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GLOBAL STRATEGY FOR ADDRESSING THE PROBLEM OF INVASIVE ALIEN SPECIES

A result of the Global Invasive Species Programme (GISP)

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Preface

This first draft of the GISP Global Strategy on Invasive Alien Species is based on contributions from the team leaders of the several topics being addressed under GISP Phase I. It summarizes some of the key findings of GISP I, and presents ten draft strategies that we believe cover the range of strategic actions that need to be considered in addressing the key issues we have identified. The final document that we will produce at the GISP workshop in Cape Town in September will set priorities among these strategies, each of which will be more specific in terms of what will be accomplished, and measurable in its objectives. GISP will also decide which of these it will itself address under its second phase.

This Strategy is directed to the decision-makers whose policies and practices are affecting the movement of species around the world. GISP has also produced numerous other volumes for more specialized audiences, providing more detailed guidance to those interested.

Comments, corrections, and improvements to this draft will be gratefully received.

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CHAPTER 1. INTRODUCTION

1. Global trade has enabled modern societies to benefit from unprecedented numbers of species. Agriculture, forestry, fisheries, the pet trade, the horticultural industry, and many industrial consumers of raw materials today depend on species that came originally from other parts of the world. Indeed, the lives of people everywhere have been greatly enriched by being able to gain access to a greater share of the world's biological diversity. Expanding global trade is providing additional opportunities for further such enrichment, as well as imposing new species on ecosystems.

2. A key point is that some established alien species may both enhance and detract from native biodiversity. Alien species may be beneficial in one part of an ecosystem or geographic region, but detrimental in another part or region. One major challenge is to identify when human influence on ecosystems is bringing about changes that are inimical to ecosystems, biodiversity, economics or other aspects of human welfare. What is the basis for making choices about trade-offs about alien species that are beneficial in some ways while detrimental in others?

3. This Global Strategy addresses:

   a) the species -- often vertebrates or plants -- that are intentionally moved to new locations to improve human welfare, but end up having quite the opposite effect; and

   b) the more numerous other species, including animals (especially insects), plants, and disease organisms (such as HIV) that are transported to new environments inadvertently and have significant negative effects on human welfare.

4. This subset of alien species that become established in a new environment, then proliferate and spread in ways that are destructive to native ecosystems, human health, and ultimately human welfare are known as "invasive alien species" (IAS). Seeking to eradicate or control these invasive individuals or populations in no way is an attack on the species as a whole, which may merit conservation measures in its natural habitat.

THE IMPACTS OF INVASIVE ALIEN SPECIES ARE IMMENSE, INSIDIOUS, AND OFTEN IRREVERSIBLE

5. Invasive alien species are now recognized as one of the greatest biological threats to our planet’s ecological and economic well-being. A plant or animal transported beyond the ecosystem where it occurs naturally may multiply out of control, endangering native species in the invaded ecosystem, undermining agriculture, threatening public health, or creating other unwanted -- and often irreversible -- disruptions. Every nation on earth is already grappling with complex and costly invasive species problems, such as zebra mussels affecting fisheries, mollusc diversity, and electric power generation in Canada and the USA, water hyacinth choking African waterways, rats extirpating native biota on oceanic islands, and deadly new

diseases attacking both temperate and tropical countries. Addressing the problem of IAS is urgent because the threat is growing daily, and the economic and environmental impacts are severe. The earlier the problem is addressed, the more cost-effective action is likely to be.

THE EARLIER THE PROBLEM OF AN INVASIVE ALIEN SPECIES IS ADDRESSED, THE MORE COST-EFFECTIVE ACTION IS LIKELY TO BE.

6. Numerous international instruments, binding and non-binding, have been developed to deal with at least certain aspects of the problem of IAS. The most comprehensive is the 1992 Convention on Biological Diversity (CBD), which calls on its parties -- numbering 178 governments in 2000 -- to "prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats, or species" (Article 8h). A much older instrument is the 1952 International Plant Protection Convention (IPPC), which applies primarily to plant pests, based on a system of phytosanitary certificates; regional agreements further strengthen the IPPC (Box 1). Other instruments deal with IAS in specific regions (such as Antarctica), sectors (such as fishing in the Danube), or vectors (such as IAS in ballast water, through the International Maritime Organization). Over 40 such instruments or programmes are already in force (Annex 2), and several more are awaiting finalization and ratification.

BOX 1: THE INTERNATIONAL PLANT PROTECTION CONVENTION

The IPPC is a multilateral treaty deposited with FAO and in force since 1952. With 111 governments as Contracting Parties, the purpose of the Convention is "to secure common and effective action to prevent the spread and introduction of pests of plants and plant products, and to promote appropriate measures for their control". Defining pest as "any species, strain or biotype of plant, animal or pathogenic agent injurious to plants or plant products", the implementation of the Convention has applied mainly to crops, but it also extends to the protection of natural flora. The IPPC Secretariat, housed at FAO, facilitates the development of internationally agreed standards for the application of phytosanitary measures in international trade to prevent and control the spread of plant pests (many of which are invasive alien species). The standards developed under IPPC are recognized by the World Trade Organization under the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement). Thus the scope of the IPPC covers any invasive alien species that may be considered to be a plant pest.

7. The evidence from expanding impact of IAS on both economic and ecological systems suggests that these international instruments have not been sufficient to solve the problem. Worse, expanding international trade is moving more organisms more quickly around the world, increasing the threat to native ecosystems and potentially overwhelming government efforts to prevent unwanted invasions. In response to these concerns, the global scientific community, represented by ICSU-SCOPE, DIVERSITAS, CABI, IUCN, and UNEP, established in 1997 the Global Invasive Species Programme (GISP). The goal of GISP is to use the best practices available to control IAS and to disseminate information to serve the higher goal of conserving global biodiversity and mitigating problems caused by invasive organisms on a worldwide scale. GISP also recognizes that it is dealing with dynamic ecosystems, not static ones; and it has no intention of trying to "freeze" any particular ecosystem in an imagined pristine state. Rather, it realizes that active management of human effects on ecosystems is required in a time of increasing human impact. This Strategy is one product of Phase I of GISP, designed to define the problem, describe its dimensions, discuss its implications, identify those economic sectors

that should be involved in action, suggest approaches to management, and recommend appropriate strategies to the responsible agencies.

BOX 2: THE GLOBAL INVASIVE SPECIES PROGRAMME

The Global Invasive Species Programme (GISP) was created in 1997 to provide information to implement Article 8(h) of the Convention on Biological Diversity. This Article calls on Parties to "Prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats, or species". GISP is operated by a consortium of the Scientific Committee on Problems of the Environment (SCOPE), CABInternational (CABI), the World Conservation Union (IUCN), and the United Nations Environment Programme (UNEP). GISP is a component of DIVERSITAS, a programme on biodiversity science. With funding from a number of sources, GISP seeks to improve the scientific basis for decision making on invasives; develop capacities to employ early warning and rapid assessment and response systems; enhance the ability to manage invasives; reduce the economic impacts of invasives and control methods; develop better risk assessment methods; and strengthen international agreements.

GISP is developing new approaches to public education about invasives, improving understanding of the ecology of invasives, examining legal and institutional frameworks for controlling invasives, developing new codes of conduct for the movement of species, and developing new tools for quantifying the impact of invasives. Its work involves dozens of scientists from all parts of the world.

CHAPTER 2. WHY THE PROBLEM OF INVASIVE ALIEN SPECIES REQUIRES AN URGENT RESPONSE

8. The scope of species invasions is global and the cost is enormous, in both ecological and economic terms. Invasive alien species are found in all taxonomic groups. They include viruses, fungi, algae, mosses, ferns, higher plants, invertebrates, fish, amphibians, reptiles, birds and mammals. They have invaded and affected native biota in virtually every ecosystem type on Earth. Many hundreds of extinctions have been caused by invasive aliens, especially under "island" conditions, either on real islands or in ecological islands, such as aquatic ecosystems. The ecological cost is the irretrievable loss of native species and ecosystems.

9. When invasive species of insects threaten native species of insect, they can also have cascading effects on insect-eating birds and on plants that rely on insects for pollination or seed dispersal. Invasive species can transform the structure and species composition of ecosystems by repressing or excluding native species, either directly by out-competing them for resources or indirectly by changing the way nutrients are cycled through the system.

10. The numbers of IAS are growing at an exponential rate in some regions. Increasing global domination by a relatively few invasive species threatens to create a relatively homogeneous world rather than one characterised by great biological diversity and local distinctiveness. Numerous species in various parts of the world -- including perhaps as many as 10% of the world's 300,000 vascular plants -- have the potential to invade other ecosystems and affect native biota in a direct or indirect way (Rejmanek *et al*., 2000).

11. In addition, the direct economic costs of invasive alien species run into tens of billions of dollars annually. Weeds reduce crop yields, increase control costs, and decrease water supply by degrading catchment areas and freshwater ecosystems. Tourists and homeowners unwittingly introduce alien plants into national parks, where they degrade protected ecosystems and drive up management costs. Pests and pathogens of crops, livestock and trees reduce yields and increase pest control costs. The discharge of ballast water introduces harmful aquatic organisms, including diseases, bacteria and viruses, to both marine and freshwater systems, degrading commercially important fisheries. And recently-spread diseases continue to kill or disable millions of people each year, with profound social and economic implications.

EVERY ALIEN SPECIES NEEDS TO BE TREATED FOR MANAGEMENT PURPOSES AS IF IT IS POTENTIALLY INVASIVE, UNLESS AND UNTIL CONVINCING EVIDENCE INDICATES THAT THIS IS NOT SO.

12. No criteria have yet been agreed upon for the minimum damage, spread or size of population needed for an alien species to be considered invasive. However, it is clear that a very small number of individuals, representing a small fraction of the species' genetic variation in its native range, can be enough to generate, through its reproduction and spread, massive environmental damage in a new environment (Mack, 2000).

2.1. The economic impacts of invasive alien species

13. The negative economic impact of IAS argues for significant investments to prevent such impacts. While considerable uncertainty remains about the economic costs of invasions, estimates of the economic costs of particular invasives to particular sectors in particular countries indicate that the problem may be very serious for those sectors and those economies. GISP has not sought to estimate an aggregated economic cost of invasions globally, but one

study from the USA indicated damage costs of $137 billion per year from a subset of invasive species (Pimentel *et al*., 2000).

14. Some examples can indicate the dimensions of impact. The value of the fish catch in Lake Erie was US$600 million before the invasion of zebra mussels around 1986, possibly via water ballast in a ship through Lake St. Clare; the value of the fish catch had declined to $200 million by the early 1990s, so a decline of $400 million worth of fish annually can be ascribed to the invasion of the zebra mussel (Bright, 1999). And the varroa mite, a serious pest in honeybee hives, has recently invaded New Zealand and is expected to have an economic cost of NZ$400-900 million, forcing beekeepers to alter the way they manage hives. Beekeepers argue that had border rules been complied with or had surveillance systems detected it earlier, then the problem could have been avoided. It appears that it now is too late to eradicate the mite, requiring a mitigation plan that is expected to cost $1.3 million in its first stage. The values of ecological services affected by the invasive *Tamarix* tree in the western USA amount to somewhere between $7-16 billion over 55 years (Zavaleta, 2000). While the range of these figures indicates their uncertainty, they do indicate the order of magnitude of impact. Other examples are listed in Box 3.

BOX 3: INDICATIVE COSTS OF SOME ALIEN INVASIVE SPECIES

SPECIES	**ECONOMIC VARIABLE**	**ECONOMIC IMPACT**	**REFERENCE**
Knapweed and leafy spurge	Impact on economy in three US states	US$40.5 million per year direct costs US$89 million indirect	Bangsund, 1999; Hirsch & Leitch, 1996
Zebra mussel and other aquatic invasives	Damages to US and European industrial plants	Cumulative costs 1988-2000=US$3.1-5.0 billion	Khalanski, 1997; Bright, 1999
Most serious invasive alien plant species	Costs 1983-92 of herbicide control in Britain	Ancient (8 spp) £104/year Modern (4 spp) £122/year	Williamson, 1998
Six weed species	Costs in Australian agroecosystems	A$170/year	Watkinson, Freckleton & Dowling, 2000
Pinus, Hakea, Acacia	Costs on South African fynbos to restore pristine	SAR 1.24 billion	Turpie & Heydenrych, 2000
Water hyacinth (*Eichornia crassipes*)	Costs in 7 African countries	US$71.4 million/year	Kasulo, 2000
Rabbits	Costs in Australia	A$600 million/year (agricultural)	White & Newton-Cross, 2000
Green crab *Carcinus maenas*	Impact on North Pacific Ocean fisheries	US$44 million per year in Oregon and Washington	Cohen *et al*., 1995

15. In addition to the direct costs of the prevention, control, or mitigation of invasives (see Chapter 5), the economic costs also include their indirect ecological consequences and other non-market values. For example, invasives may lead to changes in ecological services that are locally important by disturbing the operation of the hydrological cycle including flood control and water supply, waste assimilation, recycling of nutrients, conservation and regeneration of soils,

pollination of crops, seed dispersal, and so on. Such services have both current use value and option value (the potential value of such services in the future). In the South African Fynbos, for example, the establishment of several invasive tree species has changed water supplies to nearby communities, justifying government expenditures of US$40 million per year for manual and chemical control.

16. While the loss of crops due to weeds or alien pests may be reflected in the market prices of agricultural commodities, such costs are seldom born by the source of the introductions. Rather, they are “externalities”, costs which a given activity unintentionally imposes on another, without the latter being able to exact a compensation for the damage received. One special feature of biological invasions as externalities is that the costs of invasions are largely self-perpetuating once they are set in motion. Even if introduction ceases, damage from the invasives already established continues and may well increase over time. Thus the policies developed to deal with conventional externalities involved in the general problem of biodiversity loss -- such economic tools as taxes, subsidies, permits, and so forth -- are seldom well suited to deal with the problem of invasions. This highlights the urgent need for new approaches to deal with IAS.

17. Further, many, even most, introductions are accidental, including most invertebrates and pathogens; the costs of these cannot be readily reflected by prices or markets. But even in the case of introductions involving deliberate imports to support agriculture, horticulture, forestry, and fisheries, market prices for seeds, plants, foods, fibres, pesticides, and fertilizers do not generally reflect the ecological risks associated with their use. Thus producers have little financial incentive to take account of the cost of the loss of indigenous species through predation, browsing or competition.

18. GISP concludes that every alien species needs to be treated for management purposes as if it is potentially invasive, unless and until convincing evidence indicates that this is not so. This calls for urgent international action by a wide range of governmental, intergovernmental, private sector, and civil institutions.

CHAPTER 3. HOW INVASIVE ALIEN SPECIES AFFECT MAJOR ECONOMIC SECTORS

19. The problem of IAS is not simply the concern of ecologists or conservation biologists. Rather, it affects national economies, is an intimate part of global trade, threatens human health, and is a critical element of global climate change. This chapter indicates some of the major economic sectors that are, or should be, concerned about the issues, suggesting that new partnerships with these sectors could lead to progress in addressing the issues identified. These short sections only begin to cover the range of issues that are important for the respective sectors. GISP does not have expertise in all of these areas, but it has identified areas where action is needed.

3.1. Global trade and invasive alien species

20. The increased mobility of people and goods brings with it an increased likelihood of movement of species around the planet, either deliberately in the form of commodities such as livestock, pets, nursery stock, and produce from agriculture and forestry, or inadvertently as species are transported as unwitting passengers in packaging, ballast water, and on the commodities being traded. Globalization of the economy is demonstrated by the increase in the value of total imports from US$192 billion in 1965 to US$3 trillion in 1990, a 17-fold increase in just 25 years (World Resources Institute, 1994). Imports of agricultural products and industrial raw materials increased from US$55 billion in 1965 to $482 billion in 1990; these have the greatest potential to contribute to the problem of invasive species. Much of the global trade is carried by ships, and marine organisms are being transported around the world in their ballast water, as ships take on ballast in one port and dump it in another part of the world. This is a particularly important vector of invasive species in coastal waters (Carlton, 1989; Carlton and Geller, 1993). **Note: get updated figures at least to 1995**.

21. International trade in good, services and intellectual property between the current 139 Members of the World Trade Organization (WTO) is disciplined by the 1994 Uruguay Round Agreements. This regime provides for binding rules, enforced by a compulsory dispute settlement mechanism, designed to ensure that governments extend free market access to each other's products and services. Particularly relevant to alien species that are characterised as pests or diseases is the 1995 **WTO Agreement on the Application of Sanitary and Phytosanitary Measures** (the SPS Agreement), which allows Members to adopt national measures or standards to: (1) protect human, animal and plant life from the risks arising from the entry, establishment or spread of pests, diseases, or disease-carrying organisms or disease-causing organisms; and (2) prevent or limit other damage within the territory of the Member from the entry, establishment or spread of pests (Box 4).

22. WTO reportedly is putting increasing pressure on national quarantine agencies to tolerate "acceptable" rather than minimum risks of introduction of invasive species if there are commensurate benefits from the trade in question. This would help to accelerate the spread of exotic species, especially as East-West trade within hemispheres increasingly replaces the older North-South trade that was less conducive to invasions. Unpredictable impacts are likely to result from the growth of global economic activity because the spread of potentially invasive species is likely to accelerate as the amount of trade in biological products continues to expand.

BOX 4: WTO AGREEMENT ON SANITARY AND PHYTOSANITARY MEASURES

The SPS Agreement under the WTO is primarily designed to ensure that import restrictions are not used as a disguised form of commercial protectionism. It is not a mechanism to ensure that

governments have adequate standards in place. However, these standards must be based on scientific evidence, and applied only to the extent necessary to protect human, animal or plant life or health.

The Agreement seeks to ensure the principles of free and fair trade and makes provision for safe trade by promoting or requiring the use of:

- international standards as a basis for SPS measures;
- risk assessment based on scientific principles and evidence;
- consistency in the application of appropriate levels of protection;
- least trade restrictive alternatives;
- acceptance of equivalent measures;
- transparency through notification of trade measures.

23. The globalization of trade and the power of the Internet offer new challenges, as sales of seeds and other organisms by mail order or over the Internet pose new and very serious risks to the biosecurity of all nations. Controls on both harvest and export of species are required as part of a more responsible attitude of governments toward the potential of spreading genetic pollution around the world. Further, all receiving countries must also ensure that they are able to control what is being imported. Virtually all countries in the world have serious problems in this regard.

24. Because global trade has such a profound influence through moving species around the world, it is particularly important to ensure that concerns about IAS are built into relevant trade negotiations. Some initial efforts are being made in this regard. For example, the Biosafety Protocol under the CBD clearly is part of the global trade regime and is to be mutually supportive of any agreements under the World Trade Organization (WTO). This might be a challenge, because the Protocol is based on the precautionary principle (which essentially states that potentially dangerous activities can be restricted or prohibited even before they can be scientifically proven to cause serious damage), whereas decisions under trade law typically require "sufficient scientific evidence" to lead to such restrictions. In any case, the issue of IAS is so important that it should form part of the WTO agenda, as well as involving national ministries of commerce to address domestic aspects of trade relevant to IAS.

3.2. Tourism and invasive alien species

25. With some 650 million people crossing international borders as tourists every year, the opportunities for them to serve as vectors for IAS is profound and increasing. They can intentionally carry living plants that can be introduced back home, eventually becoming invasive. They can carry fruits and other living plant materials that carry with them potentially invasive species of insects that can have profound influences on agriculture. They can carry diseases between countries.

26. Even tourism to protected areas -- a form of trade where people travel to the resource instead of vice versa -- can facilitate the spread of invasive species, thus threatening the ecological integrity of the protected area. For example, one species of destructive root fungus (*Phytophthora cinnamomi*), is moved mainly by human activity and attacks many species of trees in disturbed situations. Increased tourism may lead to increased outbreaks of this disease threat in several parts of the world. Many other such examples are included in GISP reports.

27. While much of the responsibility for addressing tourism-related issues of IAS will rest with the usual customs and quarantine offices in the destination countries, tourism-related agencies (both public and private) should become more aware of the role that tourists might play as vectors of IAS, and take measures to educate the relevant staff, and ultimately the tourists themselves.

3.3 Agriculture and invasive alien species

28. The domestication of plants and animals that began in the Neolithic presented vast new opportunities for certain species to benefit from the way humans modified their habitats; certain strands of micro-organisms to jump species and infect humans; indeed, the problem of invasive species became significant only with the advent of agriculture.

29. The economic impact of IAS on agriculture is considerable. For example, a 1992 report by the Weed Science Society of America estimated annual crop losses due to invasive alien weeds to be between $2 billion and $3 billion and the cost for control, given the current levels of herbicide use, was estimated to be between $1.5 billion and $2.3 billion. Other costs of applying herbicides (to health, non-crop species and the like) was estimated to be around $1 billion. This implies that the total cost of non-indigenous weeds was between $4.5 billion and $6.3 billion -- approximately $5.5 billion to $7.7 billion in 2000 dollars. By contrast, Pimentel *et al*. (2000) estimated the annual cost of invasive weed species at $23.4 billion, incorporating other values, such as yield reduction due to weeds. This variability indicates that approaches to cost estimates still needs work.

30. However, many existing markets are prevented from operating efficiently in regards to IAS by agricultural policies and institutions. For example, fiscal, price, and incomes policies have all promoted management regimes that have increased the susceptibility of agroecosystems to invasions, and subsidies designed to promote cash crops as a means of increasing export revenue have encouraged the use of farm inputs that may open agroecosystems to invasion (Perrings, Richardson, and Dalmazzone, 2000). In developing countries, farm incomes may be so low that farmers are unable to take action to deal with potentially invasive species even if they wish to do so. Farm income may be depressed because of low international commodity prices and national policies designed to keep food prices low (effectively favouring the urban communities over the rural ones). This depression of income may discourage investment in habitat conservation, including control of IAS.

3.4. Genetically modified organisms (GMOs) and invasive alien species

31. Genetically modified organisms (GMOs) are organisms in which the genetic material has been altered in a way that does not occur naturally by mating or recombination. Recombinant DNA technology makes it possible to transfer genetic material through biochemical means and thus to genetically modify plants, animals and micro-organisms. Modern biotechnology can therefore introduce a greater diversity of genes into organisms than traditional methods of breeding and selection. The Convention on Biological Diversity and its new Cartagena Protocol on Biosafety refer to such organisms as Living Modified Organisms (LMOs).

66. The Protocol will enable governments to indicate whether they are willing to accept imports of agricultural commodities that include LMOs by communicating their decision to the world community via an Internet-based Biosafety Clearinghouse. LMOs include food crops, fish, or trees that have been genetically modified for greater productivity, resistance to pests or diseases, or other valued characteristics. Seeds and fish are particularly important because they are used intentionally to propagate or reproduce LMOs in the environment. Shipments of such commodities that may contain LMOs are to be clearly labelled. More strict Advanced Informed

Agreement (AIA) procedures will apply to seeds, live fish, and other LMOs that are to be intentionally introduced into the environment (and therefore might be in danger of becoming invasive). In these cases, the importer must provide detailed information to each importing country in advance of the first shipment and the importer must then authorize the shipment. The intention is to ensure that recipient countries have both the opportunity and the capacity to assess risks involving the products of modern biotechnology.

67. GMOs/LMOs are automatically "alien" to the extent that they have no normal distribution and occur nowhere in the natural environment until released. As with alien species that become invasive, it is possible that the release or escape of transgenic, recombinant or novel DNA might have severe and irreversible effects on environmental safety. On the other hand, like some intentionally introduced alien species, GMOs/LMOs have the potential to deliver substantial economic and food security benefits.

68. Some scientists believe that GMOs offer a new and more serious threat to biodiversity than do non-modified species. The crux of the issue is whether the GMOs are likely to be more competitive, or less competitive. This is not a simple issue. After all, non-modified introduced species contain millions of genes, while most GMOs have only a few of their genes modified. Further, the genetic modification is designed for specific results desired by humans, such as pest resistance or herbicide resistance; and these may not necessarily provide for better survival in the rigours of a competitive world. On the other hand, some scientists expect the effects of GMOs to be much more insidious than those of introduced non-modified organisms. For example, research in Canada on genetically modified ginseng for the cultivated ginseng industry often involves planting ginseng in woodlands where wild ginseng is also found. If the wild ginseng becomes contaminated with the modified genes, then the legal protection offered to the wild ginseng might be difficult to sustain because the new form no longer represents the wild genotype that originally was protected. Under such a scenario, wild ginseng with the original genotype may well go extinct.

32. For these reasons, a regulatory framework to control the testing, movement and release of GMOs may have many points of similarity with measures to regulate introductions of alien species. A few countries, notably New Zealand, regulate GMOs under the same legislation used to address alien species introductions.

3.5. Forestry and invasive alien species

33. Alien species of trees have long been introduced for commercial forestry, erosion control or landscaping. Tamarisk (salt cedar) was introduced from Central Asia to the south-west United States nearly 200 years ago, partly to control erosion along river banks. The tree now forms dense thickets on more than 400,000 ha of riparian habitat, but these thickets have little value for most native animals, and are estimated to absorb more water each year than all the cities of southern California combined (Corn, 1999). Many countries are experiencing great problems with alien species of eucalyptus from Australia, which can be particularly harmful in ecological terms because their leaf litter contains chemical exudates that prevent other species from growing.

10. Forestry can be seriously affected by both intentional and unintentional invasions. A dramatic example of the latter is the recent invasion of eastern Canada by the brown spruce longhorn beetle (*Tetropium fuscum*) which apparently arrived in Halifax from Europe in cheap packing wood. It has become established in the 75 ha Point Pleasant Park, where it has infested red spruce trees, burrowing too deeply to be reached by pesticides. While the beetle in its European natural habitat feeds primarily on dead wood, it is infesting healthy trees in the park, and it

poses a serious threat to the forests of the continent. Red spruce is the most economically important tree in maritime Canada, but the beetle appears also to attack white and black spruce, which are found across much of the continent. While some ecologists hope that natural predators will bring the invasive species under control, the government of Nova Scotia is so concerned at the threat to its US$1.5 billion per year softwood industry that it has decided to chop down and incinerate the 10,000 affected trees, in hopes of eradicating the beetle before it can spread (Motluk, 2000).

34. Some alien tree species that have been planted for economic reasons have become invasive, with severe economic and ecological impacts. However, careful management can minimize the danger of such escapes. Forestry agencies, both public and private, therefore need to be aware of the danger of unintentional IAS, conduct detailed risk assessments before intentionally introducing exotic species of trees, and ensure that any such species that are introduced do not become invasive. For example, careful planning of forestry operations using alien species of conifers, *Eucalyptus*, or *Acacia* can reduce the probability of their escaping and becoming invasive. Species choice, the siting of new plantations (slope, aspect, exposure, prevailing winds, etc.), plantation design (orientation, species composition) and management requirements in surrounding vegetation can all contribute to keep a beneficial alien from becoming invasive.

3.6. Fisheries and invasive alien species

35. Fish are introduced for direct release for commercial or sport fishing or for contained use in aquaculture and mariculture facilities. The risk of escape and/or spread may be particularly high in aquatic environments. The Atlantic salmon was eliminated from many rivers in Norway after the introduction of the Baltic salmon for aquaculture. In South Africa, 41 species of alien fish had naturalised by 1988 after being introduced for aquaculture, sport angling, and biological control (mosquitoes, algae) or deliberately translocated to stock artificial lakes and reinforce populations of rare species (de Moor and Bruton, 1988). In England, amphibious alien crayfish escaped from fishmongers' stalls and established themselves in London's channels and ponds (de Klemm, 1996). The Jakarta Mandate under the CBD called for particular attention to IAS in coastal and marine habitats.

36. As with forestry, fisheries have been profoundly affected by IAS. For example, the introduction of Nile perch into African lakes has increased profits from commercial fishing and contributed to foreign exchange gains, at the expense of the extinction of more than 100 endemic fish species (especially in Lake Victoria).

69. In China, fish are a particularly important invasives problems. In Dianchi Lake, more than 30 alien species of fish were found in the 1970s, reducing the number of native species from 25 to just 8 over a period of 20 years (Xie, 1999).

70. Another example of purposeful introduction gone wrong is the extensive stocking programme that introduced African tilapia (*Oreochromis*) into Lake Nicaragua in the 1980s, resulting in the decline of native populations of fish and leading to the imminent collapse of one of the world's most distinctive freshwater ecosystems. Local people have avoided fishing for the introduced tilapia because they do not like their "muddy taste". The African tilapia found Lake Nicaragua a very congenial habitat, being able to grow rapidly, feed on a wide range of plants, fish and other organisms, and form large schools that can migrate long distances. Further, they are maternal mouth brooders, so a single female can colonize a new environment by carrying her young in her mouth. They are also larger than the native cichlids and replace them in territorial conflicts. Even worse, these fish have also proven adaptable to salt water habitats, and may invade Nicaragua's coastal zone as well, affecting productive marine fisheries and valuable

estuarine nursery grounds. As McKay *et al*. (1995) point out, the alteration of Lake Nicaragua's ecosystem is likely to have effects on the planktonic community and primary productivity of the entire lake, destroying native fish populations and perhaps leading to unanticipated consequences.

71. Those involved in fisheries need to consider carefully to potential negative impacts that may follow from introduction of alien species of fish, many of which may become invasive.

3.6. Horticulture and invasive alien species

72. Introductions for ornamental purposes are reinforced by consumer demand for novelty and complicated by low levels of understanding of invasion risks. In the past, European colonisers often established acclimatisation societies to introduce familiar animals and plants. Some of these purposes were quixotic: starlings were apparently introduced to the United States in a drive to introduce all species of birds mentioned by Shakespeare's works (Corn, 1999). More than 70% of New Zealand's invasive weeds were intentionally introduced as ornamental plants. In the Auckland region, more than 615 introduced plant species are known to have become established and four new species become established there each year (Christenson, 1999). Growing economies expand consumer demand for ornamental plants. Including using the Internet to import alien species with little regard to the possibility of their becoming invasive. Responsibility under such condition s is unclear.

3.7. Human health and invasive alien species

37. Infectious disease agents often, possibly even typically, are invasive alien species. Unfamiliar types of infectious agents, either acquired by humans from domesticated or other animals, or imported inadvertently (or even on purpose) by human invaders, can have devastating impacts on human populations. Pests and pathogens can also undermine local food and livestock production, thereby causing hunger and famine. Examples:

- the Irish potato famine in the 1840s was caused by a fungus introduced from North America, with devastating impacts on the health of local people.

- rinderpest, a viral disease, was introduced into Africa in the 1890s via infected cattle, subsequently spreading into both domesticated and wild herds of bovids throughout the savannah regions of Africa, with devastating impacts; it appears that up to 25% of the cattle-dependent pastoralists may have starved to death in the early 20th century, because rinderpest wiped out their cattle populations.

- a dramatic example of an invasive species is the influenza virus, which has its origins in birds but multiplies through domestic pigs who are infected by multiple strains of avian influenza virus, acting as genetic "mixing vessels" that yield new recombinant-DNA viral strains that then infect the pig-tending humans, who then spread the disease to other humans around the world, especially through rapid air transport.

- the most severe type of malaria (*P. falciparum*) is thought to have been introduced from Southwest Asia and northern Africa into Europe via trade and military campaigns.

- the classical cities of Athens, Rome and Constantinople were dealt staggering blows by spectacular new epidemic infections brought in from middle eastern and Indian sources by traders and armies;

- the bubonic plague spread from central Asia through north Africa, Europe, and China; and

- smallpox and measles spread from Europe into the western hemisphere shortly following colonization, helping to bring down the mighty Aztec and Inca empires.

INVASIVE PATHOGENS ARE PARTICULARLY TROUBLESOME TO HUMAN HEALTH IN SITUATIONS OF ENVIRONMENTAL CHANGE AND ECOLOGICAL DISTURBANCE, BUT THE TYPE, SCALE AND TEMPO OF CHANGE IN HEALTH RISK IS ACCELERATING UNDER THE CONTEMPORARY CONDITIONS OF GLOBAL CHANGE.

38. Understanding the way that human behaviour and invasive species interact reflects the institutional and policy environment within which people make their decisions. This is especially well established in the treatment of invasive species that have direct effects on human health, such as the human immuno-deficiency virus, HIV. Control in such cases depends upon changing the behaviour that affects both the introduction and the spread of such invasive disease organisms. The dynamics among invasive pathogens, human behaviour, and economic development are highly complex, depending on interactions between the virulence of a disease, infected and susceptible populations, the pattern of settlement, and the level of development.

39. Large development projects such as dams, irrigation schemes, land reclamation, road construction and population resettlement programmes have contributed to the invasion of diseases such as malaria, dengue, schistosomiasis and trypanosomiasis. The clearing of forests in tropical regions to extend agricultural land has opened up new possibilities for wider transmission of species of viruses that carry haemorrhagic fevers that previously circulated quietly (and generally benignly) in wild animal hosts. Examples include Argentine haemorrhage fever, "Guaranito" virus, Machupo virus, Basia virus, and many others. Some of the pathways for the invasion of species are complicated. For example, lymphatic filariasis in the southern Nile Delta has increased 20-fold in prevalence since the building of the Aswan dam in the 1960s, primarily due to the increase in breeding sites for the mosquito vector of the disease following the rise in the water table caused in turn by extension of irrigation. The problem has been exacerbated by increased pesticide resistance in the mosquitoes due to heavy agricultural pesticide use and by rural-to-urban commuting among farm workers. Thus invasive species combined with variations in inter-annual rainfall, temperature, population density, population mobility and pesticide usage to contribute to one of the most profound challenges of invasive species: the threat to human health.

3.8. Climate change and invasive alien species

40. The scientific community now generally accepts that global climate change is a reality, and that this will have many biological impacts. These may include alterations in species distributions and changes in abundance within existing distributions, resulting from direct physiological impacts on individual species, changes in abiotic factors, changed opportunities for reproduction and recruitment and altered interactions among species (Karieva *et al.*, 1993). Invasive species may find that changes in climate produce more conducive conditions for establishment and spread, as well as change the suitability of local climates for native species and the nature of interactions among native communities.

41. Through these effects climate change can affect sources, pathways, and destinations of many species, making this a global problem. Climatic and landscape features set the ultimate limits to the geographical distribution of species and determine the seasonal conditions for growth and

survival. As climate changes, patterns of production and trade in agricultural commodities are likely to change as well, with crops adapted to tropical conditions being grown more competitively in higher latitudes and altitudes. The sources of tropical invasive species that may contaminate such crops will also increase.

42. One implication is that the integrity of "area freedom" under the WTO may be very sensitive to global warming, for example by creating more attractive environmental conditions for the Queensland fruit fly in Australia's citrus-growing areas. An increase in temperature of two degrees could lead to suppression costs increasing by up to 80%. While the citrus industry may be able to absorb greater costs and deal with the perceived threats to public health and the environment from intensive pesticide applications, the spread of many species with climate change will challenge the WTO surveillance systems as invasive species continue to encroach on areas that previously were designated as outside its normal range.

43. More generally, climatically induced stress on plants can reduce their ability to resist invaders. Vegetation that is stressed by a changing climate may be more prone to insect or pathogen damage, lowering their competitive power. The greatest impacts of climate change on invasive species may arise from changes in the frequency and intensity of extreme climatic events that disturb ecosystems, making them vulnerable to invasions, thus providing exceptional opportunities for dispersal and growth of invasive species. Thus a drought that kills native plants can leave gaps in vegetation that may be quickly occupied by IAS. Both droughts and freezing are likely to change in both frequency and intensity under climate change, reducing the resistance of trees to insect attack. And by altering the frequency, intensity and duration of flooding, climate change will affect the incidence of episodic recruitment events of invasive species, enabling aggressive species to escape from local, constrained refuges. For example, the woody legume *Mimosa pigra* escaped from the Darwin Botanical Gardens after 80 years of residence, during a major flood that took seed into the catchment of the Adelaide river, which transverses through the sensitive Kakadu National Park. *M. pigra* has now become a significant problem in the region.

BOX 5: CLIMATE CHANGE, GLOBAL TRADE, AND IAS: THE CASE OF THE SILVERLEAF WHITE FLY

The silverleaf white fly (*Bemisia tabaci* biotype b) is extremely invasive and feeds on many species of plants. Notorious for its ability to develop resistance to pesticides, it has spread around the world from its European origins. It has recently reached Australia, possibly on ornamental plants imported from the USA, evading quarantine precautions and spreading rapidly around the country. But it is prevented from colonising many of the open field crops by interactions with the native biotype of the silverleaf white fly and its parasites; these interactions vary geographically in response to variation in climate, demonstrating three important aspects of the risks posed by global change and invasive species:

- increasingly severe trade pressures are being put on countries to accept imports of living material that threatens natural ecosystems, agriculture and human health;
- native biodiversity can be extremely valuable in preserving the health of agriculture; and
- climate plays an important mediating effect on the interaction of insect biotypes, varying in its outcomes in different climatic environments.

3.9. Conclusions

44. This chapter has indicated some of the many economic sectors that are significantly involved in the issue of invasive alien species. This list could be extended considerably farther, but it is sufficient already to indicate that IAS are of broad social and economic relevance. Clearly, any effective programme to address IAS problems will need to involve at least the economic sectors identified in this chapter.

45. The issue becomes even more significant because combinations of events can complicate the invasive species problem. For example, any increase in the frequency and intensity of extreme climatic events associated with the intensification of the hydrological cycle under climate change has great potential to disrupt the fragile balance of food supplies and refugee problems in regions already made vulnerable by over-population and land degradation. Thus the impacts of droughts, made more severe by political unrest and over-exploitation of natural resources, can lead to increasing movements of refugees accompanied by livestock carrying exotic parasites with them. The associated food and other materials such as seeds that are provided as drought relief could also act as vectors for invasive species or include even invasive species. Such risks are greatest in Africa, which is particularly prone to drought and where political boundaries often are poorly supervised. This suggests that emergency responses to legitimate humanitarian concerns can carry long-term implications for native ecosystems, including agro-ecosystems.

46. GISP hopes and expects that this Strategy will be a significant step in achieving better coordination among these economic sectors in addressing the problem of invasive alien species. This will need to be based on the best available understanding of the biology of invasions and the management responses available.

CHAPTER 4. THE BIOLOGY OF INVASIONS

47. Scientists working on invasive species seek to address several basic questions, such as:

- Which taxa invade?
- How fast do they invade?
- What is the ecological impact of their invasion?
- What types of ecosystems are susceptible to invasive taxa and their impacts?
- How can harmful invaders be contained, controlled or eradicated?

48. This chapter will address the first four questions, while the fifth will be covered in Chapter 5. It is useful to begin by reviewing the invasion system.

4.1. The invasion system

49. Species invasions have three main elements. First, the **source population** is where the species finds its natural habitat, where it forms part of the native ecosystem (though other invaded ecosystems often are a secondary source). A species may be highly valued in such a setting and make important contributions to human welfare, though some disease organisms and weeds may be troublesome to people even as natives. Second, **pathways** are the routes by which species move from one political unit to another, either within a country or between countries. And third, **destinations** are where the new species arrives, either intentionally or inadvertently. **Vectors** are the means that a species from a source population follows a pathway to the new destination.

Sources

50. Generally, species that are potential invaders are not a problem at home where they are native species, but some are already significant invaders elsewhere. Because the problem is not perceived to be "theirs", relatively few governments are yet able to justify significant investments to prevent export of potential IAS, except perhaps for "domestic aliens" in the case of large countries.

51. Sources of invasive species are of particular concern when considering pest species of agriculture and forestry, with products often being acceptable on the international market only if they come from an area known to be pest free. Under the World Trade Organization (WTO) the source location of a potential invasive species is treated seriously enough to have led to the concept of “area freedom”, which states that a commodity may only be exported if it can be demonstrated that the invasive species is absent from the growing area (pest-free area). For example, the Queensland fruit fly *Bactrocera tryoni* is invasive wherever suitable fruits are found in favourable climates. A major citrus growing area in Australia has “area freedom” status for the fruit fly and the status is being maintained by mass releases of sterile fruit flies, which are cost-effective only at low population pressures, preceded by insecticidal baits and sprays. But with global climate change, the distribution of these pest-free areas may change and certainty about the status of different source areas may decline.

52. And of course source locations of an invasive species may at the same time be a destination for other species. Ironically, a species may be an endangered icon in its natural habitat but a dreaded pest in its new environment, strictly protected by one set of laws at home while being relentlessly pursued by another set of laws where it is invasive; the brush-tailed possum, for example, is protected in its native Australia but a pest in New Zealand.

Pathways

53. A particularly important link in the chain of invasion is the pathway, along with the vector that transports the invader along the pathway. If the vector can be intercepted, then the potential invasion by the alien species can be prevented. Most of the vectors are human-assisted transport mechanisms that serve to move organisms across their natural barriers. The probabilitiy of a species surviving a ship voyage depends on its ability to survive for relatively long periods (though this is now much less of a constraint because transport is so rapid). Thus plant seeds may be more likely than at least some insects to survive transport to distant locations, perhaps mixed with the agricultural commodity being transported; and relatively long-lived beetles that bore into wooden packing materials present different challenges than short-lived fruitflies.

54. Examples of vectors that transport organisms unintentionally include shipments of foodstuffs, household goods, wood and wood products, new or used tyres, animal and plant products in various conditions, ballast (whether dry or water), containers, pallets, internal packaging materials, and humans (including their various pathogens and disease agents such as bacteria and viruses).

55. This great diversity of vectors yields an extraordinarily complex matrix, requiring equally complex management approaches. Operationally, different vectors will have different strengths in different countries, and in different sub-regions within a country, for the various species of potential invaders. Thus ranking vectors in general as either “minor” or “major” may reduce a very complex state of affairs into a dichotomy that is oversimplified and may lead to inappropriate management responses. Multiple vectors can operate along the same pathways at the same time; and vectors are constantly changing over time and space, with some aspects more predictable than others. These general conclusions can guide and focus management, underscoring the point that many management regulations may not sufficiently encompass the diversity of vectors now in operation, their growing scale in time and space, and the diversity of living organisms potentially moving around the world at any given time.

Destinations

56. The ecological impact of an alien species -- whether it becomes invasive -- at its destination depends on what type of species it is and what ecological role it thus plays, and on additional factors such as:

- its initial success in establishment;
- its direction and rate of spread;
- its population dynamics and geographical distribution; and
- its interactions with native and economically beneficial organisms.

57. Whether a species becomes established depends especially on the competition that exists, leading some researchers to emphasize the importance of disturbance in providing temporary windows of opportunity for invasive plant species. Thus growing human disturbance of habitats around the world improves the likelihood of establishment of weeds; and this likelihood may be increased further with climate change.

58. Managing the problem of potential invaders requires interventions aimed at one or more of these elements. For example, at the source location, efforts can be made to avoid exports of species likely to become invasives. Pathways and vectors can be addressed through such measures as ensuring that potential invasive species are not carried in ballast water or in cargo containers. And measures to intercept and eradicate potentially invasive species once they have landed are

effective in some cases, as with quarantine efforts for some pathogens. GISP advocates a holistic approach to dealing with the problem of invasive alien species, including attention to sources, pathways, interception, and response at the destination. Action at the source of the potentially invasive organisms is best, because this leaves the other options available for species that slip through the prevention method.

A HOLISTIC APPROACH TO DEALING WITH THE PROBLEM OF IAS IS ADVISABLE, INCLUDING ATTENTION TO SOURCES, PATHWAYS, INTERCEPTION, AND RESPONSE AT THE DESTINATION. ACTION AT THE SOURCE OF THE POTENTIALLY INVASIVE ORGANISMS IS BEST, BECAUSE THIS LEAVES THE OTHER OPTIONS AVAILABLE FOR SPECIES THAT NONETHELESS INVADE.

59. Under GISP Phase I Richardson *et al.* (2000) developed the simple conceptualization of the invasion process as shown in Fig. 1 (here adapted to all IAS rather than only plants). Following this scheme, invasion is a process requiring a taxon to overcome various abiotic and biotic barriers. Phases of the process can be defined on the basis of the relevant barrier(s) that are (or are not) overcome. **Introduction** means that the species (or its propagule) has overcome, through human agency, a major geographic barrier (A in Fig. 1). Many introduced taxa survive as **casuals** (also "waifs", "persisting after cultivation"); such taxa can reproduce sexually or vegetatively, but fail to maintain their populations over longer periods and must rely on repeated introduction for their persistence. **Establishment** only starts when environmental barriers (B) do not prevent individuals from surviving and when various barriers to regular reproduction (C) are overcome; a taxon is successfully established after overcoming barriers A, B and C. At this stage populations are sufficiently large that the probability of extinction due to chance environmental events is low (MacArthur, 1972; Menges, 2000).

(Figure 1 from Richardson *et al*. to come)

60. Spreading of a species into areas away from sites of introduction requires that the introduced species also overcome barriers to dispersal within the new region (D) and can cope with the abiotic environment and biota in the general area (E). Many then spread into disturbed, semi-natural communities. Colonizing successionally mature, relatively undisturbed communities usually requires that the alien taxon overcomes resistance posed by a different category of factors (barrier F in Fig. 1).

4.2. Which taxa invade?

61. The species making up ecosystems respond to environmental changes in different ways, so the composition of any given ecosystem changes over time as species come and go. The species composition of an ecosystem at any given location and time depends on the current environmental conditions, levels and types of disturbance, balance of extinction and recruitment, and composition of the regional pool of species. Increasing levels of human transformation of ecosystems may accelerate the process of ecological change, and the dramatic increase in the deliberate and inadvertent transport of biota across the globe will increase the regional species pool. This combination of factors sets the stage for a radical alteration of ecosystem dynamics. Species that can take advantage of disturbances to colonize or expand their populations are often especially favoured. Since many invasive alien species are pre-adapted to disturbance, they often are able to out-compete the species native to the more mature ecosystems in the area.

62. Generally speaking, the abundance and geographical distribution of a species result from the balance between births, deaths, and movements across different environments. The distribution limits lie where the death rate begins to exceed the birth rate. When an invasive species enters a new habitat unaccompanied by its natural enemies, it benefits from "ecological release" that allows the species to reach much higher population densities than would occur in its natural range where it is constrained by various predators and competitors. Box 6 suggests some general ecological rules of invasion.

BOX 6: ECOLOGICAL RULES OF INVASION

- Of those species that are introduced, about 10% become established. Of those that become established, about 10% become invasive. So, as a rule of thumb, about 1% of introductions are likely to become invasive (Williamson, 1996).
- The probability of a species becoming invasive increases with the initial population size, so species introduced intentionally and marketed over a long period of time often have greater likelihood of establishment.
- Species having larger native geographic ranges are more likely to be invasive than those with smaller native ranges.
- A species that is invasive in one country or location is likely to be invasive in an ecologically or climatologically similar country or location.
- Species with specialized pollinators are unlikely to be invasive unless their pollinators are also introduced.
- Successful invasions generally require that the new habitat be compatible, especially in terms of climate conditions.

63. Species vary considerably in their potential for becoming invasive. A fairly robust set of "tools" has been developed for predicting which species of plants will invade and which will not, and the extent to which different systems are invaded (Box 7). Only a handful of people around the world are yet available to provide this "toolbox", so we are still a long way from having a system that could be operated by, for example, a customs inspector. Nor has this toolbox yet been applied systematically to insects, pathogens, or other taxa. Fundamentally, we are dealing with complex systems with numerous components involved, thus making it difficult to predict impacts with precision in the absence of detailed studies. Further, outcomes of invasions depend on the attributes of the invasive species as well as the vulnerability of the invaded systems, indicating the extreme complexity of such systems (Rejmanek *et al*., 2000).

BOX 7: KEY BIOLOGICAL POINTS FOR PREDICTING INVASIVENESS OF PLANTS

1. Within a genus, small genome size indicates plant invasiveness in disturbed landscapes.
2. Invasiveness of woody taxa in disturbed landscapes is associated with small seed mass, short juvenile period, and short intervals between large seed crops.

3. Vegetative forms of reproduction are an important factor, with the importance of this factor increasing with latitude.

4. Taxa belonging to genera not represented in the native flora are more likely to be invasive than alien taxa with close relatives in the native flora.

5. Plant species that depend on generalized pollinators and seed dispersers rather than specialized ones are more likely to be invasive.

6. Species with numerous, relatively small, soil-stored seeds are pre-adapted for human dispersal, and hence invasion.

Note: these generalizations, some of which explain rather than predict, are based on considerable data summarized in Rejmanek *et al*., 2000.

4.3. How rapidly do species invade?

64. It is important to know how fast a species can spread, because this rate defines how rapidly the impacts of the invader could escalate. The rate of spread is a function of both reproduction and dispersal, with species that reproduce quickly and spread easily moving much more rapidly. Disease organisms perhaps are the most rapidly-spreading of invasive species, because they can reproduce very quickly. For plants, determining the rate of spread requires detailed knowledge of the rare dispersal events that can send plants over an abnormally long distance. While the rate of dispersal is critical, other factors such as age of reproductive maturity, disturbance frequency, habitat disturbance, and fecundity also are significant. Seeds can be transported over long distances by water, wind, vehicles, or livestock, often at remarkably high speeds.

4.4. What is the ecological impact of IAS?

65. Every alien species that becomes established alters the composition of native biological communities in some way. Whether it becomes invasive (and thus harmful) depends on the particular characteristics of the alien species, the vulnerability of the host ecosystem and chance. The issue of establishment and spread of an alien species does not necessarily say anything about its potential ecological or economic impact.

66. The ecological impact of biodiversity loss due to IAS depends to a large extent on the link between native species and their contributions to ecosystem functions, such as pollination, seed-dispersal, or contribution to hydrological cycles. Whether the loss of any particular species or combination of species affects a given function depends on the number of alternative species that can support the function when the ecosystem is perturbed. Invasive species may be critical in undermining the buffering role played by ecological redundancy, though insufficient research has yet been done to provide authoritative advice on this question.

67. The changes to the state of ecosystems may be initiated by natural disturbance (storm, earthquake, volcanic eruption, fire, climate) or management regime, but are enhanced or accelerated by the invasion of alien species. The interlinkages between land transformation and invasions are illustrated diagrammatically in figure 2 (to come).

68. Data from countries where a species has previously invaded can provide useful information on invasion rate and speed, habitats prone to invasion, possible ecological and economic impacts as

well as approaches to management. This is the basis for the Early Warning System being established under GISP Phase I (Lowe and Clout, 2000).

4.5. Which types of ecosystems are susceptible to IAS?

69. While all ecosystems can be invaded (including well-protected national parks), some are more vulnerable than others. Urban-industrial areas, habitats suffering from periodic disturbance, harbours, lagoons, estuaries and the fringes of water bodies, where the effects of natural and anthropogenic disturbances are often linked, are particularly vulnerable to invasions (Kowarik, 1999). Systems with low diversity, for example islands and some arid ecosystems, are thought by some to be more susceptible to invasion than species-rich systems with well-established species interactions (Baldacchino and Pizzuto, 1996). However, species-rich landscapes can be susceptible to a greater range of invaders because of the greater diversity of habitats typical of such landscapes (Levine and D'Antonio, 1999) (Box 8).

BOX 8: ECOSYSTEMS PARTICULARLY VULNERABLE TO IAS

- Ecosystems naturally prone to fire (when fire-responsive propagules of aliens are available).
- Ecosystems that are geographically or evolutionarily isolated -- oceanic islands, certain lakes and mountains

.

- Agricultural ecosystems, which are essentially made by people
- Degraded and stressed ecosystems (through processes such as pollution, land clearance, and intensive exploitation).
- Inland water systems, especially those subject to thermal pollution.
- Enclosed marine systems, such as bays and estuaries.

70. We conclude that while virtually all ecological communities are susceptible to invasion to some degree, it appears that economic activities that disturb ecosystems increase the susceptibility of most. Therefore, the continuing expansion of economic activities is likely to increase the susceptibility of ecological communities to invasion.

4.6. Conclusions

71. The first SCOPE programme on biological invasions (Drake *et al*., 1989) was not successful in identifying general laws governing biological invasions, suggesting that scientists cannot predict -- at least at the present level of scientific understanding -- the impacts of invasive species based on general properties of either species or habitats (though some useful generalizations developed under GISP are presented in Boxes 6, 7, and 8). Understanding invasions depends on detailed knowledge of the species and habitats of interest, though of course this understanding builds on general properties of community structure. Experience suggests that extensive monitoring will be required to identify potential problems at a stage sufficiently early to enable effective response.

72. This lack of precise predictions of the behaviour, spread and impacts of alien species introduced into new environments is at least partly because too much of the data used to describe any given

situation is likely to be only guesswork. In many cases, even the taxonomic status regarding the IAS is unsolved and even dubious. This makes it essential to take an adaptive management approach, with results from early interventions modifying subsequent management investments.

THE CONTINUING EXPANSION OF ECONOMIC ACTIVITIES IS LIKELY TO INCREASE THE SUSCEPTIBILITY OF ECOLOGICAL COMMUNITIES TO INVASION.

73. The source populations of potential IAS, the pathways and the vectors that follow the pathway, and the destination regions are in a constant state of change and flux, permitting many new opportunities for species to become established. As the rate of change continues to accelerate with global trade, climate change, tourism, and habitat modifications in the name of development, the dynamism of this system is likely to grow, thus requiring a growing capacity to manage the impacts of such changes.

CHAPTER 5. THE MANAGEMENT RESPONSES TO THE PROBLEM OF INVASIVE ALIEN SPECIES

5.1. Introduction

74. At least partly because of ecological uncertainties and market imperfections, the risks of new introductions are typically borne by the state in the receiving country, governed by the quantity and effectiveness of resources committed to screening and the exclusion policy adopted (resources committed to detection and prosecution of non-compliance, incentive effects of the penalty regime, and so forth). Therefore, the management response to problems posed by IAS has become a central concern of many governments.

75. The two broad categories of potentially invasive alien species -- intentional and unintentional -- may require quite different responses, with the intentional introductions demanding effective quarantine and impact assessment, while the unintentional invasions may require such measures as effective monitoring, fumigation, and so forth.

76. Invasive species demand a special type of risk management, with the level of risk tending to increase as the management response declines. **Prevention** -- not allowing a potentially invasive species to become established in the first place -- is the first line of defence. Once an alien species has become a widespread invasive, the economic and often environmental costs of eradicating the invader, or even reducing it to a modest level, can be prohibitive, especially in landscapes that do not generate high economic returns. But once a species has invaded, management responses are mitigation and adaptation. **Mitigation** can reduce or eliminate the likelihood that a species will become established or spread, and decrease or eliminate the presence of an invader. **Adaptation**, on the other hand, involves changes in behaviour in order to reduce the impact of an invasive species. Prevention stops a bad event from happening; mitigation curtails the extent, duration, and impacts of a bad event; and adaptation reduces the consequence when a bad event is permitted to run its full course.

77. The control of invasive species has a strong public good element. Thus if control is left to the market, it is likely to be under-supplied. More important, the public good involved in the control of infectious diseases and many other invasive species is of the "weakest link variety", where the benefits from control to a whole society depend on the level of control exercised by the least effective member (Perrings and Williamson, 2000). For example, if control over a communicable disease involves eradication campaigns in all nations, that control will be only as good as the campaign run by the least effective nation.

THE POTENTIAL IRREVERSIBILITY OF THE COSTS OF INVASIONS AND THE UNCERTAINTY OF THE DAMAGES THEY MAY CAUSE FAVOUR A PRECAUTIONARY APPROACH TO THEIR MANAGEMENT.

78. Generally speaking, biological invasions are low probability events with a high potential cost. The probability that any one introduced species will become invasive appears to be somewhere around 1% (see Box 6), but the damage costs and costs of control of the species that do become invasive can be extremely high (such as the recent invasion of eastern Canada by the brown spruce longhorn beetle, which threatens the Canadian timber industry). Biological and economic factors can be used to assess the risk posed by a potential IAS, which then can be compared to the value of reducing the risk and the impact of additional risk of damages. The potential irreversibility of the costs of invasions and the uncertainty of the damages they may cause favour a precautionary approach to their management, tempered by a realistic appraisal of the costs and benefits of the options.

79. While the major invasive alien species that are pests in agriculture, forestry, and human health have been dealt with for many decades using well-known methods for prevention, mitigation and adaptation, the application of these methods to species that threaten natural habitats are still at an early stage.

80. Since introduced species differ in their reproduction, rates of spread, and impacts, managers need to establish clear priorities directed at excluding, monitoring, containing, eradicating, or controlling invasive alien species. Sound management strategies require an objective means for setting priorities, always a highly challenging task. For example, should a manager give higher priority to attacking the invader where it is most vulnerable, or to sites with high conservation value? Generally speaking, highest priority should go to infestations that are the fastest growing, most disruptive, and affect the most highly valued areas. Likelihood of success might also affect the priority. More detailed approaches to determining priorities are available in Wittenberg (2000).

5.2. Prevention

81. Prevention is the first and least costly line of defence, using tools such as those listed in Box 9. Many countries have established means of preventing the import of human pathogens and pest species of agriculture and forestry, as the essential minimum of any invasive species management programme. Ideally, no alien species should enter a country without going through an appropriate risk assessment process, following established environmental impact assessment (EIA) procedures. Of course, this is relevant only for planned introductions and depends on an appropriate exclusion apparatus (salary and training of interception personnel, plus facilities such as fumigation chambers, inspection apparatus, and quarantine quarters). At least some of these costs might be borne by individuals who wish to profit by bringing in alien species. It is also possible that some members of the public might have benefited from a planned introduction that is disallowed by the prevention apparatus, but the risk assessment process presumably would ensure that the public costs outweigh the public benefits in such cases.

PREVENTION IS THE FIRST AND LEAST COSTLY LINE OF DEFENCE

20. An important first step in prevention is to identify those alien species that may become invasive and therefore require special attention. These may be put on a "black list" and prohibited entry under national legislation. Species cleared for introduction through passing a risk assessment analysis can reasonably be declared as safe (put on a "white list"), though monitoring is still required to ensure that the prediction remains accurate over time. Further, because only about 10% of the world's species of organisms have been described, the vast majority of species are best considered an unknown threat to invade new environments (and therefore put on a "grey list") (Box 10). An important issue is when (how many years after arrival in a new region) a taxon can be declared to be "safe" (non-invasive), bearing in mind that lag phases of many decades are not unusual. One species of plant used as a hedge in South Africa was widely supported because it could replace a species that was highly invasive, but a few decades later, the "safe" species had become a serious invader in some areas.

82. Prevention can also work against unintentional introductions, involving measures such as border controls, quarantine, ballast water treatment, and so forth. And EIA of major development projects should include consideration of the extent to which conditions are established (through

new roads, plantations, irrigation systems, and so forth that will facilitate unintentional invasions.

BOX 9: TOOLS TO PREVENT INVASIONS

- Public information
- Risk assessments and environmental impact assessments
- National and international regulations on prevention measures and their enforcement with inspections and fees
- Treatment of imported commodities, including through fumigation, immersion, spraying, heat and cold treatment, and pressure
- As a last resort, trade prohibition based on international regulations under the WTO Sanitary and Phytosanitary Agreement.

5.3. Mitigation

83. Mitigation can include **eradication** (eliminating the IAS completely); **containment** (keeping the IAS within regional barriers); or **suppression** (reducing population levels of the IAS to an acceptable threshold). A critical first step in a mitigation programme is to determine the management goal. For example, is it the intention to eradicate the IAS, or to reduce it to a certain level? If the latter, to which level will it be reduced, and how will it be maintained at such a level? The management objective should also specify the geographic areas for attention, in priority order. Once the objective has been agreed among all interested parties, a plan needs to be devised for achieving the objective, involving research, surveys, identification of control options, implementation, monitoring, and follow up.

BOX 10: A SPECTRUM OF LISTS

Listing of species is one effective tool for dealing with IAS issues (Wittenberg, 2000; Shine and Gündling, 2000). Such lists can include:

- Black lists: species known to be invasive and so destructive that their introduction should be prohibited.

- White lists: species known on the basis of stringent criteria to have such a low probability of invasion that they can be introduced.

- Grey lists: the great majority of species whose probability of becoming invasive is unknown.

84. Eradicating the entire population of an IAS within a managed area is often the most desirable output, and has proven feasible in at least some situations (especially on islands). Because the cost of eradication increases dramatically the longer a species has become invasive, it is important that eradication be initiated as soon as potentially invasive species are detected. This can be done only if plans exist, along with appropriate government permits, trained personnel, equipment, and allocated funding (much like oil spill contingency plans available in many countries).

85. Numerous approaches to eradication have been developed, including mechanical, chemical, biological habitat management, and a combination of methods (Box 11). While eradication may

involve high initial economic costs, if eradication is achieved it is invariably more cost-effective than any measure that requires continuous expenditure over long periods of time. On the other hand, eradicating the last few individuals might be exceedingly expensive; for example, malaria "eradication" programmes in tropical countries have proven very cost-effective in the early stages but the last stage has seldom been achieved.

BOX 11: DESIGNING A SUCCESSFUL ERADICATION PROGRAMME

- Base the programme on science.
- Ensure that eradication of all individuals is achievable.
- Build support from the public and all relevant stakeholders.
- Ensure that the legal and institutional framework is sufficient for dealing with the issue.
- Secure sufficient funding.
- Ensure that all individuals of the target population are susceptible to the eradication technique being used.
- Ensure through prevention measures that the immigration of the target species into the area is zero
- Put in place a method to detect the last survivors.
- Include a subsequent monitoring phase to ensure that eradication has been achieved, and to prevent re-invasion.
- Ensure that methodologies/techniques are environmentally, socially and ethically acceptable.
- Include any necessary measures to restore ecosystems after eradication.

86. The high cost of eradication of an established IAS suggests that resources should be devoted to prevention of invasive aliens and early detection of potential invasive species before they can spread. Early detection of an invasive species of pathogen, plant, or animal can make the difference between being able to employ feasible offensive strategies (eradication) and the necessity of retreating to a defensive strategy that usually requires an open-ended financial commitment. The Early Warning System being developed under GISP could be a critical element of such a rapid response mechanism (Lowe and Clout, 2000).

87. If an invasive species is already widespread, then species-specific biological control may be the only practical way of going on the offensive. Biological control introductions are thought to be completely successful in 10 to 15% of efforts against arthropods, while perhaps 30 to 40% have achieved their objective against weeds. Economic analyses of successful biological control programmes have shown that they have a positive cost-benefit ratio, though some failed efforts have had disastrous ecological impacts. Modern safety standards of biological control are very rigorous, requiring a high specificity of the agents proposed and involving extensive laboratory

and field screening tests. Biological control is often the only means that is self-sustaining over the longer term, and the least disturbing in areas highly valued for biodiversity (e.g., national parks).

88. Control of an IAS reduces its population density to an acceptable level, where the ecological or economic harm it causes is minimal. At such a low level, native species may be allowed to regain ground and perhaps even further diminish the abundance of the IAS.

BOX 12: CONTROL OF INVASIVE ALIEN SPECIES: A TOOLBOX

Many methods are available for controlling IAS, as detailed in Wittenberg (2000). These tools can be applied individually or in various combinations. Given the high complexity of the ecology of invasive species and habitats affected, control measures need to be applied with the fullest possible scientific understanding.

- *Mechanical control*. Involves directly removing the species by hand or with appropriate machines such as harvesting vehicles (e.g., for water hyacinth) or firearms (e.g., for large mammals), or traps (for animals).

- *Chemical control*. Involves the use of herbicides, insecticides, and rodenticides that primarily affect the target species, are delivered in a way that avoids the potential problem of resistance developing over time, and do not accumulate in the food chain. The development of pesticide-resistant strains of pests, diseases and weeds may remove the chemical management option for their control.

- *Biological control*. Involves the intentional use of populations of natural enemies of the target invasive alien species or other methods that include, for example, mass release of sterile males of the target species, inducing resistance in the host against the IAS that is attacking it, releasing a natural enemy to control the IAS. It is essential to ensure that the biological control does not in turn become itself invasive.

- *Habitat management*. Involves measures like prescribed burning, grazing, and so forth.

- *Integrated pest management* (*IPM*). Involves a combination of the methods described above, based on ecological research, regular monitoring, and careful coordination. Likely to achieve the best results in many situations.

5.4. Legislation to support management of IAS

89. Legal frameworks are essential to support efforts to manage IAS, working at both national and international levels. GISP has produced a guide for designing legal and institutional frameworks on invasive alien species (Shine, Williams, and Gündling, 2000), seeking to provide an essential tool in this regard. Any legal framework at the national level needs to include adequate provisions for mitigating the impacts of IAS, a challenge that faces numerous constraints.

90. The “invasive” classification is quite separate from jurisdictional or administrative boundaries. If an alien species is invasive, it will not stay within the boundaries of the ecosystem, municipality or region to which it was introduced. One consequence for legal systems is that

site-specific restrictions (for example, a prohibition on introducing alien species in protected areas) can never be more than a partial strategy for preventing or mitigating impacts of invasions. Thus, we need regional collaboration between countries in regard to IAS.

91. A number of legal principles have been developed for dealing with problems of invasive alien species. Several of these are listed in Box 13, and further guidance is available from Shine, Williams, and Gündling (2000).

BOX 13: SOME LEGAL PRINCIPLES, APPROACHES, AND TOOLS FOR DEALING WITH INVASIVE ALIEN SPECIES

The *precautionary principle* or *precautionary approach* holds that "lack of full scientific certainty shall not be used as a reason for postponing cost effective measures to prevent environmental degradation" (Rio Declaration) or, lack of scientific certainty shall not be used as a reason to postpone measures to avoid or minimize a threat of significant reduction or loss of biodiversity (CBD).

The *principle of prevention* states that the protection of the environment is best achieved by preventing environmental harm rather than by attempting to remedy or compensate for such harm.

The *principle of prior informed consent* calls on decision-makers to ensure that potentially affected parties are aware in advance of the potential threat from invasive alien species, through measures such as permits, certificates, and other administrative procedures and measures.

The *principle of burden of proof* states that once a reasonable case is made that a risk of harm exists, the burden of proof is on the introducer of an alien species to demonstrate that the risk of invasion is minimized or eliminated.

5.5. Conclusion

92. Controlling or eradicating IAS is not a management goal in itself, but only one means to achieve higher goals, such as the conservation of biological diversity, protection of human health, and prevention of economic loss. Elements of this goal might include habitat restoration, preservation of relatively undisturbed ecosystems, reinstallation of the natural succession rate and time, and establishment of sustainable use of ecosystem services for local people. Where habitat restoration efforts support native species and put intact natural systems back in place, the IAS may fortuitously be driven to extinction (though few examples of this are yet available).

93. The classic method for evaluation of management options is benefit-cost analysis. This requires that the expected present value of the benefits of the control programme (that is, the net costs avoided by the control programme) are no less than the expected present value of the costs of control (the foregone benefits of the programme). While strategies to control invasive species are faced with the problem of uncertainty in the effectiveness of different management options, it is still reasonable to evaluate public investment in management options using a benefit-cost framework (Box 14). But where the costs of error are potentially very high, the management effort must protect the capacity of the system to absorb the stresses and shocks of biological invasions.

BOX 14: COST-BENEFIT RATIOS FOR MANAGING IAS IN THE USA (BASED ON

OTA, 1993) (DOLLAR FIGURES IN MILLIONS)			
IAS	Benefits of control/ prevention/eradication	Costs	Ratio
Melaleuca	183	16	11.4/1
Water hyacinth	3.8	.28	13.6/1
Sea lamprey	296	9.8	30/1
Alfalfa blotch leafminer	17	2.	8.5/1
Purple loosestrife	53	2.	26.5/1
Mediterranean fruitfly	1,829	93.	19.6/1
Foot and mouth disease	25,275	1,013.	25/1
Siberian log imports	64,704	39.	1659/1

94. Managing invasive species delivers clear economic benefits. This leads to greater social and political recognition of invasive alien species as a problem worthy of concern, a key factor in determining the extent to which they are dealt with effectively.

CHAPTER 6. TEN STRATEGIC RESPONSES TO THE PROBLEMS OF INVASIVE ALIEN SPECIES

95. Under the Convention on Biological Diversity, the Conference of Parties agreed a set of interim Guiding Principles (Annex 3), to which GISP has contributed. Keeping these in mind, we have developed a set of strategies for enabling the modern global society to respond to the challenge of invasive alien species.

STRATEGY 1. BUILD CAPACITY TO ADDRESS INVASIVE ALIEN SPECIES PROBLEMS

96. Even with well-designed legislation, political will, plentiful information, and sound policies, the problem of invasive alien species will be addressed successfully only if the national capacity has been developed for doing so. And because the problem is a global one, involving virtually all nations, a vigorous international response to building management capacity in all countries clearly is a high priority. This might include elements such as the following:

- Designing and establishing a "rapid response mechanism" to move quickly to eradicate potentially invasive species as soon as they appear; much like oil spill contingency mechanisms, this should include the necessary government permits, trained personnel, equipment, and allocate funding.

- Designing, supporting, and holding training courses for building capacity to deal with invasive alien species, including:

    - The generic issue of the threat posed by invasive aliens to native biodiversity (i.e., widening the focus from agricultural or economic aspects to include threats to native biodiversity.

    - Identification of invasive alien species (relevant to that geographic area).

    - Management methods of invasive species including prevention, eradication and control methods.

    - The use and potential of GISP's expanded Early Warning System (including database, predictive capacity etc.).

    - Risk assessment and environmental impact assessment.

    - Development and use of blacklists/white lists/grey lists.

    - Ecosystem restoration (relevant to the invasive issue).

    - How to engage key audiences in IAS management programmes, including through social marketing techniques.

- Using appropriate pilot projects (e.g., particular illustrative invasive or flagship native species at risk) for dual purposes of capacity building and public awareness raising.

- Establishing IAS specialist positions in natural resource management agencies.

- Ensuring that all those involved in agricultural quarantine or food inspection are made aware of the provisions of the CBD and its Biosafety Protocol, and the implications of these provisions for their work. While risk assessment and testing procedures may be acceptable from an agricultural perspective, they may be fundamentally flawed from the ecological perspective advocated under the CBD.

- Creating academic chairs and student fellowships in invasive species biology.

STRATEGY 2. BUILD RESEARCH CAPACITY

97. Work carried out under GISP Phase I has revealed that knowledge about invasive alien species is inadequate to enable accurate risk assessment and design of effective management responses. Research into various aspects of IAS remains a top priority for governments, because the problem of IAS is essentially an intergovernmental global concern, requiring close collaboration among all countries to address the problem effectively. Research priorities include:

- developing and improving techniques to prevent IAS introductions.

- developing and improving techniques to detect and monitor incipient populations of IAS.

- developing and improving techniques to eradicate and control IAS (such as species-specific toxins and diseases).

- developing for wider application a modified version of the host-pathogen-environment framework used by the community of scientists working on plant pathology.

- expanding research in systematics (including taxonomy), thereby building the capacity to identify, record and monitor invasions and up-date lists (an international committee to update taxonomic nomenclature for all IAS would be helpful).

- building a better understanding of the relationships among climate change, enhanced carbon dioxide, soil moisture availability, photosynthetic pathways, and plant population dynamics.

- developing a better understanding of geographical limits of species distributions.

- finding ways of making assessments that include an approximate measure of likely second-order impacts without having to fully understand the full web of interactions, for example through inferring likely disruptive changes based on a comparison of the geographical distributions of the various species concerned in any particular interaction.

- improving the basis on which biological control strategies are evaluated, and the basis for valuing the potential impacts of species introductions.

- investigating the role of biological factors vs. freak events that mediate long-distance dispersal.

- improving the understanding of how and why species establish and change into invasive species.

- assessing ways to predict the likely impact of a given invasive taxon in a given locality so that the importance of such an impact can be compared objectively with that of another taxon at a different locality.

- developing predictive indicators of invasive alien species impacts.

- developing lists (black, grey, and white) of invasive alien species at national, regional and global levels that are easily accessible to all interested parties.

- developing better methods for excluding or removing alien species from traded goods, packaging material, ballast water, personal luggage, aircraft and ships.

- developing effective, target-specific, humane and socially acceptable methods for eradication or control of invasive alien species.

- improving identification and management of pathways leading to unintentional introductions.

- characterizing differential effects of alien species on different human groups.

- developing a risk analysis model for biological introductions, concentrating on accidental introductions. This model should blend approaches based on biological species with those based on the pathway of introduction, rapidly and efficiently focus attention on the few risky activities without creating excessive costs for less risky ones, effectively characterize all environmental risks associated with those identified potentially risky activities and enable decisions that are supported by all interested parties, and adapt to changes in transportation mode or changes in the structure of the originating or receiving landscapes.

STRATEGY 3. DEVELOP ECONOMIC POLICIES AND TOOLS FOR ADDRESSING PROBLEMS OF INVASIVE ALIEN SPECIES

98. Nearly all invasions are consequences of economic behaviour and have economic impacts. And virtually every aspect of IAS management, including prevention, mitigation, and adaptation, has important economic dimensions. Therefore, economics must be central to any effort to address IAS, and integrated into all relevant activities. Key elements will include:

- research into valuation of invasives, understanding the economic-ecological dynamics of invasions, economic risk and uncertainty of invasions, and economic factors that encourage species invasions;

- assessment and prediction of economic risks of IAS;

- change the structure of incentives that influence those whose behaviour determines the spread of an invasive species;

- valuation of methods to mitigate the negative impacts of IAS, as an input into benefit-cost analysis;

- development of appropriate incentives for preventing, mitigating, and adapting to IAS; and

- identification of the full costs of IAS as a means of ensuring that those important potential invasives have a means of assessing their liability.

- development of new economic instruments. In the case of potentially invasive species, an environmental assurance bond could require importers of new species to post a bond equivalent to the conjectured damage if the species were to become invasive; the bond would be refunded if it could be shown that the risk was unfounded, or used to fund an eradication or control campaign if the risks were realized. Other incentives could include mandatory insurance, taxes and levies, and charges for permit applications, risk assessment, and EIA (see Perrings and Williamson, 2000).

STRATEGY 4. STRENGTHEN NATIONAL, REGIONAL AND INTERNATIONAL LEGAL AND INSTITUTIONAL FRAMEWORKS TO ADDRESS INVASIVE ALIEN SPECIES

99. Few countries have developed comprehensive legal and institutional systems that are capable of responding effectively to the new flows of goods, visitors and alien species described in this strategy. Strategies at the national level should aim to develop and strengthen national legal and institutional frameworks that will:

- implement and enforce, in a synergistic manner, international and regional instruments and standards, especially sanitary and phytosanitary measures and transport controls, for the international movement of alien species;

- establish legal mechanisms parallel to those used in oil and chemical spills to render parties who caused the introduction of IASs responsible for the costs of eradication or control;

- integrate alien species issues into national strategic planning processes to identify all sectors, pathways, government agencies, and stakeholders, to promote cooperation and coordination among all interested parties;

- review existing policy, legal and institutional measures to identify and correct gaps, weaknesses and inconsistencies;

- establish an appropriate set of property rights in natural resources (along with their supporting institutions); a compensation mechanism; and a supporting structure of incentives and disincentives to induce the desired response;

- distinguish between instruments for the prevention of species introductions and the control of introduced species that have become invasive;

- ensure that all categories of species, all sectors, all ecosystems and the full range of activities, vectors, and pathways that may result in the introduction of alien species are covered in the relevant national and sub-national legislation;

- harmonize relevant sectoral laws and regulations to ensure the absence of conflicting provisions and promote uniformity and consistency;

- require the establishment of a coordinating agency(ies) to provide a framework with other administrations and agencies with relevant powers or duties, and/or to ensure consistency in implementation, oversight, monitoring and compliance;

- apply preventive and precautionary approaches, using risk analysis, EIA, permits, or other appropriate tools, to control introductions into a country or province;

- provide control measures to strictly regulate and minimize the introduction of alien species, that may become invasive, at the point of origin (export), destination (import) or both;

- strictly regulate the movement and release of alien invasive species domestically, especially in or near closed or vulnerable ecosystems, geographically or evolutionary isolated ecosystems, and protected areas;

- provide for monitoring, early warning and emergency planning systems to support rapid responses when biological invasions are detected;

- provide for the establishment of cost-effective preventive and mitigation measures tailored to national conditions and capacity, building where possible on the contribution that local communities and other stakeholders can provide;

- require timely measures for the short and long-term eradication or control of species that are already or may become invasive, subject as necessary to prior risk assessment of techniques to be used, and provide for the restoration of degraded ecosystems and, where appropriate, re-establishment of native species formerly present on national territory;

- provide incentives, positive and negative, to strengthen compliance and accountability by public, commercial and private actors, and support the progressive elimination of "perverse incentives" that result in the introduction of alien species; and

- support research, training, education and public awareness.

100. A considerable number of international agreements, non-binding soft-law documents and codes of conduct deal specifically with the introduction, eradication and control of non-indigenous species, pests, and/or invasive alien species. Over 40 are already in force (see Annex 2) and about a dozen others have been agreed but are not yet in force. However, no binding instrument has yet been developed that deals with the full spectrum of invasive alien species introduction, eradication and control. GISP therefore:

- Encourages detailed review of differences, inconsistencies or gaps between the requirements and/or aims of the major international instruments that currently deal with invasive alien species with a view to encouraging resolution of such inconsistencies/differences/gaps.

- Encourages full discussion of a more comprehensive approach, including consideration of a protocol under the Convention on Biological Diversity.

- Supports the work of IMO to develop a legal instrument on marine invasives and encourages similar developments in other sectors.

STRATEGY 5. INSTITUTE A SYSTEM OF ENVIRONMENTAL IMPACT AND RISK ASSESSMENT FOR INVASIVE ALIEN SPECIES

101. Environmental Impact Assessment (EIA) procedures and risk assessment already have been adopted in many countries. The challenge now is to apply these both internationally and nationally to at least the problem of intentional introduction of alien species that might become

invasive. This should involve shifting the burden of proof to those proposing the intentional introduction of a potentially invasive species. They would need to provide conclusive evidence of the safety of the species before it can be introduced, using an accepted risk assessment process. Elements might include:

- Reviewing the WTO and IPPC risk assessment criteria to ensure compatibility of national law with international criteria.

- Developing test risk analysis, building on work undertaken by the plant and animal protection community.

- Developing criteria to measure and classify impacts of alien species on natural ecosystems, recognizing that they are dynamic assemblages.

- Assessing vulnerability based on work carried out by the climate change community under the Intergovernmental Panel on Climate Change (IPCC).

- Developing a rigorous process of risk assessment in relation to any deliberate introduction of species to new areas (not just between countries, but within a country or region as well), including detailed analysis of the balance between benefits and costs. This assessment would allow more informed decision-making in relation to species introductions.

- Factoring invasive species into the decision-making processes surrounding land use planning and development. Given that land use changes provide prime opportunities for invasion, the potential risks, costs and benefits need to be considered more explicitly in environmental impact assessments. Appropriate tools need to be developed for doing so.

- Developing detailed protocols for addressing the likelihood of invasion in specific habitats or ecosystems. Where prediction protocols exist for landscapes comprising mosaics of ecosystems, predictions for the most vulnerable system in the landscape should dictate management decisions (Rejmanek *et al.*, 2000).

- Investigating ways in which EIA can be applied to unintentional introductions. For instance, assess large engineering projects, such as canals, tunnels and roads that cross biogeographical zones, that might mix previously separated flora and fauna and disturb local biological diversity. Legislation requiring environmental impact assessment of such projects should require an assessment of the risks associated with unintentional introductions of invasive alien species.

STRATEGY 6. BUILD PUBLIC AWARENESS OF THE PROBLEM OF INVASIVE ALIEN SPECIES

102. Many citizens, key sector groups and governments have a poor understanding of the magnitude and economic costs of the problem. As a consequence, responses are too often piecemeal, late and ineffective. Therefore:

- In those countries where it is an issue, emphasize the public awareness raising that will assist in the understanding of the need for eradication, so that opportunities are not lost due to public lack of understanding and support.

- Develop a public relations campaign for invasive alien species. A plan for this campaign would include thorough assessment of the potential audiences, a clear definition of the objectives, development of key messages, and an overall strategy to ensure that messages are consistent but uniquely persuasive to each audience. The plan would seek to remove barriers -- real or imagined -- that prevent people or institutions from changing their behaviour, providing positive incentives to motivate people to change. Detailed guidance on preparing such a plan is available from Academy for Educational Development (1999).

- Put in place sufficient and adequate public information campaigns that describe in direct, simple terms what are the concerns of invasions of alien species, and why these must be managed.

- Ensure that people are aware of the full cost of their behaviour in relation to invasive species wherever the risks are known; and protect key thresholds where the costs of crossing those thresholds are uncertain but are conjectured to be high and/or irreversible.

STRATEGY 7. PROMOTE SHARING OF INFORMATION ABOUT INVASIVE ALIEN SPECIES

103. Considerable information about IAS is now available. GISP has identified nearly 120 major sources of information on invasive species that are accessible electronically (Lowe, 2000). Even so, the information that could alert management agencies to the potential dangers of new introductions frequently is not known, or is not widely shared or available in an appropriate format to enable many countries to take prompt action (assuming they have the resources, necessary infrastructure, commitment and trained staff to do so). Information sharing therefore requires greater attention, including:

- Building a monitoring system that will enable scientists to keep a sensitive finger on the pulse of regional biodiversity change, both in order to understand the scale of inflow of alien species, and to detect invasions at a sufficiently early stage to facilitate their control.

- Establishing an equivalent to the Center for Disease Control (based in Atlanta, USA, it maintains a major database on human diseases) that would provide data on the distribution, impact, movement and risks of invasive species.

- Facilitating workshops on the biology and management of specific IAS or groups of related IAS (such as rodents, grasses, cats and other small predators, marine organisms).

- Developing GISP's Early Warning System to identify new occurrences of invasive species (see Lowe and Clout, 2000, for details).

- As part of the GISP Early Warning System, establishing a database on documented invasions, as a means of informing all interested parties whether species imports of a species should be prevented and to establish priorities for control of those that have already become established.

- Establishing a database on failure and success of different eradication and control methods to ensure that all can learn from the experience. (Until reliable prediction systems are developed, such case studies have the highest predictive power).

- Establishing an international invasive species data centre, including taxonomists, GIS-oriented biogeographers, weed scientists, and a database manager, associated with major research institutions with large reference collections and extensive libraries.

- Establishing a series of linked regional or national databases on the distribution of IAS and their eradication and control.

STRATEGY 8. BUILD RESPONSES TO INVASIVE ALIEN SPECIES INTO OTHER RELEVANT SECTORS

104. The problems posed by invasive alien species are not simply the responsibility of a ministry of environment or a natural resource management department. Rather, the problem is spread through many economic sectors, both public and private. Successfully addressing the problems of IAS will require effective collaboration among these various institutions. Strategic elements to ensure such collaboration might include:

- Promote cooperation within each country among sectors whose activities have the greatest potential to introduce IAS, including public health, the military, development sector, forestry, agriculture, aquaculture, the shipping industry, tourism, wildlife agencies, and agencies responsible for water supply.

- Promote cooperation within each country between government officials with responsibilities or authorities over phytosanitary, health, environmental, trade, tourism, and other fields relevant to invasive alien species.

- Build collaboration between the different scientific communities that can contribute to addressing invasive species problems, combining these to produce a framework for the assessment of vulnerability of systems or geographical regions to invasive species.

- Bring the invasives issue to the attention of the World Trade Organization and others responsible for setting world trade policy.

- Establish close links between public health agencies (including WHO) dealing with invasive pathogens and those dealing with other parts of the IAS issue, with a view to exchanging information about effective management approaches.

- Work with the wide range of relevant international trade authorities and industry associations, with the goal of significantly reducing the risk that trade, travel, and tourism will facilitate the introduction and spread of invasive alien species.

- Encourage and contribute to the development of collaborative industry good practice guidelines or codes or conduct, which minimize or eliminate unintentional introductions.

- Apply experience in agricultural, forestry, and human health systems in combating invasive alien species to natural systems. For example, use quarantine facilities for agriculture to serve more broadly for all environmental pests.

- Encourage organizations like the International Tropical Timber Organization (ITTO), the World tourism Organization, and the Food and Agriculture Organization(FAO), and UNESCO to build invasive alien species elements into their programmes.

STRATEGY 9. BUILD INVASIVE ALIEN SPECIES ISSUES INTO GLOBAL CHANGE PROGRAMMES

105. Humans currently are changing the Earth in unprecedented ways, particularly by modifying the composition of the Earth's atmosphere, by transforming our planet's ecosystems and by utilizing and altering the composition of the world's freshwater supplies, marine fisheries, and other natural resources. An important component of these global changes is the movement of species around the globe both deliberately and inadvertently. Coupled with increased opportunities for species to invade modified ecosystems, this makes it likely that local species compositions will change dramatically. Because invasive species have the potential to have significant impacts on both natural and managed systems, invasive species themselves are an important element of global change. In response:

- Establish effective monitoring programmes of climatic trends and their ecological consequences, and couple these with modelling to ensure that adaptive management measures are progressively more relevant to the needs of managing invasive species.

- Assess potential impacts of invasive species on projections that incorporate likely changes in climate and land use.

- Develop means of considering potential scenarios based on multiple levels of uncertainty. Even qualitative analyses of likely outcomes can provide useful input to decision-making processes.

STRATEGY 10. PROMOTE INTERNATIONAL COOPERATION TO DEAL WITH PROBLEMS OF INVASIVE ALIEN SPECIES

106. Biological invasions typically involve two or more countries, with the actions of one affecting the welfare of others. Thus biological invasions involve a transboundary externality. Similarly, where the costs of failure to control invasives affect more than one country, the solution requires international cooperation. Annex 2 indicates some of the opportunities for discussion on synergies between and among the various international agreements dealing with IAS, and provides a basis for working with other international agreements and institutions on the development of effective tools and mechanisms on the introduction, eradication and control of invasive alien species. Elements might include:

- an international vocabulary, widely agreed and adopted. Note that the IPPC is currently promoting an initiative to encourage national agencies to employ the internationally accepted phytosanitary vocabulary to facilitate communication. Wherever available, internationally agreed terminology and standards should be used in implementing legislation and regulations.

- developing harmonization and linkages among the international institutions dealing with phytosanitary, biosafety, and biodiversity issues related to invasive alien species.

BOX 15: INTERNATIONAL MARITIME ORGANIZATION AND INVASIVE ALIEN SPECIES

(to be completed, but to cover the various kinds of activities relating to marine and coastal invasives).

107. Invasions often are relevant to biogeographical areas, not just jurisdictional country boundaries. Hence neighbouring countries need to cooperate, and in general, regional approaches to management need to be encouraged including:

- Working towards regional invasive strategies
- Regional development of information requirements
- Regional cooperation in prevention, eradication or control
- Regional consultation in risk assessments
- Regional cooperation in technologies/capacity building.

108. Because IAS have become an issue of considerable global concern, encourage bi-lateral and multi-lateral donor agencies must be encouraged to

- support activities relating to sectoral and national policies on invasive species
- review their planning processes with a view to ensuring that the programmes they support will not include the intentional introduction of invasive species and minimize unintentional ones.

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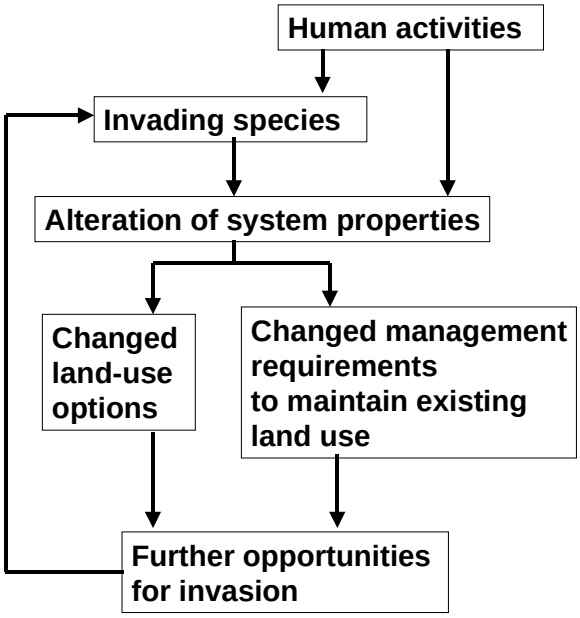

Figure 4: Interrelationships between human activities (management of ecosystems) and invasions (from Hobbs, 2000).

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ANNEX 1
DEFINITIONS OF KEY TERMS

The following terms have been adopted for this strategy, drawing from work done under GISP Phase I. Governments have not yet adopted consistent terminology in this field, so these definitions should be considered provisional until "official" terms are adopted. At national and subnational level, precise use of terms is very important. Definitions underpin most operational components of legal frameworks, including:

- the scope of powers and duties conferred on the competent authorities;
- the basis for listing species, excluding consignments at the border, restricting internal translocations, monitoring and implementing control strategies;
- the formulation of technical criteria to guide decision-making and risk assessments;
- the application of restrictions or incentives to particular activities or actors;
- criminal offences, which must be drafted in precise language if individual or corporate conduct is to be capable of prosecution and judgement in the courts.

Definitions therefore go to the heart of legal certainty. All actors, from quarantine personnel to shippers, traders and farmers, need to know where they stand. Consistent use of terms also helps to build awareness of invasive species problems.

Alien species (synonyms: non-native, non-indigenous, foreign, exotic): a species, subspecies, or lower taxon introduced outside its normal past or present distribution; includes any part, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce.

Biosecurity: The management of risks posed by organisms to the economy, environment and people's health through exclusion, mitigation, adaptation, control, and eradication.

Casual alien species: Alien species that may flourish and even reproduce occasionally in an area, but which do not form self-replacing populations, and which rely on repeated introductions for their persistence (Richardson *et al*., 2000).

Containment: keeping the IAS within regional barriers.

Eradication: the extirpation of the entire population of an alien species in a managed area; eliminating the IAS completely.

Establishment: the process of a species in a new habitat successfully reproducing at a level sufficient to ensure continued survival without infusion of new genetic material from outside the system.

GMO/LMO: A genetically-modified organism/living modified organism is a species whose genetic makeup has been purposefully altered by human technology. When the resulting organism is sufficiently different from its nearest relative to be considered a "new species", then it can be considered an alien species. These are addressed under Article 8(g) of the CBD.

Intentional introduction: the purposeful movement by humans of a species outside its natural range and dispersal potential (such introductions may be authorised or unauthorised) (IUCN, 2000) (c.f. unintentional introduction).

Introduction: the movement, by human agency, of a species, subspecies, or lower taxon (including any part, gametes, seeds, eggs, or propagule that might survive and subsequently reproduce) outside its natural range (past or present). This movement can be either within a country or between countries (IUCN, 2000).

Invasive alien species: an alien species whose establishment and spread threaten ecosystems, habitats or species with economic or environmental harm. These are addressed under Article 8(h) of the CBD.

Native species (synonym: indigenous species): a species, subspecies, or lower taxon living within its natural range (past or present), including the area which it can reach and occupy using its own legs, wings, wind/water-borne or other dispersal systems, even if it is seldom found there.

Naturalized species: alien species that reproduce consistently (cf. casual alien species) and sustain populations over more than one life cycle without direct intervention by humans (or in spite of human intervention); they often reproduce freely, and d o not necessarily invade natural, semi-natural or human-made ecosystems.

Pest: "Any species, strain or biotype of plant, animal or pathogenic agent injurious to plants or plant products" (IPPC).

Suppression: reducing population levels of the IAS to an acceptable threshold.

Unintentional introduction: a species utilising unwitting humans or human delivery systems as vectors to disperse and become established outside its natural range (IUCN, 2000).

Weeds (synonyms: plant pests, harmful species; problem plants): Plants (not necessarily *alien)* that grow in sites where they are not wanted and have detectable negative economic or environmental effects; alien weeds are invasive alien species.

ANNEX 2
INTERNATIONAL AND REGIONAL INSTRUMENTS AND INSTITUTIONS WITH PROVISIONS/PROGRAMMES/DECISIONS/RESOLUTIONS PERTAINING TO ALIEN INVASIVE SPECIES

Instrument/Institution	Relevant Provisions/Decisions/Resolutions
1. Convention on Biological Diversity (Nairobi, 1992) http://www.biodiv.org	Article 8 (h) 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".
2. Cartegna Protocol on Biosafety to the Convention on Biological Diversity (Montreal, 2000) http://www.biodiv.org	Protocol's objective is to contribute to ensuring adequate level of protection in the safe transfer, handling and use of living modified organisms resulting from modern biotechnology that may have adverse effects on the conservation and sustainable use of biological diversity.
3. United Nations Convention on the Law of the Sea (Montego Bay, 1982) http://www.un.org/Depts/los/losconv1.html	Article 196 States to take all measures necessary to prevent, reduce and control the intentional or accidental introduction of species, alien or new, to a particular part of the marine environment, which may cause significant and harmful changes thereto.
4. The Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar, 1971) http://www.ramsar.org	COP7 -- Resolution VII.14 on Invasive Species and Wetlands
5. Convention on Migratory Species of Wild Animals (Bonn, 1979) Http://www.wcmc.org.uk/cms/	Range State Parties of Endangered Migratory Species (Annex 1) to the extent feasible and appropriate endeavour to prevent, reduce or control factors that are endangering or likely to further endanger the species, including strictly controlling the introduction of or controlling or eliminating already introduced exotic species. (Article III (4)(c)) Agreements for Annex II Migratory Species "where appropriate and feasible should provide for strict control of the introduction of, or control of already introduced exotic species detrimental to the migratory species". (Article V (5)(e))
6. Agreement on the Conservation of African-Eurasian Migratory Waterbirds (The Hague, 1995) Http://www.wcmc.org.uk/cms/aew_bkrd.html	Parties shall prohibit the deliberate introduction of non-native waterbird species into the environment and take all appropriate measures to prevent the unintentional release of such species if this introduction or release would prejudice the conservation status of wild fauna and flora; when non-native waterbird species have already been introduced, the Parties shall take all appropriate measures to prevent these species from becoming a potential threat to indigenous species. (Article III(2)(g)) Action Plan §2.5 Parties to prohibit non-native animal and plant introductions if detrimental to listed species, to take precautions to prevent accidental escape of captive non-native birds, and to take measures to ensure that already introduced species do not pose a potential hazard to listed species.

Instrument/Institution	Relevant Provisions/Decisions/Resolutions
7. Convention on the Law of Non-navigational Uses of International Watercourses (New Work, 1997) Http://www.un.org	Watercourse States shall take all necessary measures to prevent the introduction of species, alien or new, into an international watercourse. (Article 22).
8. International Plant Protection Convention (Rome, 1951, as amended in 1997) http://www.fao.org/legal/treaties	Creates an international regime to prevent spread and introduction pests of plants and plant products through the use of sanitary and phytosanitary measures by Contracting Parties. Parties have national plant protection organisations established according to the Convention with authority in relation to quarantine control, pests risk analysis and other measures required to prevent the establishment and spread of all invasive alien species that, directly or indirectly, are pests of plants and plant products. Parties agree to cooperate on information exchange and on the development of International Standards for Phytosanitary Measures, which include agreements on definitions (terminology), and ways of working (procedures). Regional agreements exist for Europe and the Mediterranean, the Asia-Pacific, Near East, Pacific, Caribbean, North American, South America and Africa.
9. Plant Protection Agreement for the Asia and Pacific Region (Rome, 1956) http://www.fao.org/legal/treaties	The Contracting Governments, desiring to prevent, through concerted action, the introduction into and spread within the South East Asia and Pacific Region of plant diseases and pests. This is a supplementary agreement under Article III of the IPPC.
10. Agreement for the Establishment of the Near east Plant Protection Organisation (Rabat, 1993) http://www.fao.org/legal/treaties	The objectives are to promote implementation of the provisions of the International Plant Protection Convention with particular attention to measures for the control of pests, and advise Governments on the technical, administrative and legislative measures necessary to prevent the introduction and spread of pests of plants and plant products.
11. Convention for the Establishment of the European Mediterranean Plant Protection Organisation (Paris, 1951) Http://www.fao.org/legal/treaties	Organisation to act, in agreement with FAO, as a recognised regional plant protection organization under the IPPC; to advise Member Governments on the technical, administrative and legislative measures necessary to prevent the introduction and spread of pests and diseases of plants and plant products.
12. Phytosanitary Convention for Africa (Kinshasa, 1967)	Heads of African State and Government of the Organization of African Unity, to take steps to: (a) prevent the introduction of diseases, insect pests, and other enemies of plants into any part of Africa; (b) eradicate or control them in so far as they are present in the area; and (c) prevent their spread to other territories within the area.
13. Agreement on the Application of Sanitary and Phytosanitary Measures (Marakech,1995) http://www.wto.org/english/tratop_e/sps_e/spsagr.htm	A supplementary agreement to the World Trade Organisation Agreement. Provides a framework for measures governing human, animal and plant life or health regulations. Applicable to all sanitary and phytosanitary measures directly or indirectly affecting international trade. Sanitary and phytosanitary measures are defined as any measure applied a) to protect human, animal or plant life or

Instrument/Institution	Relevant Provisions/Decisions/Resolutions
	health (within a Member's Territory) from the entry establishment or spread of pests, diseases, disease carrying organisms; b) to prevent or limit other damage (within the Member's Territory) from the entry, establishment or spread of pests (Annex A).
14. International Health Regulations (Geneva, 1982) (adopted by the 22nd World Health Assembly in 1969 and amended by the 26th World Health Assembly in 1973, and the 34th World Health Assembly in 1981) http://www.who.int/emc/IHR/int_regs.html	Purpose is to ensure the maximum security against the international spread of diseases with a minimum interference with world traffic. Following the increasing emphasis on epidemiological surveillance for communicable disease recognition and control, the amended Regulations are intended to strengthen the use of epidemiological principles as applied internationally, to detect, reduce or eliminate the sources from which infection spreads, to improve sanitation in and around ports and airports, to prevent the dissemination of vectors and, in general, to encourage epidemiological activities on the national level so that there is little risk of outside infection establishing itself. The goals are to: (1) detect, reduce or eliminate sources from which infections spreads; (2) improve sanitation in and around ports and airports, and (3) prevent dissemination of vectors. The Regulations require mandatory declaration of cholera, plaque and yellow fever (in 1981, the regulation was amended to remove small pox , in view of its global eradication). Represents a revised and consolidated version of the previous International Sanitary Regulations (adopted by the World Health Assembly 1951)
15. Agreed Measures for the Conservation of Antarctic Fauna and Flora (Brussels, 1964) http://www.antcrc.utas.edu.au/opor/treaties/	Participating governments shall prohibit introduction of non-indigenous plants and animals into the Treaty Area except in accordance with a permit. Permits shall be drawn in terms as specific as possible and shall be issued to allow importation only of the animals and plants listed in Annex C. (Article IX (1-4).
16. Protocol to the Antarctic Treaty on Environmental Protection (Madrid, 1991) http://www.antcrc.utas.edu.au/opor/treaties/	No species of animal or plant not native to the Antarctic Treaty Area shall be introduced onto land or ice shelves, or into water of the Antarctic Treaty Area, except in accordance with a permit. (Annex II, Article 4(1))
17. Convention on the Conservation of Antarctic Marine Living Resources (Canberra, 1980) http://www.antcrc.utas.edu/opor/treaties	Parties should prevent changes or minimise the risk for changes in the marine ecosystem not potentially reversible over two or three decades, taking into account the state of available knowledge including the effect of the introduction of alien species.
18. Convention Concerning Fishing in the Waters of the Danube. (Bucharest 1958)	Acclimatisation and breeding of new fish species, other animals and aquatic plants prohibited in Danube waters without consent of Convention Commission. (Annex Part V Article 10).
19. Convention on the Conservation of European Wildlife and Natural Resources (Bern, 1979) http://www.coe.fr/eng/legaltext/104e.htm	Each Contracting Party undertakes to strictly control the introduction of non-native species. (Article 11(2)(b))

Instrument/Institution	Relevant Provisions/Decisions/Resolutions
20. Benelux Convention on Nature Conservation and Landscape Protection (Brussels, 1982) http://sedac.ciesin.org/pidb/texts/benelux.landscape.protection.1982.html	Parties to prohibit introduction of non-native animal species into wild without authorisation from national authority; pre-introduction assessment required; communications between parties about planned introductions. (Benelux Council of Ministers Decision 17.10.83)
21. Protocol for the Implementation of the Alpine Convention in the Field of Nature Protection and Landscape Conservation (Chambery, 1994)	Parties guarantee that species of wild fauna and flora not native to the region in the recorded past are not introduced; exceptions possible when introduction needed for specific use will not "disadvantage" nature and landscape. (Article 17).
22. Protocol Concerning Mediterranean Specially Protected Areas (Geneva, 1982) http://sedac.ciesin.org/pidb/texts/acrc/mspecp.txt.html	Parties to progressively take measures to prohibit the introduction of exotic species into marine protected areas, regulate acts likely to harm or disturb the fauna or flora, including the introduction of indigenous zoological or botanical species. (Article 7)
23. 23. Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean (Barcelona, 1995) http://sedac.ciesin.org/pidb/texts/	Parties to take protection measures to regulate the introduction of any species not indigenous to the specially protected area in question, or of genetically modified species, as well as the introduction or reintroduction of species which are or have been present in the specially protected areas (Article 6). Parties to take appropriate measures to regulate the intentional or accidental introduction of non-indigenous or genetically modified species to the wild and prohibit those that may have harmful impacts on the ecosystems, habitats or species in the area to which the protocol applies (Article 13(1)). Parties to eradicate species that have been introduced when, after scientific assessment, it appears that such species cause or are likely to cause damage to ecosystems, habitats or species. (Article 13(2).
24. ASEAN Agreement on the Conservation of Nature and Natural Resources (Kuala Lumpur, 1985) http://sunsite.nus.edu.sg/apcel/kltreaty.html	Parties endeavour to regulate and, where necessary, prohibit the introduction of exotic species. (Article 3(3)(c)).
25. Protocol for the Conservation and Management of Protected marine and Coastal Areas of the South East Pacific (Paipa, 1989)	Parties to take measures to prevent or reduce and control the extent possible the introduction of exotic species of flora and fauna, including transplants. (Article (VII (2)).
26. Convention on the Conservation of Nature in the South Pacific (Apia, 1976) http://sedac.ciesin.org/pidb/texts/nature.south.pacific.html	Parties shall carefully consider the consequences of deliberate introduction into ecosystems of species not previously occurring therein. (Article V (4)).
27. African Convention on the	In any strict nature reserve or national park, Parties to take measures

Instrument/Institution	Relevant Provisions/Decisions/Resolutions
Conservation of Nature and Natural Resources (Algiers, 1968) http://www.unep.org	against any act likely to harm or disturb the fauna and flora, including the introduction of zoological or botanical specimens, whether indigenous or imported, wild or domesticated, is to be strictly prohibited. (Article III (4)(a)(ii) and (b)).
28. Agreement for the Preparation of a Tripartite Environmental Management Programme for Lake Victoria (Dar es Salaam, 1994)	Kenya, Tanzania and Uganda agree to implement a 5 year programme to strengthen regional environmental management of Lake Victoria including control of water hyacinth; biological control to proceed when environmental risks are found acceptable by national authorities; other forms of control to be explored. (Article 1, Attachment I, para. 7)
29. Convention for the Establishment of the Lake Victoria Fisheries Organization (Kisumu, 1994)	Organisation to foster co-operation among Parties, harmonize national measures for the sustainable utilization of the living resources of the Lake. Organisation to consider and advise on the effects of direct or indirect introduction of any non-indigenous aquatic animals or plants into the waters of lake Victoria or its tributaries and adopt measures regarding introduction, monitoring, control or eliminating of such animals or plants.
30. Protocol concerning Protected Areas and Wild Fauna and Flora in the Eastern African Region (Nairobi, 1985)	The Contracting Parties shall take all appropriate measures to prohibit the intentional or accidental introduction of alien or new species which may cause significant or harmful changes to the Eastern African region. (Article 7). The Contracting Parties shall take measures to regulate any activity likely to harm or disturb the fauna or flora, including the introduction of non-indigenous animal or plant species. (Article 10).
31. Convention on Great Lakes Fisheries Between the United States and Canada (Basic Instrument for the Great Lakes Fisheries Commission - GLFC) http://www.gllfc.org/pubs/conv.htm	The Convention establishes the GLFC whose purpose is to control and eradicate the non-native, highly invasive Atlantic sea lamprey from the Great Lakes.
32. North American Free Trade Agreement (1982) http://www.sice.oas.org/tradee.asp#NAFTA	Each Party may adopt, maintain or apply any sanitary or phytosanitary measure necessary for the protection of human, animal, plant life or health in its territory. (Article 712(1)). Each party shall adapt any of it s sanitary or phytosanitary measures relating to the introduction, establishment or spread of an animal or plant pest or disease, to the sanitary or phytosanitary characteristics of the area where a good subject to such a measure is produced and the area in it s territory to which the good is destined, taking into account any relevant conditions, including those relating to transportation and handling, between those areas. (Article 716).
33. North American Agreement on Environmental Co-operation (1993) http://www.cec.org	The Council of the Commission on Environmental Co-operation may develop recommendations regarding exotic species which may be harmful. (Article 10 (2)(h)))
34. Convention for the Conservation of the Biodiversity and the Protection of Wilderness Areas in Central America	Parties agree that all mechanisms shall be established for the control or eradication of all exotic species which threaten ecosystems, habitats and wild species. (Article 24).

Instrument/Institution	Relevant Provisions/Decisions/Resolutions
(Managua, 1992)	
35. Protocol Concerning Specially Protected Areas and Wildlife to the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (SPAW) (Kingston, 1990) http://www.cep.unep.org/pubs/legislation/spaw.html	Each Party shall take all appropriate measures to regulate or prohibit intentional or accidental introduction of non-indigenous or genetically altered species to the wild that may cause harmful impacts to the natural flora, fauna or other features of the Wider Caribbean Region. (Article 12)
36. IUCN-Guidelines for the Prevention of Biodiversity Loss Caused by Alien Invasive Species (2000) http://www.iucn.org/themes/ssc/pubs/policy/invasivevseng.html	Guidelines designed to increase awareness and understanding of the impact of alien species. Provides guidance for the prevention of introduction, re-introduction, and control and eradication of alien invasive species.
37. Guidelines for the Control and Management of Ships´ Ballast Water to Minimize the Transfer of Harmful Aquatic Organisms and Pathogens. (Resolution A.868 (29)1997, International Maritime Organisation) http://www.imo.org	Provides guidance and strategies to minimise the risk of unwanted organisms and pathogens from ballast water and sediment discharge. Updates the previous guidelines. "Guidelines for preventing the Introduction of Unwanted Organisms and Pathogens from Ships' Ballast Water and Sediment Discharges" (IMO Resolution A.774 (18) 1991).
38. Recommendation No. R (84) 14 (1984) of the Committee of Ministers to the Council of Europe Member States Concerning the Introduction of Non-native Species http://www.coe.int	Recommends that Member State governments prohibit non-native species introductions into the natural environment; exceptions allowed provided study undertaken to evaluate probable consequences for wildlife and ecosystems.
39. Agenda 21 – United Nations Conference on Environment and Development (Rio, 1992)	Chapter 11: Combating Deforestation: Increase protection of forests from disease and uncontrolled introduction of exotic plant and animal species. (Chap. 11.14(g)) Chapter 12: Managing Fragile Ecosystems: Combating Desertification and Drought : Develop, test and introduce, with due regard to environmental security considerations, drought resistant fast growing and productive plant species appropriate to the regions concerned. (Article 12.19(b)) Chapter 15: Conservation of Biological Diversity: Acknowledgement that inappropriate introduction of foreign plants and animals has contributed to biodiversity loss and continues. (Chap. 15.3). Chapter 17 Protection of Oceans States to assess individually, regionally and internationally, within IMO and other relevant international organisations, need for adopting

Instrument/Institution	Relevant Provisions/Decisions/Resolutions
	appropriate rules on ballast water discharge to prevent spread of non-indigenous organisms. (Chap. 17.30(vi)) States to analyse aquaculture's potential and apply appropriate safeguards for introducing new species. (chap. 17.83) Chapter 18 Protection Freshwater Resources: States to control of noxious aquatic species that may destroy other aquatic species (chap. 18-40(e)(iv)).
40. Programme of Action for the Sustainable Development of Small Island States (1994) http://www.unep.ch/islands/dsidscnf.htm	Introduction of certain non-indigenous species noted as one of a number of significant causes of biodiversity loss. (Para. 41). Countries to formulate strategies at the national level for conservation and sustainable use of marine and terrestrial biodiversity including protection from certain non-indigenous species. (Para. 45A(i)).
41. Code of Practice on the Introductions and Transfers of Marine Organisms (ICES/EIFAC 1994)	Recommends practices and procedures to diminish risks of detrimental effects from marine organism introduction and transfer, including those genetically modified. Drafted in co-operation with the FAO European Inland Fisheries and Advising Committee (EIFAC) and applicable to freshwater organisms. Requires ICES members to submit a prospectus to regulators, including a detailed analysis of potential environmental impacts to the aquatic ecosystem.
42. Code of Conduct for Responsible Fisheries (FAO, 1995) http://www.fao.org/fi/agreem/codecond/ficonde.asp	Sets out principles and international standards of behaviour for responsible fishing practices, including aquaculture. The aim is to ensure effective conservation, management and development of living aquatic resources, respecting ecosystems and biodiversity. Legal and administrative frameworks are encouraged to facilitate responsible aquaculture. Pre-introduction discussion with neighbouring states when non-indigenous stocks are to be introduced into transboundary aquatic ecosystems. Harmful effects of non-indigenous and genetically altered stocks to be minimised especially where significant potential exists for spread into other states or country of origin. Adverse genetic and disease effects to wild stock from genetic improvement and non-indigenous species to be minimised.
43. Code of Conduct for the import and release of exotic biological control agents (FAO, 1995) http://www.fao.org	Aims to facilitate the safe import, export and release of such agents by introducing procedures of an internationally acceptable level for all public and private entities involved, particularly where national legislation to regulate their use does not exist or is inadequate. Outlines specific responsibilities for authorities of an exporting country, who should ensure that relevant regulations of the importing country are followed in exports of biological control agents.
44. Preventing the Introduction of Invasive Alien Species. Resolution A-32-9, International Civil Aviation Organisation (ICAO) (1998). http://www.icao.int/icao/end/res/a32_9.htm	Urges all Contracting States to use their civil aviation authorities to assist in reducing the risk of introducing, through civil air transportation, potentially invasive species to areas outside their natural range. Requests the ICAO Council to work with other United Nations organisations to identify approaches that the ICAO might take in assisting to reduce the risk of introducing potential invasive species.
45. Global Programme of Action for the Protection of the Marine	Introduction of Alien Species acknowledged to have serious effects upon ecosystem integrity. (para. 149).

Instrument/Institution	Relevant Provisions/Decisions/Resolutions
Environment from Land-based Activities (UNEP, 1995) http://www.unep.org/unep/gpa/pol2a.htm	

Source: Shine, C., Williams, N., & Gündling, L., ***A Guide to Designing Legal and Institutional Frameworks on Alien Invasive Species.*** 2000 (in press). IUCN Environmental Law Programme, Bonn, Germany.

Note: There are several other international and regional agreements with provisions that relate to AIS issues, some of which are not yet in force.

ANNEX 3
INTERIM GUIDING PRINCIPLES FOR THE PREVENTION, INTRODUCTION AND MITIGATION OF IMPACTS OF ALIEN SPECIES

The interim guiding principles below have been included in recommendation V/4 of the Conference of Parties of the CBD. Standardized terminology on "alien", "alien species" and "invasive alien species" has not yet been adopted.

A. GENERAL

GUIDING PRINCIPLE 1: PRECAUTIONARY APPROACH

Given the unpredictability of the impacts on biological diversity of alien species, efforts to identify and prevent unintentional introductions as well as decisions concerning intentional introductions should be based on the precautionary approach. Lack of scientific certainty about the environmental, social and economic risk posed by a potentially IAS species or by a potential pathway should not be used as a reason for not taking preventative action against the introduction of potentially invasive alien species. Likewise, lack of certainty about the long-term implication of an invasion should not be used as a reason for postponing eradication, containment or control measures.

GUIDING PRINCIPLE 2: THREE-STAGE HIERARCHICAL APPROACH

Prevention is generally far more cost effective and environmentally desirable than measures taken following introduction of an invasive alien species. Priority should be given to prevention of entry of invasive alien species (both between and within States). If entry has already taken place, actions should be undertaken to prevent the establishment and spread of alien species. The preferred response would be eradication at the earliest possible stage (principle 13). In the event that eradication is not feasible or is not cost-effective, containment (principle 14) and long-term control measures (principle 15) should be considered. Any examination of benefits and costs (both environmental and economic) should be done on a long-term basis.

GUIDING PRINCIPLE 3: ECOSYSTEM APPROACH

All measures to deal with invasive alien species should be based on the ecosystem approach, in line with the relevant provisions of the Convention and the decisions of the Conference of the Parties.

GUIDING PRINCIPLE 4: STATE RESPONSIBILITY

States should recognize the risk that they may pose to other States as a potential source of invasive alien species, and should take appropriate actions to minimize that risk. In accordance with Article 3 of the Convention on Biological Diversity, and principle 2 of the 1992 Rio Declaration on Environment and Development, States have the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction. In the context of invasive alien species, activities that could be a risk for another State include:

(a) The intentional or unintentional transfer of an invasive alien species to another State (even if it is harmless in the State of origin); and

(b) The intentional or unintentional introduction of an alien species into their own State if there is a risk of that species subsequently spreading (with or without a human vector) into another State and becoming invasive.

GUIDING PRINCIPLE 5: RESEARCH AND MONITORING

In order to develop an adequate knowledge base to address the problem, States should undertake appropriate research on and monitoring of invasive alien species. This should document the history of invasions (origin, pathways and time-period), characteristics of the invasive alien species, ecology of the invasion, and the associated ecological and economic impacts and how they change over time. Monitoring is the key to early detection of new alien species. It requires targeted and general surveys, which can benefit from the involvement of local communities.

GUIDING PRINCIPLE 6: EDUCATION AND PUBLIC AWARENESS

States should facilitate education and public awareness of the risks associated with the introduction of alien species. When mitigation measures are required, education and public-awareness-oriented programmes should be set in motion so as to inform local communities and appropriate sector groups on how to support such measures.

B. PREVENTION

GUIDING PRINCIPLE 7: BORDER CONTROL AND QUARANTINE MEASURES

1. States should implement border control and quarantine measures to ensure that:

   (a) Intentional introductions are subject to appropriate authorization (principle 10);

   (b) Unintentional or unauthorized introductions of alien species are minimized.

2. These measures should be based on an assessment of the risks posed by alien species and their potential pathways of entry. Existing appropriate governmental agencies or authorities should be strengthened and broadened as necessary, and staff should be properly trained to implement these measures. Early detection systems and regional coordination may be useful.

GUIDING PRINCIPLE 8: EXCHANGE OF INFORMATION

States should support the development of database(s), such as that currently under development by the Global Invasive Species Programme, for compilation and dissemination of information on alien species that threaten ecosystems, habitats or species, to be used in the context of any prevention, introduction and mitigation activities. This information should include incident lists, information on taxonomy and ecology of invasive species and on control methods, whenever available. The wide dissemination of this information, as well as national, regional and international guidelines, procedures and recommendations such as those being compiled by the Global Invasive Species Programme should also be facilitated through, *inter alia*, the clearing-house mechanism.

GUIDING PRINCIPLE 9: COOPERATION, INCLUDING CAPACITY-BUILDING

Depending on the situation, a State's response might be purely internal (within the country), or may require a cooperative effort between two or more countries, such as:

(a) Where a State of origin is aware that a species being exported has the potential to be invasive in the receiving State, the exporting State should provide information, as available, on the potential invasiveness of the species to the importing State. Particular attention should be paid where exporting Parties have similar environments;

(b) Agreements between countries, on a bilateral or multilateral basis, should be developed and used to regulate trade in certain alien species, with a focus on particularly damaging invasive species;

(c) States should support capacity-building programmes for States that lack the expertise and resources, including financial, to assess the risks of introducing alien species. Such capacity-building may involve technology transfer and the development of training programmes.

C. INTRODUCTION OF SPECIES

GUIDING PRINCIPLE 10: INTENTIONAL INTRODUCTION

No intentional introduction should take place without proper authorization from the relevant national authority or agency. A risk assessment, including environmental impact assessment, should be carried out as part of the evaluation process before coming to a decision on whether or not to authorize a proposed introduction. States should authorize the introduction of only those alien species that, based on this prior assessment, are unlikely to cause unacceptable harm to ecosystems, habitats or species, both within that State and in neighbouring States. The burden of proof that a proposed introduction is unlikely to cause such harm should be with the proposer of the introduction. Further, the anticipated benefits of such an introduction should strongly outweigh any actual and potential adverse effects and related costs. Authorization of an introduction may, where appropriate, be accompanied by conditions (e.g., preparation of a mitigation plan, monitoring procedures, or containment requirements). The precautionary approach should be applied throughout all the above-mentioned measures.

GUIDING PRINCIPLE 11: UNINTENTIONAL INTRODUCTIONS

1. All States should have in place provisions to address unintentional introductions (or intentional introductions that have established and become invasive). These include statutory and regulatory measures, institutions and agencies with appropriate responsibilities and with the operational resources required for rapid and effective action.

2. Common pathways leading to unintentional introductions need to be identified and appropriate provisions to minimize such introductions should be in place. Sectoral activities, such as fisheries, agriculture, forestry, horticulture, shipping (including the discharge of ballast waters), ground and air transportation, construction projects, landscaping, ornamental aquaculture, tourism and game-farming, are often pathways for unintentional introductions. Legislation requiring environmental impact assessment of such activities should also require an assessment of the risks associated with unintentional introductions of invasive alien species.

D. MITIGATION OF IMPACTS

GUIDING PRINCIPLE 12: MITIGATION OF IMPACTS

Once the establishment of an invasive alien species has been detected, States should take steps such as eradication, containment and control, to mitigate the adverse effects. Techniques used for eradication, containment or control should be cost-effective, safe to the environment, humans and agriculture, as well as socially, culturally and ethically acceptable. Mitigation measures should take place in the earliest possible stage of invasion, on the basis of the precautionary approach. Hence, early detection of new introductions of potentially invasive or invasive species is important, and needs to be combined with the capacity to take rapid follow-up action.

GUIDING PRINCIPLE 13: ERADICATION

Where it is feasible and cost-effective, eradication should be given priority over other measures to deal with established invasive alien species. The best opportunity for eradicating invasive alien species is in the early stages of invasion, when populations are small and localized; hence, early detection systems focused on high-risk entry points can be critically useful. Community support, built through comprehensive consultation, should be an integral part of eradication projects.

GUIDING PRINCIPLE 14: CONTAINMENT

When eradication is not appropriate, limitation of spread (containment) is an appropriate strategy only where the range of the invasive species is limited and containment within defined boundaries is possible. Regular monitoring outside the control boundaries is essential, with quick action to eradicate any new outbreaks.

GUIDING PRINCIPLE 15: CONTROL

Control measures should focus on reducing the damage caused rather than on merely reducing the numbers of the invasive alien species. Effective control will often rely on a range of integrated techniques. Most control measures will need to be regularly applied, resulting in a recurrent operating budget and the need for a long-term commitment to achieve and maintain results. In some instances, biological control may give long-term suppression of an invasive alien species without recurrent costs, but should always be implemented in line with existing national regulations, international codes and principle 10 above.

ANNEX 4

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