed islets. In recent years there has been an increasing emphasis on adaptive management of reintroduced plants.

This intensive management has had some notable successes. Among the birds, it has helped the kestrel reach a population of over 600. Since this is a healthy population size for an island raptor, the Mauritius kestrel is now considered to have been saved from extinction (C.G. Jones, pers. comm.). The pink pigeon and echo parakeet currently have wild populations of 350- 450 and 150-

170 birds, respectively. Both populations are on their way to safety, although they still require intensive management, particularly predator control. The potential for self-sustaining pink pigeon and echo parakeet populations in the long term is limited by the lack of available habitat (unlike the Mauritius kestrel, these birds have not adapted well to secondary forest). For this reason, long-term success is likely to require an integration of the species recovery programs with the ecosystem recovery programs.

The intensification of plant species recovery efforts in Mauritius and Rodrigues in recent years has resulted in the cultivation of large numbers of endangered plants. From 1998 to 2001, 70,000 individuals of 39 species of endangered plants have been propagated on Rodrigues, and 17,000 individuals of 21 endangered plant species have been propagated on Ile aux Aigrettes. Nearly 9,000 individuals of 48 endangered plant species have been propagated on the Mauritius mainland over a period of 10 years to the end of 2000 (M. Puttoo, pers. comm.). Most of these nursery-raised plants have been reintroduced into suitable areas of managed native forest.

Weeded and fenced conservation management areas (CMAs)

The concept of establishing small managed areas for the protection of endangered forest types and critically endangered plant species was spearheaded in the late 1930s by Vaughan and Wiehe (1941). These authors surveyed ten 50 x 20 m plots in the Macabé Forest in the southwestern uplands of Mauritius. One of the ten plots, known as “Vaughan’s plot,” was designated for intensive study. The authors recommended that this plot be weeded of all alien species and fenced to keep out introduced deer and pigs. The plot was weeded sporadically from the late 1930s but was not fenced until 1986. In that year, Strahm and Dulloo resurveyed the woody plants in this plot (Strahm, 1994b). In spite of the inconsistent management, Vaughan’s plot was considerably more diverse in 1986 than was an adjacent unmanaged plot.

The results at Macabé inspired a series of weeded and fenced CMAs in different parts of the upland forest. Sites were chosen to be representative of the different ecotypes identified by Vaughan and Wiehe in 1937. The CMAs in the National Park are managed by the Mauritian Government’s National Parks and Conservation Service (NPCS), in consultation with the Mauritian Wildlife Foundation (MWF). MWF also manages individual projects within the National Parks and the CMAs. The CMAs outside the park are managed by a variety of public and private agencies.

In addition to other criteria, the CMA sites are chosen for their relatively high proportion of native canopy cover. Even so, initial weeding is still a labor-intensive task. The first step is hand-weeding of all easily removed alien seedlings, saplings, and herbaceous vegetation. This is followed by the cutting of woody alien plant stems with a machete and manually uprooting their stumps. Treating cut stumps with herbicides has been tried sporadically, but with little consistent documentation of the method or efficacy (Mungroo 1997). A current trial of initial weeding with herbicide treatments is underway (J.R. Mauremootoo and F.B.V. Florens, unpublished data). If individuals of non-native species remain or have regenerated in highly degraded areas, they are gradually removed as native species establish themselves.

The number of man-hours needed for initial weeding depends upon such biotic factors as initial forest quality, site substrate, and alien species composition. Also important are logistical considerations, such as the remoteness of the site and the motivation of the labor team. Studies have estimated initial weeding times to vary from 315 to 890 man-hours per hectare, and to cost an average of US \$9,000 per hectare (Y. Mungroo, pers. comm.). (US dollar values are estimated using 2001 prices and exchange rates.)

The CMAs are fenced with 2 meter chain link of 7.5 mm mesh size, topped with barbed wire. Fence posts are spaced 3 meters apart and are made of treated wooden poles. In most instances the

base of the fence on the outer side is covered with small rocks to prevent pigs from burrowing underneath. The fence costs about US \$70 per meter.

Until recently, each weeded area has been “maintenance” weeded four times per year. The NCPS annual budget for maintenance weeding of the 39 hectares of weeded CMA is US \$74,000. Since 1999, maintenance weeding has been reduced to three times per year (Y. Mungroo, pers.comm.).

Predator control is carried out in CMAs where intensive management of native birds, especially pink pigeons and echo parakeets, is a high priority. For example, cats and mongooses have been systematically controlled in the Brise Fer, Mare Longue, and Fixon CMAs since the early 1990s (Roy, 2001). The predators are live-trapped throughout the year in an intensive grid and along access points. Rats have been controlled sporadically in some CMAs since 1992, using mainly the anti-coagulant rodenticide Brodifacoum.

In order to gauge the effectiveness of CMA management, several studies in and around Black River Gorges National Park have been undertaken to assess the densities of key taxa inside CMAs and in comparable, adjacent unmanaged areas. Currently eight weeded and fenced CMAs, covering an area of about 39 hectares, have been created in the park. Two additional plots covering a weeded area of approximately 6.5 hectares are being managed in a similar way outside the park (Table 4).

Table 4. Fenced and weeded Conservation Management Areas in Mauritius. Total fenced area is 24 hectares, including 19 weeded hectares.

CMA name	Location	Size (ha)	Date first weeded
Bellouget	Black River Gorges National Park	2.5	1994
Brise Fer	Black River Gorges National Park	19	1986-87
Fixon	Black River Gorges National Park	4.3	1994
Florin	Black River Gorges National Park	2.53	1995
Pétrin	Black River Gorges National Park	6.2	1994
Macabé	Black River Gorges National Park	0.4	1986
Mare Longue	Black River Gorges National Park	3.46	1993
Montagne Cocotte	Black River Gorges National Park	0.338	1987
Mondrain	Outside the National Park	5	1985
Perrier	Outside the National Park	1.44	1969

Studies have been undertaken on the following taxa: native tree and shrub saplings (Eydatoulah, 1999), native butterflies (J.R. Mauremootoo, unpublished data), native and non-native land snails (Florens, 1996) and native passerines (Hill, unpublished data; Ali Boyla, 2000). No CMA management studies have focused on pink pigeons and echo parakeets because the data could be confused by the fact that these birds are being released and fed in these areas. It has been observed, however, that parakeets and pigeons increase their use of CMAs immediately after initial weeding (C.G. Jones, pers. comm.). The effect of CMA management on kestrels cannot be easily gauged because of methodological difficulties.

The results of these studies can be summarized as follows. First, consistent weeding and maintenance of fences appears to result in a high level of regeneration of native flora. In the Brise Fer ‘Old Plot’ (first weeded and fenced in 1987), 53 to 68 percent of native tree taxa are regenerating compared to 32 to 40 percent regeneration in an equivalent unmanaged area. Additionally, 4.5 times more individuals are regenerating in managed areas than in unmanaged areas. It is our expectation that the number of regenerating species would have been higher if this plot were larger, given the species/area relationship. But some species would be unlikely to regenerate even in a larger plot, since some alien mammal species cannot be excluded by conventional fences.

The diversity of native seedlings and saplings is lower in a more recently managed part of Brise Fer and in the nearby Mare Longue CMA. In the former, this may be due to the fact that several deer were fenced into the CMA for over two years. In the latter, rocks were not placed at the foot of the fence, thus allowing pigs to burrow into the plot.

Native butterflies were on average nineteen times more abundant in the surveyed CMAs than in unmanaged areas. Species composition varied between different CMAs in relation to the extent of native canopy cover, which tended to expand with the number of years since initial weeding.

The results for native birds were equivocal. In general, seriously degraded forest areas were poor habitat for native birds. However, the endemic grey white-eye (*Zosterops borbonica*) was found in higher numbers in unmanaged areas with equivalent native canopy. The grey white-eye is not threatened.

The densities of some native snail groups were lower in the “Old Plot” than in an equivalent unmanaged area. This may be due to nontarget effects of persistent rat poisoning, combined with changes in habitat after initial weeding.

These summaries show that the current CMA methodology can be highly effective if the fencing is maintained to a consistent standard, and if any incursions of deer and pigs are dealt with rapidly. They also show that weeding methods may have to be modified to minimize non-target damage. For example, weeding could be carried out in relatively small patches, in contrast to current practices of weeding contiguous areas systematically. This could provide relatively sessile organisms with refugia from which to recolonize weeded areas as native vegetation regenerates. In addition, non-regenerating or negatively affected species may have to be managed individually. Finally, as rat and monkey predation of eggs, chicks, fruits, and seeds are likely to be major limiting factors in the recovery of more sensitive bird and plant species, it may be helpful to complement or replace current CMAs with areas protected by predator-exclusion fences. Predator-exclusion fences are increasingly being used successfully in analogous situations in New Zealand and Australia. Pilot testing of this technology is about to begin on Mauritius.

Active restoration of degraded areas by weeding and planting

In some cases, even intensive weeding and fencing will not be enough to achieve restoration goals. Some of the restoration sites have become so degraded that weeding alone may result in germination of the huge invasive alien plant seed bank, rapidly choking the area’s native vegetation. There are likely to be very few native species in the seed bank to compete with the alien plants. In these cases, plans call for weeding, and reestablishment of native pioneer species, in order to colonize the site. The weeding would be either partial or complete, depending on such factors as slope and shade requirements of the pioneer plants. Some of these highly degraded sites were chosen for restoration because they contain some very endangered plant and animal species (for example, Grande Montagne). Others were chosen because they form a part of an otherwise fairly well conserved ecosystem (the areas on Ile aux Aigrettes close to the ebony forest zone), or because they are part of a small island which may eventually be almost completely restored to native cover with low risk of reinvasion from alien seed sources (for example, Flat Island, a key area for future restoration work).

Initial weeding of extremely degraded areas is very intensive and expensive, as can be seen from these figures from Ile aux Aigrettes, which are typical for Mauritius and Rodrigues in general. Initial weeding (mainly by hand) takes about 1,920 man-hours per hectare and costs about US \$3,000 per hectare. These weeded areas are then planted with nursery-grown native pioneer species. Bouts of follow-up weeding must then be undertaken because the sudden increase in light in the newly weeded areas results in rapid germination of the large alien plant seed bank. Such high maintenance weeding may take another 1,920 man-hours per hectare in the first year of management. The effort diminishes in subsequent years as the alien plant seed bank is exhausted

and as planted native species grow, shading the ground and increasing competition. Once a good canopy is established (within 4 to 10 years of initial weeding) the area requires weeding only once every five years. This translates into a long-term maintenance cost of about US \$140 per hectare.

This type of restoration has focused on the two main island nature reserves of Rodrigues (Grande Montagne and Anse Quitar), and on Ile aux Aigrettes. Intensive restoration of extremely degraded areas of Round Island had just begun in mid 2002.

From 1998 to 2002, around 15 hectares of degraded forest had been restored in Grande Montagne and Anse Quitar. The native plants have grown faster than anticipated; some species have grown more than a meter in a year. Survivorship has also been high, with many species showing over 80 percent survival. The more mature restored upland plots at Grande Montagne are now beginning to attract rare endemic birds that are using the newly planted trees as nest sites.

From 2000 to 2002, about 7 hectares of degraded forest has been actively restored on Ile aux Aigrettes. Growth and survival rates of the introduced plants have been similar to those on Grande Montagne, and the more mature restored areas are beginning to attract the reintroduced pink pigeon.

Islet restoration

In theory, most of the islets that surround Mauritius and Rodrigues could be restored, given that it is relatively easy to eradicate mammals such as rats and cats, reinvasion can be minimized, and our ability to grow and plant out native plants is increasing. But resources are always limited, so the management of Mauritian islets has been prioritized based on each islet's intrinsic conservation value, its predicted ease of restoration, and the competing priorities of other sectors. The following categories have been identified (Bell et al. 1994):

- *Strict nature reserves*: Islets with high endemism and relatively few invasive species problems, for example, Round Island.
- *Open nature reserves*: Islets with conservation potential that can be used for controlled tourism, but on which many invasive alien species are present, for example, Ile aux Aigrettes.
- *Tourism and recreational islets*: Those that are highly degraded but have important leisure and tourism value and long-term potential for restoration.
- *Passive reserves*: The remaining islands, on which any developments must be carefully considered so that current and potential conservation values are maintained.

Once an island has been chosen for restoration, the first step is to legally ensure that there are no inappropriate development projects. The next step is to eradicate introduced vertebrates as far as possible, and finally to manage vegetation with a combination of the CMA approach and active restoration. Once the restoration process has begun, good quarantine controls are essential and must continue indefinitely. This is necessary to prevent reinvasion of eradicated mammals, invasion of mammals that have not yet reached the island, and to exclude alien plant species, many of which would be difficult or practically impossible to eradicate even from very small islands (Rejmanek & Pitcairn, in press).

Through the application of these techniques, rabbits and goats were eradicated from Round Island in 1986 and 1979, respectively (Merton et al., 1989). Rats and cats were eradicated from Ile aux Aigrettes; hares were eradicated from Gunners Coin; and mice were eradicated from Ile aux Cocos (Rodrigues). Pilot restoration activities on Round Island were carried out periodically from the early 1980s to mid 2002, when a major acceleration of intensive vegetation restoration on

Round Island began. A major weeding and planting effort will be completed on Ile aux Aigrettes by 2003. Rats have also been eradicated from a number of other islets with high conservation potential. Restoration of these islets will be possible, given additional funding, time, enhanced techniques, and avoidance of inappropriate development projects.

The next step: the challenge of large scale restoration

In Mauritius, after some 25 years of hands-on conservation, we can define a number of major accomplishments:

- 1) We have saved many of our most endangered plants and vertebrates from the brink of extinction.
- 2) We have learned how to propagate most of the country's endangered plant species.
- 3) Conservation capacity in Mauritius has increased enormously in recent years.
- 4) We can probably save most of our remaining endangered species, given sufficient resources.
- 5) We know how to restore Mauritian forest ecosystems to something approaching their former state in a relatively short time through intensive restoration programs.
- 6) Our conservation efforts have inspired other countries in similarly desperate circumstances to believe that success is possible.

These achievements are very impressive but we are working to conserve a very small proportion of the areas that have restoration potential. Currently we are actively restoring only 18 percent of the islet areas and only 2 percent of mainland areas that have high restoration potential. In the meantime, good quality unmanaged native forest is rapidly degrading (Motala, 1999).

It is clear from our work thus far that we can only create truly viable populations of our endangered species if we scale up our existing efforts. There are several reasons why this is imperative:

- **Lack of habitat for many endangered species:** the critically endangered echo parakeet population, for example, is food-limited, and its numbers are far lower than what would be a minimum viable population. The echo parakeet is also limited by nesting sites; it nests in cavities in large native emergent trees, and such trees are dying rapidly due to weed competition. (It might, however, be possible to solve this problem with artificial nest boxes.) Pink pigeons, known to favour native foliage, flowers, and fruit, are also probably food-limited and are currently dependent on supplementary feeding (Swinnerton 2001). Many native tree species are showing good regeneration rates in the best managed CMAs, but most species are only regenerating in very low numbers because of a lack of suitable areas. Without very significant expansion in the area of managed upland forest, it is likely that over the long term, much genetic diversity within species will be lost and many entire species will probably disappear as well, because of such processes as genetic drift and stochastic factors, especially cyclones.
- **Probable extinction of many species for which individual recovery programs are not practical:** we are well aware that the situation is critical for our endangered birds and plants. It is also very likely that habitat loss is resulting in an unseen but equally dramatic loss in less charismatic biota, such as native invertebrates and lower plants.

- **Viability of managed areas is likely to be positively related to fragment size:** the smaller CMAs like Vaughan's plot at Macabé are proving very difficult to maintain because the weed reinvasion rates are so rapid. In addition, such plots provide limited native plant parent material, a problem exacerbated by the degradation of the surrounding unmanaged area. The effects of cyclones are also increasing because the forests surrounding CMAs are being converted to a low thicket system, dominated by Chinese guava. Consequently, the taller vegetation within the CMAs has less and less cyclone protection.

The current restoration programs are expensive, primarily because they are so labor-intensive. In order to scale up operations, we must either reduce the cost of restoration per unit area, or raise additional funding, or both. We recommend several approaches on both fronts, as outlined below.

Reducing costs

It is clear that we can improve the efficiency of current practices. For example, initial weeding costs can be halved by replacing labour-intensive uprooting with paintbrush herbicide application to cut stumps (Mauremootoo, 1999). Observations indicate that it is not necessary to weed CMAs as frequently as current practice dictates once the alien seed bank has been substantially depleted. Maintenance weeding can also be focused on removal of select species that present a threat to native species regeneration, rather than removing every alien plant in order to produce a "clean" plot. Weeding can also be considerably reduced through the use of biodegradable mulches, as has been shown in small-scale trials on Round Island and Rodrigues. It may also be possible to save on fencing in the upland forests by conducting park-wide deer and pig control, by granting concessions for responsible hunting. These measures would make it possible to increase the area of managed CMAs by at least five-fold within the current budget.

Expanding rat control is likely to be a cost-effective way of dramatically increasing the regeneration rate of native plants, as has been demonstrated on islands such as Ile aux Aigrettes. Such operations could be scaled up following the example of the programs in New Zealand, where poisoning has in many areas been replaced by trapping, with equal effectiveness and similar cost (A. Saunders, pers. comm.). Over the long term, it may even be possible to eradicate rats from Rodrigues. It appears that rats have been successfully eradicated from New Zealand's Campbell Island, an island the size of Rodrigues, and there have been discussions about a possible rat eradication campaign on New Zealand's Stewart Island, which is the size of Mauritius. We are not advocating any such attempts on Rodrigues and Mauritius in the near future, however, since the challenges on densely populated tropical islands are much greater than those in New Zealand. But the trend in island rat eradication is encouraging.

The use of fire may also increase the efficiency of alien plant management. Fire has been used for this purpose in many other countries (Hardy & Arno, 1996). In some ecosystems, burning is a way of stimulating the regeneration of native species. This is not the case in Mauritian and Rodriguan ecosystems, where the native plants show no signs of being adapted to fire, so it would not be helpful to burn areas that already have good native cover. But in areas almost completely covered with alien plants, a controlled burn may be the most efficient way of initially reducing the infestation. Such burns could therefore significantly reduce the costs of restoration in highly degraded areas.

Grazing animals could play a role as well. The Mauritian ecosystem has lost many of its key components in the 400 years since human colonization (Cheke, 1987). For example, two species of giant tortoise that once roamed the Mauritian landscape in enormous herds are now extinct (Arnold, 1981). These animals must have had a huge influence on the ecology of pristine Mauritius and may have been keystone grazers and seed dispersers. Because the tortoise densities were so high, plants would have been under strong selection pressure to defend themselves against tortoise herbivory. It has been proposed that heteroblasty (markedly different leaf forms on the

same plant, varying with the distance of the foliage from the ground), which is very pronounced in many Mauritian and Rodriguan plants, is an evolutionary response to tortoise herbivory (Eskildsen, 2000). Furthermore, anecdotal evidence suggests that Mauritian native plant species are very tolerant of trampling.

Although the Mauritian giant tortoises are now extinct it may be possible to use an alien but closely related extant species, the Aldabran giant tortoise (*Geochelone gigantean*), as a functional analogue. Aldabran giant tortoises were experimentally introduced to Ile aux Aigrettes in late 2000. Preliminary results suggest that under certain conditions, they can keep alien plant populations at low levels but they cannot suppress well grown stands of woody alien plants in the short term. Tortoises are also effective seed dispersers of both native and alien species. Overall, it appears that tortoises might be an aid to restoration after the initial suppression of alien plant populations. But the potential negative effects on native species, especially rarer species, have not yet been studied, so it is too soon to draw final conclusions on the suitability of tortoise introductions.

Even if giant tortoise grazing does prove to be a safe and effective management tool, it would take several decades to breed enough tortoises to have a significant effect. Tortoises may also be less effective in the cooler and wetter uplands than in lowland areas such as Ile aux Aigrettes. But they could be used seasonally in upland areas, to simulate the migratory, seasonal grazing that may have occurred in these areas before human arrival (V. Florens, pers. comm.). In the meantime, an alternative possibility is to use alien mammalian grazers (for example, sheep) as part of a managed program to scale up restoration.

Finally, biological control of major weed species could also help expand the restoration effort. Several successful alien plant biocontrol programs have been conducted on Mauritius (Fowler et al., 2000). But no new work has been done in this area for the last 30 years. In theory, biocontrol represents the perfect, sustainable solution to our invasive alien plant problems. But biocontrol programs are very expensive, costing about US \$1 million per target species (S. Fowler, pers. comm.). Biocontrol options for most problem alien plants on Mauritius and Rodrigues have yet to be developed. Even such programs were successful, biocontrol for our most invasive alien species might not greatly advance restoration in the short term, since the controlled species might only be replaced by others that could be equally problematic. This displacement of one invasive alien plant species by another has been termed the ‘Sisyphus effect’ by Mack and Lonsdale (in press), an analogy with the character in Greek mythology who must pass eternity rolling a rock up a mountain, only to have tumble down again every time he reaches the summit.

Even so, we believe that there is a role for biocontrol on Mauritius and Rodrigues, over both the short and long terms. In the short term, it may be possible to benefit from economies of scale by “piggy-backing” a biocontrol campaign onto developments elsewhere. For example, the work currently being carried out on *Rubus* by CIRAD and CABI could, in theory, be extended to Mauritius and Rodrigues by using island sites for a small number of host range tests on key non-target species. This would cost relatively little. Management of *Rubus* using biocontrol would be especially useful since *Rubus* is a highly dispersive primary gap coloniser which, by virtue of its thorns, is difficult to manage manually.

Guava is another species that could be targeted for biocontrol. Guava has a long and prolific fruiting season during the winter months, and the fruit supports high densities of pigs and monkeys. In the summer when guava is not producing fruit, these animals prey on native plants and animals. Guava is not, therefore, “just another invasive alien plant.” Even if biocontrol were to result in its displacement by another alien plant species, this would still be deemed a conservation success.

It may also be possible to undertake larger biocontrol projects if groups of nations hosting the same alien plants can be brought together to share program costs. If suitable biocontrol agents could be found for most of the major invasive alien plant species affecting our native terrestrial biodiversity, this would contribute hugely to our long-term restoration efforts.

An important consideration with biocontrol is public acceptability. For example, guava is a highly-prized fruit in Mauritius and any biocontrol program for it is likely to be strongly opposed by the general public. In contrast, a large scale clearing of guava from native forest need not be unpopular because the fruit is generally collected from roadsides; guava in such readily accessible areas could be left for public use. In a multi-national biocontrol program for guava, Mauritius could concentrate on building public awareness while other nations, where conflicts of interest are minimal, actually implement biocontrol. The public awareness work would pave the way for future biocontrol on Mauritius. On the other hand, a biocontrol program for *Rubus* could be undertaken as soon as the necessary host specificity testing and risk assessment have been completed, since the fruits of *Rubus* species are not highly prized on Mauritius.

To maximize the efficacy of any programs to control individual species, it is crucial to minimize the chances of importing any additional problem plant species, by adopting strict biosecurity measures. The Mauritian authorities are currently looking at ways to do this (M. Chinappen, pers. comm.).

Integrating cost reduction measures

These new tools, combined with a fine-tuning of current methods, could substantially reduce the costs of integrated large-scale ecosystem restoration programs on Mauritius and Rodrigues. Below we give a hypothetical generic scheme for an integrated approach of this type. (We assume that the scheme is used as a complement to existing plant and animal species recovery programs.)

- 1) Initial weeding of a degraded area using an integrated approach (area-specific combinations of manual and mechanical weeding, and possible use of herbicides, fire, grazers, or browsers).
- 2) Sowing of non-invasive pasture grasses into weeded area to suppress alien plant resurgence from the soil seed bank.
- 3) Regular monitoring of the level of alien plant regeneration.
- 4) Fencing of managed area to exclude domestic stock from zones under long-term management, or from degraded but as yet unmanaged zones.
- 5) Release of domestic stock, at carefully determined levels, into the managed area to control alien plant resurgence.
- 6) Removal of domestic stock when the alien plant seed bank is nearing exhaustion.
- 7) Allowing managed area to regenerate from native parent trees in the vicinity, or if the density of such trees is very low, from newly established plantings of native “framework” species.
- 8) Mulching around plantings as appropriate.
- 9) Selective occasional weeding as necessary.
- 10) Possible periodic introduction of livestock if the browsing proves to be relatively selective and favors native species.

- 11) Possible introduction of tortoises or mammalian grazers as a permanent or seasonal feature, to aid in alien plant suppression and native seed dispersal.
- 12) Large-scale rat control during the main seasons of native plant fruit production, to allow a pulse of recruitment.
- 13) Adoption of biocontrol measures as appropriate, based on considerations of cost, target specificity, public acceptance, and the degree to which control is likely to confer an ecological benefit.

Locating mainstream funding for restoration

Ultimately, the key to raising the money needed for restoration is to incorporate conservation into mainstream concerns. Moving in this direction would not only improve funding prospects, but would make conservation more important in peoples' lives. Below we give a range of financing ideas, including some already established initiatives.

Wood use: Initial weeding usually produces a large quantity of brush, which is either left to decompose or burned. Either way, a potential resource is being ignored. This wood could be chipped and used as a weed-suppressing mulch, or perhaps for biomass fuel. A limitation of these approaches is the need to get a chipper close to the weeded area. A trailer chipper can be used in many forest areas but not in those far away from good trails.

A tax on forest products: Anything that is harvested from the forest could conceivably be taxed to fund restoration. Alien monkey exports from Mauritius are already taxed for such purposes. About 8,000 wild-caught or captive-bred monkeys are exported each year for biomedical research, and a levy of US \$50 per monkey is paid into the National Parks and Conservation Fund.

Leasing of grazing rights in restoration areas: We have already mentioned grazing as a possible tool for more extensive restoration. Leasing the grazing rights could cover some of the project costs. This approach is increasingly being adopted in restoration schemes throughout the world (for example, Simpson et al., 1998).

Leasing of hunting rights predator control: Many of the mammal species that can or do damage native wildlife are valued game. Regular culls may be self-financing to some extent if the hunting rights are leased. Mauritius has a strong hunting constituency which would probably support such initiatives.

Ecotourism: Mauritius is host to about 600,000 mostly affluent tourists every year, many of whom would likely be interested in contributing to the protection of the country's natural heritage if this concept were properly marketed. Most visitors are unaware of our greatest natural island treasures. Round Island is rightly kept as a restricted access nature reserve because of the treacherousness and fragility of its terrain, and the vulnerability of its biota to invasive alien species. Access to many of the best endemic bird-watching areas is also restricted because of intensive management. Only the island nature reserve of Ile aux Aigrettes is geared for both conservation and ecotourism. Well-designed attractions on the mainland would not only provide steady income for conservation but also serve as powerful educational tools.

A tourism tax: This approach has been pioneered by Ecuador to help finance the conservation of the Galapagos Islands. To raise funds for general environmental protection, the Government of Mauritius has already established an "environmental protection fee" within the tourism industry (a 0.75 percent levy on hotel revenue). The money is invested in the National Environment Fund, which is managed by the Ministry of Environment. Perhaps some of these funds could be made available for large-scale restoration.

Investment in ecosystem services: Native forest likely provides important ecosystem services, such as watershed protection, although on Mauritius, much of this service appears to be provided by secondary forest. But this does not seem to be the case on Rodrigues, which is drier, and where much of the alien forest is composed of highly water-demanding trees such as *Eucalyptus* species. Chronic water shortages are one of the biggest problems on Rodrigues, so there is a great opportunity there to implement a watershed rehabilitation scheme of the type pioneered by the “Working for Water” (WfW) program in South Africa (Van Wilgen et al., 1998). By presenting alien plant removal as a way of providing water, the South African program has managed to tap into funding that would not be available for biodiversity conservation alone.

Meaningful public employment: Even at optimum efficiency, ecosystem restoration will remain labor-intensive. One project with a US \$35 million annual budget employs 25,000 people (Anon., 2001), and WfW heavily emphasizes its socio-economic value as a generator of meaningful employment. Restoration could help address the widespread unemployment and under-employment on Rodrigues. For example, both forest and marine conservation could be strengthened through an employment program designed to eliminate abuses within the “bad weather payments” system. “Bad weather payments” are subsidies paid to all registered fishing people every day that fishing is prevented by bad weather. This system results in severe over-fishing of the Rodrigues lagoon, notably by “piqueses d’ourite” (fisher women) who walk on the reef to spear octopus. Many of these women admit that their fishing income is negligible, and that they only register as fishers in order to receive the payments. The government could thus address two conservation problems by redirecting the subsidy into wages for these effectively unemployed people, for work on forest restoration projects.

On Mauritius, where watershed restoration is not likely to serve as the basis for a public works program, forest restoration could serve a different economic need. The sugar industry, long a major employer on Mauritius, is in the process of mechanizing because Mauritian wages are relatively high and preferential EU prices for Mauritian sugar will soon be phased out. Mechanization is likely to throw a great number of field laborers out of work. Many of these people are over 40 years old, have no educational qualifications, and are unlikely to re-train in the higher technology sectors Mauritius is promoting for its development. Forest restoration would be an ideal means of creating employment for this group; such a program could help prevent the social problems that generally accompany long-term unemployment.

The use of volunteers: Current conservation projects on Mauritius would not be as successful as they have been if it were not for the contributions of volunteers, some of whom are highly skilled. The Mauritian Wildlife Foundation uses volunteers to some extent in most of its projects. A great deal of the field labor in the pink pigeon recovery project is provided by volunteers, most of them expatriate. Volunteers have carried out a little over half of the work undertaken in the restoration of Grande Montagne Rodrigues. These people are mostly Rodriguan; the local interest owes much to Rodriguan management of the project, and to the existence of an active community education effort that brings the conservation message to all Rodriguans. Local management and community outreach could increase local volunteer participation on Mauritius as well.

The above list is far from exhaustive, but it indicates that an integrated approach to the financing of restoration activities, coupled with a similar approach on the ecological side, could create a very exciting future for ecosystem restoration on Mauritius and Rodrigues. We are convinced that our conservation community can restore large areas of indigenous forest by harnessing the same creativity and energy that have been responsible for the conservation and economic-development successes in our country to date.

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An overview of opportunities for international scientific cooperation on invasive alien species

Dr. Ian A. W. Macdonald

International Environmental Consultant

PO Box 12236

Die Boord 7613

South Africa

macdonfam@kingsley.co.za

Abstract

Growing international awareness of the enormous problems caused by invasive alien species (IAS) has led to an upsurge in efforts to prevent and manage biological invasions. International scientific cooperation is essential to these efforts, and key to preventing new invasions. International cooperation is also integral to improving the management of existing invasions, establishing the necessary corps of trained experts, and creating effective policy. In the latter context, international scientific cooperation is crucial for demonstrating to policymakers, in a scientifically defensible way, the enormous costs that will accrue if this problem is not accorded the necessary priority and resources. Accordingly, promoting international cooperation should be a top priority for every organization involved in IAS issues. So as to avoid wasting scarce resources, this work should be accomplished, whenever possible, within the framework of existing initiatives, mechanisms, and organizations. The Global Invasive Species Programme (GISP) is poised to play a central role in fostering international cooperation. However, despite the importance of international efforts, the current reality is that almost all IAS management is done at national or sub-national levels. International scientific cooperation can, nevertheless, be structured in a way that supports and benefits from action at these levels.

Background

In recent years, the scientific community has come to recognize that introduced species can cause massive ecological, economic, and social disruption. It has been estimated that the invasion of alien species currently poses one of the greatest threats to biodiversity, along with the direct transformation of natural habitats and climate change (Sala et al., 2000). The scale of the IAS problem is enormous; the global economic losses currently attributed to IAS exceed the total economic output of the African continent (Pimental, 2002).

Social impacts of IAS are difficult to assess on a global scale. However, some recent, well-publicized invasions demonstrate that the problems can be significant. For example: introduction of the Nile perch (*Lates niloticus*) transformed Lake Victoria fisheries and forced a restructuring of communal fishing practices (Bright 1998) and, in the United Kingdom, two introduced livestock diseases (mad cow disease = bovine spongiform encephalopathy and foot-and-mouth disease) caused significant financial losses to the livestock and tourist industries (Meyerson & Reaser, 2003).

In the 1980s, the Scientific Committee on Problems in the Environment (SCOPE), a subsidiary body of the International Council of Scientific Unions (ICSU), recognized the global nature of the IAS problem and launched the first ever international program to synthesize information on the topic. This program was exceptionally successful; it provided the scientific community with major advances in understanding of the ecological factors that contribute to biological invasions, and increased appreciation among the public and policymakers of the threats IAS pose to both ecosystems and human well-being (Drake & Mooney, 1989).

SCOPE's efforts inspired creation of the Global Invasive Species Programme (GISP; see Preston, this volume), as well as other national and international activities to address IAS. The following section provides an overview of actions that the scientific community could take collectively to further minimize the spread and impact of IAS.

Prevention of new invasions

In general, the most cost-effective way of dealing with IAS is to prevent them from entering a new ecosystem (or, more typically, a new country), or failing that, to eradicate them before they can become established in a new location. Sharing information internationally in order to prevent new invasions is possibly the single most important area for improved international scientific cooperation. The mechanisms for increasing this cooperation are many and diverse. Several bodies are attempting (or have attempted) to create massive regional or global IAS databases (see list in Wittenberg & Cock, 2001). If properly maintained and networked, such databases would enable rapid access to information that could inform a wide range of stakeholders.

Another popular approach is to create international networks of experts and then to use Internet appeals to solicit information on particular species. The Invasive Species Specialist Group (ISSG) of the World Conservation Union's (IUCN) Species Survival Commission (SSC) is one such network (issg@auckland.ac.nz). However, membership in the ISSG is by invitation only.

In its second phase of operations, GISP has established an Evaluation and Assessment Working Group that is open to all experts who wish to contribute. At the request of the Convention on Biological Diversity, this working group has undertaken global assessments of the ecological and socio-economic impacts of IAS in inland water ecosystems and island ecosystems. The working group is also conducting a pilot study to determine which species are attacking plants native to the United States that are being grown in botanical gardens elsewhere in the world. The objective is to identify plant pests and diseases that could be seriously disruptive if they were to be introduced into the United States. This project might eventually be expanded into a global program in which botanical gardens would monitor attacks on their foreign collections and notify appropriate officials of any species that should be added to their lists of quarantine pests. Anyone interested in contributing to this study should contact Professor Richard Mack (rmack@wsu.edu), co-chair of the working group.

Through these and other mechanisms, the scientific community can obtain and share information that will enable governments to:

- (1) Conduct pre-emptive screening of intentional introductions. A species is normally defined as potentially invasive to a given area if it has invaded and caused harm in similar environments elsewhere. Pre-screening of intentional introductions using a "dirty" or "black" list demands prior knowledge of the organisms' range, biological characteristics, and interactions in natural and human-managed landscapes (e.g. agricultural systems).
- (2) Identify pathways that might lead to the accidental introduction of IAS. For example, knowledge of the "hitchhiking" behaviour of the highly invasive brown tree snake (*Boiga irregularis*) inspired officials in the state of Hawaii to develop an inspection program for planes arriving from the Pacific island of Guam where they snake has caused significant ecological and economic harm. This approach has thus far prevented the snake from reaching the forest of Hawaii (Van Driesche & Van Driesche, 2000).

- (3) Create “clean” or “white” lists of alien species that have not caused harm where they have been introduced and might thus be authorized for introduction. Unfortunately, due to the complexity of invasion processes, this approach can be very risky (Rejmanek et al., 2003)³⁰.
- (4) Share information on the best available methods for preventing accidental introductions (for example, treatment methods for wood packaging and products to prevent the introduction of insects or fungi associated with wood, and methods for preventing the introduction of marine species in ship’s ballast). The International Plant Protection Convention (IPPC) provides an international mechanism for sharing information on methods for preventing the introduction of plant pests. The International Maritime Organization (IMO) has developed guidelines for preventing ballast water introductions. There is an urgent need for similar efforts in many fields, to develop methods for managing the multitude of introduction pathways that currently exist. Once such methods have been developed, binding treaties might be necessary to ensure that these measures are effectively implemented by all nations - to address their potential as both sources and recipients of IAS.

Improved management of existing invasions

Where IAS have already become established, international scientific cooperation can improve the ability of policy makers and resource managers to make timely decisions based on sound science. SCOPE has already played a crucial role in this effort, first through its synthesis project on the ecology of biological invasions in the 1980s (Macdonald et al., 1986; Drake & Mooney, 1989) and more by inspiring research into the linkages between IAS and global climate change (Mooney & Hobbs, 2000). Most recently, GISP has spearheaded international efforts in this regard (McNeely et al., 2001, Wittenberg & Cock, 2001). These organizations need to work alongside governments and intergovernmental organizations to:

- (1) Identify and disseminate best practices for the management of particular IAS. The international scientific community has developed mechanisms for sharing biological control agents, as well as information on biological control methodologies. Because the same species of IAS are typically a problem for numerous countries, this sharing of resources helps minimize the costs of research and development and increases the likelihood that the management efforts will be successful. Unfortunately, the international community has not yet developed adequate means for cooperating in the areas of mechanical, chemical control, or integrated pest management. Nevertheless, a recent best management practices symposium convened under the aegis of the South Africa-USA Bi-National Commission (Preston et al., 2000), and the GISP *Toolkit* (Wittenberg & Cock, 2001) provide good examples of what can be achieved when such cooperation does take place.
- (2) Share national data on the taxonomy, means of identification, behavior, and distribution of important IAS internationally. National synthesis publications, such as those on invasive alien plants in South Africa (Stirton, 1978, Henderson, 2001) or IAS in general in the United States (US Congress, 1993) have greatly advanced the ability of resource managers to minimize the spread and impact of IAS. Regional responses to invasions have been improved by regional inventories of major IAS, such as those on invasive aquatic animals in southern Africa (de Moor & Bruton, 1988) and on all IAS in the

³⁰Wherever possible, a native species or a non-invasive alien species should be used instead of a newly introduced alien species. Any introductions of new alien species should first be tried experimentally, under controlled conditions that permit immediate eradication if the species shows invasive tendencies. Such experiments should be paid for by the persons or agencies proposing the introductions; their responsibilities and liabilities should be clearly spelled out in a trial introduction permit.

islands of the Pacific (Sherley, 2000). Information on the spatial distribution of IAS can, for example, enable resource managers to prioritize their management efforts, define economic impacts, and produce bioclimatic models of potential areas of infestation. The Southern African Plant Invaders Atlas (SAPIA) project, which aims to map the occurrence of invasive alien plants throughout Southern Africa (Henderson, 1995, 1998, 2001), is an instructive example of what can be achieved in this regard.

Establishing a corps of trained experts

Programmes to prevent and manage IAS require a corps of suitably trained professionals. International scientific cooperation can make important contributions by strengthening academic collaboration among countries through internships and scholarships, as well as by exchanging students and staff. Taxonomy, the scientific field that provides the species identifications needed for both the prevention and management of IAS, is a discipline that could greatly benefit from such activities; the number of taxonomists is declining, especially in the developing countries, at the same time that the IAS problems are increasing. Clearly, our ability to minimize the problems caused by IAS will greatly depend upon the success of international programs designed to build taxonomic expertise, such as those being fostered by the Global Taxonomy Initiative³¹, International Union of Biological Sciences³², and BioNET International³³.

Creating an appropriate policy environment

Currently, the management of IAS is hampered in virtually every country by a lack of resources. International scientific cooperation has a crucial role to play in demonstrating to national governments, in a scientifically defensible way, the enormous ecological and economic costs that will accrue to their nations if this problem is not accorded the necessary priority. Organizations such as IUCN and its partners in GISP have conducted and inspired work in this area, but there is much yet to be done. The IUCN has addressed this issue through its international Secretariat, world conservation congresses, and various commissions. For example, its first World Conservation Congress included a symposium on IAS (Rubec & Lee, 1997) the IUCN Invasive Species Specialist Group of its Species Survival Commission (SSC) publishes the newsletter *Aliens*³⁴. More generally, the SSC, with its global network of over 5,000 leading conservation scientists, provides a useful forum for the development of expertise and the dissemination of findings. The work of the ISSG resulted in a series of guidelines on best practices for preventing and managing IAS (IUCN, 2000). Through GISP, IUCN has played a major role in developing the first estimates of the global economic damage of IAS (Perrings et al., 2000), evaluating the human dimensions of the problem (McNeely, 2001), and assessing opportunities to address the problem through legal and institutional frameworks (Shine et al., 2000).

Conclusion

In many fields, international scientific cooperation is often the cheapest and most effective way to advance both knowledge and best practices. The last two decades have seen amazingly rapid advances in both our understanding of biological invasions and in political awareness of the problems they cause. For example, the Subsidiary Body on Scientific Technical and Technological Advice (SBSTTA) to the Convention on Biological Diversity³⁵ has made IAS a cross-cutting theme. Similar steps are being taken elsewhere—for example, at the World Wide Fund for Nature (Cronk & Fuller, 1995), in the Ramsar Convention on Wetlands³⁶, and in the

³¹ <http://www.biodiv.org/programmes/cross-cutting/taxonomy/default.asp>

³² <http://www.iubs.org>

³³ <http://www.bionet-intl.org/>

³⁴ <http://www.issg.org>

³⁵ <http://www.biodiv.org>

³⁶ <http://www.ramsar.org>

International Maritime Organization³⁷. These advances are attributable in no small measure to international cooperation. The efforts of groups such as SCOPE, IUCN, and other GISP partners are clearly paying off.

In the struggle to manage IAS, promoting international scientific cooperation should be a top priority on all national, regional, and global agendas. Wherever possible this should be done within the framework of existing mechanisms so as to maximize the use of scarce resources. GISP is poised to play a crucial role in this process globally and to build the capacity to minimize the spread and impact of IAS at national and sub-national levels.

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The status of invasive alien tree species in Zimbabwe, Zambia, and South Africa

Dr. Betserai I. Nyoka

Ministry of Environment

Forestry Commission

Forest Research Centre

P.O. Box HG 595, Highlands

Zimbabwe

bnnyoka@frchigh.co.zw

Abstract

A wide range of trees species were introduced into southern Africa (South Africa, Zambia, and Zimbabwe) for a wide range of purposes. Unfortunately some of these species have become invasive, threatening the biodiversity of the region. Some of the documented environmental damage to the ecosystems of the region includes: reduction in plant species richness and stream flow, and alteration of the nutrient status of soils. In South Africa, an estimated 100,739 km² (i.e. 8.07% of the country's total area) has been affected by invasive alien tree species. Figures are not readily available for Zimbabwe, but an estimate of 4,500 km² invaded by non-native trees would be a conservative figure. Zambia is considered to relatively affected by invasive alien tress, although lack of awareness could be contributing to this notion. Control programmes for invasive alien tree species in Zimbabwe and South Africa cost US \$100 000 and US \$20 million annually, respectively.

Introduction

This paper is based on a report commissioned by the Food and Agriculture Organization (FAO) entitled, *A case study on the status of invasive forest trees species in Southern Africa*. The specific objective of the study was to review available literature on the importance of invasive tree species, and their impact on biodiversity and economic development in Zambia, Zimbabwe, and South Africa.

Documented introductions of tree species in southern Africa date back to the middle of the 17th century when the first non-native trees were introduced into South Africa (Troup 1932, Streets 1962). In Zimbabwe, the earliest recorded case of forest tree introduction was in circa 1874, some 16 years before the occupation of the country by European settlers (SRFC 1956). As many as 750 tree species have now been introduced into southern Africa (van Wilgen et al. 2001).

The plantation forestry sector, the primary source of timber and tannin bark in southern Africa, is entirely based on alien tree species. The economic and social contribution of this sector to these three southern African countries is shown in Table 5. Besides the direct and tangible economic benefits derived from alien trees species used in commercial forestry, alien trees species have also been used to provide such ecosystem services as firewood, fodder, fruits, windbreak, and shade.

Invasive alien tree species and the extent of their invasions

The introduction and subsequent use of alien tree species in southern Africa has not been without cost. Some of the species introduced became invasive, causing immense environmental damage. Table 5 shows some of the major invasive tree species in southern Africa. It is apparent that alien tree species from a cross section of uses are all contributing to the invasions. The total area invaded by alien trees in South Africa is about 100,739 km² which is 8.07% of the country's total area (van Wilgen et al. 2001). In Zimbabwe, the total area invaded is not known but estimates put the area at more than 4,500 km². All the major ecosystems in South Africa and Zimbabwe have

been affected. With the exception of *Ziziphus mauritiana*, most alien tree species in Zambia are regarded as noninvasive. There is documented evidence that species such as patula pine (*P. patula*) and black wattle (*A. mearnsii*) the most invasive tree species in South Africa and Zimbabwe, were unsuccessful in Zambia due to environmental limitations.

Table 5. Summary of statistics on plantation forestry and on invasive alien tree species in three southern African countries.

	South Africa	Zimbabwe	Zambia
Land area (km ²)	1 227 600	386 850	743 900
Area under plantation (km ²)	15 000	1180	570
Contribution of plantation to GDP	2%	3%	1%
Contribution of plantation forestry	US\$300 million	US\$90 million	US\$6 million
No. of people employed	100 000	13 600	100 000**
Annual invasive alien tree control programme budget	US\$20 million	US\$100 000	na
Uncondensed area affected by invasive alien trees (km ²)	107 000	4500*	na
Major invasive alien species (plantation)	9 <i>Pinus</i> spp. 2 <i>Acacia</i> spp.	6 <i>Pinus</i> spp. 2 <i>Acacia</i> spp.	na
Major invasive alien species (ornamentals, windbreak, shade, etc)	11 <i>Acacia</i> spp. <i>M. azedarach</i> <i>J. mimosifolia</i> <i>P. canescens</i> <i>Bauhinia</i> spp.	4 <i>Acacia</i> spp. <i>M. azedarach</i> <i>J. mimosifolia</i> <i>P. canescens</i> <i>Bauhinia</i> spp.	na
Major invasive alien species (fruits)	<i>Psidium guajava</i> <i>P. cattleianum</i> <i>P. guineense</i>	<i>Psidium guajava</i> <i>P. cattleianum</i> <i>Z. mauritiana</i>	<i>Z. mauritiana</i>
Major invasive alien species (fodder)	<i>Prosopis</i> spp.	na	na

na = information not available or not an issue; *figures are estimates;

**figure is suspiciously large

Environmental damage caused by invasive alien trees and their control

Documented environmental damage caused by invasive alien tree species in southern Africa includes reduction in stream flow, change in soil nutrient status, reduction in species richness, increased biomass in some ecosystems, and genetic pollution (Van Wilgen et al. 2001). The control of invasive alien species in South Africa began in the 1940s and in the 1980s in Zimbabwe. Early efforts were largely uncoordinated and erratic, and, as a result, did little to stem their spread. Today, the main methods of control are mechanical, chemical, fire, and biological control.

Conclusions

The cost of managing invasive alien tree species has to be weighed against the economic and social benefits derived from them. The wattle industry, based on the black wattle for example, a major invasive tree species in South Africa and Zimbabwe, contributes respectively R800 million and US\$3 million annually. The patula pine another major invasive alien tree species in South Africa and Zimbabwe, is planted in an area of 3373 km² and 491 km² respectively and forms the basis of multi-million dollar timber (as pulp and paper) industries in the two countries. There is therefore, a need to look at both the advantages and disadvantages associated with each species

and decisions need to be taken species by species, rather than as a generic single approach, in order to best balance contradictory requirements.

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Addressing marine IAS globally and regionally – the IMO Globallast programme

Adnan Awad

IMO – GloBallast Programme
C/o GISP-NBI Kirstenbosch
Private Bag X7, Claremont 7735
South Africa
awad@nbi.ac.za

Abstract

Potentially harmful marine organisms are being transferred around the world daily and introduced to new environments through ships' ballast water. Some of these species have caused major impacts to sensitive natural resources, pristine environments, coastal industries, and even human health. The GloBallast Programme is a global initiative launched by the International Maritime Organization (IMO) and the United Nations Development Programme (UNDP) with funding provided by the Global Environment Facility (GEF). This programme is operating in six countries, each representing a developing region, to help minimize ballast water facilitated introductions. The Southeast African programme is based in Cape Town, South Africa, and is seeking to replicate activities throughout the southern African region. These activities include raising awareness and educating relevant audiences, conducting baseline surveys at ports of entry and coastal monitoring for alien species, conducting port-level ballast water risk assessments, developing and implementing new policy and legislation to manage ballast water, providing the necessary training to port and shipping personnel, and installing systems at the ports to monitor and enforce compliance with new regulations. The programme will be operating until December 31, 2004, and a regional phase of the Programme may be initiated thereafter. GloBallast is seeking to build strong links and partnerships throughout the region in order to lay the groundwork for more effective future activities.

Introduction

The International Maritime Organization (IMO) is a specialised agency of the United Nations responsible for maritime matters. The IMO has initiated a US \$11 million project to help South Africa, along with five other countries representing developing regions, to prevent alien marine species from being introduced into their waters via ships' ballast water.

The introduction of alien marine species is considered to be one of the four greatest threats to the world's oceans, following over-fishing, marine pollution, and physical modification of marine habitats.

The ballast water problem

Large bulk carriers calling at Saldanha and other South African ports can discharge up to 150,000 tonnes of ballast water on each visit. It is estimated that a total of 8 million tonnes of ballast water are discharged at Saldanha each year and more than 22 million tonnes at all South African ports each year. Globally, up to 12 million tonnes of ballast water are transferred between oceans and seas each day (Andersen et al., 2002). It has been estimated that up to 7,000 species of marine organisms may be present in this ballast water at any given time (Carlton, 1999).

Ballast water is carried by ships to provide balance, stability and structural integrity when the ship is empty of cargo. When the ship loads cargo the ballast water is discharged. Serious impacts can occur when this ballast water contains various marine species taken on at the port of origin.

Almost any type of marine organism may be carried in ballast water, because most have a planktonic stage in their life cycle. Planktonic, or free floating, organisms are most susceptible to being taken up in ballast tanks, and subsequently transferred to new regions and introduced to new environments. Such introductions may include bacteria and viruses.

Two examples of severe impacts that have been caused in other parts of the world from such introductions are the European zebra mussel (*Dreissena polymorpha*) in the North American Great Lakes and the North American Leidy's comb jellyfish (*Mnemiopsis leidyi*) introduced to the Black Sea. The zebra mussel has caused between US \$750 million and US \$1 billion worth of damages as of 2000 (Pimentel et al. 2000), through the clogging of industrial cooling water intake pipes. The comb jelly has contributed to the massive collapse of fisheries in the Black Sea, resulting in losses of US \$240 million per year from fisheries revenue in the late 1980's (Zaitzev and Ozturk 2001). Similar catastrophes could easily occur in southern Africa from such introductions.

What is being done to combat the problem?

The IMO has a Ballast Water Working Group within its Marine Environment Protection Committee. This group is responsible for the development of voluntary ballast water management guidelines released in 1996 as Resolution A(868). The guidelines advocate best practices for ballasting and deballasting procedures, and call for increased reporting of all ballast water movements. The primary tool contained within the guidelines for reducing the risk of species introductions is the exchange of ballast water in mid-ocean. This practice may not be possible in sea conditions where the safety of the ship and crew would be compromised (IMO 1996).

The IMO is currently developing a mandatory ballast water management regime to be released in late 2003 as a new convention. The convention will focus on a standard of organism removal or deactivation to be met, before ballast water may be discharged. This standard will help boost, the already active, research into, and development of, improved shipboard ballast water treatment technologies.

The GloBallast Programme in South Africa

The GloBallast Programme in South Africa, being coordinated by the Department of Environmental Affairs and Tourism (DEAT), is funded by the Global Environment Facility (GEF). The United Nations Development Programme (UNDP) is implementing the programme globally, and the IMO is providing technical assistance and operating all activities within each country to help reduce the risk of marine introductions. A large number of South African agencies are involved, including the National Ports Authority (NPA), the South African Maritime Safety Authority (SAMSA), West Coast Peninsula Transitional Council, Council for Scientific and Industrial Research (CSIR), University of the Western Cape, University of Cape Town, the shipping industry and the Saldanha Water Quality Forum.

The main activities of the programme include:

- raising awareness and education on marine alien species issues.
- conducting biological baseline surveys within the major ports.
- conducting ballast water risk assessments at the ports.
- developing and implementing new ballast water policy and legislation.
- training port and shipping personnel in techniques to minimise and monitor introductions.
- installing the necessary systems to support new ballast water management regulations at each port.

Roll out of the South African programme to the southern African region

The Programme will seek to replicate these activities to the extent possible throughout the southern African region. The regional activities will be steered through a Regional Programme Task Force (RPTF) comprising representatives from each of the southern African countries, including the Island States. The RPTF will be assembled through nominations from the appropriate ministries within each country, and will convene an initial meeting in Cape Town to develop a regional action plan. Follow-up meetings of the RPTF will be held within other countries of the region. GloBallast funds will be used to survey two ports within the region for the presence of alien species. This will initiate activities and awareness raising campaigns within the region.

Mr. Adnan Awad has been employed by IMO to implement the Programme in South Africa. The project is believed to represent a major step forward in efforts to protect the coastal and marine resources of Saldanha, South Africa and the southern African region in general.

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4. *Appendices*

Appendix 1. Agenda of the Lusaka workshop

Monday, 10 June 2002

Day 1-Morning

Plenary Session I

Co-chairs: Lubinda Aongola, Geoffrey Howard

"Defining the issue on the global and regional scale"

- 08h30 Welcome and opening ceremony**
Mr. David Dunn, American Ambassador, U.S. Embassy
Mr. Lubinda Aongola, Director: Planning and Information, Ministry of Environment and Natural Resources, Republic of Zambia
- 09h00 Overview of the workshop objectives**
Dr. Geoffrey Howard (Kenya)
- 09h15 Overview of the invasive alien species issue globally – problem definition, causes, and consequences**
Dr. Geoffrey Howard (Kenya)
- 09h35 Overview of international instruments addressing invasive alien species issues**
Mr. David Nowell, FAO (Italy)
- 10h00 Panel session**
Statements by national delegates:
Botswana, Malawi, Mauritius, Mozambique, Namibia, South Africa, Seychelles, Swaziland, Tanzania, Zimbabwe
- Questions to be addressed by a representative of each country:**
1. Main challenges and mechanisms for addressing the problem within each country
 2. Perceived needs and opportunities for cooperation throughout southern Africa
- 10h30 Break**
- 11h00 Panel session continued**
- 12h30 Lunch**
- Day 1- Afternoon
- Plenary Session II
- Co-chairs: Lubinda Aongola, Geoffrey Howard
- " Defining the issue on the global and regional scale"**
- 14h00 Overview of the Global Invasive Species Programme (GISP) and the Global Strategy on Invasive Alien Species**
Dr. Guy Preston (Republic of South Africa)
- 14h20 The Global Invasive Species Information Network and SAFRINET initiatives addressing invasive alien species**
Dr. Connal Eardley (Republic of South Africa)
- 14h40 Overview of options and opportunities for managing invasive alien species, a toolkit of best prevention and management practices**
Dr. Sean T. Murphy (United Kingdom)
- 15h00 Regional case study on prevention and management practices: Alien species management for ecosystem restoration in Mauritius and Rodrigues.**
Dr. John Mauremootoo (Mauritius)
- 15h20 Break**

- 15h50 Overview of mechanisms and opportunities for international scientific cooperation on invasive alien species issues** Dr. Ian A.W. Macdonald (Republic of South Africa)
- 16h10 Regional case study on international scientific cooperation: The status of an invasive alien tree species in Zimbabwe, Zambia and South Africa**
Dr. Betserai Isaac Nyoka (Zimbabwe)
- 16h30 Questions and answers**
- 17h00 Summary of conclusions and recommendations**
- 17h30 Announcements and adjournment**

Tuesday, 11 June 2002

Day 2 - Morning

Working Groups Session I

Moderator: Adnan Awad

"Exploring approaches to achieving success throughout the region"

08h00 Overview of directives for working groups

Geoffrey Howard

08h10 Participant introductions and the objectives for the region

09h00 Working Groups on regional cooperation

To address the following questions:

1. What do we want the region to achieve collectively?
2. What are the challenges to achieving regional cooperation?
3. What are the necessary elements for a strategy to facilitate regional cooperation?
4. How can we promote collaboration and cooperation within existing frameworks?

10h30 Break

11h00 Plenary – presentation of group A & B summaries - Group A & B working group chairs

11h30 Group discussion

12h30 Lunch

Day 2 - Afternoon

Working Groups Session II

Moderator: David Nowell

"Exploring approaches to achieving success throughout the region"

13:30 Overview of directives for working groups

13:40 Working groups on regional cooperation

To address the following questions:

1. What are the existing resources that can be utilized to achieve regional cooperation?
2. What additional resources are needed?
3. Who needs to be involved? When and where?

15h00 Break

15h30 Plenary – presentation of group A & B summaries - Group A & B Working Group Chairs

16h00 Group discussion

17h00 Expected meeting outcomes - regional recommendation

17h30 Announcements. Overview of Day 2 program and objectives, adjourn

Wednesday, 12 June 2002

Day 3 – Morning

Working Groups Session III

Moderator: Geoffrey Howard

"Exploring approaches to achieving success throughout the region"

08h00 Overview of Working Group Session II conclusions and directives for Day 3

08h10 Presentation of draft regional recommendations

08h30 Group discussion

09h00 Working groups on regional cooperation

Working groups to address the following questions:

1. What are the steps to establish regional collaboration and promote action?
2. What are the steps that can be taken immediately and who should take them?

10h30 Break

11h00 Plenary – presentation of group summaries

11h30 Finalization of regional recommendations

12h30 "The road ahead – Where to from here?"

12h45 Closing remarks

13h00 Adjourn

Appendix 2. List of participants

Mr. Lubinda Aongola

Ministry of Tourism, Environment and Natural Resources, P.O. Box 34011
Lusaka, Zambia
Tel: + 260 1 238772 or 229410-13
Fax: + 260 1 229420 or 238772
E-mail: laongola@menr.gov.zm

Mr. Adnan Awad

IMO – Globallast Programme
c/o GISP, National Botanical Institute
Private Bag X7, Claremont 7735
Cape Town, South Africa
Tel: +27 21 799 8815
Fax: +27 21 797 1561
E-mail: awad@nbi.ac.za

Prof. Emmanuel Chidumayo

University of Zambia, Biological Sciences
P.O. Box 32379
Lusaka, Zambia
Tel: +260 1 233409
E-mail: echidumayo@natsi.unza.zm

Ms. Ingrid Chite

American Embassy, P.O. Box 90
Gaborone, Botswana
Tel: +267 353982 Ext. 5378
Fax: +267 356504
E-mail: chiteim@state.gov

Dr. Connal Eardley

SAFRINET / ARC-PPRI
Private Bag X134
Pretoria, South Africa
Tel: + 27 12 3238540
Fax: + 27 12 3256998
E-mail: vrehcde@plant5.agric.za

Dr. Geoffrey Howard

(GISP Executive Board)
Eastern Africa Regional Office
IUCN, P.O. Box 68200
Nairobi, Kenya
Tel: +254 2 890 605/12
Fax : +254 2 890 615
E-mail: gwh@iucnecaro.org

Mr. Abú Jone

Ministry of Agriculture & Research
Development
Plant Protection Department – Biological Control
Maputo, Mozambique
Tel: +258 1 460195/ 460591
Fax: +258 1 460195
E-mail: sanidadevegetal@tropical.co.mz
or abujone@hotmail.com
or biod@virconn.com

Mr. Alfred Kabeleka

Ministry of Transport
Maritime and Inland Waters
P.O. Box 50346, Lusaka, Zambia
Tel: +260 1 250716
Mobile: +260 096 457468
Fax: +260 1 253165
E-mail: kabeleka@netscape.net

Mrs. Francisca Katagira

Ministry of Agriculture & Food Security
Crop Development – Plant Health Services
P.O. Box 9071, Dar-es Salaam, Tanzania
Tel: +255 022 2865641/3
Fax: +255 022 2865641/2
E-mail: pps@kilimo.go.tz
or ipm@africaonline.co.tz
or fkatagira@hotmail.com

Mrs. Neeta Leckraz

Ministry of Agriculture
Plant Pathology Division
Morcellement Boucan
Nalletamby – Phoenise, Mauritius
Tel: +230 4665307
Fax: +230 4659591
E-mail: plpath@intnet.mu

Mr. Patrick Marsh

Working for Water
Water Affairs – Forestry
P.O. Box 28321
Port Elizabeth, South Africa
Mobile: +27 82 4146433
E-mail: marsh@dwaf.ecape.gov.za

Dr. Ian A. W. Macdonald

International Environmental Consultant
P.O. Box 12236, Die Boord 7613, South Africa
Tel: +27 21 8528077
Mobile: +27 82 534 9588
Fax: +27 21 852 9055
E-mail: macdonfam@kingsley.co.za

Dr. Susan Macdonald

International Environmental Consultant
P.O. Box 12236, Die Boord 7613, South Africa
Tel: +27 21 8528077
Mobile: +27 82 781 6087
Fax: +27 21 852 9055
E-mail: macdonfam@kingsley.co.za

Mr. Tonny Maulana

Ministry of Agriculture & Irrigation
Department of Agricultural Research &
Technical Services
Bvumbwe Agricultural Research Station
P.O. Box 5748, Limbe, Malaŵi

Tel: +265 1 471419
Fax: +265 1 471312
E-mail: pesticideboard@malawi.net

Dr. John Mauremootoo
Mauritian Wildlife Foundation
MWF Black River Office
Ave. Bois des Billes
La Preneuse, Mauritius
Tel: +230 483 5038/8933/8340
Fax: +230 483 5038
E-mail: cjmaure@intnet.mu

Dr. Christo Marais
Working for Water
Private Bag X 4390
Cape Town 8000, South Africa
Tel: +27 21 405 2200
Fax: +27 21 425-7880
E-mail: chris@dwaf.gov.za

Ms. Lungile Magagula
Ministry of Tourism, Environment &
Communication
Swaziland Environment Authority
P.O. Box 2652, Mbabane, Swaziland
Tel: +268 404 6420
Fax: +268 404 1719
E-mail: seabiodiv@realnet.co.sz

Mr. Similo Mavimbela
Ministry of Agriculture
Agriculture Research Division
P.O. Box 4, Malkerns, Swaziland
Tel: +268 5283017
Fax: +268 5283360
E-mail: malkernresearch@africaonline.co.sz
or seemelo@yahoo.com

Ms. Margaret C. Mweene
IUCN Zambia Office
Lotti House, 7th Floor
Cairo Road, North-end
Private Bag W 356, Lusaka, Zambia
Tel: +260 1 231866
Fax: +260 1 231867
E-mail: iucn@zamnet.zm

Dr. Isiah Mharapara
Agricultural Research Council
79 Harare Drive, Marlborough
Harare, Zimbabwe
Tel: +263 4 309574-6
Fax: +263 4 300012
E-mail: mharapara@mango.zw

Ms. Mpho Mosate
Southern Africa Biodiversity Support
Programme, National Conservation Strategy
Coordinating Agency

Ministry of Lands, Housing and Environment
Private Bag 0068, Gaborone, Botswana
Tel: +267 302050
Fax: +267 302051
E-mail: mmosate@hotmail.com
or envirobotswana@gov.bw

Mr. Lishomwa Mulongwe
Ministry of Tourism, Environment
and Natural Resources - Department of Forestry
Division of Forest Research
P.O. Box 22099, Kitwe, Zambia
Tel: +260-2-221337
Fax: +260-2-224110

Dr. Sean T. Murphy
(GISP Executive Board)
CAB International
Silwood Park, Ascot, Berkshire SL5 7TA
United Kingdom
Tel: + 1491 829 159
Fax: +1491 829 123
E-mail: s.murphy@cabi.org

Mr. Mpeta Mwanyongo
Ministry of Natural Resources and
Environmental Affairs Department
Private Bag 394, Lilongwe 3, Malawi
Tel: +265 1 771111 or 771703
Fax: +265 1 773379
E-mail: ambanda@sdp.org.mw
or dstores@sdp.org.mw

Ms. Laurie Neville
then Coordinator
Global Invasive Species Programme (GISP)
Department of Biological Sciences
Stanford University
Stanford CA 94305, USA
Tel: +1 650 7231530
Fax: +1 650 7239253
Email: lneville@stanford.edu

Dr. David C. Nowell
Food and Agriculture Organisation
Agricultural Officer (Plant Protection)
Room B-661, Viale delle Terme di Caralla-00100
Rome, Italy
Tel: +39 065 7052034
Fax: +39 065 7056347
E-mail: dave.nowell@fao.org
Internet: <http://www.fao.org>, <http://www.ippc.int>

Dr. Betserai I. Nyoka
Ministry of Environment
Forestry Commission, Forest Research Centre
P.O. Box HG 595, Highlands, Zimbabwe
Tel: +263 4 496878
Fax: +263 4 497070
E-mail: bnnyoka@frchigh.co.zw

Ms. Misozi D. Phiri

Senior Inspector: Natural Resources
Management
Environmental Council of Zambia
P.O Box 35131, Lusaka, Zambia
Tel: +260 1 254130/31 or 254023
Fax: +260 1 254164
E-mail : mphiri@necz.org.zm

Dr. Guy Preston

(GISP Executive Board)
Working for Water
Private Bag X 4390
Cape Town, South Africa
Tel: +27 21 4052200
Fax: +27 21 4257880
E-mail: gpreston@mweb.co.za

Ms. Hélette Prinsloo

Ministry for Agriculture and Land Affairs
Land Use & Soil Management
Private Bag X 120
Pretoria, South Africa
Mobile: +27 82 9233310
Fax: +27 12 3925938
E-mail: helettep@nda.agric.za

Mr. Manikchand Puttoo

National Parks and Conservation Service
Ministry of Agriculture, Food Technology &
Natural Resources
Seebamth Lane, Feneal, Mauritius
Tel: +230 4644016
Fax: +230 4651184
E-mail: npcsagr@intnet.mu

Mr. Dennis Rangii

CAB International Africa
P.O. Box 633, Nairobi, Kenya
Tel: +254 2524462
Fax: +254 2522150
E-mail: drangi@cabi.org

Mr. Selby Remie

Conservation Section Seychelles
P.O. Box 445
Victoria, Mahé, Seychelles
Tel: +248 224644
Fax: +248 224500
E-mail: chm@seychelles.net

Mr. George Rhodes

Ministry of Agriculture Water &
Rural Development
Quality Management & Regulatory Services
Private Bag 13184, Windhoek, Namibia
Tel: +264 61 2087464
Fax: +264 61 2087778
E-mail: rhodesg@mawrd.gov.na

Dr. Dana Roth

Biodiversity and Foreign Affairs Officer
Department of State, OES/ETC Room 4333
2201 C Street, NW
Washington, DC 20520, USA
Tel: +1 202-736-7428
Fax: +1 202-736-7351
E-mail: rothds@state.gov

Dr. John Saka

University of Malawi
Natural Resources and Environment Centre
Chancellor College, P.O. Box 280,
Zomba, Malawi
Tel: +265 1 524 222
Fax: +265 1 524 046
E-mail: narec@chanco.unima.mw
or jsaka@chanco.unima.mw

Mr. Arundel Sakala

Coordinator, Phytosanitary Service
Mt Makulu Research Station
Private Bag 7, Chilanga, Zambia
Tel: +260 1 278141
Fax: +260 1 278141
E-mail: pqpsmt@zamtel.zm

Mr. Silvest Samali

Ministry of Agricultural and Food Security
P.O Box 1253, Hortitengeru
Arusha, Tanzania
Tel: +255 27 2553096/67
Fax : +255 27 2553067
E-mail : silvesta@yahoo.com

Ms. Desiree Sehlapelo

Working for Water
Water Affairs and Forestry
Private Bag X 9506
Pietersburg 0700, South Africa
Tel : +27 15 290 1283
Fax : +27 15 295 3249/50
E-mail : sehlapelo@iafrica.com

Dr. Simon Sithole

Plant Protection Research Institute
Box CY 550, Causeway, Harare, Zimbabwe
Tel: +263 4 700339
Fax: +263 4 700339
E-mail: ssithole@africaonline.co.zw

Dr. Sarah Simons

CAB International Africa
Box 633, Nairobi, Kenya
Tel: +254 2 542462
Fax: +254 2 522150
E-mail : s.simons@cabi.org

Ms. Gabriella Richardson-Temm

IUCN Zambia Office
Lotti House, 7th Floor
Cairo Road, North-end
Private Bag W 356,
Lusaka, Zambia
Tel: +260 1 231866
Fax: +260 1 231867
E-mail: gabriella.richardson@iucn.org

Mr. Innocent Tyolo

Minerals Energy and Water Affairs
Private Bag 07, Maun, Botswana
Tel: +267 660452
Fax: +267 660372
E-mail: ityolo@gov.bw

Mr. Benjamin Van Staden

Department of Water and Forests
Private Bag X 4390, Cape Town, South Africa
Tel : +27 21 405 2200
Fax : +27 21 425 7880
E-mail : ben@dwaf.gov.za

Dr. Helmuth Zimmermann

Plant Protection Research Institute
c/o Dept. of Environmental Affairs & Tourism
Private Bag X 134, Pretoria, South Africa
Tel: +27 12 329 3276
Fax: +27 12 329 3278
E-mail: riethgz@plant2.agric.za