INVASIVE ALIEN SPECIES
a threat to biodiversity




Convention on
Biological Diversity

UNEP

INTERNATIONAL DAY FOR BIOLOGICAL DIVERSITY

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The Global Invasive Species Programme (GISP) has contributed to the content and review of this booklet:

Global Invasive Species Programme (GISP) is an international partnership dedicated to addressing the global threat of invasive species. Established in 1996, GISP's mission is to conserve biodiversity and sustain livelihoods by minimising the spread and impact of invasive species. Constituted as an autonomous legal entity, GISP comprises four partner organisations, the Centre for Agricultural Bioscience International (CABI), IUCN, the South African National Biodiversity Institute (SANBI) and The Nature Conservancy (TNC), and is co-ordinated from a Secretariat hosted by CABI in Nairobi, Kenya. The programme provides support to the implementation of Article 8(h) of the CBD and has contributed extensively to the knowledge and awareness of invasive species through the development of a range of products and publications including the *Global Strategy on Invasive Alien Species* (2001) and *Invasive Alien Species: A Toolkit of Best Prevention and Management Practices* (2001). GISP aims to build partnerships, provide guidance, develop a supportive environment and build capacity for national approaches towards the prevention and management of invasive species by pursuing three key objectives: Supporting policy and governance; Facilitating information exchange; and, Promoting awareness among key decision makers. (www.gisp.org).

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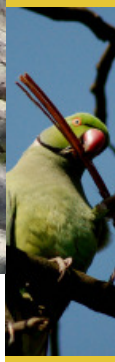


PREFACE

To increase understanding and raise awareness of biodiversity issues, the United Nations declared 22 May the International Day for Biological Diversity (IDB). This year, the Convention on Biological Diversity proclaimed invasive alien species as the theme of IDB 2009.

The rapid increase of biological invasions by alien species is widely recognized as being a significant component of human-induced global environmental change. While there is no doubt that the transportation of animals, plants and microorganisms provides a variety of goods and services and contributes to human well-being, global economic growth has opened pathways for invasive alien species to enter, establish and spread to new habitats and ecosystems. Climate change, disturbance and modification of the landscape may also cause the further spread and impact of invasive alien species on a wide range of ecosystems.

Biological invasions by invasive alien species often results in significant economic losses and decreased biological diversity and ecosystem function. In the United States alone, the yearly damage and control cost of invasive species is estimated to be more than US$138 billion. Worldwide, it is estimated at US$1.4 trillion annually[1].

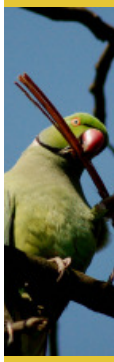
In light of the impact invasive alien species have, the Convention on Biological Diversity recognizes the importance of preventing the introduction of, and controlling or eradicating alien species which threaten ecosystems, habitats and native species.

This brochure highlights the threat invasive alien species pose to biodiversity and what each of us can do to tackle the problem. Relevant to every type of ecosystem, the issue of invasive alien species is central to the achievement of the three objectives of the Convention on Biological Diversity – the conservation of biological diversity, its sustainable use, and the fair and equitable sharing of benefits arising from the utilisation of genetic resources.. As we are only one year away from 2010, the International Year of Biodiversity and the target date for the 2010 Biodiversity Target, urgent action is needed to tackle the threat of invasive alien species.

I thank all the contributors who provided information, knowledge and financial resources for the production of this brochure. Particular thanks to the European Commission, for providing the financial resources for the production and dispatch of this brochure.

Ahmed Djoghlaf
Executive Secretary, The Convention on Biological Diversity

1 Pimentel, D.; R. Zuniga and D., Morrison (2005). "Update on the environmental and economic costs associated with alien-invasive species in the United States." *Ecological Economics* **52**: 273–288.



Key Messages

Words in bold are defined in the Glossary

Invasive alien species have affected native biodiversity in almost every type of ecosystem on Earth. As one of the greatest drivers of biodiversity loss, they pose a threat to ecosystem integrity and function and therefore, to human well-being.

Globalization has resulted in greater levels of trade, transport, travel and tourism, all of which can facilitate the introduction and spread of non-native (or alien) species. Some of these can establish themselves in the new habitat and become invasive.

For an alien species to become invasive, it must arrive, survive and thrive. It must successfully out-compete native organisms for food and habitat, spread through its new environment, increase its population and harm ecosystems in its introduced range.

The impacts of invasive alien species are exacerbated by other drivers of biodiversity loss, including climate change, habitat loss, pollution and human-induced disturbance. **Climate change** may shift the geographic distribution and abundance of species by affecting the environment in which it lives, leading to a change in their physiology.

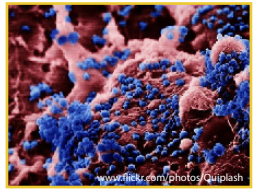
Prevention is the most cost-effective and feasible method of controlling invasive alien species. It requires collaboration among governments, economic sectors and non-governmental and international organizations.

The **Convention on Biological Diversity (CBD)** is addressing the threat of invasive alien species by setting global priorities, and guidelines, as well as collecting information and facilitating the coordination of international actions.

INTRODUCTION

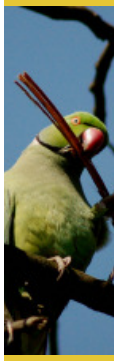
Invasive Alien Species

WHAT are they?



Invasive alien species (IAS) are species whose introduction and/or spread outside their natural habitats threaten **biological diversity**. While only a small percentage of organisms transported to new environments become invasive, their negative impacts on food security, plant, animal and human health and economic development can be extensive and substantial.

Most nations already grapple with complex and costly invasive species problems. Examples include: zebra mussels (*Dreissena polymorpha*) affecting fisheries, mollusc diversity, and electric power generation; the water hyacinth (*Eichhornia crassipes)* blocking waterways, decimating aquatic wildlife and the livelihoods of local people, and creating ideal conditions for disease and its **vectors**; rats exterminating native birds on Pacific islands; and deadly new disease organisms, such as avian influenza A (H5N1), attacking human and animals, in both temperate and tropical countries. Addressing the problem of invasive alien species is urgent because the threat is growing daily, and the economic and environmental impacts are severe.



WHY are they of concern?

The problem of invasive alien species continues to grow, essentially due to global trade, transport and travel, including tourism, at an enormous cost to human and animal health and the socio-economic and ecological well-being of the world. Since the 17th century, invasive alien species have contributed to nearly 40% of all animal extinctions for which the cause is known (SCBD, 2006). They pose the greatest threat to **biodiversity** on isolated ecosystems, such as islands, as these lack natural competitors and predators that usually control populations of invasives. Invasive alien species also alter land-use and natural **disturbance** patterns (e.g. fires, insect outbreaks, disease), as well as ecosystem processes such as **nutrient cycling**. The annual environmental losses caused by introduced **pests** in the United States, United Kingdom, Australia, South Africa, India and Brazil have been calculated at over US$ 100 billion.

Invasive alien species also exacerbate poverty and threaten **sustainable development** through their impact on agriculture, forestry, fisheries, human health and on wild biodiversity, which is often a basis of livelihoods of people in developing countries. Damage caused by invasive alien species can also be aggravated by climate change, pollution, habitat loss and other human-induced disturbances (e.g. roads, agriculture).

Fig 1: Economic impact of some invasive alien species

	Species	Economic Variable (US dollars/year)	Economic impact (one coin = approx. 20 million US dollars)
	Rats *(Rattus rattus and R. norvegicus)*	US $19 million per year in losses and damages in the US (Pimentel et al. 2005)	$
	Feral pigs *(Sus scrofa)*	US $800 million per year in losses and damages in the US (Pimentel et al. 2005)	$ $
	Water hyacinth *(Eichhornia Crassipes)* and other alien water weeds	US$100 million per year in costs related to water use to developing countries (GISP 2004b)	$ $ $ $ $
	Vegetable leaf miner *(Liriomyza sativae)*	US $80 million per year for economic losses in China (Li and Xie 2002)	$ $ $ $
	Small Indian mongoose *(Herpestes javanicus)*	US $50 million in damagesper year in Puerto Rico and the Hawaiian Islands alone (GISP 2004b)	$ $
	Coffee berry borer *(Hypothenemus hampei)*	US$ 300 million per annum in India (GISP 2004b)	$ $ $ $ $ $ $ $ $ $ $ $

HOW do they spread?

A species introduction is usually vectored by human transportation and trade both intentionally and unintentionally. If a species' new habitat is similar enough to its native habitat, it may survive and reproduce. For a species to become invasive, it must successfully out-compete native organisms for food and habitat, spread through its new environment, increase its population and harm ecosystems in its introduced range. To summarize, for an alien species to become invasive, it must arrive, survive and thrive.

Common characteristics of invasive alien species include:

- Rapid reproduction and growth
- High dispersal ability (ability to move from one place to another)
- Ability to adapt physiologically to new conditions
- Ability to survive on various food types and in a wide range of environmental conditions.

Ecosystems that have been invaded by alien species may not have the natural predators and competitors that controlled the population in its native environment. Natural ecosystems that have undergone human-induced disturbance are often more prone to alien invasions because there is less competition from **native species**. For example, imported red fire ants (*Solenopsis invicta*) are more successful in establishing themselves in disturbed areas, such as roadsides and agricultural fields, and rarely colonize intact closed forests.

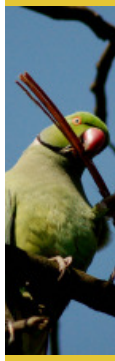
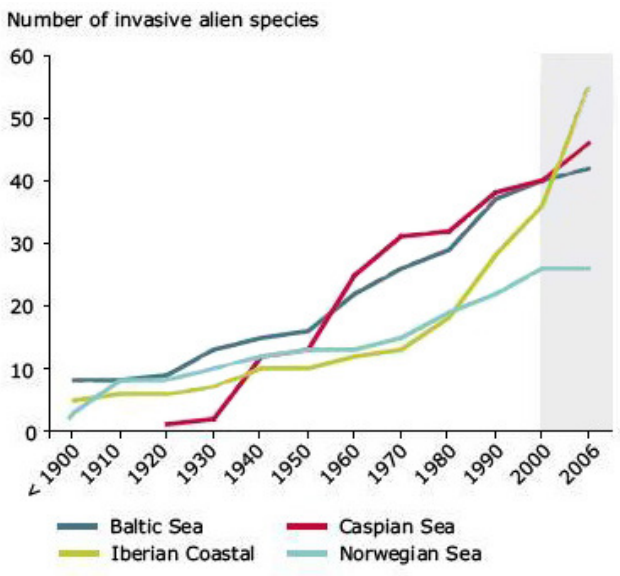


Fig. 2. Spread of Marine Invasive Species in European Seas (Source: European Environment Agency 2007)



More than 1000 alien marine and estuarine species have been introduced to several seas in the pan-European region, the majority in the last century. The Mediterranean Sea has suffered most, with approximately 740 introduced species mainly associated with the opening of the Suez Canal.

one

THREAT AND IMPACT

Invasive alien species are one of the most important direct **drivers of global biodiversity loss**. They cause enormous damage to biodiversity and to the valuable ecosystems upon which we depend.

The Millennium Ecosystem Assessment (2005) concluded that the relative impact of invasive alien species on biodiversity varies across **biomes**, and that for all biomes, the impact is either steady or increasing as follows:

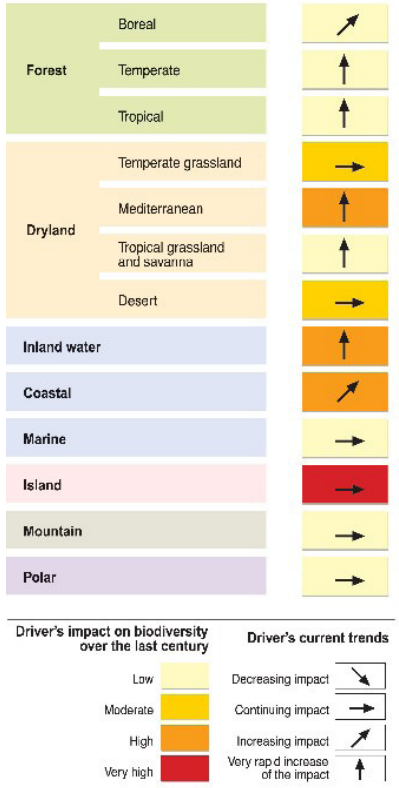


Fig. 2. Impact of Invasive Alien Species on Biodiversity across Biomes (Millennium Ecosystem Assessment)

The cell colour indicates impact of invasive alien species on biodiversity in each type of ecosystem over the past 50–100 years. High impact means that over the last century the particular driver has significantly altered biodiversity in that biome; low impact indicates that it has had little influence on biodiversity in the biome. The arrows indicate the trend in the driver. Horizontal arrows indicate a continuation of the current level of impact; diagonal and vertical arrows indicate progressively stronger increasing trends in impact. The Figure presents global impacts and trends that may be different from those in specific regions.

Here are some examples of the effects of invasive alien species on local populations, livelihoods, human health and sustainable development:

Islands

Islands, such as Australia, New Zealand, Madagascar, the Hawaiian Archipelago, and the Galapagos, have a high proportion of endemic and specialized flora and fauna. The geographic isolation of islands limits immigration of new species, allowing established species to evolve with few strong competitors and predators. Invasive alien species introduced by human activity are a leading cause of species extinctions and population declines on island ecosystems worldwide. Invasive alien species pose a particular risk to Small Island Developing States by threatening the ecosystems, livelihoods, economies and public health of inhabitants. Many island nations lack scientific and technical information, and resources to address the problem of invasive alien species**.**

The Nile perch: Responsible for loss of biodiversity, ecosystem function and local livelihoods

- As the local population grew and fishing techniques improved, fishing pressure on Lake Victoria in Africa increased. By the early 1950s it was clear that overfishing had caused a drastic decline in fish stocks. In an effort to reverse the situation, British officials introduced the Nile perch (*Lates niloticus)*, as well as the Nile tilapia, into the lake. With no natural predators and plenty of prey, the Nile perch flourished, driving at least 200 species to extinction
- Oilier than that of local fish, the flesh of the Nile perch must be dried over a fire in order to be eaten. Hence more trees were felled by the local population for fuelwood. The resulting deforestation caused increased erosion and runoff, which raised nutrient levels in the lake, promoting infestation by water hyacinths.
- The Nile perch's palatable bone-free white flesh, as well as products made from its swim bladder and hide, found favour on foreign markets, generating as much as US$400 million in export income for the three countries bordering Lake Victoria
- Kenya, Uganda and Tanzania. However, the export demand pushed up the price of fresh fish, making it too expensive for the local population. It also stimulated more intensive fishing, and by the mid-1990s it was clear that the Nile perch was being overfished. Catch rates declined and the average size of landed fish dropped from over 50 kilograms in 1980 to less than 10 kilograms in 1996.

'No crop' effects on agriculture in Africa

Parthenium hysterophorus, commonly called parthenium or congress weed, is an aggressive invader native to Mexico. As the weed was first seen growing in Ethiopia in 1988 near food aid distribution centres, it is presumed that imported wheat grain was contaminated with its seeds. Once introduced, the weed was able to spread rapidly, as the seeds are readily dispersed in mud adhering to vehicles, machinery and animals, as well as by water and wind. Because of its devastating effect on crop production in Ethiopia it earned a local name meaning 'no crop'. Unpalatable to livestock, the invasion of the weed results in grazing shortages; if it is mixed in with fodder, it taints the meat and milk of the animal. Parthenium also poses a health problem for both humans and livestock. Contact with the plant or pollen can cause allergic reactions such as dermatitis, asthma and hay fever. The weed has also invaded the subtropical regions of South Africa – where it is especially problematic in sugarcane and banana plantations – as well as Swaziland, Mozambique, Zimbabwe and Madagascar. Although individual plants can be killed with foliar application of herbicides, rapid regeneration from seed soon follows and control has been particularly problematic.

Human health

Infectious diseases agents are often, and perhaps typically, invasive alien species. Unfamiliar types of infectious agents, either acquired by humans from domesticated or other animals, or imported inadvertently by travelers, can have devastating impacts on human populations. Pests and diseases can also undermine local food and livestock production, thereby causing hunger and famine.

Important historic examples include:

- Bubonic plague spread from central Asia through North Africa, Europe and China using a flea vector on an invasive species of rat
- 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
- The viruses causing smallpox and the measles spread from Europe into the Western Hemisphere shortly following European colonization. The low resistance of indigenous peoples to these parasites played a part in bringing down the mighty Inca and Aztec empires
- Rinderpest, a viral disease, was introduced into Africa in the 1890s via infected cattle. Subsequently it spread to both domesticated and wild herds of bovids (related to cows) throughout the African savannah, altering the mammalian composition of much of the continent. 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.

Avian influenza and health in wild birds and humans

Avian influenza (AI) is a highly contagious viral disease affecting many avian species. The AI viruses are divided in two groups based on their ability to cause disease. Highly pathogenic avian influenza (HPAI) virus spreads rapidly, may cause serious disease and result in very high mortality rates while low pathogenic avian influenza (LPAI) can cause mild disease that may give rise no symptoms at all in infected birds. Wild birds provide a reservoir for AI viruses.

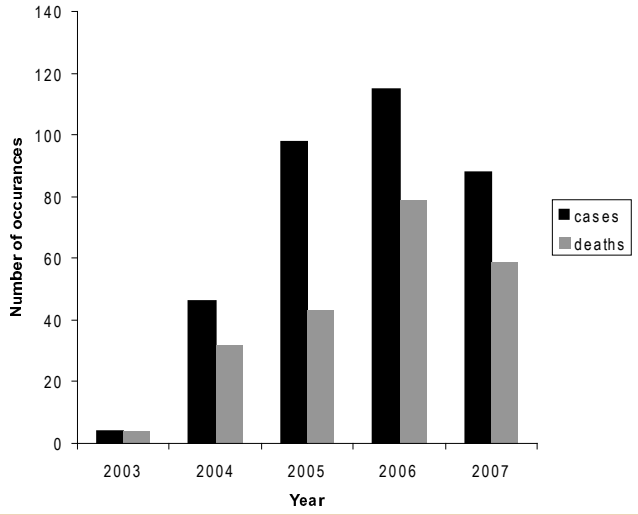
AI viruses can infect people, with potentially fatal results. The current global AI disease situation has focused the attention of the international community for several years now because of the risk of HPAI causing an influenza pandemic in human populations globally.

The OIE is the international standard setting body recognized by the World Trade Organization for the control and reporting of animal diseases and zoonoses. The OIE lists significant diseases, including those that can infect humans (i.e. zoonoses) and those that are serious but do not affect humans (e.g. rinderpest). The criteria for such listing include the scope for the diseases to cause significant problems in animals and/or human populations, their capacity for international spread via the movement of animals and animal products and the global distribution of the diseases. The methods of detection, prevention and control of listed diseases are published by the OIE and are the key references for national veterinary services in their programmes to prevent and control animal diseases.

The OIE in cooperation with the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO) provides policy advice, strategy design and technical assistance for the control and eradication of AI.

Fig.3. Cumulative Number of Confirmed Human Cases of Avian Influenza A (H5N1) Reported to WHO (2003-2007)

(Source: www.who.int/csr/disease/avian_influenza/country/cases_table_2008_06_19/en/index.html)



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PATHWAYS OF INVASION

Rapidly accelerating human activities, such as trade, transport, travel, globalization and the expansion of the human population has increased the threat and impacts of invasive species. These impacts are exacerbated by climate change, habitat loss, pollution and human-induced disturbance.

The increased mobility of people and their goods bring an increased likelihood of movement of species around the planet, often in the form of commodities such as livestock, pets, nursery stock, and produce from agriculture and forestry.
The **pathway** and **vector** that transports an invasive alien species are important links to the invasion. If the vector can be intercepted, then the invasion can be prevented. Most vectors are human-assisted transport mechanisms that move organisms across natural barriers.

China's economy booms and accelerates biological invasions

China has undergone an enormous economic boom in the last 25 years, largely as a result of increased international trade (Ding et al. 2008). There are more than 400 recorded invasive alien species in China, most of which became invasive in the last 25-30 years. The total number of alien species intercepted at the Chinese border increased tenfold from 1990-2005. Preliminary reports suggest that China may suffer annual economic losses of about US$ 14.5 billion from invasive insects and plants.

Important pathways for invasive species invasions include:

Ship ballast water

There is little doubt that movement of ships is the most import pathway in the movement of marine organisms from country to country and from sea to sea. The most significant pathways for marine bioinvasions are in the ballast tanks of ships and the fouling on the outside of ships' hulls. Literally hundreds of species can be found alive in samples from a single ship. The GEF/UNDP/IMO Global Ballast Water Management Programme (GloBallast) is helping developing countries reduce the transfer of harmful aquatic organisms, microbes and diseases through ballast water.

Pets released into the wild and aquarium trade

Exotic aquarium fish and plants, as well as pets, can become invasive alien species if they are intentionally or accidentally released and become established. Pets and aquarium inhabitants, if not wanted, are often released "back" into the wild with well-meant intentions. Reptiles, amphibians, aquarium fish and flora released into ponds and down toilets easily find their way into the local water system. There are no specific international standards concerning risks of invasions involving the trade of pets, aquarium species, live bait and live food. Furthermore, there has been an increase in such trade due to Internet-based transactions, for which there are no international and national controls and regulations in place.

Hitchhikers

Organisms may hitchhike in or on timber, packaging, machinery equipment and vehicles. Unprocessed wood and wood products are a source of forest pests and diseases. Machinery and vehicles are often shipped from place to place without cleaning. Air transport is also an important pathway for invasive alien species. Species may be moved inside the cabin in passengers clothing or luggage, stowaways in cargo, in packing materials, wheel wells and other aircraft parts.

Plants introduced for agricultural or forestry purposes

A large proportion of important crops and trees, including the plants for biofuel production, are grown in areas outside their natural distribution for a better economy and effective food production. These foreign species can pose a risk to biodiversity when they naturalize and penetrate conservation areas encroached by these fields.

Ornamental plants

A high percentage of plant invaders were originally introduced as ornamentals. About half of the 300 most invasive plants in North America, and more than 70% of New Zealand's invasive weeds, were intentionally introduced to gardens and parks as ornamental plants.

Biological control

Biological control is a pest control strategy making use of living natural enemies, antagonists or competitors and other self-replicating biotic entities. **Exotic species** are often used to control pest species, but can become invasive pest species themselves. This has been a problem, particularly in earlier introductions. Today, the safety standards for biological control are far more rigorous. They are regulated by laws and regulations, and risk analysis is conducted before an application for import can be submitted.

Emergence of *Batrachochytrium dendrobatidis*: Consequences of the amphibian trade

The highly transmissible fungus *Batrachochytrium dendrobatidis* (Bd) has resulted in the disease chytridiomycosis, causing global declines or extinctions of about 200 species of frogs (Skeratt et al. 2007). Amphibian chytridiomycosis has been described as the "worst infectious disease ever recorded among vertebrates in terms of number of species impacted, and its propensity to drive them to extinction". The cause of the disease is suspected to be the global trade of amphibians, which often brings the animals in contact with wild populations.

In Japan, molecular technology to rapidly detect *Bd* from DNA was developed. Pets and wild frogs suspected of carrying *Bd* are examined by collecting swab samples.

***Caulerpa taxifolia* or "Deathweed"**

Caulerpa taxifolia is an invasive seaweed that is used as a decorative aquarium plant. A hardier cold-tolerant clone developed for aquarium purposes was introduced in 1984 into the Mediterranean Sea from the Monaco Oceanographic Aquarium. Covering one square metre at the time, it has now spread to more than 13,000 hectares of seabed. Deathweed overgrows natural seagrasses, excludes almost all marine life and reduces local fishery resources. Eradication is no longer considered feasible in the Mediterranean. It has also been recorded in eastern Australia and the United States.

Hull fouling

Fouling organisms on ship hulls have caused economic losses since ships first began to sail the oceans. After arriving at a distant port or worksite, any vessels laid up for an extended period in harbour, anchorage or estuary provide fouling biota the opportunity to mature or spawn. This pathway can vector marine invasive species on any type of vessel and on all external and internal wetted surfaces and niches. Where anti-fouling coatings are old, damaged or absent, surfaces and crevices become colonised by communities containing members from the following biofouling groups:

- Biofilms developed by bacteria, cyanobacteria and diatoms
- Filamentous green algae and turfing red and brown algae
- Sessile organisms including sponges, hydroids, corals, sea anemones, tube-building worms, barnacles, bivalve molluscs, bryozoans and sea squirts; and mobile animals including polychaete worms, amphipods, crabs, welks, and territorial fishes

There may also be a range of microbes, parasites and pathogens accompanying the above taxa.

Preventing marine invasive alien species introductions requires effective hull cleaning and anti-fouling programmes. Education programmes are necessary to raise the awareness levels of boat operators and ship owners of the potential for the vessel to carry invasive alien species and the steps they should take to reduce the risks.

Hull fouling is thought to be responsible for:

- 74% of non-indigenous marine invertebrates transported to the Hawaiian Islands
- 42% of marine species unintentionally introduced into Japan
- More than half of species introduced via ships into the North Sea
- 70% of species that have invaded coastal North America via ships (biofouling alone or biofouling and ballast water jointly)

Aquaculture and mariculture

Sustainable aquaculture and mariculture are important strategies for improving rural livelihoods and for poverty alleviation, and are one of the fastest growing sectors of the global food economy. However, aquaculture and mariculture provide pathways for **unintentional introduction**s of alien species including escaped fish, their parasites and diseases; self dispersal of larvae and spawn; and introduction of foreign microbes and diseases in processed fish feed for carnivorous farmed fish.

The European green crab (*Carcinus maenas*)

Native to Europe and northern Africa, the European green crab was introduced to the United States, Australia and South Africa through various pathways: Ship's ballast water, hull fouling, aquaculture, aquarium trade and live food trade. A voracious predator, the crab has caused the decline of other crab and bivalve species in its introduced range. The species is ranked among the "100 of the World's Worst Invasive Alien Species" by the IUCN/SSC Invasive Species Specialist Group.

Tourists and their luggage

The dramatic increase in tourist volume and mobility is swiftly increasing in importance as a vector for introduction of alien species into remote areas. In 2007, there were over 903 million international tourist arrivals, which provide an increasing and astounding vector for invasive alien species. People not only transport species on soil-contaminated equipment etc. accidentally, but many tourists bring home plants, plant parts or live animals as souvenirs. People also return home with fruits or other preserved living plant material that may carry potentially invasive insects or microbes that can have profound effects on agriculture. Public awareness and education of tourists, travel consultants, agencies, guides, and staff of the problems involved with invasive alien species are an essential element of prevention programmes.

Sorry, no free rides from the Torres Strait

Sunstate Airlines provides a daily service between Cairns in mainland Australia and Horn Island in the Torres Strait for tourists and business people. Through a practical programme, Sunstate makes sure that it does not carry the pests and diseases that are found in the Torres Strait to Cairns. The airline keeps clear of these unwanted passengers by providing quarantine information to passengers and through regular disinfection of its aircraft. Every passenger gets a quarantine message in their ticket wallet. Quarantine information cards are placed in every aircraft seat and the Sunstate flight attendants receive training on quarantine regulations. They are also tested regularly to ensure they are up to date and informed on quarantine.

(Source: *Australian Quarantine and Inspection Service, Department of Agriculture, Fisheries and Forestry, press release from 23 May 2000 available through www.aqis.gov.au/)*

CBD

three

CLIMATE CHANGE AND INVASIVE ALIEN SPECIES

Invasive species and climate change are considered some of the greatest threats to biological diversity. These two drivers of ecological change acting together could produce extreme outcomes. However, their joint effects on biodiversity loss have been little explored and poorly understood. The extinction of native species under climate change has been a concern among scientists, governments, institutions and organizations, but little attention has been paid to which species will replace them. Nevertheless, there is a general consensus that climate change will favour invasive alien species and exacerbate their impact on ecosystems.

Changes in climate may produce more conducive conditions for the **establishment** and spread of invasive species, as well as change the suitability of local climates for native species and the nature of interactions among native communities.

Under the influence of climate change, invasions can occur through:

- Introduction of new species
- Spread of already established species
- Established non-invasive species becoming invasive under new ecological conditions.

Climatic and landscape features set the ultimate limits to the geographical distribution of species and determine conditions for growth and survival. For example, climatically induced stress on plants can reduce their ability to resist invaders and they may be more prone to insect and disease damage, lowering their competitive capacity.

Some of the greatest impacts of climate change on invasive species may arise from the changes in frequency and intensity of extreme climatic events, such as droughts, fires or freezing that disturb ecosystems, making them vulnerable to invasion.

Climate change may allow previously inhospitable climates to become favourable to certain species. This is expected to cause northern range expansions of southern species, with some of these colonizers possibly becoming invasive. Some invasive species are at an advantage in warmer climates and can withstand climatic extremes with less mortality than native species. Certain properties of invasive species are likely to confer an advantage under climate change, such as tolerance of a wide range of climates, the ability to shift ranges rapidly, and the lack of dependence on other organisms for pollination and seed dispersal.

Plants

Climate change will likely have complex effects on the invasive potential of plants and may entail a dramatic re-organization of the plant community. The loss of keystone species or functional groups of plants could also influence the vulnerability of native plant communities to invasive plant species. Furthermore, atmospheric CO_2 concentration has increased 35% since pre-industrial times and continues to dramatically increase. This **greenhouse gas** has, in numerous studies, been shown to stimulate **photosynthesis** in plants, and invasive species are often more strongly stimulated than closely related native species in the same habitat by elevated CO_2. However, there remains a lack of evidence to properly confirm this claim.

Marine organisms

Increasing ocean warming may facilitate marine alien species invasions by increasing the magnitude of their growth and recruitment relative to natives, facilitating a shift to dominance by aliens, and accelerating the homogenization of global biodiversity.

Climate change is predicted to affect marine organisms by:

- Increasing ocean temperatures
- Increasing sea levels
- Changing ocean circulation
- Decreasing ocean salinity.

These factors directly alter physical and chemical conditions and contribute to changes in communities. Warming trends in middle to high latitude ocean waters may allow previously lower latitude restricted species to expand their range and colonize higher latitudes. Species that have warmer water affinities may increase in abundance. Warming oceans can cause physiological stress and mass mortalities of marine organisms, which can lead to empty niches to be potentially colonized by alien species. Increased ocean temperature can also cause pathogen range expansions.

Insects

Insects are strongly influenced by temperature. Many species are limited by the availability of summer heat and/or extreme temperatures for growth, reproduction and survival. Climate change is therefore likely to affect insects in terms of range expansion/contraction. However, depending on the life-history of the insect species and resource/niche availability, complex and diverse effects of climate change can be expected. Insects that have certain traits that are conducive to invasiveness, such as generalist feeding (feeds on a range of foods), cosmopolitan distribution and ability to adapt physiologically to new conditions, may be favoured by climate change

Evidence suggests that vector-borne diseases (e.g. involving insect carriers) could increase in frequency and shift its range in response to climate change. Many vectors are likely to expand their range within Europe and new vectors may be introduced from the tropics. For example, *Aedes albopictus*, a mosquito that transmits of dengue fever, spread to 22 northern provinces of Italy eight years after it was introduced.

Impacts of climate change on range expansion by the mountain pine beetle

Insect life cycles are extremely dependant on temperature and are expected to respond rapidly to climate change by shifting their geographic distributions to take advantage of new niches that become available. Since the mid 1990s, mountain pine beetle, *Dendroctonus ponderosae*, populations have erupted in British Columbia into the largest outbreak ever recorded and causing massive damage to lodgepole pine forests (other pine species can also be affected). In recent decades, hot summers have facilitated beetle reproduction and mild winters have allowed for greater survival of offspring.

Under normal conditions, native bark beetles, such as mountain pine beetle, attack dead or dying wood and provide vital ecosystem services such as nesting habitat for birds, food sources for predators and nutrient cycling. With the changing climate, many habitats that were uninhabitable to mountain pine beetle due to climate are now hospitable. It is predicted that most of the boreal forest will be available for infestation by mountain pine beetle, with continued eastern expansion probable. *(*Source: Carrol, A.L. et al. 2006. Mountain Pine Beetle Initiative Working Paper. Canadian Forest Service*)*

four

LET'S FIGHT BACK

Prevention is the most cost-effective and feasible method against invasive alien species. Halting the establishment of potentially invasive species in the first place is the first line of defence. Governments conduct customs checks, inspect shipments, conduct risk assessments and set quarantine regulations to try to limit the entry of invasive species. However, global inspection and risk analysis capacity is usually not sufficient.

Prevention involves regulating **intentional introductions** and minimising **unintentional introductions** through the identification of potential high-risk species and pathways. Measures to prevent the establishment of invasive alien species can be applied pre-border (before it leaves the source country), at the border (as it enters a country), or post-border (once it is already within a country).

Prevention tools for intentional alien species introductions

• *Risk analysis:* Evaluates the likelihood of an invasive alien species entering and establishing in an area and its potential environmental and economic impacts. It can be performed on an invasive alien species or a pathway and should be based on the precautionary approach. (A summary of concepts and **tools used for risk assessment is available at:** www.issg.org/Animal%20Imports%20Webpage/AnimalImports.html).

• *Environmental Impact Assessment (EIA):* Takes the findings of the risk analysis and considers other implications besides the risk of a species becoming invasive.

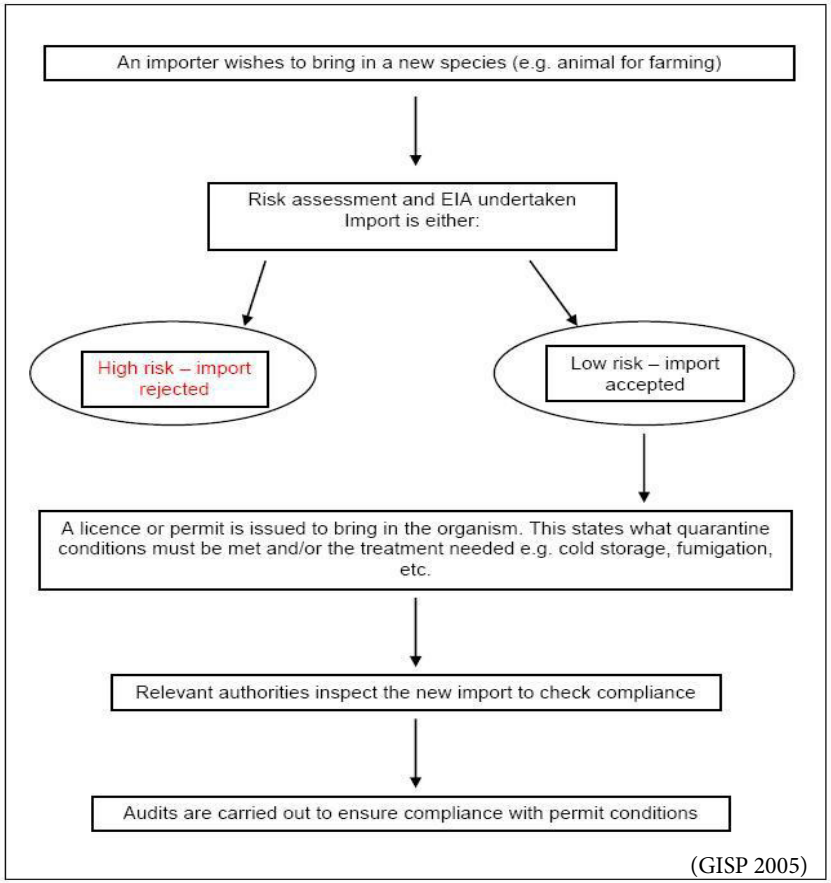
• *Authorisation procedures:* Authorisation procedures for permits and licenses are some of the most important tools for controlling the movement of alien species between and within countries. Permits may be granted with certain conditions, with specific penalties and fines if those conditions are violated.

• *Species lists:* Once risk assessments have been done, a species is then either placed on the red or green list (sometime these are referred to as black and white lists, respectively). The term "Grey list" is used for alien species of unknown, and therefore potentially invasive, status.

• *Quarantine and Border control:* Quarantine and border controls for intentional introductions are important when the identity of the species being imported is unclear. Quarantine measures should be in place so that the organisms can be held safely and without risk of escape, until they can be correctly identified by an appropriate authority.

• Participate in the development of international standards/references to help governments put in place systems to prevent the spread and introduction of invasive alien species similar to standards/references developed under the International Plant Protection Convention (IPPC) and Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

Fig. 4. Summary of management procedures for an intentional introduction



Prevention tools for unintentional and illegal introductions

• *Managing pathways and vectors:* Managing pathways is considered more effective than targeting specific species. Monitoring pathways and vectors can screen out many potential invasive alien species without additional time or money per species. It also avoids the problem of 'false negatives', i.e. species incorrectly assessed as non-invasive or innocuous.

• *Quarantine and border control* (see above).

• *Treatment or vector control:* Routine treatment of commodities (fruit and vegetables) is a standard procedure for removing hitchhiker species. There are a great many treatments that can be used for different target species and different products (see Table 3.2). The objective is to remove all propagules, of all species. If a single treatment method is not 100% effective, a combination of treatments should be employed.

• *Raising awareness and education.*

Beagle Brigade assists in the search for forbidden imports

The US Department of Agriculture's (USDA) Beagle Brigade is one facet of the Animal and Plant Health Inspection Service's (APHIS) agricultural quarantine and inspection (AQI) programme. The Beagle Brigade is a group of non-aggressive detector dogs and their human partners. They search travellers' luggage for prohibited fruits, plants, and meat that could harbour harmful plant and animal pests and diseases. These detector dogs work with APHIS inspectors and x-ray technology to prevent the entry of prohibited agricultural items. On average, APHIS officers make about two million interceptions of illegal agricultural products every year. The Beagle Brigade programme averages around 75,000 seizures of prohibited agricultural products a year. (Source: USDA's Detector Dogs: Protecting American Agriculture, http://www-mirror.aphis.usda.gov/lpa/pubs/usdabbb.pdf)

Dealing with established invasive alien species

Prevention does not always work and there are times that invasives become established. The four main strategies for dealing with established invasive alien species are eradication, containment, control and mitigation.

Eradication

Eradication is the elimination of an invasive alien species from a country or zone. Eradicating the entire population of an invasive alien species within a managed area is often the most desirable output, and has proven feasible, particularly with regards to small islands. Because the cost of eradication dramatically increases the longer a species has become invasive, it is important that eradication be initiated as soon as the potentially invasive species is detected. While eradication may involve high initial economic costs, if it is achieved, it is invariably more cost-effective than any measure that requires continuous expenditure over long periods of time.

Eradication is generally more environmentally sound and ethical than long-term control, which may involve the sustained use of toxins, trapping or shooting. Control can involve increased environmental risks and more animal deaths than a short eradication campaign. Numerous approaches to eradication or control have been developed, including mechanical, chemical, biological, habitat management and a combination of methods.

Eradication is often sufficient to allow the return of the original native wildlife. However, active management, such as replanting of native flora and reintroduction of fauna is frequently necessary to fully restore a damaged area. Once an area is restored, prevention is also required to keep an invasive species from returning to the island.

Eradicating screwworms from North America and North Africa

Screwworms, the larvae of the screwworm fly, are parasites that cause great damage by entering open wounds and feeding on the flesh of livestock and other warm-blooded animals, including humans. Left untreated, screwworm-infested wounds lead to death. The New World screwworm fly (*Cochliomyia hominivorax)* is native to the tropical and subtropical areas of North, South, and Central America. In the 1950s the infestation moved northward, with annual losses to livestock producers in the United States exceeding $400 million.

Screwworms are eradicated through a form of biological control called sterile insect technique (SIT). Millions of sexually sterile screwworm flies are artificially raised and released into the wild to mate with native fly populations, where no offspring will result from the matings. These unsuccessful matings lead to the gradual reduction of native fly populations.

This SIT was used operationally in Florida in 1957. By 1959, screwworms had been eradicated from the southeast United States. It was next applied in the more extensively infested southwest starting in 1962 and was subsequently eliminated from the United States by 1966. Since then, a co-operative international programme has been eradicating it from Central America. Hence, when an infestation of the New World screwworm appeared in Libya in 1988, the tools for its eradication were already available. The SIT campaign was successful in achieving eradication, preventing the enormous losses that would have occurred if the infestation had spread.

(Source: USDA-APHIS: http://www.aphis.usda.gov/international_safeguarding/screwworm.shtml)

Successful eradication programmes in the past have been based on:

- Mechanical control, e.g. hand-picking of snails and hand-pulling of weeds
- Chemical control, e.g. using toxic baits against vertebrates and spraying insecticides against insect pests
- Biopesticides, e.g. *Bacillus thuringiensis* sprayed against insect pests
- Sterile male releases, usually combined with chemical control
- Habitat management, e.g. grazing and prescribed burning
- Hunting of invasive vertebrates.

Containment

Containment of invasive alien species is a special form of control. The aim is to restrict the spread of an alien species and to contain the population in a defined geographical range. Containment programmes also need to be designed with clearly defined goals: barriers beyond which the invasive species should not spread, together with habitats that are not to be colonized and invaded, etc. An important component of a containment programme is the ability to rapidly detect new infestations of the invasive species spreading from the margins of its distribution. The nearest suitable habitat for the species should preferably be separated by a natural barrier, or an effective artificial barrier. The most suitable cases for containment are habitat islands without suitable connections that would allow the easy spread of invasive species. Frequently, for invasive alien species that affect plants, these areas can be set up as quarantine zones under national plant protection legislation. This helps stop the movement of these invasives outside their containment area.

Control

Control, with regard to damage to biodiversity and economy, aims for the long-term reduction in density and abundance of invasive alien species to below an acceptable threshold. Suppression of the invasive population below that threshold can tip the balance in favour of native competing species. The weakened state of the invasive species allows native species to regain ground and even further diminish the abundance of the alien species.

Mitigation

If eradication, containment and control are not options, or have failed in managing an invasive alien species, the last resort is to "live with" this species in the best achievable way and mitigate its impacts on biodiversity and endangered species. Mitigation as used in this context differs from containment and control in that the activity undertaken does not directly affect the invasive species in question but rather focuses on affected native species. At its simplest and perhaps most extreme form it could mean the translocation of a viable population of the endangered species to an ecosystem where the invasive species of concern does not occur or, in the case of a rehabilitated system, no longer occurs. It should be noted that mitigation can be labour intensive and costly and is often seen as an intermediate measure to be taken in tandem with eradication, containment or control for immediate mitigation efforts to rescue a critically endangered native species from extinction.

CBD

five

WHAT CAN BE DONE

Here are some examples of what you can do about invasive alien species[1]:

Policymakers

- Improve coordination among multilateral environmental agreements and other international institutions
- Develop a national strategy summarizing goals and objectives as the first step in formulating an alien species plan. An initial assessment, including a survey of native and alien species and their impacts, will help define the starting-point and serve as a base for comparison as the programme progresses. Engage support of all stakeholders during the entire programme, ideally using a social marketing campaign. Legal and institutional frameworks will define the basic opportunities for prevention and management of invasive alien species
- Put in place national regulations that may provide a level of enforcement for the control of invasive alien species such as legislation in accordance with the International Plant Protection Convention.

Consumers

Pet owners

- Purchase pets from reputable dealers. Non-native pets should be properly labelled, legally imported, and free of foreign pests and diseases that can spread to native wildlife

Travellers

- Leave natural items in their natural habitats. Clean hiking boots before walking in a new area as invasive weed seeds are common hitchhikers
- Abide by local and international quarantines to prevent the spread of insect pests, weeds and diseases.

1 **URL's used to compile this list:** Union of Concerned Scientists. www.ucsusa.org/invasive_species/what_you_can_do/what-you-can-do-to-prevent.html; US Fish & Wildlife Service. www.fws.gov/invasives/what-you-can-do.html; USDA National Invasive Species Information Centre. www.invasivespeciesinfo.gov/news/whatyou.shtml; Protecting Native Plants and Animals. Taking on the Invaders and Volunteer Opportunities (can select by State). The Nature Conservancy. www.nature.org/initiatives/invasivespecies/; Non-natives - What Can I Do to Help? Florida Fish and Wildlife Conservation Commission. http://myfwc.com/nonnatives/WhatCanIDo.html

CBD

Boating and Fishing

- Remove all aquatic plants and animals from hulls, propellers, intakes, trailers and gear before leaving a launch area and dispose of these organisms where they won't wash back into the water
- Always wash boats with hot, high pressure, tap water on the land-side before travelling to a new waterway. Let boat dry five days before using it in another waterbody
- Remove suspicious material and wash all fishing equipment.

Horticulturalists/ Landowners

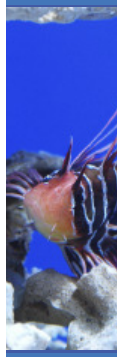
- Landscape and garden with native plants to your area (especially pollinator-friendly species), which provide food, cover or nesting sites for local wildlife, including butterflies and birds. There are many resources available on the Web for information on exotic, invasive and native garden plants
- Be particularly cautious when buying plants and seeds on the Internet or by mail order
- If you see your local nursery selling invasive plants or seeds, inform them about your concerns
- Drain backyard containers where invasive mosquitoes breed
- Regulate invasive plants as quarantine pests.

Educators

- Public education is an important tool to minimize invasive species releases. Provide information, including brochures, posters and lectures on invasive alien species in community centrers, libraries, schools and plant nurseries.
- Teachers should explore the role of introduced species in our natural ecosystems and how to prevent their introduction with their classrooms. There are many online resources with information, interactive games and classroom activities.

Youth

- Volunteer to help with local invasive plant eradication or control initiatives. Many parks and nature reserves need volunteers to manually remove invasive plants. This can be a great way to get some exercise, enjoy time outdoors, meet new friends and help protect nature. For older youth, there are also possibilities of recruitment overseas. Small tropical islands may be attractive to volunteers from developed countries with environmentally conscious populations and traditionally miserable climates
- Learn to recognize invasive species in your area and keep aware for signs of new potential threats. There are many resources available online and in public libraries. If you think you've found a new infestation, contact your local agricultural agent or department of natural resources
- Share your knowledge about invasive alien species with your family, friends and neighbours.



What you should not do!

Pet owners

- Don't release any pets: for example, rabbits can damage native habitats; cats prey on small mammals and birds; pet amphibians and reptiles may prey on native species and carry diseases
- Don't release any kind of aquarium fish into a natural body of water. Return unwanted pet fish to a local pet shop for resale or trade, or donate it to a friend, school, nursing home, or hospital
- Don't dispose of your aquatic plants or aquarium water into local waters. Many aquarium plants are highly invasive.

Travellers

- Don't carry fruit, seeds, live plants, berries, soil, insects, snails, lizards, snakes, or other animals while travelling between countries
- Don't transport items such as hay, wood, soil, sod or gravel from one part to another of the same country. They may contain fungi, seeds, diseases, insects or other potentially invasive species.

Boating and fishing

- Never transport water, animals or plants from one waterbody to another
- Don't release live fish, including bait, into a new body of water.

Horticulturalists/landowners

- Avoid buying and planting mixtures of seeds, such as packages labelled "wildflowers." Many contain invasive species while others are too poorly labelled to tell
- Never dispose of unwanted plants or lawn or garden clippings in a nearby park or natural area.

Community participation in control of *Salvinia* in Papua New Guinea

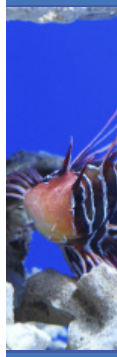
Giant salvinia, *Salvinia molesta*, is an aquatic floating fern from South America. Capable of forming dense mats, this invasive species reduces dissolved oxygen levels in the water, hinders water transport and obstructs intake pipes for irrigation in agriculture. In Papua New Guinea, the impact of *Salvinia* was particularly severe in the Sepik River, which drains much of the north-eastern part of the island of New Guinea. The lives of the regions' people are linked very closely with the river, which is their main source of food and the principal means of travel in an area lacking roads. A biological control programme using weevils was rapidly achieved in 1982-85 in lagoons on the lower Sepik River. The challenge then was how to redistribute the weevils to the rest of the river system. Redistribution was easy in principle since bags of *salvinia* fern together with weevils could be collected from the infested lagoons and simply released into other affected parts of the watershed. In practice the lack of infrastructure made this very challenging.

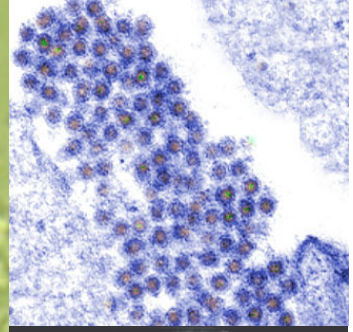
Messages were sent out via radio suggesting that villagers further up river visit the infested lagoons, collect bags of material (*salvinia* with weevils), take them back to their water bodies and release them. Canoes were used to ferry infested *salvinia* up the river. A single engine aircraft was also used to ferry infested *salvinia* longer distances. The involvement of the main stakeholders in the Sepik ensured that the biological control agents were well distributed. The resultant rapid control of the alien weed is one of the most successful stories of biological weed control. *(Prepared with input from Peter Room and Mic Julien, CSIRO, Brisbane.)*

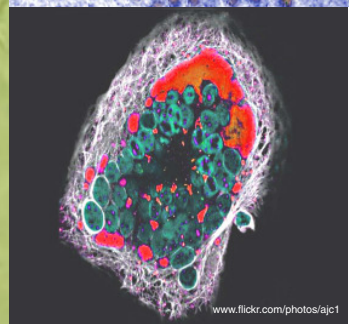
Social and environmental benefits of the Fynbos Working for Water Programme

The Fynbos "Working for Water Programme" is a sub-programme of the South African Department of Water Affairs and Forestry's "Working for Water Programme". South Africa has an enormous problem with invasive alien plants, especially in the Western Cape Province with its unique fynbos (natural shrubland or heathland vegetation in South Africa), where 80% of the threatened species are endangered because of invasive alien species. Because of extensive budget cuts during the political transition of South Africa, the invasive alien plant clearing programme had come to a virtual halt. At a November 1993 workshop to discuss the effects of invasive alien plants on runoff from fynbos catchments, a "road show" presentation was created, to demonstrate the effect of invasive alien plants on both water runoff and biodiversity, and the potential socio-economic consequences of this to policy makers. In 1995, due to the awareness created by this road show, R25 million (US$5.5 million) was allocated to the national programme, with R13.5 million of this going to the 1.14 million hectares of fynbos catchments of the Western Cape Province. The Fynbos Working for Water Program employed more than 3000 people at its (first) peak in 1996 and tens of thousands of hectares of invasive vegetation was cleared in less than a year. More people were employed following the injection of a further R40+ million into the project.

(Source: The Fynbos "Working for Water" Programme" in Aliens (1997) 5, p. 9-10, by Christo Marais, Programme Manager, and Dave Richardson, University of Cape Town. ASE STUDY)







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GLOBAL ACTION

The invasive alien species problem is global in scope and requires international cooperation to enhance the actions of governments, economic sectors and individuals at national and local levels. Sharing of information and expertise at a global level is a critical component in prevention and management of invasive alien species. A country can only prevent invasions if it is known what species are likely to become invasive, where they may come from and what are the best management options. There are some international and regional initiatives listed below that are dedicated to the compilation and dissemination of information on invasive alien species as well as to facilitate collaboration, networking and partnerships.

What is the Convention on Biological Diversity doing?

The United Nations Convention on Biological Diversity (CBD) and its member Parties and governments recognize that there is an urgent need to address the impact of invasive alien species. The CBD sets global priorities, guidelines, collects information and coordinates meetings and workshops on invasive alien species. The CBD invasive alien species programme was established as a cross-cutting issue, meaning that it is relevant to all other CBD programmes. The CBD also adopted the Guiding Principles for the Prevention, Introduction and Mitigation of Impacts of Alien Species that Threaten Ecosystems, Habitats or Species[1] (see: www.cbd.int/invasive/cop-decisions.shtml).

1 One representative entered a formal objection during the process leading to the adoption of this decision and underlined that he did not believe that the Conference of the Parties could legitimately adopt a motion or a text with a formal objection in place. A few representatives expressed reservations regarding the procedure leading to the adoption of this decision (see UNEP/CBD/COP/6/20, paras. 294-324).

What is the CBD?

At the 1992 Earth Summit in Rio de Janeiro, world leaders agreed on a comprehensive strategy for "sustainable development" – meeting our needs while ensuring that we leave a healthy and viable world for future generations. One of the key agreements adopted at Rio was the Convention on Biological Diversity. This pact among the vast majority of the world's governments sets out commitments for maintaining the world's ecological underpinnings as we go about the business of economic development. The Convention establishes three main goals: the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of the benefits from the use of genetic resources for the benefit of present and future generations. As of 2009, there are 191 Parties to the Convention.

Key invasive alien species resources:

International organizations working on invasive alien species

- International Plant Protection Convention (www.ippc.int)
- Convention on International Trade in Endangered Species of Wild Fauna and Flora (www.cites.org)
- The Global Invasive Species Programme (www.gisp.org/)
- IUCN's Invasive Species Specialist Group (www.issg.org)
- The Nature Conservancy (www.nature.org/initiatives/invasivespecies/)

International initiatives promoting information sharing

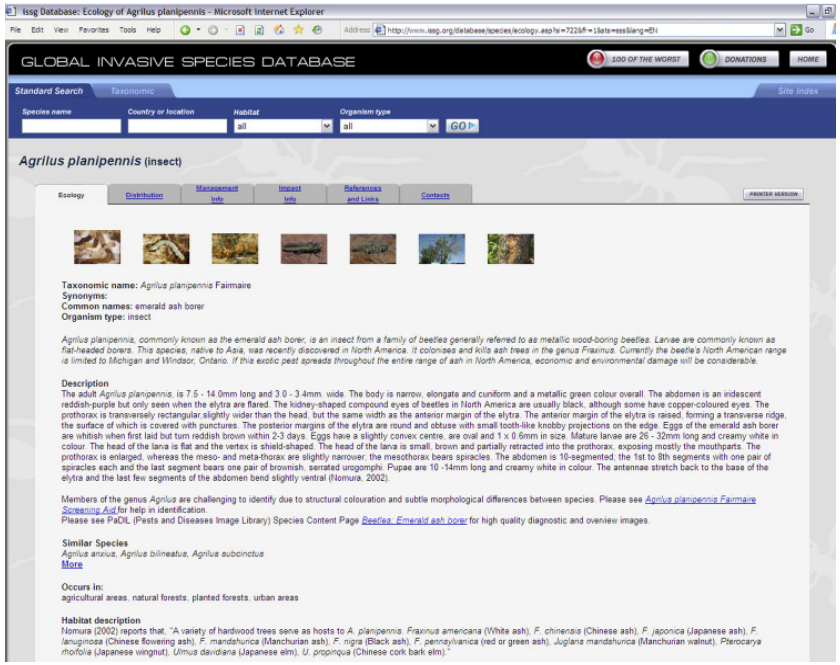
- CAB International (www.cabi.org/)
- Global Invasive Species Database (GISD) of ISSG (www.issg.org/database/welcome/)
- Global Invasive Species Information Network (GISIN) (www.gisinetwork.org/index.html)
- Global Register of Invasive Species (GRIS) of ISSG
- NISbase (www.nisbase.org/nisbase/index.jsp)

Regional and National Networks and Initiatives

- Regional Plant Protection Organisation (see listing on www.ippc.int)
- Aquatic Invasive Alien Species Web portal for ASEAN countries (www.aapqis.org/ias/home.html)
- Asia-Pacific Forest Invasive Species Network (APFISN) (http://envfor.nic.in/divisions/fret/apfisn.htm)
- BioNET's regional networks (www.bionet-intl.org)
- CIESM Atlas of Exotic Species in the Mediterranean (www.ciesm.org/online/atlas/index.htm)
- Delivering Alien Invasive Inventories for Europe (DAISIE) (www.europe-aliens.org/)
- Forest Invasive Species Network for Africa – FISNA (www.fao.org/forestry/site/26951/en/)

- Inter-American Biodiversity Information Network (http://i3n.iabin.net/)
- National Introduced Marine Pest Information System NIMPIS – An information system for marine introductions in Australia. (www.marine.csiro.au/crimp//nimpis/)
- The North European and Baltic Network on Invasive Alien Species (NOBANIS) (www.nobanis.org/About.asp)
- The North American Plant Protection Organization (NAPPO) Phytosanitary Alert System (PAS) (www.pestalert.org/aboutus.cfm, www.nappo.org)
- European Plant Protection Organisation (www.eppo.org/DATABASES/databases.htm)
- Regional Biological Invasions Centre (RBIC) (www.zin.ru/)
- USDA National Invasive Species Information Center (www.invasivespeciesinfo.gov)

Examples of Invasive Alien Species fact sheets available online:



Global Invasive Species Database (www.issg.org/database)

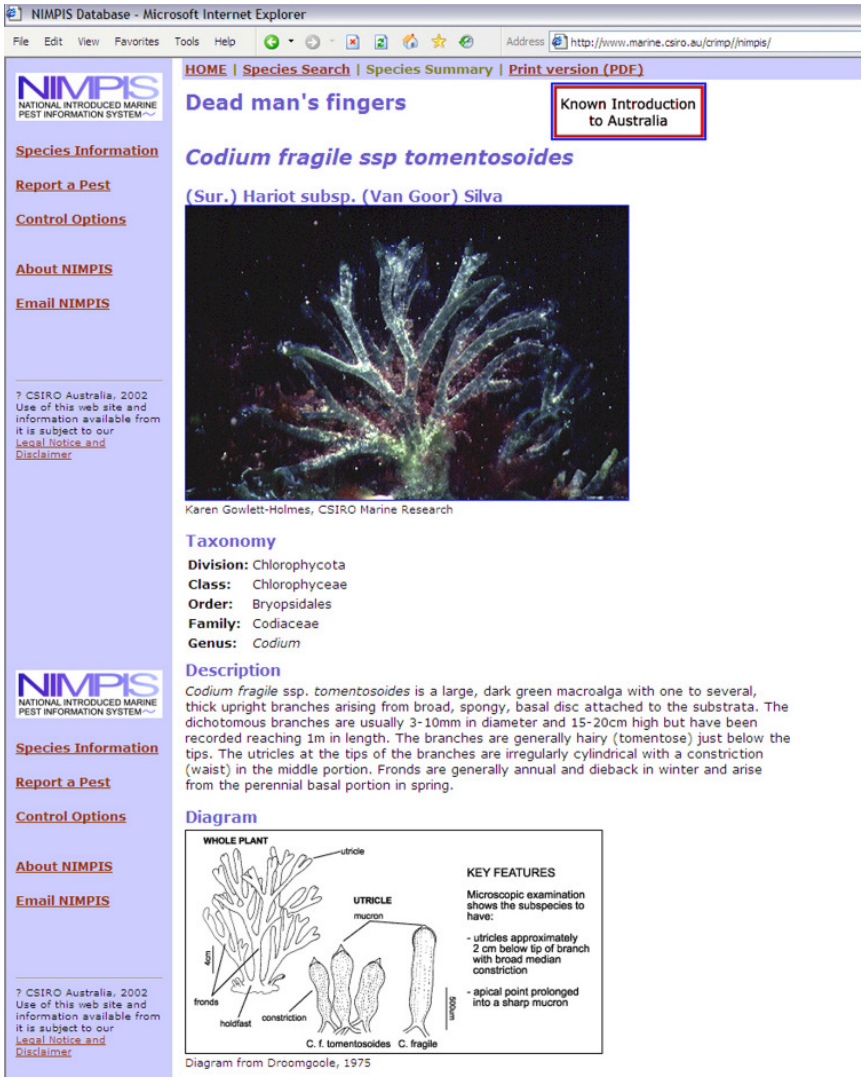
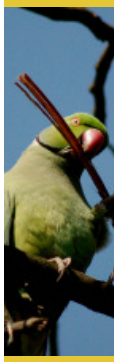


Diagram from Droomgoole, 1975

National Introduced Marine Pest Information System (www.marine.csiro.au/crimp/nimpis)

Words defined in the Glossary are in bold the first time they appear in the text

Term	Source	Definition
Biological diversity or Biodiversity	Convention on Biological Diversity (CBD)	The variability among living organisms from all sources including, *inter alia*, terrestrial, marine and other aquatic systems and the ecological complexes of which they are part of; this includes diversity within species (genetic), between species and of ecosystems.
Biome	Millennium Ecosystem Assessment (2005)	The largest unit of ecological classification that is convenient to recognize below the entire globe. Terrestrial biomes are typically based on dominant vegetation structure (e.g. forest, grassland).
Climate change	CBD	A variation either in the mean state of the climate or in its variability, persisting for an extended period, typically decades or longer.
Driver	Millennium Ecosystem Assessment (2005)	Any natural or human-induced factor that directly or indirectly causes a change in an ecosystem.
Ecosystem	CBD	A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit.
Establishment	CBD	The process of an alien species in a new habitat successfully producing viable offspring with the likelihood of continued survival .
Exotic species	United Nations Environment Programme-World Conservation Monitoring Centre (UNEP-WCMC)	An organism that exists in the free state in an area but is not native to that area. Also refers to animals from outside the country in which they are held in captive or free-ranging populations.
Globalization	Millennium Ecosystem Assessment (2005)	The increasing integration of economies and societies around the world, particularly through trade and financial flows, and the transfer of culture and technology.
Greenhouse gas	Intergovernmental Panel on Climate Change (IPCC)	Greenhouse gases are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation emitted by the Earth's surface, the atmosphere itself, and by clouds. This property causes the greenhouse effect. Water vapour (H2O), carbon dioxide (CO2), nitrous oxide (N2O), methane (CH4) and ozone (O3) are the primary greenhouse gases in the Earth's atmosphere.
Intentional introduction	CBD	The deliberate movement and/or release by humans of an alien species outside its natural range.

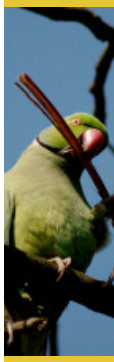


Introduced species	International Council for the Exploration of the Sea (ICES)	Introduced species (= non-indigenous species = exotic species): any species transported intentionally or accidentally by a human-mediated vector into aquatic habitats outside its native range. Note: secondary introductions can be transported by human-mediated or natural vectors.
Invasive alien species	CBD	"An alien species whose introduction and/or spread threaten biological diversity (for the purposes of the present guiding principles, the term "invasive alien species" shall be deemed the same as "alien invasive species" in decision V/8 of the Conference of the Parties to the Convention on Biological Diversity)."
Native species	UNEP-WCMC	Plants, animals, fungi and microorganisms that occur naturally in a given area or region.
Nutrient cycling	Millennium Ecosystem Assessment (2005)	The processes by which elements are extracted from their mineral, aquatic, or atmospheric sources or recycled from their organic forms, converting them to the ionic form in which biotic uptake occurs and ultimately returning them to the atmosphere, water, or soil.
Pathway	International Plant Protection Convention (IPPC)	Any means that allows the entry or spread of a pest.
Pest	IPPC	Any species, strain or biotype of plant, animal or pathogenic agent injurious to plants or plant products.
Photosynthesis	IPCC	The process by which green plants, algae and some bacteria take carbon dioxide from the air (or bicarbonate in water) to build carbohydrates. There are several pathways of photosynthesis with different responses to atmospheric carbon dioxide concentrations.
Protected area	CBD	A geographically defined area which is designated or regulated and managed to achieve specific conservation objectives.
Sustainable development	CBD	Meeting our needs while ensuring that we leave a healthy and viable world for future generations.
Unintentional introduction	CBD	All other introductions which are not intentional.
Unintentional introduction	International Union for Conservation of Nature (IUCN)	An unintended introduction made as a result of a species utilising humans or human delivery systems as vectors for dispersal outside its natural range.
Vector	ICES	Any living or non-living carrier that transports living organisms intentionally or unintentionally.

Sources used *(that are not cited in references):*

CBD	COP decisions or Convention text
IPPC	International Plant Protection Convention. International Standard for Phytosanitary Measure #5 (Glossary of Phytosanitary Terms), 2006.
IPCC	Glossary of the IPCC Fourth Assessment Report, 2007.
IUCN	Guidelines for the Prevention of Biodiversity Loss Caused by Alien Invasive Species, 2000. Approved by the IUCN Council, Feb 2000.
ICES	International Council for the Exploration of the Sea. Code of Practice on the Introduction and Transfer of Marine Organisms, 2005.
UNEP-WCMC	UNEP World Conservation Monitoring Centre – Glossary of Biodiversity Terms (www.unep-wcmc.org/reception/glossary).

CBD



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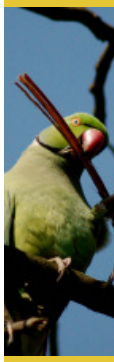

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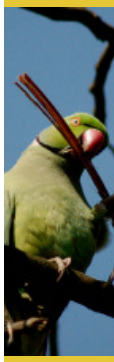

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