Invasive Alien Species and Protected areas: A Scoping Report Part I.

Scoping the scale and nature of invasive alien species threats to protected areas, impediments to IAS management and mean to address those impediments.

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The Global Invasive Species Programme

INVASIVE ALIEN SPECIES AND PROTECTED AREAS
A SCOPING REPORT

Produced for the World Bank as a contribution to the Global Invasive Species Programme (GISP)

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PART I

SCOPING THE SCALE AND NATURE OF INVASIVE ALIEN SPECIES THREATS TO PROTECTED AREAS, IMPEDIMENTS TO IAS MANAGEMENT AND MEANS TO ADDRESS THOSE IMPEDIMENTS.

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EXECUTIVE SUMMARY

Invasive alien species (IAS) are found in all taxonomic groups and virtually every ecosystem type, in any region of the world has been affected to some extent. Biological invasions by alien species are now considered one of the main factors in the loss of biodiversity worldwide. Impacts from IAS on biodiversity can be direct, indirect, and cumulative.

In protected areas, as elsewhere, impacts from invasive alien species take the form of impacts on ecosystem function, impact on ecosystem structure, and impacts at the level of species communities or habitats as well as at the level of species. IAS directly or indirectly impact on livelihoods and poverty alleviation, through affecting ecosystem services or sustainable use of biodiversity or through impinging on cultural and heritage values.

The Convention on Biological Diversity (CBD) recognises the importance of this global issue and calls on contracting parties to: *"prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats and species"* (Article 8 (h). The Conference of the Parties to the Ramsar Convention addresses IAS in coastal and inland wetlands. Resolution VIII/18 (Invasive Species and Wetlands) urges Ramsar Parties, among other, *"to address the problems posed by invasive species in wetland ecosystems in a decisive and holistic manner…"*.

The Vth IUCN World Parks Congress, in Durban, South Africa, September 2003, considered the need to manage IAS as an "emerging issue", stating that *management of invasive alien species is a priority issue and must be mainstreamed into all aspects of protected area management.*

This scoping study found that there is a shortage of consolidated information at global, international and/or regional level, on invasive alien species impacts, threats and management in protected areas. While there is a wealth of information available at site level and to some extent at national level, this is very dispersed, not standardised, and as such it is difficult to gain an overall, global, view of the scale and significance of invasive alien species impacts and threats to protected area values.

The aim of this study is to provide a general scoping of the issue of invasive alien species as they affect protected areas at a worldwide level. It should not be interpreted as an in depth global assessment. The situation described and discussed in this scoping report is only "the very tip of the iceberg".

The scoping result shows that invasive alien species in protected areas are not limited to a few regions, a few countries, or a few species. On the contrary, in spite of the practical limitations of this scoping, we were able to identify

- 487 protected area sites with invasive alien species recorded as an impact or threat
- 106 countries where protected area(s) have been recorded as having invasive alien species as an impact or threat; in all regions, but especially in Asia, Africa, South and Central America (including Mexico and the Caribbean and Europe).
- 326 IAS species recorded as an issue for protected areas

Invasive alien species are a problem in a great variety of types of protected areas, with national as well as with international designations.

Our findings showed 277 Ramsar sites where IAS are reported as a threat either from within the site or from within the catchment. This is 17% of all Ramsar sites, and yet still likely an under-estimation. More than half of the Parties to Ramsar, namely 84 countries, have IAS threats to at least one of their sites. The number of such countries is especially high in Africa, Asia, South America and Europe.

We also have information on 27 World Heritage (WH) sites where invasion by alien species is already taking place. This is 15% of the total number of Natural and Mixed sites, and almost certainly a significant under-estimation.

With regards to IUCN Categories, Cat II, Cat IV and Cat V show the highest number of sites with IAS problems (for those sites in our information sources where the IUCN Category was known). While the sample available was relatively small, and therefore any interpretation should be seen as tentative only, it is of concern that relatively speaking, a high number of Cat II sites were found to be under threat by IAS.

Our findings confirmed that threats to protected areas can be associated with IAS in the wider landscape, rather than just in the site itself. They also confirmed, at least for wetlands, that the issue of native invasive species deserves attention, especially in the African region. These confirms the need to address invasive alien species in an ecosystem context.

The limited scale of the pilot study meant that it was not possible to specifically attempt to analyse IAS threats to protected areas for different habitats, ecosystems or biomes, but we approached this question through a literature review on IAS threats on biodiversity in general. The overall conclusion is that ecosystems all over the planet have been invaded to a greater or lesser degree, terrestrial, freshwater and marine, on islands and on continents, in cold, temperate and tropical climates. Protected areas are no exception to this. Even remote zones such as mountain areas, wildernesses, or the Sub-Antarctic uninhabited islands are not free of invasive alien species and their impacts.

The designation of a site as a protected area, can in fact increase the risks of biological invasion. An increase in visitors has been associated with an increased number of alien species introductions, and hence an increased probability for the arrival of potentially invasive ones. Roads, construction, etc. are also high-risk pathways. Even one of the most ecologically acceptable methods to protect natural areas, such as ecotourism or nature tourism may facilitate the introduction of alien species into hitherto little disturbed natural habitats by bringing in large numbers of humans from far away.

Increased global trade and travel, increased fragmentation of protected areas, synergies with other global change (such as climate change), and the presence of a potentially large number of "sleeper invaders" means that the threat of invasive alien species to protected areas will increase in future.

While effective methods to address existing invasions continuously improve, in general the priority is to apply prevention, early detection and rapid response.

Our scoping found that the key impediments and challenges to dealing with invasive alien species in protected areas include lack of capacity for mainstreaming invasive alien species management into overall protected areas management; lack of capacity for site based effective IAS management; lack of awareness of the impacts of invasive alien species on PA values as well as lack of awareness of the options for management – especially the importance of prevention and early detection; lack of consolidated information at international level and lack of practical management information at site level; lack of funding and other resources; clashes of interest; and lack of institutional, legal, and other high level support.

The key to addressing these impediments is to:

(1) Develop and/or foster capacity for mainstreaming of invasive alien species issues into all aspects of protected area management (including site assessment, recognition of future threats from species that have not yet reached their invasion potential in or near the site, and management effectiveness evaluation).

(2) Develop and/or foster capacity at site level for all aspects of effective invasive alien species management (including risk assessment, prevention, early detection and rapid response as well as eradication and control).

(3) Develop and/or foster awareness at all levels, from site managers to decision makers and politicians, and also including the international conservation community, and funders.

(4) Foster development of consolidated information source(s) at national, international and global level, on invasive alien species impacts, threats and management in protected areas

Protected areas cannot be seen as safe and sound places that, once designated, can be "left for nature to get on with things" . Without management to prevent and address invasive alien species, protected area values, including ecosystem services and biodiversity, will inevitably be eroded. Far from leading to despondency, however, this threat should be an incentive to arm protected area managers with the resources and capacity to effectively fight back. Prevention, early detection and rapid response at the site level (or system level) are the key to future-proofing protected areas, the values they contain and the livelihoods they support; eradication and control can be deployed to maintain biodiversity and livelihood outcomes, or restore those that have been lost.

In conclusion, while the underlying causes of invasive alien species threats to protected areas are significant and global in nature, protected area managers are far from helpless. Provided there is awareness, capacity and resources, the global threat from biological invasions can effectively be dealt with at the local site level.

GLOSSARY

Terminology relating to invasive alien species (IAS) has developed independently in different sectors such as agriculture, health, and conservation, and in the key international instruments that address them, reflecting their different mandates. This glossary explains the terminology used (in the invasive alien species context and/or in the protected areas context) in this publication.

> *Invasive alien species (IAS):* in the context of the Convention on Biological Diversity (CBD), invasive alien species means an "alien species whose introduction and/or spread threaten biological diversity" (CBD 2002). Operationally, practitioners will often express invasiveness in terms of impacts caused, in the case on animal IAS, and in terms of *establishment*, spread and (sometimes) abundance for IAS that are plants. Invasive alien species are often a threat to ecosystem services and livelihoods as well as to biodiversity itself. For the purpose of this publication, invasiveness can also include any other type of threat to *protected area* values resulting directly or indirectly from the introduction of an alien species. *Pest* and *weed* are sometimes used as synonyms, but these terms can also be used in different meanings; often "invasive species" is used as a synonym, even though it is better to limit that term to situations where the species showing invasiveness can be either alien or native. When we use "biological invasion" in this publication, we use it predominantly as a synonym for "invasion by invasive alien species" with the understanding that in some circumstances the concepts discussed can also be applicable to native invasive species.
>
> *Protected area (PA)*: IUCN definition "an area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means" (Chape *et al.* 2003). In practice this can include sites with have been designated by authorities at national, sub-national (e.g. province, state, municipality), or international level, as well as sites under traditional or community-based management.

Alien species: a species, subspecies or lower taxon, *introduced* outside its natural past or present distribution; includes any part, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce (CBD 2002). "Exotic", or "non-native" species is sometimes used as a synonym.

Capacity: the ability to perform functions, solve problems, and to set and achieve objectives (Barber *et al*. 2004). Capacity to manage has many components (see Hockings *et al*. 2000).

C*ontrol*: a specific type of *IAS management*, reducing the density or distribution (or both) of an IAS population to below a pre-set acceptable threshold.

Decision makers / managers cover managers and decision makers at site level as well as at system level for protected areas. These will be often be personnel of national or local government agencies with a mandate for protected areas; however, in many cases, they could be NGO staff, traditional or private owners, villagers, etc.

Early detection: a specific type of *IAS management*, using surveys, fortuitous detection etc., to find and identify known or potential future invasive alien species as early as possible; the aim is to allow for *rapid response*.

Eradication: a specific type of *IAS management*, namely 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.

IAS management: see *Management (of IAS).*

Introduction: the movement, by human agency, of a species, subspecies or lower taxon outside its natural range (past or present). This movement can be either within a country from a location where the species is native to a location within the same country where it is not native, or the movement can be between countries (or even continents).

Management (of IAS): includes *prevention, early detection, rapid response, eradication, control* and *mitigation.*

Managers (e.g. of a site) – see *Decision makers*

Mitigation: reducing the impacts of an IAS on features of the environment e.g. by supplementing the resource that the IAS is depleting or by moving native species elsewhere. (Note: mitigation deals with the impact of the IAS, not with the IAS itself.)

Pathway: For the purpose of this manual, a pathway is broadly defined as the means (e.g. aircraft, vessel or train), purpose or activity (e.g. tramping, erosion control, stocking ponds with fish, road building, forestry, etc) or commodity (e.g. packs or boots, building material, fishing gear, snorkelling gear) by which a (potential or known) invasive alien species may be transported to a new location, either intentionally or unintentionally.

Pest: This term is sometimes used as synonym to invasive alien species. Others use it to mean a species that is harmful in an agricultural/economic sense. It can also be used for native animals that are invasive. If it is used in this publication, its meaning will be clear from the context.

Prevention: particular type of *IAS management*. In this publication, it refers mostly to the keeping IAS out of particular sites (or out of specific locations within a site). Elsewhere it is often used at country level: keeping IAS out of a country (e.g. through import restrictions, border control etc). Prevention includes:

- the prevention of intentional *introductions* of any alien species unless they have been determined to be acceptable (e.g. through *risk assessment*), and
- the minimisation of unintentional *introductions* of alien species

Rapid response: a particular type of *IAS management*, consisting of a systematic effort to *eradicate*, or *control* invasive or potentially invasive alien species at an early stage, before they are *established* and/or widely spread.

Risk assessment: evaluation of the likelihood of invasiveness for an alien species, including an estimate of the nature and magnitude of potential impacts, and a judgement of their significance. Note: the aim of such assessment is not to produce an ecological model, but simply to support *IAS management* decisions.

Threat : we consider an invasive alien species as a threat to protected area values either when an impact has been identified or otherwise observed, or when a relevant risk has been determined through risk assessment; Future threats result from species already present that, while not invasive yet, will likely become so in future; future threats also result from risk-species not present yet but likely to be introduced in future.

Weed: a plant growing where it is not wanted; Sometimes used as synonym for IAS that is a plant, but also sometimes used for native invasive plants. If it is used in this publication, its meaning will be clear from the context.

1 INTRODUCTION

1.1 Invasive alien species

The natural biogeographical barriers of oceans, mountains, rivers and deserts provided the isolation essential for unique species and ecosystems to evolve. Now these barriers have lost their effectiveness - as economic globalisation has resulted in an exponential increase in the movement of organisms from one part of the world to another through trade, transport, travel and tourism. While many of the deliberate movements of organisms into new ecosystems where they are alien are beneficial to people (food and other economical uses), nevertheless tremendous damage results from those that are detrimental. This report addresses the latter group: "Invasive alien species" (IAS).

Invasive alien species are found in all taxonomic groups: they include introduced 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, in all regions (see e.g. *www.issg.org/database*, UNEP 2001, Lowe *et al*. 2000, Matthews and Brand 2004, Matthews 2004,2005). Biological invasions by alien species are now considered one of the main factors in biodiversity loss and endangered species listings world wide (OTA 1993), and almost certainly the worst one on islands (Clout 1999, Clout and Lowe 2000). The *2004 IUCN Red list of Threatened Species – A Global Species Assessment* includes the following examples: for freshwater fishes globally, preliminary analysis points to invasive alien species having contributed to 50% of species extinctions; on islands, 67% of oceanic-island globally threatened birds are affected by IAS (Baillie *et al.* 2004).

The Millennium Assessment confirms that IAS have been one of the main drivers of biodiversity loss over the last 50 to 100 years, and assesses that the trend in the impact (at global level) will continue or increase in all biomes (UNEP 2005a,b). The cost includes the loss of native species, biodiversity and ecosystem functioning, ecosystem services and livelihoods.

Impacts of invasive species can be very straightforward - *R. norvegicus* effectively wiped out the puffin population of Ailsa Craig, a protected area in the UK, by preying on eggs and chicks (ICEG 2004). Kaziranga National Park is a vital habitat for the world's largest population of the Great One-horned Rhinoceros (*Rhinoceros unicornis)* The grasslands of the Kaziranga National Park are threatened by two alien species of Mimosa: *M. rubicaulis* and *M. diplotricha* which have spread across the grasslands and hampered the growth of the palatable grasses, thereby threatening the rhinoceros as well as ungulates (Gureja, N. Personal communication. 2003, and also see *www.wti.org.in*).

Rattus and *Mimosa* species have been introduced in several areas of the world (intentionally or unintentionally), and have become invasive in protected areas around the globe. For an example of a wide-spread invasive amphibian, see Box 3.1.
A complicating factor is the fact that impacts on biodiversity or ecosystem functioning, caused by IAS, are often more complex and more "surprising" than the impacts of, for example, agricultural weeds on crops. For instance, in the South African St Lucia protected area *Chromolaena odorata*, an invasive plant, has been linked to Nile crocodiles' sex ratio changes. (Leslie & Spotila 2001). An alien species

may be "dormant" and show no signs of being invasive for years or decades and then turn invasive: for instance, the spread of invasive trees in the Florida Everglades was delayed until the area became more prone to anthropogenic disturbance and/or hurricanes (Crooks and Soulé 1999). Another complicating factor is that alien species, over time, may "change" and develop evolutionary adaptation to their new environment (Cox 2004) – for instance, cane toads at the forefront to spread in Australia (including the spread towards Kakadu National Park), have evolved into being faster that those in the areas where they have been established a long time (Phillips 2006).

Often impacts are indirect or cumulative, and it is not always possible to determine them quantitatively – especially in the case of impacts on plant species (which do not often lead to extinction, but rather to ecological dysfunction). Rather than being unimportant, such hard to measure effects can be the most pervading and insidious ones. The threats from IAS should not be underrated. In the context of Switzerland, for instance this has been expressed as: *one of the major consequences, which is undoubtedly unfolding before our eyes, is global homogenization (catchily called McDonaldization), with the unique character of places such as Switzerland being lost, the characteristic flora and fauna invaded by organisms which often accomplish to form the largest biomasses in certain ecosystems. This is fact and cannot be argued about, while confirmation of impacts is difficult to obtain and can be controversial* (Wittenberg 2005).

Even without any complicating factors, in the usual pattern of invasion IAS have a lag phase during which they are low in abundance and their impacts are not noticeable. This is sometimes called a "sleeper" stage. However, eventually the population reaches a phase where it increases rapidly (explosion phase) and the impacts usually become very apparent. The lag phase can be short or last over a century. Following the explosion phase, the population levels out as the population reaches the carrying capacity.

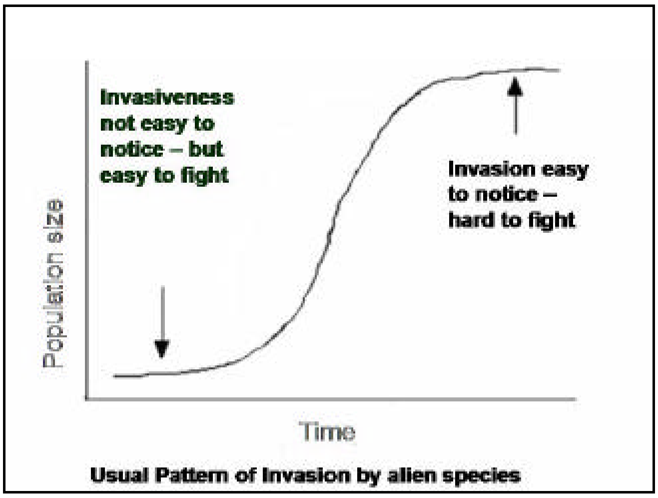

Figure 1.1: usual pattern of biological invasion

As a result of these complexities, if managers are aware of the threats posed by an alien species at an early stage, when the population is not very large yet, and the species is not well established and/or not widely spread yet, they can usually still eradicate relatively easy. However, if the problem is only noticed much further down the line, when the invasion is much further advanced, it will be much more difficult and costly (and sometimes impossible) to address it through eradication or control. (see Fig 1.1)

The good news is that methods to fight back against IAS are constantly improving, and a growing number of success stories documents the significant biodiversity and livelihood outcomes that can be achieved by IAS management at site level. For instance, in 1989 the kakerori (Rarotongan flycatcher) was one of the world's rarest birds (29 individuals). The Takitimu Conservation Area (Rarotonga, Cook Islands) was created by traditional owners (clans) of the area. Clans manage the area and the ship rat (*Rattus rattus*) is controlled. As a result, in 2002 more than 250 birds were alive and well and the area is a flagship for income generating activities (ecotourism). (UNDP 2002). This is an excellent example of what can be achieved with "fighting back". However, even more importantly, when risk assessment, prevention, early detection and rapid response are applied, biological invasion threats can be stopped at an early stage, and environmental costs, livelihood costs and financial costs are much lower.

The Convention on Biological Diversity (CBD) recognises the importance of this global issue and calls on contracting parties to: *"prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats and species"* (Article 8 (h)).

IAS in coastal and inland wetlands were addressed by the Conference of the Parties to the Ramsar Convention on Wetlands. Resolution VIII/18 (Invasive Species and Wetlands) urges Ramsar Parties, among others, *"to address the problems posed by invasive species in wetland ecosystems in a decisive and holistic manner…"*.

1.2 Invasive alien species in protected areas

Farmers have been fighting "weeds" and "pests" as an integral part of agricultural activities for centuries, if not millennia, but the general global problem of invasive alien species impacts on biodiversity and ecosystem functioning has been brought to the world's attention only relatively recently. With protected areas, one of the additional challenges we face is a philosophical one: the fact is that in many, or even most, protected areas, "leaving nature alone to get on with itself" is no longer an option: the threat from invasive alien species means that ecological integrity depends on ongoing human intervention in the form of IAS management, and will be lost without it. In the "IAS community", the threat to protected areas, caused by IAS has been publicised for at least two decades (e.g. Macdonald *et al.* 1989, Usher 1988), and more recently awareness of the major threat from IAS to the overall concept of protected areas has been recognised in the "international protected areas community" as well. Mulongoy and Chape (2004), in an overall overview of key issues facing protected areas state: *Another widespread threat [to PAs] is that of alien invasive species which may be released, deliberately or accidentally, within a protected area, or may move in from surrounding areas.* A growing number of publications assessing the state of the protected areas system, highlight the issue (e.g. Carey *et al.* 2000, Pomeroy *et al.* 2004).

Similarly, the survey of participants at the Vth IUCN World Parks Congress, in Durban, South Africa, September 2003, showed that participants rated invasive alien species as one of the key threats to PA resources. Table 5 from these survey results (IUCN 2005) is reproduced as Fig 1.2.

Table 5. Key threats to PA resources

	All respondents (%)
Inappropriate adjacent land use	46.5
Overharvesting for commercial purposes	33.0
Invasive species	31.6
Infrastructure development	28.2
Agricultural encroachment	26.1

Figure1.2 Participants' survey, Vth World Park Congress
From IUCN (2005)

Not surprisingly, the theme of invasive species and their threat to protected areas was reflected also in the "emerging issues" (IUCN 2005) of the World Parks Congress:

Management of invasive alien species is a priority issue and must be mainstreamed into all aspects of protected area management.

The wider audience of protected area managers, stakeholders and governments needs urgently to be made aware of the serious implications for biodiversity, protected area conservation and livelihoods that result from lack of recognition of the IAS problem and failure to address it.

Promoting awareness of solutions to the IAS problem and ensuring capacity to implement effective, ecosystem-based methods must be integrated into protected area management programmes. In addition to the consideration of benefits beyond boundaries, the impacts flowing into both marine and terrestrial protected areas from external sources must be addressed.

1.3 Why this scoping report on invasive alien species in protected areas?

The most accessible publications on IAS impacts and management in protected areas are predominantly from Australia, New Zealand, USA, and South Africa (e.g. Pestat 2006, Loope 2004, McDonald *et al.* 1989, DOC 2000, Goodman 2003b). As far as habitats go, there is generally no doubt that for islands and for freshwater ecosystems IAS are a large, if not the largest, threat to conservation – and hence it is generally accepted that IAS management is a significant issue for PA management in such ecosystems (Baillie *et al.* 2004, Saunders *et al.* 2002, Sherley 2000, GISP 2003, Barber 2004).
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However, in the PA management community at large, while there is growing acceptance of IAS as an issue, there is not necessarily yet an understanding on how widespread this situation is. There also seems to be a discrepancy in awareness and understanding between practitioners on the one hand, and decision makers and the wider stakeholder community on the other. For Europe, for instance, Scalera and Zaghi (2004) conclude: *although wildlife managers recognize the growing threat of*

alien species [for Natura 2000 sites], decision makers and the general public still seem to underestimate the problem". Furthermore, lack of awareness on ways to address IAS at local level may contribute to an unwarranted sense of despondency in decision makers either at site level, or at system level.

In contrast, within the IAS community there is a much wider held opinion that the threat to PAs is generally applicable, and that any site anywhere is likely to either already have alien species in it which are, or will be a problem, or that risk species are increasingly likely to arrive (e.g. Macdonald *et al.* 1989, Usher 1988, De Poorter and Ziller 2004). In addition, IAS experts will point out that far from being "too hard", management of IAS at protected area site level is already done by many in their day to day work, including in low resource situations (e.g. Veitch and Clout 2002, Scalera and Zaghi 2004, Aliens 2003, Park Science 2004; for an inspiring example in the American Samoa National Park, see Togia 2003, and for one from a site in traditional ownership, see UNDP 2002).

1.4 Aims of this scoping

This report has been produced to provide a general scoping of the issue of IAS and protected areas at an overall world wide level. In view of the divergent perceptions of the level and scale of threat that IAS may pose in PAs, the production of such a report is timely. It should, however, not be confused with an in depth global assessment of IAS in PA situation – this would require the collection of a huge amount of information on PA sites, which is simply not possible with the limited amount of resources available;

In the first part of this report, the issues covered are:

1) What consolidated information sources are available and accessible about the issue of IAS in PAs at global, international, and regional level? What other , non consolidated, sources are there? What is the situation with information at national level and at individual site level?

2) How widespread is the threat of invasive alien species to protected areas worldwide

3) Is the threat limited to some biomes, ecosystems and habitats or is it widespread?

4) What are the impacts of IAS in protected areas? How are their values affected?

5) What is the likely future trend of the threat of IAS to protected areas?

6) What are the main challenges and impediments to effective management of IAS in protected areas?

7) Solutions: addressing the challenges and impediments

In the second part (a separate document) we suggest possible roles for IUCN.

2 INFORMATION COLLECTED, COLLATED AND ANALYSED FOR THIS SCOPING REPORT

We used information from the following sources:
Literature search (desktop survey and analysis), contributions from ISSG (Invasive Species Specialist Group of IUCN's Species Survival Commission) and WCPA (World Commission on Protected Areas) networks, a collection of records collected specifically by ISSG (Pilot sample), a query specifically designed and run in the Global Invasive Species Database (GISD), the combined results of several Ramsar database queries, and relevant results from a 2005 IUCN survey on marine protected areas (MPAs).

2.1 Pilot sample of information on IAS in protected areas (Pilot sample)

The ISSG team had already started a collection of "IAS in PA" facts/records prior to this scoping project. A first phase of this scoping consisted of adding further records to this material. Collection of information was carried out at multiple levels. The WDPA dataset was used to generate lists of global PAs. Requests for information/feedback on IAS in protected areas, their impacts on the values of these areas, management strategies in place and impediments encountered, was sent out to ISSG and WCPA networks. A focussed desktop survey of published literature on IAS in PAs was also carried out.

Information collected for each record included (as possible): name of the protected area, country, size, IUCN Category (or WH criteria), designation, location, WCPA Region, PA values, what species of IAS are an issue in it, impacts resulting from the IAS presence in the site(s), management to address them, impediments to management, and the information source. We later added a field for the region used in this scoping. Most records are for specific protected areas (site specific), while others are for multiple-sites, or more generic for the PA system in a country or region. In addition, information of relevance but relating to IAS issues in general in a country was also collected as appropriate (see Table 2.1 [a & b]).

Table 2.1a Pilot Sample	
Records with IAS information specific to PA site	196
Records with IAS information on multiple sites or PA system generic	41
Records with other IAS information of interest (e.g. country level IAS issues)	83
TOTAL RECORDS	320

Table 2.1b Pilot Sample: Further details on the records with IAS information specific to PA site or multiple sites or the PA system	
Total Records (n)	237
Records with IAS species specified	208
Records with information on IAS impact or, at least with some information on the PA values of the site(s) where IAS is having an effect	183
Records with some indication of extent or severity of IAS impact	74
Records with some indication of management to address IAS (including those where only identification and/or monitoring of IAS has been done)	146
Records with some indication of impediments to IAS management	43

Prioritising An overall comment with regards to this scoping study is that due to the limitation on time and resources we had to prioritise and focus on some regions at the cost of others. We also had to prioritise the type of information-sources that we tried to locate for the collection of records. It must be stressed that this report is an initial scoping – not a detailed nor full assessment:

1) In first instance we focussed on finding reviews or consolidated sources that could give information about the PA system (or sites) at global, international or regional level. Information at the national or at site level was also collected, but as a lower priority.

2) We focussed on information available in English. This means that our coverage of e.g. South America had to be a lower priority than for other regions. Future work would significantly benefit from inclusion of Spanish, Portuguese, French and Chinese sources (among other).

3) We prioritised the Asian and African regions in our search for information at the national or site level. South America was a lower priority, due to the limitations of language for this scoping. Oceania was also a lower focus, given that at the global scale, its number of officially declared protected areas is relatively low, and at the same time, information about IAS issues in traditionally owned or community managed locations is not easy to find yet. Moreover, the impacts of IAS on biodiversity and livelihoods are well documented in general for this region (Sherley 2000) and can not be questioned.

There were 237 records with IAS information specific to a protected area site or to multiple sites or a protected area system more generally and 83 other records of interest. We refer to this set of records as the "Pilot sample". The Excel files containing these records are available upon request.

2.2 Global Invasive Species Database (GISD) query

The Global Invasive Species Database (GISD), developed and managed by ISSG, is a free, online source of authoritative information about alien species that negatively impact biodiversity. It contains comprehensive profiles of all kinds of invasive species from plants, mammals, invertebrates, birds, reptiles, fish and amphibians, to macro-fungi and micro-organisms (for more information, see *www.issg.org/database)* GISD profiles cover the biology, ecology, native and alien range of invasive species and include references, contacts, links and images. Information either created or reviewed by acknowledged international invasive species experts and is being updated on an ongoing basis. The GISD includes records specifically related to IAS in protected areas and additional records are being added, in the context of a number of funded projects and soon-to-be funded projects, on a regular basis. These records were extracted by database query (in an access database format) using the fact that protected areas, along with Islands and Island groups are identified as specific 'Location Types' in the GISD. We transferred the Access format query results into an Excel file for further calculations and analysis.

Each record has information (as possible) on: the name of the protected area and the country it is in, the IAS species, its biostatus (several fields in the table), and location specific information on the impact it has, the category of impact (if assigned), management, references etc. We later added a field for the region used in this scoping. If a species has more than one impact in a location, there is a specific record for each impact.

Of the 150 records that were returned in the query, 26 were discarded from use in this report. This was because the species was not identified as invasive in the specific location (= protected area) – in other words, where the record indicated "not invasive" (6 cases), "not specified" (16 cases), or "uncertain" (2 cases), the records were not used. Another 2 records were discarded because the "occurrence" field of the species for that location showed "extinct" or "absent" (1 each). Records where the occurrence field showed "eradicated" were retained, because eradication is the result of management and hence relevant to our analysis.

This left 124 records for calculation and analysis. We refer to this set of records as the "GISD query". The Excel file containing these records is available upon request.

2.3 Combined result from several Ramsar searches (Ramsar query)

The reporting system of the Ramsar Sites Database includes an advanced search facility (*http://www.wetlands.org/RSDB/default.htm*). After each search the database will give the number of sites found, the total area of the selected sites, and a list of sites that fulfil the criteria. Selected data can be exported and saved as an excel for further analysis. In our searches we used the following categories of threat to represent invasive alien species: "Introduction/invasion of exotic animal species" or "Introduction/invasion of exotic plant species" or " Introduction/ invasion of exotic species (unspecified)".

We obtained the search reports for threats within the site, as well as for threats within the catchment (=outside the site), and by removing the overlaps we combined these into an overall Excel file with records for Ramsar sites with invasive alien species in the site and/or the catchment. This gave us 277 records. These records were used for further calculation and analysis, and we refer to them as the "Ramsar query". The records contain information such as the site name, country, Ramsar region and subregion, threats in the site and in the catchment, as well as information pertinent to Ramsar sites (criteria, designations etc). We added a field for the region used in this scoping. There is also information on other designations that a site may have – such as whether it has other international or national designations.

We did similar searches for the native invasive species, using the one threat category available: "Infestation of a native plant species leading to habitat degradation or loss". This allowed us to prepare a combined Excel spreadsheet of threats by native plants from within the site and/or from within the catchment (outside the site). There were 62 such records.

Table 2.2 gives an overview of the information in records for the Pilot sample, GISD query and Ramsar query combined:

Table 2.2 Types of information contained in the information sources			
No. records with	Pilot sample	GISD query	Ramsar query
IAS info specific to PAs	237	124	277
IAS species specified	208	124	NA
Information on IAS impacts, or at least on values affected	183	42	NA
Impact type (standardised)	NA	42	NA
Identification of impediments at PA level	43	NA	NA

2.4 Countries/Regions for this scoping

When grouping countries into regions, we decided to separate out Australia and New Zealand from the rest of Oceania, and Canada/USA from the rest of the "Americas", in order to avoid undo weighing of the results for these regions. We expected to find much more information available for these 4 countries than for the other countries in their respective regions due to the dual factor of higher awareness and larger amounts of resources available (see Table 2.3 [a&b]).

Table 2.3 (a) List of countries and overseas territories in each region that have IAS recorded as an issue for protected areas in either the GISD query, Pilot sample or Ramsar query

AFRICA	**ASIA**	**EUROPE**	**SOUTH, CENTRAL AMERICA & MEXICO**
Algeria	Bangladesh	Albania	Argentina
Benin	Bhutan	Austria	Barbados
Cameroon	Cambodia	Belarus	Bermuda (UK OT)
Chad	China	Belgium	Bolivia
Comoros	India	Bulgaria	Brazil
Cote Divoire	Indonesia	Croatia	Cayman Islands (UK OT)
Djibouti	Iran (Islamic Rep. of)	Czech Republic	Chile
Ghana	Israel	Denmark	Costa Rica
Guinea	Japan	Estonia	Cuba
Kenya	Kazakhstan	Finland	Ecuador
Lesotho	Korea (Rep. of)	France	El Salvador
Liberia	Lebanon	Germany	Guatemala
Madagascar	Malaysia	Hungary	Honduras
Mauritania	Mongolia	Ireland	Jamaica
Mauritius	Nepal	Italy	Mexico
Morocco	Pakistan	Latvia	Netherlands Antilles (Netherlands OT)
Niger	Singapore	Moldova (Rep. of)	Peru
Nigeria	Sri Lanka	Norway	Puerto Rico (USA OT)
Senegal	Taiwan	Poland	Turks & Caicos (UK OT)
Seychelles	Vietnam	Portugal	Uruguay
South Africa		Romania	Virgin Islands (USA OT)
Tanzania (Un. Rep. of)		Russian Federation	Venezuela
Uganda		Serbia and Montenegro	
Zambia		Slovak Republic	
		Spain	
		Sweden	
		Switzerland	
		Ukraine	
		United Kingdom	

Table 2.3 (b) List of countries and Overseas territories in each region, with IAS recorded as an issue for protected areas (ctd)			
AUSTRALIA/NEW ZEALAND	USA/CANADA	OCEANIA	OTHER
Australia New Zealand	United States of America Canada	American Samoa Cook Islands French Polynesia Marshall Islands Micronesia (Federated States of) Papua New Guinea	Tristan (UK OT in South Atlantic)

2.5 Information From IUCN MPA Survey (2005)

The IUCN Global Marine Programme (GMP) and the IUCN/SSC Invasive Species Specialist Group (ISSG) undertook a brief survey in 2005 to start evaluating some aspects of invasive species in marine protected areas. Participation was solicited via GMP and ISSG networks, the Listserv Aliens-L etc. A questionnaire with 25 questions was returned by 37 respondents. Results of relevant to this project were used.

3 SCOPING RESULT: AVAILABILITY OF INFORMATION ON INVASIVE ALIEN SPECIES IN PROTECTED AREAS

3.1 Prioritising

An overall comment with regards to this scoping study is that due to the limitation on time and resources we had to prioritise what regions to focus on, and what information sources to locate (see section 2.1). A priority was to find out what sources existed on IAS in protected areas, with information at global or international level (e.g. for international instruments relating to protected areas or to IAS), or at regional level and to use the information contained in them. Second came a focus on information sources at national level, and to a limited extend at site level. We decided to make Africa and Asia a high priority for this, and give low priority to South America and Oceania, as explained in section 2.1. Even though we decided to give a higher priority to Africa and Asia there is a lot more information available at site level for any particular country than what this scoping was able to collect, and it needs to be kept in mind that this is a first scoping only, not a full assessment.

3.2 Global level

Some information on the presence and /or impacts of invasive alien species in specific protected areas sites can be found through international on line sources such as the World Database on Protected Areas (WDPA) [*http://www.unep-wcmc.org/wdpa/]* the official World Heritage [*http://whc.unesco.org*], Biosphere Reserves Ramsar [*http://www.ramsar.org/*] websites or PALNET. WDPA is the most comprehensive dataset on protected areas worldwide, containing information on the status, environment and management of individual protected areas, for about 110,000 sites (as of march 2007). Through the WDPA Site Sheets information is provided on historical and species details, geographical and habitat descriptions, and relevant links. Such links can be to World Conservation Monitoring Centre (WCMC) Site Sheets or to websites from various other entities such as national agencies or departments. World Heritage- , Biosphere Reserve- and Ramsar websites also can provide such links.

With regards to IAS information, PALNET has a facility to extract references to invasive alien species, but its focus is on IAS references found in PA management plans, not on IAS presence, species, impacts, or specific IAS management projects.

For the other web based information resources mentioned, with the exception of Ramsar (see below), if IAS information is held at all it is found inside documents such as the WCMC Site Sheets which have to be accessed and analysed separately, one by one - there is no overall search or query mechanism to facilitate this. Moreover, there is no standard terminology used – the issue is often not identified as "invasive alien species" presence or impact but instead is worded in many different ways (e.g. encroachment of species xx, or simply: the presence of (alien) species yy) which means that each case needs to be looked at individually: is this an alien species or a native species? is it merely present or is it actually or potentially invasive? what is the impact? on what?). In many, if not most, cases, the Site Sheets or other links do not contain information in relation to IAS at all, even if IAS issues for those sites have been reported and discussed elsewhere. This may be due to the Site Sheets' updates predating awareness of IAS issues, or because IAS issues are not considered in the present ongoing official reporting.

The Ramsar Sites Database is the only publicly available consolidated source of information on protected areas that includes a search facility that can be used: the "advanced search" facility [*http://www.wetlands.org/RSDB/default/htm*] allows to build specific queries, including criteria of whether threats to the sites include IAS. We used this facility to run several queries which we could then combine and use to identify the sites where a threat from IAS either in the site or in the catchment has been recorded (see section 2). However, there is no search facility to find the names of IAS species, impacts, IAS management projects, etc. Some of the latter types of information may be contained in the Site Sheets, but these need to be accessed individually. Site Sheets or other links do not necessarily contain information in relation to IAS, even if IAS issues for those sites have been reported and discussed elsewhere. For instance, our preliminary work on IAS issues for Ramsar sites using other information sources has led to an estimate that at least another 100 sites are currently under threat, above those 277 currently brought up by the queries (Pagad pers. comm.). This estimate is supported by the finding that 9 of the 36 Ramsar sites which are included in our Pilot sample were not found in the Ramsar searches (and hence they do not show in the Ramsar query).

We also approached the issue from the other angle: what information is available on protected areas in the information sources on IAS and their distribution, impacts, management etc. At the moment, some information at this level of location-detail is already provided within the Global Invasive Species Database [*www.issg.org/database]* for instance, on the "Impacts" page, with a hyperlink to the specific record for the location (see Box 3.1).

Box 3.1

Bullfrog impacts in protected areas (from GISD)

Excerpt from "Impacts" page of the Global Invasive Species Database (GISD) for the bull frog: *Rana catesbeiana* (amphibian). When consulting this online or on the CDROM version, hyperlinks are provided to the location specific record in the GISD as well as to the IUCN Red List (where impact is Red List species)

Humacao Nature Reserve (Puerto Rico)
Predation: There have been reports of bullfrogs preying on several bird species, including a duckling of the threatened white-cheeked pintail (*Anas bahamensis*)
Colusa National Wildlife Refuge (United States (USA))
Predation: Bullfrogs prey on giant garter snakes (see *Thamnophis gigas* in IUCN Red List of Threatened Species) in the Colusa National Wildlife Refuge in California, USA, although the snake population still appears to be sustainable, and the snakes will also prey on small bullfrogs and tadpoles.

Other international information exchange systems do not usually provide much information specifically in the context of the protected area and IAS issue. For instance, in the case of thematic reports to the Convention on Biological Diversity (CBD), those on IAS in general do not contain information on IAS in protected areas, and those on protected areas only rarely contain information on invasive alien species in them.

The Global Invasive Species Programme (GISP) has several publications that give an overview of IAS species for several regions of the world (Matthews and Brand 2004, Matthews 2004, 2005) and they contain some references to IAS in protected areas, but overall they are aimed at giving a more generic picture of IAS; in addition reports are available of GISP regional IAS workshops, for most continents (Lyons and Miller 2000, Reaser *et al.* 2002, Hernández *et al.* 2002, Neville *et al*. 2004, Macdonald *et al.* 2003, Pallewatta *et al.* 2003, Shine *et al.* 2003, CABInternational 2004). These are focussed on management at national government level and regional cooperation, and do not include details of the IAS situation at protected areas level.

3.3 Regional

Asia: Publications that give a regional scale overview on the IAS are scarce in general. Pallewatta *et al*. (2003) and Bambaradeniya (2004) give a good overview of the regional IAS situation but the focus is on the national level rather than the protected area level. We decided to make Asia one of the focus regions for the Pilot sample information collection at national or site level (to the extend possible).

Africa: the situation is similar to the Asian one; Lyons and Miller 2000 and CAB International (2004) for instance are good regional source on IAS issues, but the general focus is on country level management rather than protected area level management. We decided to make Africa one of the focus regions or the collection of information at site and country level for the Pilot sample (to the extend possible).

North America: There were good resources which related to the management of invasive alien species in protected areas, particularly National Parks. Loope (2004) gives a good overview of the problems that reserves in the USA face with introduced plant species, mentioning at least 23 specific reserves. Similarly, Mosquin (1997) is an excellent document for information on the IAS management gaps which need to be addressed for the management of protected areas (National Parks) in Canada.

Europe: In 1992 the European Union established the Financial Instrument for the Environment (LIFE) which is today the main source of EU level funding for field activities aimed at invasive alien species in Europe. Scalera and Zaghi (2004), and the website *http://ec.europa.eu/environment/life/project/Projects/index.cfm* provided information on a wide range of IAS management options being implemented in protected areas across Europe.

South America : At a regional level, Hernández *et al.* 2002, Neville *et al*. 2004, are good sources of information on IAS at the country level of management – but they do not contain much information at the protected area site level (see Hernández *et al.* 2002, for some good examples on particular sites though).

For Brazil, a very good source of information on the presence of alien species in PAs is provided by the Horus Institute for Environmental Conservation and Development and The Nature Conservancy (*www.institutohorus.org.br*). Records on the presence of alien species in PAs are contributed widely and help build the picture. However, their initial focus has to be on the presence of alien species – in most cases it has not been possible yet to confirm the invasiveness of the species in the locations where they are reported, and this database was hence not used in this pilot scoping.

For reasons already explained, in the search for information at national and site level, this scoping had to give lower priority to this region. Future work on this region would significantly benefit from inclusion of Spanish and Portuguese sources.

Oceania: A good source of information on IAS species and issues at the regional level is the SPREP technical report (Sherley 2000), but it does not give information specifically about the IAS situation at protected area level. Shine *et al.* 2003 contains information on IAS management issues at the country level rather than at the protected areas level. For reasons already explained, in the search for information at national and site level, this scoping had to give lower priority to this region. It should be noted that traditionally owned and community managed areas should be included as possible in future further work on IAS and protected areas.

3.4 Information at national level and for individual sites

There is quite a lot of information "out there", electronically or hardcopy on IAS in individual sites, with some indication of their impacts, management implemented to address it, outcomes of that management etc. but this information is very spread out, and dissipated; Useful information is also often in the form of internal reports rather than in publicly available sources. Material exists in many languages other than English. Examples of the sorts of information available are illustrated in the Pilot sampling records and the GISD query records. A case study, for India and Nepal, is included below (see box 3.2). If support was available for it, a large amount of relevant information could be collected, standardised, and made accessible as a consolidated source (see section 12.2).

3.5 Conclusion

There is a shortage of consolidated information on IAS in protected areas available at global, international, or regional level.

There is a wealth of information available at site level and to some extent at national level, that could be collected for the creation of a source of consolidated information, and for a global assessment, but such information is very dispersed, not standardised, and time consuming to collect or access.

Box 3.2

CASE STUDY – INDIA AND NEPAL (Provided by Syama Pagad, Species Information Officer, Global Invasive Species Database (GISD), s.pagad@auckland.ac.nz

Information is available from varied sources: Government agencies, NGOs e.g. World Wildlife Fund (WWF) and individuals involved in conservation work.

WWF Nepal had some information and data on IAS threats to PAs in their region. We had begun corresponding with Dr Chandra Prasad Gurung and Dr Tirtha Man Maskey who had offered assistance. This collaboration was sadly cut short by the air crash in 2006. We have started building networks again.

The International Centre for Integrated Mountain Development (ICIMOD), have a database of plants for the protected areas of the Hindu Kush-Himalayan (HKH) Region. There is no differentiation made between native and alien/introduced/invasive species in the database, but a subset of IAS can be extracted by comparing to a master list of IAS.

Scientists and researchers from the Ecoinformatics Centre of ATREE (Ashoka Trust for Research in Ecology and the Environment) whose efforts are currently focused on the Western Ghats and the Eastern Himalayas have some knowledge about IAS threats and management in selected PAs, where they have been carrying out long-term research on the role of invasives and restoration ecology. At the Ecoinformatics Centre they have data on the 'modelled probable distribution' of most of the invasives in India and can extract information about threats from invasives for most PAs.

Researchers affiliated to the Wildlife Institute of India (WII) which trains, carries out research, and advises on matters of conservation and management of wildlife resources in India, have collated valuable data on the threat to PAs in that region by IAS. Researchers whose study area are the Andaman Islands are ready to share information collected as soon as their study is complete and information can be published.

Information on alien species has been recorded during the latest tiger census carried out by the Government of India. In due course of time they will have data on exotic species from their field data collection format.

Researchers at the University of Kashmir are documenting information on IAS threats in the terrestrial and freshwater regions of the Kashmir valley and have made available information on one species.

Government departments and agencies hold Datasets on occurrence of exotic/ introduced/invasive species. Contacts and networking with people involved will open access to these datasets.

Availability of data : Some of the datasets are not available for public use. For example: Species databases held at IIRS/NRSA Indian Institute of Remote Sensing (National Remote Sensing Agency Department of Space Govt of India). Datasets include introduced/ exotic/invasive species encountered during the field sampling in an ongoing study on "Biodiversity characterization at Landscape level using RS and GIS". The study is concentrated mainly on the two hot-spot regions - North Eastern Himalayas and South-Western Ghats and in addition the Lahaul and Spiti region of the Western Himalayas. It is hoped that the outputs of the project will provide valuable database for planning biodiversity conservation efforts in these eco-regions. The information on species is in the form of point data.

In response to our request the Dean of IIRS informed us that at present mechanisms to share the species databases between Government-to-Government organizations in India have been developed. However, a mechanism to share the databases with International agencies is being defined by the National Bioresources Development Board, Government of India (and hence does not exist yet at this stage).

4 SCOPING RESULTS: SITES, COUNTRIES, IAS SPECIES

The information sources that we used for the findings reported in this section are the Pilot sample (237 records with IAS information specific to PA site or multiple sites or PA systems in general), the GISD query (with 124 records of IAS in PA locations), and the Ramsar query (with 277 records of Ramsar sites where IAS are reported as a threat either from within the site or from within the catchment).

4.1 Overall result

Excel files with the records resulting from the Pilot sample, the GISD query, and the Ramsar query were used for calculations and analysis.

The information sources combined contained records on

- 487 protected area sites with invasive alien species recorded as an impact or threat
- 106 countries with protected areas(s) where IAS have been recorded as an impact or threat
- 326 IAS species reported as an issue for protected areas

(see Table 4.1)

Table 4.1: results, per region and for regions combined, for the combined Pilot sample, GISD query, and the Ramsar query. Afr. = Africa; Eur. = Europe; USA/CAN = United States of America and Canada; Aus/NZ = Australia and New Zealand; S&C Am & Mex = South America, Central America (including Caribbean) and Mexico, including overseas territories (OT) of the UK, Netherlands. Other = Tristan (UK Overseas Territory in South Atlantic). For full list of countries and overseas territories in each region, see Table 2.3

All sources combined	Afr	Asia	S & C Am & Mex	Eur	USA/CAN	Aus/NZ	Oceania	other	All Regions combined
Countries with PA sites affected by IAS	24	20	22	29	2	2	6	1	106
IAS species recorded	58	43	18	58	109	87	19	4	326
PA sites affected by IAS	63	56	63	144	74	77	9	1	487

4.2 Number of protected areas in the records, where invasive alien species are recorded as an issue

Using the records from the Pilot sample that contained information on a specific protected area site, all records from the GISD query, and all from the Ramsar query, we obtained the number of sites with IAS recorded as an impact or threat for a specific PA site, for each of the information sources. The GISD query had such information on 92 sites, the Ramsar query on 277 sites, and the Pilot sample on 174 sites. Removing duplication (where the same site features in more than one information source), the overall number of sites was determined as 487 for the combined information sources used. Results are shown in Table 4.2 and Fig4.1 .

Table 4.2: number of sites with IAS recorded as an issue for a specific PA site. GISD = GISD query; RAMSAR = Ramsar query; Overall = combined records of GISD query Pilot sample and Ramsar query (after removal of duplication). Regions abbreviated as in Table 4.1.

Region	GISD (n=92)	PILOT SAMPLE (n=174)	RAMSAR (n=277)	OVERALL (n=487)
Eur	17	40	96	144
Aus/NZ	23	40	36	77
USA/CAN	27	43	12	74
S & C Am & Mex	11	5	50	63
Afr	4	20	46	63
Asia	9	21	34	56
Oceania	1	5	3	9
other	0	1	0	1
Total (sum)	92	174	277	487

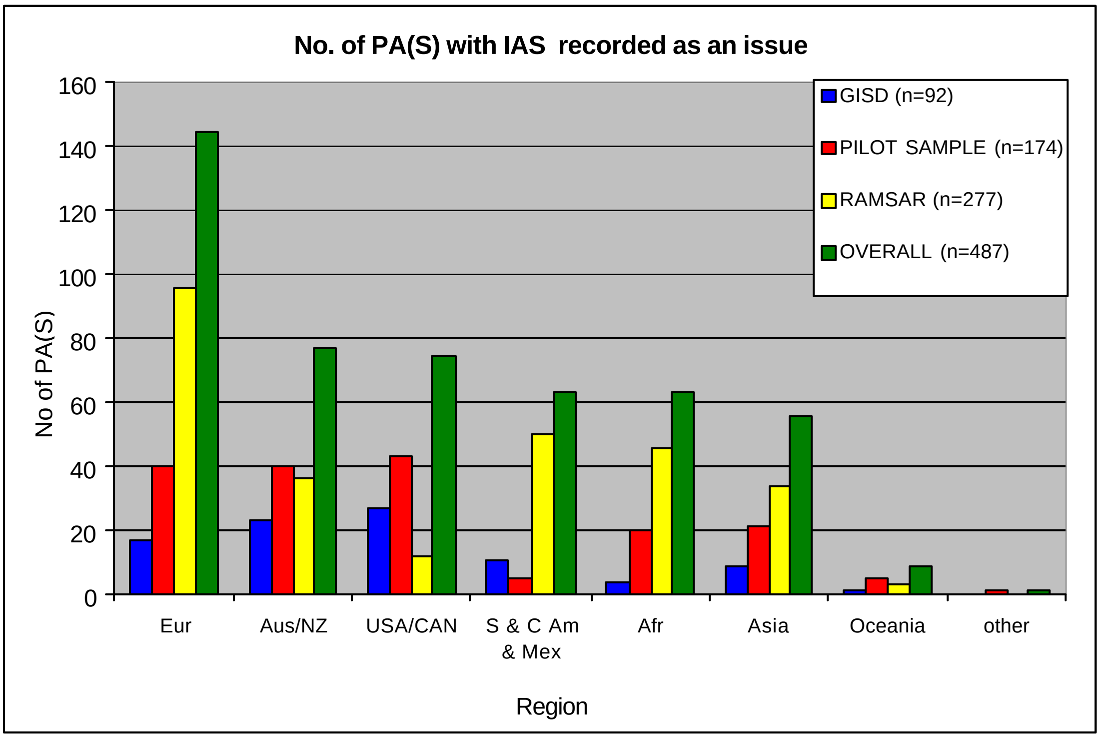


Figure 4.1: number of sites with IAS recorded as an issue for a specific PA site. GISD = GISD query; Ramsar = Ramsar query; Overall = combined result for GISD query, Pilot sample and Ramsar query (after removal of duplication). Regions abbreviated as in Table 4.1

4.3 Number of countries in the records that have protected area(s) where invasive alien species are recorded as an issue

Using the records from the Pilot sample that contained information on a specific protected area site or on multiple sites or the PA system in general for a country, all records from the GISD query, and all from the Ramsar query, we obtained the number of countries with IAS recorded as an impact or threat for PA(s), for each of the information sources. The GISD query had such information on 26 countries, the Ramsar query on 84 countries, and the Pilot sample on 46 countries. Removing duplication (where the same country features in more than one information source), the overall number of countries was calculated as 106 for the combined information sources used. Results are shown in Table 4.3 and Fig. 4.2

Table 4.3: number of countries with PA(s) with IAS recorded as an impact or threat. Abbreviations as in Table 4.2 and 4.1

Region	GISD (n=26)	PILOT SAMPLE (n=47)	RAMSAR (n=84)	OVERALL (n=106)
Eur	7	14	25	29
Afr	2	8	20	24
S & C Am & Mex	7	3	17	22
Asia	5	13	16	20
Oceania	1	4	2	6
Aus/NZ	2	2	2	2
USA/CAN	2	2	2	2
Other	0	1	0	1
Total (sum)	26	47	84	106

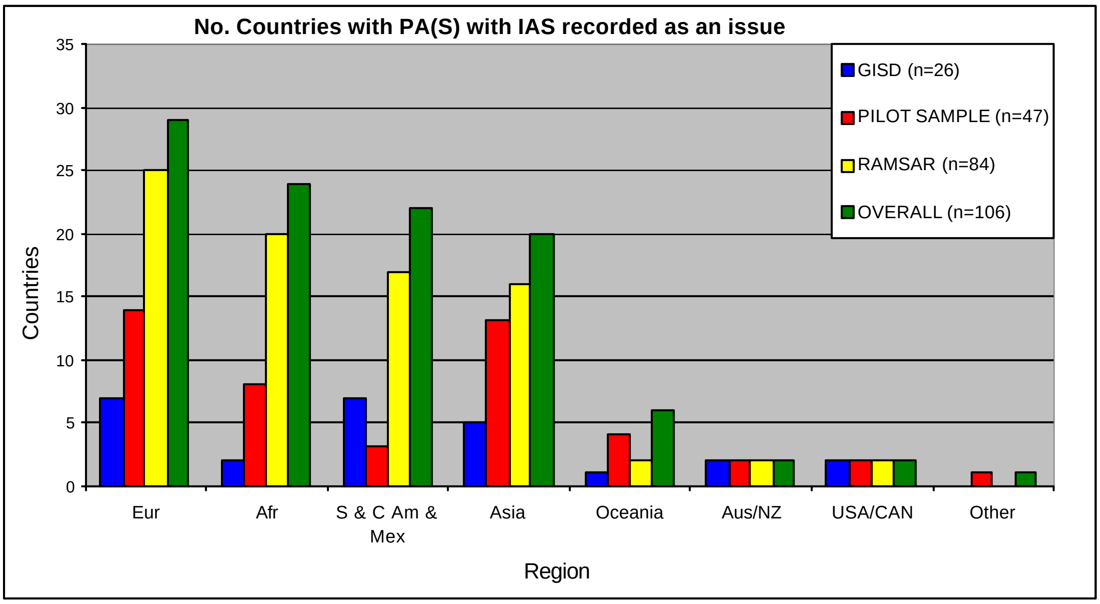


Figure 4.2: number of countries with PA(s) with IAS recorded as an impact or threat. Abbreviations as in Fig. 4.1

4.4 Number of IAS species recorded as an issue for protected areas

The Ramsar query system does not allow to find information on the specific species of IAS that are a threat to Ramsar sites. Such information would only be able to be retrieved manually from various documents for each site – an amount of effort that was beyond the resources available in this scoping. Using the records from the Pilot sample that contained information on IAS species that were an issue for a specific protected area site or for multiple sites or the PA system in general for a country, and all records from the GISD query, we obtained the list of IAS species that were recorded as an issue for PA(s). We did not include records from the Pilot sample that gave an indication of IAS species of concern only at the country level rather than the PA level – even though it is very likely that such species would feature in protected areas as well. We prepared a list of IAS for each region using the Pilot sample and the GISD query, as well for the two information sources combined with duplication between the information sources removed. We prepared an overall list of IAS species for the regions combined – removing duplication of species that featured for more than one region. The GISD query contained information on 55 IAS species, and the Pilot sample provided information on 299 IAS species. Removing duplication between the two information sources, the overall number of IAS species found is 326. Results are shown in Table 4.4 and Figure 4.3. The lists of species for the combined information sources are given in Appendix 1 (regions) 2 (overall for the regions combined).

Table 4.4 Number of IAS species recorded as an impact or threat in PA(s). Abbreviations as in Table 4.2 and 4.1

Region	GISD (n=55)	PILOT SAMPLE (n=299)	GISD + PILOT SAMPLE (n=326)
USA/CAN	22	94	109
Aus/NZ	21	77	87
Afr	6	55	58
Eur	7	55	58
Asia	7	37	43
Oceania	1	18	19
S & C Am & Mex	9	9	18
OTHER	0	4	4
Overall combined (not sum)	55	299	326

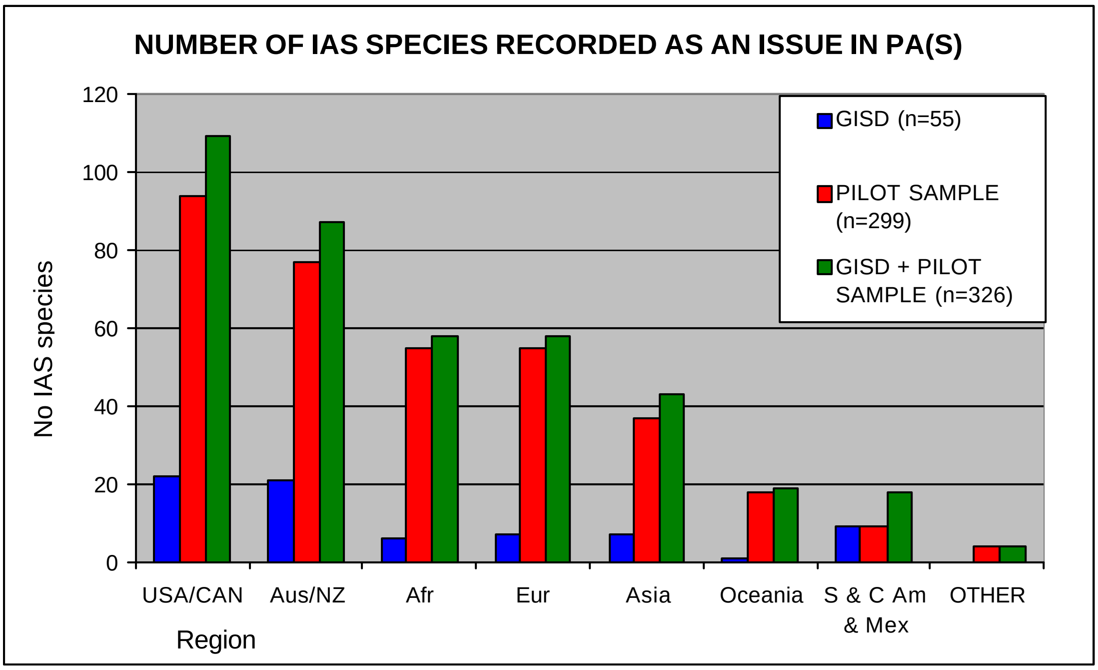


Figure 4.3: number of IAS species recorded as an issue in PA(s). Abbreviations as in Table 4.2

4.5 Discussion: number of sites, number of countries, number of IAS

The overall result (green on the graphs) shows that invasive alien species threats and impacts in protected areas is not an issue limited to a few regions nor a few countries, or species.

- With the exception of Oceania (explained elsewhere), all regions, including Asia, Africa and Southern Americas (South America, Central America and the Caribbean plus Mexico) as well as Europe, USA/Canada and Australia/New Zealand showed a significant number of protected areas where invasive alien species have been recorded as an issue. It should be noted that we included only records where the species was recorded as an issue because of invasiveness, and that we did not use information sources that were non-specific about whether an alien species was invasive or simply alien and present.
- Africa, Asia, Southern America and Europe all showed a significant number of countries that have invasive alien species recorded as an issue in protected area(s). For reasons explained further on, results were not expected to "deliver" much information on Oceania, and neither of course would Australia/New Zealand and USA/Canada score in the number of countries, given they have been designated only 2 countries each to start with.
- In addition to those in USA/Canada and Australia/New Zealand, a significant number of IAS species have been recorded as an issue in protected areas for Africa, Europe and Asia, in spite of the limited amount of information that we were able to access. The low score on IAS species for Oceania and the Southern Americas reflects the fact that we could not focus on them in this scoping. In the case of Southern America, the low number of IAS species in spite of a significant number of sites and countries being affected reflects the fact that the Ramsar query was our best information source for this region – but it does not provide information on the particular IAS species.

Oceania was a low priority in the collection of information for the Pilot sample (see section 2.1), and moreover it does not have many designated Ramsar sites – hence a low number of protected areas and a low number of countries and species are shown in these results. We know that this does not represent the true situation with regards to IAS impact on biodiversity and livelihoods in this region (e.g. Sherley 2000). The "other" category only applied to one site and one Overseas Territory – and hence also shows low numbers for sites, countries and species.

The results on the number of protected areas in the Pilot sample and the GISD query reflects the findings (section 3) that consolidated information, to the extend it exists, has a focus on Australia/New Zealand and USA/Canada as expected as well as on Europe which was less expected, and reflects the very rapidly growing awareness and resourcing for management in that region.

As explained, consolidated information on IAS and protected areas was not available for Southern America in the collection of the Pilot sample, and given the scale of the scoping we could not focus on finding much country specific or site-specific information for this region. The low numbers shown for this region in the Pilot sample are a reflection of the limited effort that could be put into it. The Ramsar information for Southern America shows a significant amount of sites and countries where IAS are an issue, and if further resources were available to focus on the region, a lot more information could be collected.

In spite of the absence of consolidated data for Asia and Africa and the limited resources to look for site-specific information the Pilot sample on its own already shows 20 PAs each for Asia and Africa, as well as 13 and 8 countries and 37 and 55 IAS species each for these two regions of focus, confirming the importance of the IAS/PA issue, and the usefulness of dedicating further resources to the collection of further site- specific information.

4.6 IAS threats from within the wider landscape vs. threats from within the site itself

In the case of the Ramsar query, the number of sites where IAS are a threat either from within the site or from within the wider catchment, had to be calculated by combining the report from the Ramsar web query process for "within site" and the separate report from the Ramsar web query process for "within catchment" , while removing the overlap. This allowed some insight, at least for Ramsar sites, in the role of threats from the wider catchment (Table 4.5). The information contained in the Ramsar query showed that 261 sites recorded a threat by IAS within the site and 80 recorded a threat of IAS within the wider catchment.

Table 4.5 Ramsar query: threats from within the site vs. from within the catchment (outside the site itself), and threats from native invasive species (NIS) vs. invasive alien species (IAS)				
Number of sites with threat recorded	Threat in site	Threat in site and catchment	Threat in catchment	Threat in site and/or catchment
IAS	261	64	80	277
IAS and NIS	33		4	34
NIS	60	8	10	62
IAS and/or NIS	288	69	86	305

Discussion: these findings confirms that threats from IAS need to be approached in the context of the wider landscape, and not just the protected area site itself. Only 16 sites recorded a threat from the catchment only – but it needs to be kept in mind that these recorded threats are predominantly, if not only, from biological invasion already taking place; if resources and capacity were available for managers to do risk assessments covering all alien species in the site and wider landscape, further threats from within the wider landscape would almost certainly be identified.

4.7 Native invasive species issues

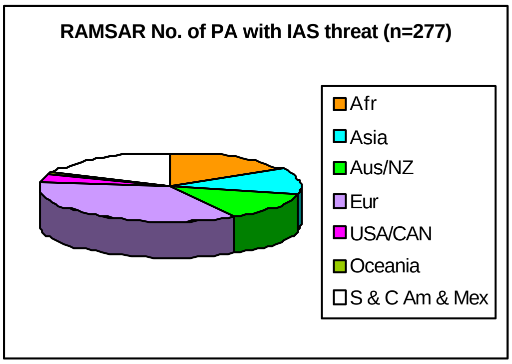
While this scoping predominantly concerns itself with the impacts of biological invasion by alien species, it is important to point out that local native species can also respond to changes in circumstances and become invasive, in such a way as to make them deleterious to the objectives of protected area management (Howard and Matindi 2003). The native invasiveness is usually due to some other disturbance to the site, e.g. a change in water level or salinity. Invasiveness by native species is particularly of significance in Africa (Howard and Matindi 2003) but not limited to that continent. It is not unusual for management issues of native and alien invasive species to be closely linked. Eradication of IAS, especially plants that had already been established (e.g. waterhyacinth or Salvinia) can for instance result in the release of invasiveness by a local native species (e.g. Typha species), which up to then had been suppressed by the alien invader. This is an illustration of the need to manage invasive alien species in an ecosystem context.

In addition to collecting the Ramsar information on invasive alien species, we also ran query reports for the native invasive plant species (threat inside the site and threat in the catchment), allowing us to prepare a combined Excel file with records of threats by native plants either from within the site and/or from within the catchment. This gave records on 62 sites Of the 62 sites with threats from native invasive species (NIS), the majority also had threats from alien invasive species: 34 out of the 62 sites also showed up in the Ramsar query with invasive alien species threats (Table 4.5).

Table 4.6 and Fig 4.4 show a regional breakdown.

Table 4.6 number of Ramsar sites with invasive alien species (IAS) recorded as a threat, and with native plant infestation recorded as a threat. Regions abbreviated as in Table 4.1

Region	No. of Ramsar sites with threat from IAS recorded	%	No. of Ramsar sites with threat from native plant infestation recorded	%
Afr	46	17	18	29
Asia	34	12	7	11
Aus/NZ	36	13	6	10
Eur	96	35	18	29
USA/CAN	12	4	3	5
Oceania	3	1	2	3
S & C Am & Mex	50	18	8	13
Total (sum)	277	100	62	100

a) 

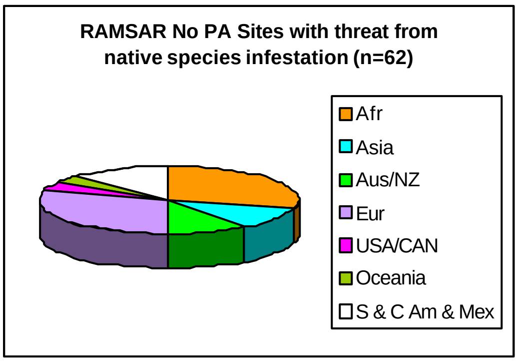
b) 

Figure 4.4 a)Ramsar sites with IAS recorded as a threat, and b) with native plant infestation recorded as a threat. Regions abbreviated as in Table 4.2;

Result and Discussion: The results confirm that, at least for wetlands, the issue of native invasive species (in this case native plants) also needs attention, especially in the African Region. Given the number of sites where both native an invasive species are causing threats through invasion, and the experience that management of invasive alien species can have implications for native species infestation, the results conform the wisdom of linking alien- and native invasion issues in management, and confirm the need to carry out IAS management in protected areas in an ecosystem context.

4.8 Information on protected area types

The information sources that we could use to analyse different types of protected areas are the Pilot sample and the Ramsar query.

The Pilot sample has records on 174 named PAs where IAS are an issue, and in many instances this includes information on the type (designation) of the protected area. However, the Pilot sample record for a PA site will show the designation for the site as it was given in the reference used for the record. A site with a national designation can also have an international designation, or be a component of a larger international designation encompassing several individual sites. If the reference underpinning the record for the site does not mention this, it will not be picked up in the Pilot sample information; this is a complexity that requires further information from other PA information sources – and it fell outside the analysis possible in this limited scoping. The Pilot sample is hence likely to contain more information of relevance to e.g. internationally designated sites than what has been used in this analysis.

The Ramsar query has information on 277 Ramsar sites where IAS are reported as a threat either from within the site or from within the catchment. In addition, the Ramsar database also contains information on other international or national designations of the Ramsar sites, and this information is included in the records of the Ramsar query.

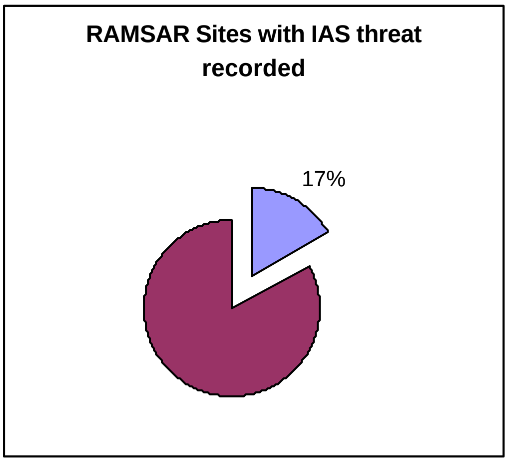
The GISD query does not provide information on the type or designation of the PA.

4.9 Wetlands of international importance (Ramsar sites)

The Convention on Wetlands of International Importance Especially as Waterfowl Habitat was signed in Ramsar (Iran) in 1971,and came into force in December 1975. This Convention provides a framework for international cooperation for the conservation of wetland habitats. As of February 2007, there are 1641 designated sites, with a total area of 146,428,199 ha. 154 countries are a Party to this convention.

The Ramsar query has information on 277 Ramsar sites where IAS are reported as a threat either from within the site or from within the catchment. This is 17% of all Ramsar sites by number, as well as by total size of sites. Our Ramsar query shows 84 countries, that have IAS threats to at least one of their sites. This is more than half of the Parties to Ramsar (see Table 4.7 and Fig. 4.5). If we break down the results from the Ramsar query by region (Table 4.8 Fig 4.6), it can be seen that IAS are a threat to Ramsar sites in all regions.

Table 4.7 overall results from Ramsar query.			
RAMSAR query	No. Sites	Countries	Total size of sites
Threat by IAS	277	84	24,628,578
All Ramsar sites	1641	154	146,428,199
% of total affected by IAS	17%	55%	17%

a) 

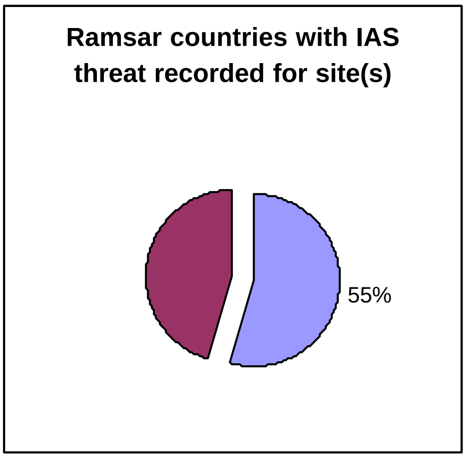
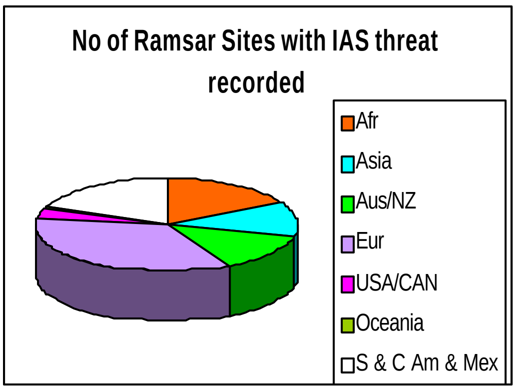
b) 

Figure 4.5: threat of IAS to Ramsar sites shown in the Ramsar query, as percentage for a) Ramsar sites and b) Countries (Parties to Ramsar)

Table 4.8: Ramsar query - number of Ramsar sites with IAS recorded as a threat, and number of countries with such sites. Regions abbreviated as in Table 4.2		
Region	No of PA with IAS	No countries with PA(S) with IAS
Afr	46	20
Asia	34	16
Aus/NZ	36	2
Eur	96	25
USA/CAN	12	2
Oceania	3	2
S & C Am & Mex	50	17
Total (sum)	277	84

a) 

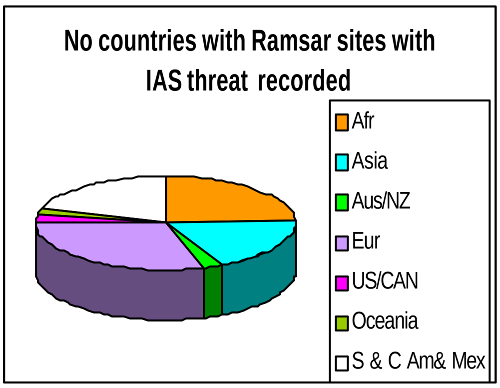
b) 

Figure 4.6: Ramsar query - (a) Ramsar sites with IAS recorded as a threat and (b) number of countries with such sites. Regions abbreviated as in Table 4.2

Discussion: invasive alien species have already been recorded as a threat in more than 1 out of 6 of all Ramsar sites. Moreover, as mentioned above, we have estimated that at least another 100 sites are likely to have IAS threats in addition to the ones currently picked up in the website search mechanism (see section 3.2). This would mean that the proportion of Ramsar sites with invasive alien species threats could be as high as one in 4 or 5, word wide. The number of countries that have IAS issues in at least one site is high in Africa, Asia, South America and Europe, and overall already more than half of Ramsar Parties have IAS as a threat in at least one of their sites. These findings confirm that addressing the invasive alien species issue is a high priority for the Ramsar system.

4.10 World Heritage sites

The Convention Concerning the Protection of the World Cultural and Natural Heritage was adopted in Paris in 1972,and came into force in December 1975.The Convention is administered by UNESCO and provides for the designation of areas of "outstanding universal value "as World Heritage sites, with the principal aim of fostering international cooperation in safeguarding these important areas. A check on the World Heritage official website shows 186 sites for the Natural or Mixed category (March 2007).

The Pilot sample and Ramsar query combined showed 27 World Heritage sites where invasion by alien species is already taking place – 15% (in other words, more than 1 in 7) of the total number of natural and mixed sites (Fig. 4.7).

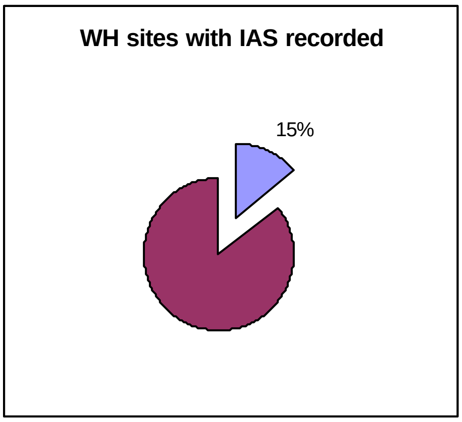


Figure 4.7: percentage of World Heritage Natural and Mixed sites with IAS recorded as an issue, in the Ramsar query or Pilot sample.

Discussion: the 27 sites shown in our records are almost certainly not the total number under threat – because a) records are for sites with invasion already happening, and do not include those where future threats have been identified through risk assessment b) no specific search was done to find IAS information on World Heritage Sites and the number found has to be assumed to be a subset only c) as explained above, some sites in the Pilot sample show IAS information for nationally designated sites that also have an international designation. Where the reference used mentions the dual designation, it can be taken into account, but due to the limits of this scoping, it was not possible to check for all such situations. This means that not all information that is relevant to WH sites will have been picked up from the records we used. A dedicated search for IAS issues in WH Sites, taking into account the above comments, would be a worthwhile exercise for the future. For instance, in Australia 9 out of 14 (in 2006) World Heritage sites were under threat by invasive alien animals alone (Pestat *et al.* 2006).

4.11 Biosphere Reserves

Biosphere reserves are areas of terrestrial and coastal/marine ecosystems that are internationally recognised under UNESCO 's Man and the Biosphere (MAB) Programme. They are designed to promote and demonstrate a balanced relationship between people and nature. The reserves are nominated by national governments and remain under the sovereign jurisdiction of the States where they are situated. In 2003, there were 436 Biosphere Reserves recorded in the UN List (Chape *et al.* 2003).

The Pilot sample and Ramsar query combined showed 22 Biosphere Reserves sites being threatened by IAS. Given that no specific search was done to find IAS information about such sites, this is not the total number of sites affected. It would be a worthwhile exercise for the future to do a focused search for IAS information for such sites.

4.12 Other types of sites

The Pilot sample contained information on the designation for most of the sites. It must be noted, however, that terminology is not standardised around the world – national and sub-national protected area designations are not directly comparable across countries because of different legislative regimes. Over 1,000 different terms are known to be used around the world to designate protected areas (Chape et al 2003). Table 4.9 illustrates a variety of types of PA that have been affected by IAS, as shown in the Pilot sample.

Table 4.9: PA sites of various different types in the Pilot sample

International (I) and national (N) designations. Note: for national designations, a similar name may indicate quite different type of values protected from one country to another	No.
Unesco Biosphere Reserves (I)	7*
RAMSAR (I)	36
World Heritage (I) Natural	9*
World Heritage (I) Cultural	1*
Natura 2000 site (I)	6
National Parks (N)	39
Nat. Wildlife Ref. (N)	9
Marine Park (N)	6
"Nature reserve" (N)	6
Traditional ownership	1
Coral reef Ecosystem Reserve (N)	1
Various other types (N)	53
TOTAL SITES	174
* For number of sites in Pilot sample and Ramsar query combined, see above	

4.13 IUCN Categories

The classification of protected areas into 6 IUCN Management Categories enables a distinction to be made on the basis of management objectives that countries are applying to their conservation estate, ranging from sites that are strictly protected through to those under sustainable use. The overview of global statistics indicates that 67% of the world's protected areas have been assigned an IUCN management category (Chape *et al*. 2003). Table 4.10 and Fig. 4.8 shows the numbers of PAs in the different categories, where that information is available in the Pilot sample and Ramsar query. For the Pilot sample and the Ramsar query each, the number of sites where designation is given is 87. There are no overlaps (= sites featuring in both) between the two sources. Where no designation is given in these records, it is either because the information is not provided, or because the site has not received an IUCN designation.

Table 4.10: numbers of PAs in the different categories, where that information is available in the Pilot sample and Ramsar query

	PILOT SAMPLE	RAMSAR QUERY
IUCN Cat Ia	6	9
IUCN Cat Ib	3	0
IUCN Cat II	43	17
IUCN Cat III	8	3
IUCN Cat IV	17	34
IUCN Cat V	7	15
IUCN Cat VI	3	9
	87	87

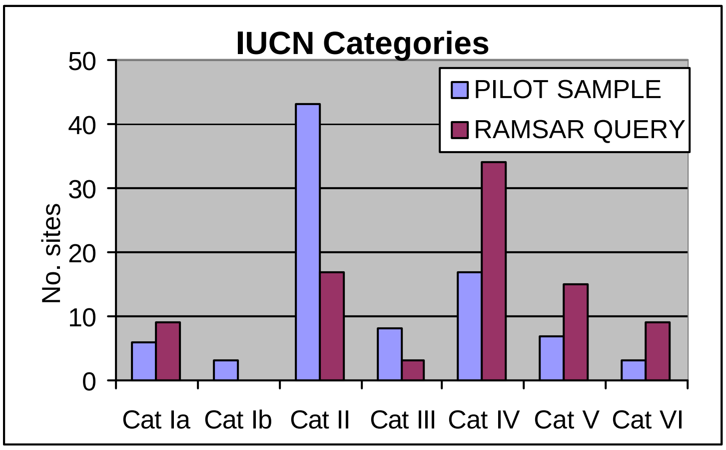


Figure 4.8: numbers of PAs in the different categories, where that information is available in the information

Cat II (National Park: protected area managed mainly for ecosystem protection and recreation), Cat IV (Habitat/Species Management Area - protected area managed mainly for conservation through management intervention) and Cat V (Protected Landscape/Seascape - protected area managed mainly for landscape/seascape conservation and recreation) show the highest number, for those sites in our information source that contained information on Category.

Discussion: while the sample is relatively small, and therefore any interpretation should be tentative only, it is rather of concern that such a high number of Cat II sites has been found to be under threat by IAS in our scoping – given that the number of such sites designated globally is small: of 3881 Cat II sites that have been designated worldwide (Chape *et al.* 2003), our very limited scoping already includes 60 sites as being affected by biological invasion.

4.14 Our results are only "the top of the iceberg"

One overall challenge of evaluating the situation in protected areas is that in many parts of the they have been so little studied or monitored that it is virtually impossible to get a detailed picture of the scale and types of threats to them (Barber *et al.* 2004, Hockings *et al.* 2000, Carey *et al.* 2002). IAS experts are convinced that PAs anywhere, in any ecosystem, will sooner or later be under threat from IAS (Macdonald *et al.* 1989, Usher 1988, De Poorter and Ziller 2004) and that a large number already are. This would mean that the information used in this scoping only represents the absolute top of the iceberg. However, there is a discrepancy in perception on this issue, with non-IAS experts still sometimes not according it much weight in the overall picture of PA management (see section 8.5). We therefore decided to explain in more detail why we are confident that this report shows merely the "tip of the iceberg":

1) A large amount of "sleeping " invasive alien species are already present, unrecognised as threats: alien species that have not reached their full invasion potential yet, but are likely to do so in future (see section 1). Such alien species are not recognised, nor assessed by management and hence not recorded or reported as IAS threats.

2) Given the overall lack of monitoring or surveying, and lack of management capacity and funding for PAs worldwide, a very large number of sites have not been surveyed for threats in general (Barber *et al. 2004, Carey et al.* 2002). In other words, in many protected areas even currently ongoing biological invasions will not have been recognised or recorded/reported.

3) This situation will be even more pronounced when the threats from IAS in the wider landscape around PA sites are taken into account.

4) Of the information on IAS in protected areas that is available, very little is accessible through consolidated sources. A great deal of information on the impacts and threats of IAS on protected areas is available – but as discussed, due to the practical limits of this scoping, only a small amount of such site-level available information could be collected and used for this report. Some examples illustrating this are given in Table 4.11.

Conclusion: our information sources are only showing a small amount of the IAS/PA reality; the situation described and discussed in this scoping is only "the very tip of the iceberg.".

Table 4.11 information in our results in relation to other indications of extend of IAS impacts and threats to protected areas	
IAS problems in the Nature Reserves in China are a serious concern. "IAS have been reported everywhere, except in a few remote Reserves in Qinghai-Tibet Plateau, Hengduan Mountain, Xinjiang and Inner Mongolia. Many Nature Reserves in China have been heavily threatened by IAS" (Xie 2003),	Our information sources contain only 1 PA site for China
i) IAS are a significant issue for protected areas in India (see section 14) ii) Many (dispersed) information sources are available on IAS information of relevance to protected areas in India (see Box 3.2) iii) Individuals and Institutions have advised us that they have much more additional information on IAS in protected areas in India	Our information sources contain only 10 sites for India
Management Effectiveness analysis was carried out for 110 protected areas throughout KwaZulu-Natal (KZN) Province, South Africa. Some threats such as alien plant invasion are a major problem affecting most (if not all) PAs across the entire province. Goodman P. S. (2003a)	Our information sources contain only 16 PA sites for all of South Africa
Alien plant invasion poses a major threat to biodiversity throughout KwaZulu-Natal Province (South Africa). Protected areas, have suffered severe infestation by alien plants, with a list of 73 invader alien plants for the province. (Goodman 2003b)	Our information sources show a total of 58 IAS species - all taxa, not just plants- and for the whole of Africa
The Swaziland Draft National Biodiversity Strategy and Action Plan (1999) identifies the threat to protected areas by alien plant invasion, as one of the main hindrances to biodiversity conservation through the formation of a network to protected areas (a well as lack of communicating between agencies and lack of funding) (Anon 1999)	Our information sources show no PA sites for Swaziland
BRAZIL – more than 100 PA in the Brazilian protected areas invasive alien species database (The Horus Institute for Environmental Conservation and Development/The Nature Conservancy) with alien species. (*www.institutohorus.org.br)* [We did not have access to data showing how many of those cases are not likely to be or become invasive, but it is unlikely that many will have been assessed and judged as "safe". Moreover, IAS experts are immensely concerned about the impact of IAS on PAs in Brazil (Ziller Pers. comm.)	Our information sources contain only 6 PA sites total for Brazil.
i) In the National Wildlife Refuge System (USA) more than 250 wildlife refuges have been infested by invasive alien species (Audubon 2003) ii) In the National Parks System (USA) Exotic Plant Management Teams have developed site-specific strategies for combating exotic plants that reflect the needs and resources of more than 145 Parks (Drees 2003.) iii) For more than 60% of The Nature Conservancy's more than 1,500 Preserves, alien plants are among the top management dilemmas (TNC 1996)	Our information sources contain only 60 PA sites total for the USA
240 invasive weed species adversely affect indigenous biota and ecosystems of lands and water bodies managed by the New Zealand Department of Conservation (Reid 1998, in Froude 2002)	Our information sources show only 87 IAS species, of all taxa (including animals) and for New Zealand plus Australia combined.
Ramsar query, it is estimated that up to another 100 Ramsar sites are threatened by IAS giving an estimated total to somewhere near 375 sites at least with IAS threats (this is discussed in more detail in sections 3.2 and 4.9)	Ramsar query shows 277 sites.
In the EU, 109 projects which where completely about IAS management, or at least included a component of IAS management were funded by the EU LIFE financial instrument, aimed at the development of Natura 2000. (Scalera and Zaghi 2004)	Our information sources show less than 30 PAs identified in the records as Natura 2000 sites

5 SCOPING RESULTS: IAS IMPACTS IN PROTECTED AREAS

5.1 Introduction

A variety of impacts of invasive species in nature reserves were reviewed by Macdonald *et al.* (1989), and this publication has a wealth of examples. It divides impacts in two main categories: impacts on ecosystem function and impact on ecosystem structure including the acceleration of soil erosion rates, alteration of other geomorphological processes, alteration of biogeochemical cycling, alteration of hydrological cycles, alteration of fire regimes (Macdonald *et al.* 1989). In addition to impacts on ecosystem structure and functioning, impacts can be at the level of species communities or habitats (e.g. fewer native species and/or more alien species, physical changes in vegetation cover, etc). At the level of species the following types of impacts can occur:

- Predation on native fauna
- Herbivory: damage to native plants through grazing or browsing by invasive animals
- Competition for resources such as light, nutrients, prey, space and niches within a habitat
- Habitat change or physical changes
- Disease (vector and/or pathogen)
- Hybridisation of alien species with native species
- Endangerment
- Extinction

Of course these impact types are not mutually exclusive, and effects at species level will of course also have ramification at the community and ecosystem levels. Invasion by one alien species can facilitate and an accelerate further invasion by other species – sometimes reaching the level of 'invasional meltdown' (see box 5.1).

All the above impacts on native species, communities and ecosystems, are likely to directly or indirectly impact on livelihoods and poverty alleviation, through affecting ecosystem services or sustainable use of biodiversity or through impinging on cultural or heritage values.

Box 5.1

Invasional meltdown.

Alien crazy ants *Anoplolepis gracilipes* have formed extensive super colonies on Christmas Island (Australia), most of them in the Christmas Island National Park, since the mid-1990s. Red crabs (*Gecarcoidea natalis*) are highly vulnerable to these crazy ants. This has manifold further consequences for the dynamics and structure of the native forest, including deregulation of seedling recruitment, seedling species composition, litter breakdown and density of litter invertebrates. Due to the crab's migratory nature, effects also result, in areas not (yet) invaded by the crazy ant. In addition, mutualism between this invasive ant and introduced/cryptogenic scale insects has amplified and diversified rain forest impacts (O'Dowd *et al* 2001). On top of this, crazy ant invasion has facilitated the invasion of native rainforest by the giant African land snail (*Achatina fulicata*), woody alien weeds and alien cockroaches (Green *et al*, 2001).

5.2 Effects of disturbance, small size and/or isolation of protected areas

While, no doubt, many alien species that are present in the "used" or "inhabited" locations of protected areas will not be able to invade the natural or semi-natural locations of high conservation value, there is increasing evidence that the risks are nevertheless higher than previously thought. In several cases such alien species previously judged as "harmless" have been able to invade into the natural areas after disturbances (e.g. into clearings after storms or felling) and interfere with re-generation (e.g. Peters 2001). Even without such specific disturbances, the fragmentation, and isolation of protected areas can result in edge effects, which compound overall impacts caused by IAS. For instance, within New South Wales (Australia) the remaining habitat of the endangered Mitchell's Rainforest Snail *Thersites mitchellae* is predominantly in small areas of remnant rainforest including narrow strips of rainforest bordering coastal wetlands, and such sites are at risk of edge effects such as desiccation, habitat disturbance, frequent fire and invasion by exotic weeds and feral animals.

5.3 Impact Types in the GISD query

This scoping study's Pilot sample contained 183 records with information on IAS impact, or at least with information on the PA values of the site(s) where IAS are having an effect. 42 of the GISD query records include information on impacts from IAS in protected areas. The GISD query also contained 42 records where standardised impact types had been assigned. (The GISD itself provides standardised information, such as these impact types, where possible – the 42 records in the query are for impacts of IAS in specific protected area locations). These are shown in Table 5.1. Some examples with more detail are shown in Table 5.2.

Table 5.1: standardised impact types from the GISD query	
Impact Types	No. records
Reduction in native biodiversity	10
Ecosystem change	7
Predation	7
Competition	5
Threat to endangered species	5
Habitat alteration	3
Economic / Livelihoods	1
Modification of fire regime	1
Modification of natural benthic communities	1
Modification of successional patterns	1
Physical disturbance	1
TOTAL	42

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Conclusion: the GISD query and Pilot sample information on impacts, confirm the wide range of impacts caused by IAS, and the wide range of PA values affected.

Table 5.2 : example of IAS Impact Types in PAs (and impact details) from Pilot sample				
PA	IAS	Type	Detail	Reference
Kaziranga National Park, India	*Mimosa diplotricha*	Threat to endangered species	'The grasslands of the Kaziranga National Park are threatened by two exotic species of Mimosa: *M. rubicaulis* and *M. diplotricha*. The weeds have rapidly spread across the grasslands and hampered the growth of the palatable grasses, thereby threatening the rhinoceros as well as ungulates. Kaziranga National Park is a vital habitat for the world's largest population of the Great One-horned Rhinoceros (see *Rhinoceros unicornis* in IUCN Red List of Threatened Species)	Gureja, N. pers. comm. 2003
Haleakala National Park, Hawai'i (USA)	*Linepithema humile*	Threat to endangered species	Argentine ant reduces the numbers of native insect species, including pollinators, consequent indirect effects may be felt on native plants dependant on such pollinators. There are at least two endangered plant species on upper Haleakala National Park that are dependent on native pollinators for seed set, including the “silversword” (see Argyroxiphium spp. in IUCN Red List of Threatened Species)	Krushelnycky, *et al.* 2004
Ailsa Craig, United Kingdom	*Rattus norvegicus*	Threat to endangered species	*R. norvegicus* effectively wiped out the puffin population of Ailsa Craig, by preying on eggs and chicks (see *Fratercula arctica* in IUCN Red List of Threatened Species. They have bred successfully on the island since the eradication of the rats.	ICEG 2004
Taitung Cycad Nature Reserve, Taiwan	*Aulacaspis yasumatsui*	Reduction in native biodiversity	Aulacaspis yasumatsui is endangering an indigenous species of cycad, prince sago (see *Cycas taitungensis* in IUCN Red List of Threatened Species).	Jung-Tai Chao, pers. comm. 2005
Donana National Park, Spain	*Linepithema humile*	Reduction in native biodiversity	Argentine ants are able to displace all native ant species in the Doñana National Park, causing a decrease in ant biodiversity	Carpintero *et al.* 2005
Mgahinga Gorilla National Park (MGNP) Uganda	*Acacia mearnsii*	Modification of successional patterns	The level of regeneration in the encroachment area is influenced by the intensity of cultivation and soil nutrients. The advanced growth beneath the exotic woodlots, especially black wattle (Acacia mearnsii) and Eucalyptus sp. stands is relatively impoverished. This condition beneath the exotic species suggests that a low diverse community of native species is able to exploit this environment.	Lejju 2004.

Table 5.2 (ctd).				
Donana National Park, Spain	*Procambarus clarkii*	Habitat alteration & Ecosystem change	At high densities *P. clarkii* significantly reduces aquatic macrophyte biomass, modifying the routes of energy transfer and the availability of food resources and refuges for other species and significantly altering the structure and function of the marsh	Gutierrez-Yurrita, and Montes 1999
Archipelago National Park, Finland	*Mustela vison*	Predation, Reduction in native biodiversity, & Threat to endangered species	American mink are affecting indigenous biota in the south-west archipelago of Finland. They predate heavily upon black guillemot (see *Cepphus grylle* in IUCN Red List of Threatened Species) and razorbill (see *Alca torda* in IUCN Red List of Threatened Species) which are not adapted to this type of predator, as well as smaller species of waterfowl, such as tufted duck (see *Aythya fuligula* in IUCN Red List of Threatened Species) and velvet scoter (see *Melanitta fusca* in IUCN Red List of Threatened Species. The presence of mink also affects the distribution of species richness and abundance in bird populations in the archipelago.	Council of Europe. 2002
Slonsk Reserve, Poland	*Mustela vison*	Predation	The breeding success of geese at Slonsk Reserve is lower than it was prior to the arrival of mink.	Bartoszewicz and Zalewski, 2003.
Mojave National Preserve, USA	*Equus asinus*	Competition & Ecosystem change	Competition for forage, is negatively affecting the threatened desert tortoise. Feral E. asinus populations in Mojave are having deleterious and potentially irreversible impacts on native flora and fauna. Damage has been Documented in plant communities, soils, wildlife, and water quality.	Stubbs 1999

5.4 Uncertainty of impacts

It is not always possible to absolutely "prove" IAS impact on biodiversity – often the resources are not available to carry out research, and baselines are often not known. Moreover, demonstration of environmental impacts is often difficult because of the complexity of ecosystems. Wittenberg (2005) gives examples (in a Swiss context), where biodiversity impacts are known to exist even though they are not necessarily "proven": *species occurring in high numbers, such as Japanese knotweed (Reynoutria japonica) totally covering riversides, or an animal biomass of alien species of up to 95% in the Rhine near Basel, must have impacts on the native ecosystem - all species use resources and are resources to other creatures and so they alter the web and nutrient flow of the ecosystems they are living in.* Of course, many alien species will <u>not</u> become invasive. But given that the impacts from alien species can be direct, indirect, cumulative and/or complex, unexpected, surprising and counter-intuitive, and that they often only show after considerable lag times, every alien species needs to be managed as if it is potentially invasive, until convincing evidence indicates that it presents no such threat (McNeely *et al*. 2001). This uncertainty adds to the complexity of including IAS pressures and threats into PA management. However, it is the nature of management decisions that they are taken in a context of uncertainty, and assessments of IAS risks are not required to provide ecosystem modelling – they are merely required to provide effective support for management decisions (see also section 10.2).

6 SCOPING RESULT: IMPACT IN DIFFERENT HABITAT AND ECOSYSTEMS

Ecological communities all over the planet have been invaded to a greater or lesser degree (*www.issg.org/database*, UNEP 2005a,b, UNEP 2001). Areas set apart for the conservation of biodiversity are no exception: alien plants and animals are spreading in protected areas of various types in nearly all parts of the world (UNEP2001). The limited scale of this scoping meant that it was not possible to specifically attempt to analyse IAS threats to protected areas in the different habitats or ecosystems but we can look at this question more generally, through a review of literature on IAS threats in general to biodiversity or livelihoods in different habitats and ecosystems.

6.1 Undisturbed habitats and successionally advanced communities

As a general rule, disturbance increases the risks of biological invasion, but undisturbed habitats, ecosystems or sites are not safe from biological invasion. For example, the relatively undisturbed New Zealand South Island *Nothofagus* forest has suffered severe alteration of its ecosystem processes, as a result of the combined effect of alien Vespulid wasps (which colonised in the 1970s) and other invasive alien species (Clout and Lowe 2000). In the oakwoods of Killarney, Ireland, the replacement of *Ilex* by *Rhododendron* is another example of the successful invasion of an undisturbed community by an alien species (Usher 1988). One author bluntly states: *The concept of invasion of undisturbed communities being rare is no longer tenable. Either this is because undisturbed communities are not resistant to invasion, or it is incorrect because all communities on this planet are now disturbed, at least slightly. The reason is unimportant since nearly all areas of the planet have invasive species* (Usher 1988).

According to some studies, only very few alien species invade successionally advanced plant communities (e.g. Rejmanek 1989) However, shade-tolerant species such as *Alliaria petiolata*, *Microstegium vimineum* and *Sapium sebiferum*, can invade successionally advanced plant communities and they therefore represent a special challenge to managers of protected areas (Rejmanek *et al.* 2005). Rejmanek *et al.* (2005) also caution against: *any overconfident interpretation of patterns that may suggest resistance to invasion: when the 'right' species are introduced, even ecosystems that have been viewed as invasion-resistant for a long time may turn out to be susceptible*. They give the example of the Mojave and Sonoran deserts which are facing recent invasions by *Brassica tournefortii* and *Pennisetum ciliare*.

6.2 Island and freshwater systems

There is general agreement that the problems of invasive alien species are especially acute in geographically and evolutionarily isolated systems such as islands and other isolated areas such as lakes and isolated streams. For Tahiti for instance: *the current situation of parks and nature reserves in the tropical oceanic islands of French Polynesia (South Pacific Ocean) is critical …the main threat to these protected areas remains the invasion by alien plant and animal species.*(Meyer 2003). An example for invertebrates: since 1970, seventy-two percent of the Partula snail species native to the Society Islands have gone extinct as a result of the introduction of the predatory wolf snail *Euglandina rosea* (Baillie *et al.* 2004). Freshwater ecosystems are among the most affected: for freshwater fishes globally, preliminary analysis points to invasive alien species having contributed to 50% of species extinctions (Baillie *et al.* 2004). Not surprisingly, in these systems, IAS are often the most important issue for the management of protected areas for conservation. Especially in the designation of fresh water protected areas, very high value should be given to area free of alien species (Saunders *et al.* 2002); this principle merits being more widely be applied to protected areas in general.

6.3 Continental situations

The very high vulnerability of islands has sometimes led to a false sense of security regarding the risks for continental terrestrial habitats. Unfortunately, parts of the world which are most dominated by invasive plants in large landscape areas are found mainly on continents: North and South America and Australia and to a lesser extent in Africa and India (UNEP 2001). Continental forest ecosystems have also been affected: in the Eastern USA, alien European and Asian organisms have led successively to the decline of six dominant forest species or groups of species - first oaks (due to gypsy moth), then five-needle pines (due to a rust), then the American chestnut (first by *Phytophthora* followed by chestnut blight), then firs (by the Balsam woolly adelgid), then hemlocks (by the Hemlock wooly adelgid) and the American elm (by Dutch elm disease). All of these declines have led to marked changes in forest composition and their consequent ability to deliver forest services (Macdonald *et al.* 2002)

There is now increasing evidence that tropical forests also are not impenetrable or safe from IAS. In tropical America, the removal of forests for grazing was accompanied by the widespread introduction of African *Brachyaria* grasses which out-compete native grasses and which have begun to convert forested areas into grasslands (Macdonald *et al* 2002). An example from Asia: *Clidemia hirta* is a highly invasive shrub but it has had little success invading mainland sites and undisturbed forests. In the early 1990s, however, *Clidemia hirta* was for the first time reported to have invaded an undisturbed continental tropical forest at Pasoh, Peninsular Malaysia, with most individual located in high light gaps or gap edges. The implication of this study was that by competing with native species in gaps, *C. hirta* invasion has the potential to alter forest regeneration at Pasoh (Peters 2001). Alien creepers, particularly *Dioscorea sanibariensis* and *Mikania* species, thrive along rainforest edges and pose a serious threat to remaining rainforest in Singapore. (CBD Thematic Report on Alien and Invasive Species – Singapore, undated). Even if tropical rainforest invasions were limited to trails and gaps, this would still be of concern to protected areas, which are subject to fragmentation, edge effects, and increasing construction of roads. However, large tropical areas are not necessarily free of IAS risks. In the Brazilian Amazon region, the giant African snail (*Achatina fulica*) is present in many urban areas such as Manaus. In the Atlantic Forest this alien has already gone beyond the cities to move into well-conserved forests, and it may well do the same in the Amazon (Ziller pers comm. 2006). In the case of tropical forests, the major routes for species introduction over the last three centuries have traditionally operated North-South between these tropical forest countries and their

European colonial powers. In recent years however there has been an upsurge in South-South routes, and the possibility of forest species with invasion potential being moved between tropical South and Central America and Asia, is increasing. (Macdonald *et al*. 2002).

6.4 The marine environment

In the marine environment, invasive alien species has been rated as one of the 4 greatest threats to the world's oceans. For example, in the Northern Atlantic, microscopic Japanese algae have recently been floating around while Pacific crabs are now roaming off the Norwegian coast. Invasive alien species are common and highly significant agents of change in coastal and marine environments including estuaries, bays, rocky shores, coral reefs, deep continental waters, mangroves, and open water areas. A variety of taxonomic groups such as protozoans, sponges, cnidarians, flatworms, polychaete worms, molluscs, crustaceans, bryozoans, tunicates, fish, seaweeds have contributed to major invasions in recent years (UNEP 2001). Increase of shipping worldwide has made it the most important pathway of spread of invasive alien species attached to surfaces of ships, boats, and drilling platforms (usually as communities of fouling organisms); through ballast water and ballast sediment; and in sea chests. More than 75% of commercial goods now traverse the earth by ship. Billion tons of ballast water per year, and *daily* at least 10,000 species are being transported around the world (Carlton 1999)

Many areas of high ecological value have suffered from marine invasive species. For example: the Wadden Sea is the largest unbroken stretch of mudflats worldwide and the largest European wetland. Over the last 100 years, it and its estuaries have been invaded by numerous alien species. (Nehring 2003, Nehring and Klingenstein 2005). A similar story repeats itself in the marine environments around the world, from the Baltic Sea and North Atlantic, to the Mediterranean, the tropical coral reefs, or the southern shores of Tasmania. Even the Antarctic is no longer free of alien marine species. Marine protected areas have no physical barriers to invasion and the threat posed by marine IAS to MPAs is significant (Ricciardi 2006, UNEP 2001).

6.5 Mountain and wilderness areas

Being far away from the main centres of civilisation is no bullet-proof protection against IAS either. Mountains are often highly susceptible to harm from invasive alien species. For instance, Stirling Range National Park, in Australia contains a number of isolated mountain peaks which act as 'islands in the sky'. These biodiversity hotspots contain some 1517 plant species, some being endemics with narrow ecological ranges. The main threat to the alpine floral communities in the park is plant disease caused by the introduced pathogen *Phytophthora cinnamomi*, also known as 'dieback disease'. It appears that it is spread by transport of infected soil, mainly by foot access. Around one-quarter of all vascular plant species listed as 'rare' in South-Western Australia are under threat from this pathogen (Watson and Barret 2003). Of course, such mountain areas are also ecological islands which could lead to suggest that it is predominantly the "island nature" that makes them vulnerable. It is therefore important to also consider the situation in very large wilderness areas.

Mittermeier *et al*. (2003) analysed 24 wilderness areas - each larger than 1 million hectares, more than 70% intact and with human densities of less than or equal to five people per km^2. All continents (except Antarctica) were included. Their analysis found invasive alien species as a threat in 15 of the 24 wilderness areas, including areas in the Tropical Humid Forest (2), Tropical Dry Forests (2), Temperate Forests (5), Wetlands (1), Deserts (4) and Tundra (1). In the Southern Ocean, biological invasions, of mammals, invertebrates and plants, have been devastating on the Sub Antarctic islands in spite of their remoteness and while no alien species has become invasive (yet) on the Antarctic continent, alien organisms have regularly arrived and survived there, and the Antarctic Treaty System is taking the potential threat seriously and developing ways to apply increased prevention (De Poorter *et al.* 2006) .

6.6 Overall Conclusion

The overall conclusion is that biological communities all over the planet have been invaded to a greater or lesser degree: terrestrial, freshwater and marine, on islands and on continents, in cold, temperate and tropical climates. Remote areas such as wilderness areas, or the Suba Antarctic uninhabited islands are not free of IAS either. Areas set apart for the conservation of biodiversity are no exception to this: no matter what habitat or ecosystem, it is only a matter of time until invasive alien species will need to be addressed.

7 SCOPING RESULT: ASSESSMENT OF FUTURE TRENDS

Estimates for the United States indicate land conversion by invasive species growing at 2,000 hectares per day or 14% per year (Bartuska 2002). There are a variety of reasons why in future, protected areas will be under even more risk from invasive alien species than they already are.

7.1 IAS issues caused by designation of a site

The designation of a site as a protected area can increase the risks of invasion by alien species. Marine protected areas, for instance are points of significant attraction for marine tourism, including recreational boating, yachting, the diving and snorkelling industry, and, where allowed, recreational and artisanal fishing. All these activities are likely to lead to increased risks of introducing alien invasive marine species, associated with hull fouling, ballast water, or on wetsuits and bait material. (Méliane 2004). Of particular relevance in the case of protected areas is the construction of roads, and other facilities. Pauchard and Alaback (2004) confirmed the importance of roads as corridors of plant invasions from disturbed landscape matrices into protected areas in temperate forest regions. Construction of accommodation, and other facilities is a well known pathway for alien species introductions, through propagules attached to construction material, equipment, soil etc. (Wittenberg and Cock 2001). Macdonald *et al.* (1989) confirm this for reserves in South Africa, where habitat modification for roads, campsites and similar has lead to an increase in alien plants species. Even protected area staff quarters can be a focus for potentially invasive alien species, notably through plants grown in their gardens(Foxcroft 2000, 2004). Pathways for introduction are also associated with visitors. In general, the number of visitors to an area has been shown to be associated with the numbers of introduced alien species - e.g. see MacDonald *et al*. (1989) for vascular plants in South African reserves, and Chown *et al.* (1998) for Sub Antarctic islands. Increased numbers of visitors means increased numbers of introductions of alien species and hence increased risk of introducing species that will become invasive. Pathogens may be transferred by tourists in clothing or on boots, seeds of IAS plants may be brought on camping equipment, animals may be "hitchhiking" in people's belongings, vessels or vehicles. For example, in Stirling Range National Park, Australia plant species are under threat from a plant disease caused by the introduced pathogen *Phytophthora cinnamomi* ('dieback disease'). It appears that it is spread by transport of infected soil, mainly by foot access, via hikers (Watson and Barret 2003).

With good prevention, (see section 10.2), such pathways to alien introduction can be blocked, but in the absence of awareness, capacity or funding, if prevention measures are not effectively applied, the number of alien species introductions into protected areas will rise, and with it, the risks of biological invasion will ever increase. There is an increasing trend to develop protected areas, and encourage visitation While this may be necessary from the point of view of stakeholder benefits (IUCN 2005), it will almost inevitably increase the risk of biological invasion significantly. It is paradoxical that one of the most ecologically acceptable methods to protect natural area, such as ecotourism or nature tourism may facilitate the introduction of alien species into hitherto little disturbed natural habitats by bringing in large numbers humans from far away (UNEP 2001).

7.2 Trade and travel

Biological invasions now operate on a global scale. Increasing globalization of markets, explosive rises in global trade, travel, tourism, and exchange of goods are conveying more and more species from and to all parts of the world and thus enhancing the possibility of biological invasions across all ecosystems in all areas of the world (UNEP2001).

Whether it is over land, sea, or through the air, volumes (and speed) of trade, travel, and tourism have increased massively. For example, we are now capable of moving more marine organisms around the world in one month, than we used to do in one whole century, in the ballast water of ships – several thousands of species are carried around the world in ballast water and on ship's hulls every day (Carlton 1999, Ricciardi 2006). Not only is the diversity of traded commodities increasing, and the volume of trade intensifying – there is also an increasing diversity and number of pathways. An increasing South-South interaction for instance, has been linked with an increased chance of alien invasion in the tropics, including tropical forests (Macdonald *et al.* 2002). The scale of the daily transfer of organisms, the magnitude and diversity of pathway is such that the chances of a species from some part of the world being introduced to an environment in another part of the world where it eventually will thrive is now higher than ever. For terrestrial plants, for instance, Macdonald *et al*. 1989 state*: in fact, the indications are that plant introductions are likely to occur with increasing frequency unless improved preventative measures are implemented. All reserves can look forward to receiving propagules of all the world's worst weeds.*

7.3 Other global change

The current spread of invasive alien species is inextricably linked to key global changes especially land use change, human induced disturbance of natural systems, habitat destruction, overexploitation of resources, chemical pollution, and climate change (UNEP 2001) and the actual impacts of invasion are also being compounded by global climate change and land use changes worldwide (Mooney & Hobbs 2000).

Climate change for instance will exacerbate the impact of invasive alien species on natural systems, as well as on modified systems, for a variety of reasons:

- It can favour aggressive and adaptable invasive alien species over less adaptable native one; stress on crop plants can reduce their ability to resist invaders (McNeely et al 2001);
- Changes in intensity and frequency of extreme climate or weather events (e.g. storms, cyclones, floods, tsunami) disturb ecosystems and in doing so provide exceptional opportunities for the development of invasiveness; in the South Pacific, the concern has been raised that a higher frequency of storms in future may also result in more shipping accidents and associated release of invasive alien marine species;
- A possible indirect risk of climate change could be caused if carbon-sequestration schemes were to result in the increased use of invasive alien species for re-forestation. Instead, the use of native species should be encouraged. For instance, The Nariva protected area (7,000ha) is one of the most important protected areas

in Trinidad and Tobago. A project funded by The World bank Carbon Finance Unit will afforest the area and restore the ecological characteristics of Nariva, and will therefore contribute to the conservation of one of the most diverse areas in the Caribbean. The project will only use native tree species (*http://carbonfinance.org/Router.cfm?Page=BioCF&FID=9708&ItemID=9708&ft=Projects& ProjID=9643&stp=Yes*)

7.4 Time delays

Invasive alien species, even after introduction, may take quite some time before they become invasive, for all kinds of reasons (see Fig. 1.1). For instance, with relatively few weed species at their full environmental potential, in New Zealand the main future threat to protected areas comes from the "weed reservoir" provided by the 20,000 alien species currently already in the country, growing in and around urban centres. Nationwide, 12-20 new plant species become naturalised each year, turning them into risk species from the point of view of protected areas. All of the new weeds of the immediate future are hence already growing in the country (Lee *et al*. 2001). For trees and shrubs this time delay between arrival and invasiveness phase can be substantial – e.g. Kowarik (1995) reported, for the German province of Brandenburg, that the average duration of the time lag between introduction and initiation of expansion (one of the pre-requisites for invasion in the case of trees) was 131 years and 170 years respectively for shrubs and trees.

This means that the number of invasive alien species in a region today is reflecting pathways and volumes of trade and travel of decades, if not centuries ago (or even longer). The major increase in trade, travel, tourism etc of the last decades, will at most only just have started to result in increased invasion at the PA site level. Even if trade and travel stopped overnight (hypothetically), risks from biological invasion would continue to dramatically increase in future.

7.5 Conclusion

The increasing threat from IAS to protected areas was already predicted almost twenty years ago by Macdonald et al (1989): *Given the fragmentation of the world's major biomes into relatively small "quasi –insular" reserves with all the attendant changes in faunal composition, altered microclimates, altered fire regimes, and increased proximity to transformed areas, we can actually predict that the circumstances conductive to the invasion of introduced species will become more widespread in the future, not less wide spread*. The message that the threat of biological invasion will keep growing is one that can not be ignored, and that, if anything today we know to be more urgent than it was two decades ago. Fostering capacity for IAS management at protected area level, including prevention, early detection and rapid response, a well as addressing established invasives, will arm future generations of protected are managers against the waves of biological invasion that they will be facing.

8 SCOPING RESULTS: IMPEDIMENTS/CHALLENGES TO ADDRESSING IAS IN PA(S)

Protected area management in general faces impediments and challenges at a wider scale than merely as it affects IAS management. Issues of capacity, funding, stakeholder participation etc are of relevance throughout PA management as a whole. We are restricting our analysis and discussion, however, to those challenges and/or impediments that are particularly affecting the management of invasive alien species in protected areas. For a general overview of management issues facing protected areas, see e.g. Barber *et al.* (2004), Hockings *et al.* (2000) and IUCN (2005).

8.1 Sources of Information used

Several sources of information were used to in the identification and discussion of key impediments to the management of IAS in protected areas and/or PA systems for this scoping report: literature search, expert's comments, relevant records in the Pilot sample, and relevant results from a IUCN Global Marine Programme (GMP)/ IUCN/SSC ISSG brief survey in 2005 of Marine protected area issues.

8.2 Pilot sample results

In the Pilot sample, of 237 records with IAS information on PAs (site level or multiple site or generic PA System level) - 46 records, from various sources, contained at least some indication of impediments to the management, as identified at the PA site or system level. It needs to be kept in mind that these are records from instances were IAS were identified as an issue in the PA, so no information is included from PAs where the issue has not been understood or identified.

In the Pilot sample of 83 records with "Other information of relevance" - 29 had been summarised from thematic reports on IAS, prepared by countries, and submitted to the Convention on Biological Diversity (CBD). Individual reports are available on the CBD website through the Clearing House Mechanism (CHM). These records provide an insight at the impediments to addressing the overall invasive species issue at the national level rather than at the specific PA system or site level. However, any PA management takes place in a wider context, and the inclusion of the "country" level of impediments identified hence provides additional insights.

Because the records were sourced from a variety of sources, description of the challenges/impediments was not standardised. We assigned individual descriptions to one of the following categories of impediments: Lack of resources or finance (FR); Lack of information (LI); Lack of Capacity (CAP); High Level Impediments (HLI); Lack of awareness (AW); Clash of interest (CLI). Table 8.1 shows a the range of issues assigned to each category

Table 8.1: Pilot Sample - examples of impediments in the different categories		
Category of impediment	PA level impediments in PILOT SAMPLE (46 records – various sources)	Country level impediments in PILOT SAMPLE (29 records – summarised from IAS thematic reports to CBD)
Finance/Resources (lack of -, or insufficient)	Finances insufficient Resources (specific such as "staff" or unspecific) insufficient	Resources "limited" or "lacking" or "extremely limited"
Lack of Information	Not enough research Absence of monitoring	Not known what aliens there are, No surveys done, Impacts not known No case studies
Capacity (lack of -, including lack of know-how, lack of training)	Lack of strategy at PA level Insufficient knowledge/know-how Insufficient capacity (unspecified)	Lack of capacity (unspecified) Lack of facilities Insufficient staff or time No ability to do risk assessments Technical constraints Lack of information management
High Level Impediment (e.g. legal, institutional or strategic, and beyond the PA system's control)	Restrictions on pesticide use Law change at national level required (e.g. to allow /hunting or removal of IAS)	No national strategy Lack of systematic approach Sector based approach but no coordination Insufficient legal coverage Risk Assessments on alien species (at national / border control level) not including biodiversity impacts
Awareness (lack of-)	Stakeholders not keen to cooperate (no interest to manage IAS on their private land adjacent to PA) "Attitude towards IAS" Lack of awareness (e.g. of biological effects) Absence of political recognition of need for management	Lack of awareness
Clash of Interest	Public opposition to removal Wish to use of IAS for recreational, hunting, erosion control or other purposes	NA (not mentioned)
Countries where information in the records is from	Australia, Bhutan, Canada, China, Ecuador, French Polynesia, Germany, India, Indonesia, Ireland, Mauritius, Nepal, New Zealand, Singapore, Slovak Republic, South Africa, Spain, USA, UK	Australia, Austria, China, Eritrea, Estonia, EU, Germany, Hungary, Iran, Korea, Macedonia, Moldova, Namibia, Netherlands, Oman, Pakistan, Philippines, Poland, Quatar, Romania, Saudi Arabia, Seychelles, Sri Lanka, Sweden, Tanzania, Thailand, Turkey, UK, Vietnam

Results are shown in Table 8.2 and Fig. 8.1. Lack of funding and other resources is, not surprisingly, mentioned many times, both in the case of impediments at country level, and at site level. This is to be expected, given it is an overall issue with PA management and capacity (Barber *et al.* 2004, Hockings *et al.*2000, IUCN 2005).

Lack of information is mentioned many times in the case of country level impediments – confirming the lack of information at national levels which often underlies the lack of action at national level. At the site level, given that the pilot sample has records from PAs where IAS have been identified as an issue, lack of information would not be expected to be as big an issue and the results are consistent with this.

Issues relating to lack of capacity are in the medium range in both types of situations.

Table 8.2: Pilot sample **-** Number of cases for each Category of impediments, at country level, and PA level; Lack of resources or finance (FR); Lack of information (LI); Lack of Capacity (CAP); High Level Impediments (HLI); Lack of awareness (AW); Clash of interest (CLI).		
	Country impediments	PA level impediments
FR	23	17
LI	12	5
CAP	9	10
HLI	6	5
AW	2	12
CLI	0	5
	Impediments; n = 52	Impediments: n = 54
	29 records	46 records
	(29 countries)	(19 countries)

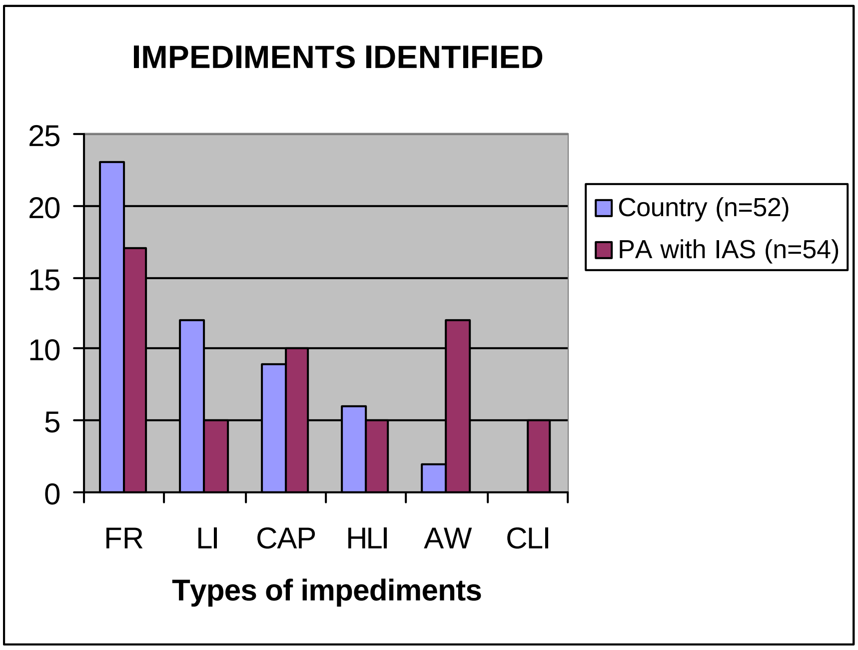

Figure 8.1: Pilot sample - number of cases for each category of impediments, at country level, and PA level; Lack of resources or finance (FR); Lack of information (LI); Lack of Capacity (CAP); High Level Impediments (HLI); Lack of awareness (AW); Clash of interest (CLI).

Quite interesting is the fact that High Level Impediments do not show up very frequently at the site level (cf. the results of the marine survey and only somewhat more at the country level.

Quite noticeable is the frequency with which awareness issues are identified at the site level as a challenge. Clash of Interest type issues were also mentioned at the site level;

8.3 Marine survey results

The IUCN Global Marine Programme (GMP) and the IUCN/SSC Invasive Species Specialist Group (ISSG) undertook a brief survey in 2005 to start evaluating some aspects of invasive species in Marine protected areas. Participation was solicited via GMP and ISSG networks, the Listserv Aliens-L etc. A questionnaire with 25 questions was returned by 37 respondents. Results relevant to this scoping report include:

Of the 37 respondents: 34 answered "yes" to the question: "Are you aware of the threat that invasive species could pose to the integrity of the MPA?" and 12 answered "yes" to the question: "Are there any recognized alien invasive species in the MPA?" However, 19 answered "no" to the question: "Does your MPA regulation allow eradication of invasive species in case of an incursion?";

Of the 37 respondents : 31 responded "yes" to the question:" Do you have a monitoring programme for the MPA?" but only 14 also responded "yes" to the additional question;" If Yes, does it include a component targeting invasive species?"; While 34 responded "yes" to the question: "Do you provide information or any awareness material or brochures in your MPA?" but only 9 also responded "yes" to the additional question: "If yes, do you address marine invasive species?". This is illustrated in Fig. 8.2 below.

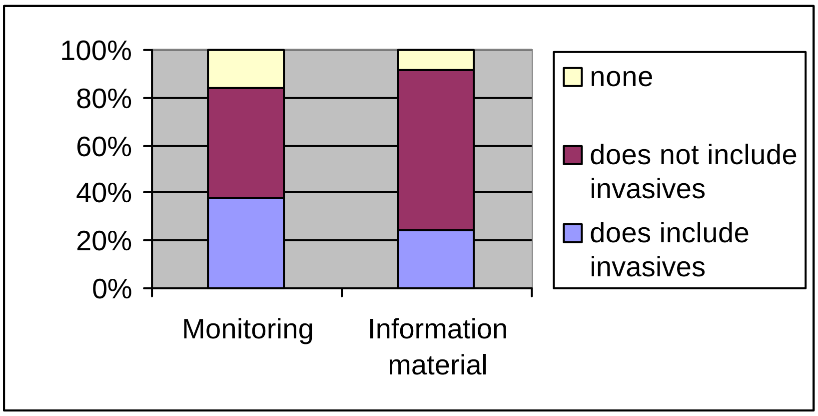

Figure 8.2: Mainstreaming of IAS into monitoring, and information provision (based on 2005 IUCN GMP and ISSG survey of Marine protected Area issues)

High level impediments: the survey results show that most respondents were aware of the threat that would be posed by marine invasive if they arrived in their MPA but over half of respondents reported that their MPA regulations did not have provisions for eradication, even if they found such new incursions, in other words, they did not have a mandate. While some respondents elaborated that they would be able to seek ministerial or other approval to take action in such cases, others simply stated that they would be able to do "nothing".

IAS not incorporated in monitoring: if IAS issues were incorporated in monitoring and surveying, the chances of picking up a newly arrived alien in time to respond would be higher. Lack of monitoring, and hence lack of information on what IAS are in the site (or near the site), restricts the ability for early detection and rapid response.

IAS not including in awareness material / information: while respondents themselves were aware of the IAS, the IAS issues were often not included in awareness- or information materials at the site, increasing the risk that visitors or users inadvertently contribute to introductions.

The lack of incorporation of IAS issues in monitoring and awareness/PR materials illustrates the degree to which IAS issues are not mainstreamed in the overall PA management, lowering the potential for effectively addressing IAS.

8.4 Expert Comments

Experts on IAS and PAs were kind enough to contribute to this scoping and to offer comments on what the impediments are to management of IAS in protected areas. The emphasis were very markedly on lack of awareness, and resulting lack of understanding and capacity. Representative examples include:

*Lack of awareness and technical background are key gaps, as people tend to wait for invasion to become obvious problems and then think there is not much that can be done (*Sílvia R. Ziller, Instituto Hórus de Desenvolvimento e Conservação Ambiental, Brazil)

The lack of understanding is immense [ ] alien species are not at all recognised as a significant problem. For example, in the "research world", the establishment of aliens in the Wadden Sea and their effects are described only as interesting biological phenomenon up to now – and a critical discussion about their effects on the natural integrity of the Wadden Sea is missing. In addition, in the debate about environmental problems for the near future, only climate change is discussed, and alien species are again absent from the discussion. (Dr. Stefan Nehring, IAS Management consultant, AeT umweltplanung, Germany).

PA staff in Poland at first would have to be enlightened about the whole IAS problem, and then instructed what to do to reduce it. It seems that in the majority of Polish PAs, the first step to reduce it would be to actually see what is there. (Wojciech Solarz, Institute of Nature Conservation, Poland).

Unfortunately marine invasive species are still not on the radar screen of many decision makers and donors (Imène Méliane, IUCN Global Marine Programme).

8.5 Discussion based on the findings in the marine survey, pilot sample, expert comments and literature

Lack of capacity includes several aspects, and can be separated out in two main types of problems:

(1) A lack of capacity at overall PA management level: Management of IAS is not integrated or mainstreamed into PA management, affecting the overall protected area management effectiveness. For example: IAS pressures and threats are not being

identified resulting in degradation of the values of the PA; PA management activities are actually contributing to IAS introductions (e.g. unintentionally through construction activities or intentionally through use of invasive alien species in stocking of ponds, erosion control, or visitor facilities); or it is not realised how damaging IAS are in comparison to other threats and pressures, and hence they are not given sufficient overall priority compared to other management activities. This should be addressed through capacity building at the PA management level (mainstreaming IAS).

(2) A lack of capacity to effectively implement IAS management, through lack of knowledge, training, information management, etc resulting in non effective or non efficient IAS management at sites. This also includes the lack of understanding of the importance of carrying out prevention and early detection/ rapid response activities.

Of course, there are linkages between the various challenges and impediments. Lack of awareness can underlie the lack of capacity, as shown in the following quote: *Whilst weed control in cultivated lands receives much attention, the impacts of alien invasive plants in natural ecosystems of the Mekong Delta have not been well aware of. The invasion of Mimosa pigra at Tram Chim is an example that shows how ignorance and slow response to an invasive environmental weed can result in an costly eradication afterward (*Triet 2000).

Awareness is not surprisingly the most frequently mentioned challenge or impediment for management of IAS at site level – in the pilot sample, as well as in literature and by experts. Where decision makers within the PA system are not aware of the IAS issues, management to address them at site level will not be sufficiently developed, resourced or funded within the overall allocations for that site.

Lack of awareness outside the actual PA system itself actually has wide implications for IAS management at site level. Where politicians or decision makers do not understand the gravity of the issue, funding and other support is not made available, and national strategic approaches will not be developed. Where international funding entities do not understand the relevance of IAS management (including prevention) to the conservation of biodiversity and the maintenance of ecosystem functioning, it is nigh impossible to obtain the external finance that often will be required for particular management projects at the PA system or site level.

Awareness of course will be different from one country to the next, and often it is different for the various stakeholders within the same country. For instance, awareness by the scientific community may not be reflected in the general population (Usher 1988) – or decision makers.

Even within the international conservation (and sustainable development) community the issue seems sometimes not to be well understood: in contrast to the WCPA participants assessment of IAS as a significant issue to PA management (see section 1), the IUCN protected areas Programme PARKS issue (Vol 14 no 4, 2004), a special issue on the Durban World Parks Congress, when searched by us did not contain a single word like "alien", "invasive", "weed" or "pest". This illustrates the degree to which, within the conservation and protected area community, a discrepancy in awareness exists between those at the coal face of day to day PA management, and those that are further removed from the sites in their day to day work. Possibly this may be related to an unfortunate perception in those working on the "bigger" picture that the IAS issue is just too overwhelming and/ or that there is not much that can be done about it at site level, which may explain e.g. statements like: *Preventing new IAS is a global challenge that must be addressed at the international as well as national level, and is thus largely beyond the scope and powers of protected area managers......*(Barber 2004). This in sharp contrast with the many protected area managers all over the world who are actively and effectively addressing at least some aspect of the IAS issue in their day to day work at site level. Scalera and Zaghi (2004), reviewing the European situation, remark: *although wildlife managers recognize the growing threat of alien species, decision makers and the general public still seem to underestimate the problem.*

Lack of information is mentioned many times as an explanation for inaction, in the case of country level impediments (Pilot sample), as well as at the site level (literature and experts comments).

The lack of access to consolidated information on IAS issues in protected areas, at global, international or regional scale perpetuates the problem of lack of knowledge, lack of awareness and consequently, lack of supportive action at national or international level. The development of an easy to use source of consolidated information about IAS in PAs will make it easier to understand the international scale of IAS threats to protected areas. As a result, it should be easier to convince those in control of financial and other resources to make them available for IAS management in protected areas. Consolidated information would also make it possible to assess trends over time, and to evaluate whether efforts to address them are paying off. Lack of consolidated information and lack of awareness form an insidious vicious circle which needs to be broken.

At the site level, lack of information on what IAS are there, or what threats they might pose, seems to be a main impediment resulting in inaction. Managers do not only need to know what the situation is in their own PA and its surrounds, they also need to access and share information and expertise globally at practitioners level. Sharing lessons learned, on the ecology, impacts on PA values, and practical management of invasive alien species (successes and failures of approaches and projects) is a priority for successful management at local and site level. In addition, knowledge of past invasiveness of IAS is critical information for use in risk assessments underpinning prevention, early detection, and prioritisation (De Poorter and Browne 2005).

Funding and resourcing, not surprisingly are mentioned very regularly as an issue. Lack of funding and/or resources is a general challenge for protected areas and not specific to IAS management (IUCN 2005). However, acerbating the case for IAS management, is the lack of awareness about the relevance of IAS management in the protection of PA values. This is an underlying cause of lack of resourcing from within the available overall PA resources as well as of lack of funding from external sources (such as international funders / donors). Addressing the global funding situation of protected areas is beyond the scope of this report; the particular challenges of lack of finance and resources faced by IAS management in protected areas should be addressed in first instance by developing awareness at all levels, including with funders and politicians, and by improving capacity to mainstream IAS issues into PA management.

High level impediments include legal prohibitions to address IAS, such as prohibitions to hunt IAS, wildlife laws actually protecting IAS, restrictions on biocide use in protected areas, etc. There can also be high level impediments at institutional level, where the PA agency or site management does not have a mandate to take action such as restricting movement into a site or restricting use of alien species within a PA site, responding to new incursions of (potential) invasive species, etc. In some cases a lack of mandate at the site level can be overcome by involving another stakeholder who has the appropriate mandate. For example, authorities at local (e.g. municipal or county) level may be able to impose restrictions on bringing in alien species into the area of the site. (e.g. see examples in section 10.2). However, most high level impediments can not be remedied at the site or PA system level. The Indian Wildlife Protection Act,1972, for example creates problems for the very species it is supposed to protect on the Andaman Islands. Many of the species that are alien and invasive in the Andamans, including in the protected areas, can not be removed because they are protected by this legislation - these include chital and elephant which were introduced to the islands and are damaging biodiversity, including in the Interview Island Sanctuary (Sivakumar 2003). In other cases, even species that are alien to all of the country are protected because the law makes no distinction between alien or native species. (See Shine *et al.* 2000 for more examples and discussion).

The solution to such impediments is to develop national strategic frameworks to deal with IAS. Frameworks should consistently provide integration of the four key components: overall goal (the bigger picture), implementation (what needs to be done in practice), institutional mandates and arrangements (whose job it is/ who decides) and legislation & regulatory aspects (what are the legal obligations and rights) (Shine *et al* 2000). The development of a national strategic framework will usually start with an assessment of the national situation, including obtaining answers to questions such as "how much damage is done by IAS?, what values are they threatening?" Hence, lack of awareness and lack of information at consolidated level will form perpetual circles, causing inaction at national and international level. Increasing awareness, and developing sources of consolidated information on the IAS in PA issue are starting points to address this, and these actions are within the mandate and strengths of the protected area and conservation "community".

It is also needs to be kept in mind that an ever growing number of protected area managers have found ways to overcome high level impediments, or at least have identified effective IAS management that they can legitimately carry out in spite of them. Part of the change of attitude in successful IAS management, is to realise that there is always <u>something</u> that can be done (De Poorter and Ziller 2004), and fostering such attitude when building capacity will also assist in addressing the high level impediments where possible.

Clashes of interest can occur within sites, for instance when recreational users of the PA would like waterways stocked with invasive alien fish species that would be detrimental to the conservation values of the site; they can even occur within the PA management team, when alien invasive species are proposed for use in erosion control, or grown in gardens around visitor facilities etc. They can also occur in the wider landscape, e.g. when local communities value a species for some of its uses, while the PA values may be detrimentally affected by it. Such "dual personality species" are a particular challenge for management, as further discussed in section 10. Stakeholder participation is a critical component in effective and successful management of IAS, in PAs as elsewhere. Lack of stakeholder support and clashes of interest can be one of the biggest impediments to addressing IAS at the site level. However, when this is the case it usually is because there is insufficient awareness about the species' impacts on biodiversity or livelihoods, or because the PA management lacks the skills and training (= capacity) to deal with stakeholder issues and develop management approaches that satisfy all parties. As such, this can be addressed by building capacity at the site or system level, and by developing and fostering awareness.

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Box 8.1

Experts' view on addressing impediments and challenges:
In my opinion it is absolutely essential to awake politicians, area managers etc to realize that aliens are one of the key threats to native species and ecosystems and other aspects of biodiversity as well as that aliens have incalculable negative economic effects. (Dr. Stefan Nehring, AeT umweltplanung ,Germany)

Addressing the lack of awareness and insufficient technical background are key requirements, as people tend to wait for invasions to become obvious problems and then think there is not much that can be done. It is critical to build capacity for national and state protected areas: ideally, protected area management of IAS needs to become a part of the management plans, but even if they are not in the management plans there needs to be training to build capacity so that prevention, early detection and control can be implemented quickly. Training has to cover the federal environmental agency and state environmental agencies, as there are protected areas in the two levels. Priorities can be established according to existing information and levels of biodiversity and threat. (Sílvia R. Ziller, Instituto Hórus de Desenvolvimento e Conservação Ambiental, Brasil)

I agree [ ] that our effort to quickly identify, locate and properly document the IAS [ ] is crucial. (Dayne Buddo, The Institute of Jamaica) Jamaica

8.6 Summary : Impediments, challenges, and how to address them

Table 8.3 below summarises the key impediments and challenges to addressing present and future IAS threats to protected areas, and the way forward to address them. The focus of this scoping is on what can be achieved by the PA community rather than what can be achieved by national government level action. The key solutions to addressing challenges and impediments are;

(1) Develop and/or foster capacity for mainstreaming of invasive alien species issues into all aspects of protected area management (including site assessment, recognition of future threats from species that have not yet reached their invasion potential in or near the site, and management effectiveness evaluation).

(2) Develop and/or foster capacity at site level for all aspects of effective invasive alien species management (including risk assessment, prevention, early detection and rapid response as well as eradication and control).

(3) Develop and/or foster awareness at all levels, from site managers to decision makers and politicians, and also including the international conservation community, and funders.

(4) Foster development of consolidated information source(s) at national, international and global level, on invasive alien species impacts, threats and management in protected areas.

Table 8.3 Summary - Impediments, challenges, and how to address them	
Impediment or challenge	What can be done by the "PA community" to address it
(1) Lack of capacity for mainstreaming of IAS management into PA management overall	Develop and/or foster capacity for mainstreaming of IAS in all aspects of PA management (including PA assessment and PA management effectiveness evaluation)
(2) Lack of capacity for IAS management at site level	Develop and/or foster capacity at site level for all aspects of IAS management
(3) Lack of awareness of IAS impacts on PAs, of the options for fighting back, and of the urgency of prevention and early detection	Develop and/or foster better awareness at all levels (including at PA management level, at political / decision making level and international level, including, foundations and other funding entities, international conservation or sustainable development organisations, etc)
(4) Lack of consolidated information on IAS issue in protected areas at national, international and global level	Develop and/or foster development of consolidated information source(s) on IAS in PAs, at national, international and global level
(5) Lack of Information at site level: of what alien species are present , what risks they pose and how to manage them	Develop and/or foster development of consolidated information source(s) on IAS in PAs, at national, international and global level Develop and/or foster capacity for site level IAS management
(6) Lack of funding and other Resources	Develop and/or foster awareness (with funders, decision makers, etc) Develop and/or foster capacity to mainstream IAS management into PA management (including prioritising)
(7) High Level Impediment e.g. legal, institutional or strategic issues	Develop and/or foster better awareness at all levels (e.g. with decision makers, politicians etc) Develop and/or foster development of consolidated information source(s) on IAS in PAs, at national, international and global level
(8) Clashes of interests	Develop and/or foster capacity to mainstream IAS management into PA management (stakeholder relations) Develop and/or foster better awareness at all levels (including stakeholders)

9 SCOPING SOLUTIONS: DEVELOP AND FOSTER CAPACITY TO MAINSTREAM IAS ISSUES INTO PROTECTED AREAS MANAGEMENT

9.1 Introduction

In general, building capacity for effective and adaptive management of protected areas requires action in the following areas: developing strong institutions and capacities for protected areas planning and management; strengthening the skills and abilities of protected area managers; building greater public awareness of and support for protected areas; establishing a supportive policy and legal framework; and securing adequate and sustainable financial resources; (Lillo *et al.* 2004).

In the face of global changes, protected area management will have to anticipate, respond and adapt to changes. Managers need to build on the best ideas and practices of the past and combine them with inspiration, innovation and initiative for the future. They can not afford to make the same mistakes over and over, or to ignore successes and good initiatives (Leverington and Hockings 2004). Management effectiveness needs to be measured and evaluated from various points of view, ranging from the status of the area and the way in which a PR is designed through to the outcomes of management actions and the overall state of conservation of the area. Evaluation of management effectiveness is applied more and more often, either at site level, or at the level of PA systems or national PA management (Hockings *et al.* 2000; also see this reference for further information on such evaluation in general, and the work of IUCN's World Commission on Protected Areas' Management Effectiveness Taskforce).

Such evaluations are ideal opportunities to foster the mainstreaming of IAS issues into protected areas management. However, the degree to which IAS issues are included in such evaluation will depend not only on access to information on the IAS situation, but also about the IAS awareness in those that participate in the evaluations ("You only think about what you know"). IAS will only be dealt with to the extent that they are actually recognised as the threat or potential future threat that they are.

Our scoping resources did not allow an in depth analysis of how IAS issues are incorporated in the tools and guidance for PA assessment and PA management effectiveness evaluation; nevertheless we carried out a preliminary analysis.

9.2 IAS issues in PA management effectiveness evaluation

The WWF Rapid Assessment and Prioritisations of Protected Areas Management (RAPPAM) methodology provides protected areas agencies with a country-wide overview of the effectiveness of protected area management, threats, vulnerabilities and degradation. It provides follow-up recommendations, and is an important first step in assessing and improving protected area management. The RAPPAM methodology (Ervin 2003) specifically mentions invasive alien species in its methodology publication. The application of the methodology in the case of KwaZulu-Natal for instance, shows the priority of dealing with alien plants and indicates how this is dealt with (Goodman, P. S. 2003b), and in the case of Nepal also, alien plants are recognised as pressure and threat, and included in the management effectiveness assessment (Nepali S. 2006). In other instances however, such as the assessment for Romania, IAS were not included the pressures or threats considered for the assessment during the brainstorming session by participants to the workshop (Stanciu and Steindlegger 2006).

Whether or not IAS is identified as a pressure/threat will not only depend on whether they are a threat to the site or sites in question, but also to a very significant extent, on the degree to which the individuals involved are aware of the IAS issues - especially, the degree to which they are aware of the need to not only look at "obvious current invasives" but also to carry out a long-term-focussed risk assessment on (alien) species to identify those that are not a (huge) problem yet but are likely to become so in future. The latter are especially important, given that these species are one of the highest priorities for IAS management (ideal candidates for prevention and early detection / rapid response). The RAPPAM methodology for instance, focuses on how the pressures/threats that are identified are then prioritised and addressed; it is not usually applied to evaluate the actual accuracy of the identification itself of pressures and threats. We recommend that an evaluation of the extent to which IAS threats are recognised, and where possible an actual assessment of the current and future threat posed by IAS (carried out by someone familiar with the IAS issue), should be included where possible in the process of evaluating management effectiveness of protected areas. There is a useful precedent in the marine area for instance, with IUCN's publication : *How is your MPA doing? A Guidebook of Natural and Social indicators for Evaluating Marine Protected Area Management Effectiveness,* very specifically incorporating indicators on IAS that should be included in the evaluation (Pomeroy 2004).

9.3 IAS issues in assessing site value and vulnerability

With regards to surveying or assessing biodiversity in the process of determining conservation values, there are also great examples of assessments which have taken into account IAS. For instance the WWF's *Sourcebook for Conducting Biological Assessments and Developing Biodiversity Visions for Ecoregion Conservation, Volume II: Freshwater Ecoregions.* (Abel *et al.* 2002) mentions the IAS issue clearly. The CI *Biological Assessment of the Wapoga River Area of Northwestern Irian Jaya, Indonesia* (Mack and Alonso 2000) highlights the absence of aquatic IAS in combination with the presence of native fish species as one of the values to be considered. It would be useful to review in more depth to what extent IAS is highlighted as an issue in other assessment tools and publications, especially in ecosystems other than the freshwater aquatic or marine ones. We recommend that a more in depth survey could be carried out and recommendations made to the "assessing community" as appropriate.

9.4 Mainstreaming IAS issues into protected area management

In addressing the threats that are caused by invasive alien species to protected areas there are two distinct but obviously related components of capacity that need to be addressed: capacity to mainstream (integrate) IAS issues in effective protected area management, as well as capacity for effective IAS management at site level itself. The latter is dealt with in section 10. The importance of mainstreaming is confirmed in this scoping. It had already been recognised by the 5th World Parks Congress (Durban September 2003): *"Management of IAS is a priority issue and must be mainstreamed into all aspects of protected area management. ....Promoting awareness of solutions to the IAS problem and ensuring capacity to implement effective, ecosystem based methods must be integrated into PA management programs…"*

All stages of protected areas management are relevant to the mainstreaming approach, as illustrated in Box 9.1

Box 9.1

Mainstreaming IAS issues in all stages of protected area management

Identifying Values of the PA Site/Landscape: This includes: the identification (at a taxonomy or para-taxonomy level) of species, habitats, ecosystem functioning, livelihood aspects using either rapid assessment methods and/or in depth surveys. IAS mainstreaming would ensure that :

(1) Species/taxa are also identified as alien or native (which in turn will allow assessing whether the alien ones may pose a risk), and

(2) The IAS situation is taken into account in the judgement of ecosystem integrity.

Setting PA Objectives & Vision: This includes making a judgement on the significance of values (including at global, national or local scale, and including different stakeholder interests), deciding on priorities within the values to be protected, determination of the degree of protection, zoning for different uses etc. IAS mainstreaming would ensure that:

(3) IAS are incorporated into criteria to decide on: significance of values, urgency of protection, degree of protection required, allocation of zones for different uses, etc. For example, populations of native fish or other aquatic natives in a fresh water location without alien species could be of very high conservation value (Saunders *et al.* 2002). Another example: recreational fishing can be a pathway for introductions through the use life bait (unintentional) or stocking (intentional) - if recreational fishing is one of the uses of the PA, zoning should make sure that it takes place where high value native populations will not be put at risk, for instance by only stocking alien species of high value to anglers in sites that are already disturbed, or by keeping predatory fish well away from ponds and lakes where endangered native species reproduce (see e.g. Park Science 2004).

Identify Threats To Pa Values And Underlying Causes: This includes identifying present and future threats to PA values and/or objectives, identifying or estimating the magnitude, scale and/or importance of the threats. It usually also includes an identification of the underlying causes of threats. IAS mainstreaming would ensure that

(4) All present impacts and risks as well as all potential future risks and threats by IAS are incorporated appropriately in identification and evaluation of pressures and threats to PA values and objectives. This needs to include: species that are already invasive (having an impact on PA values); risks from populations of alien species that show no invasiveness yet at the moment but are almost certain or likely to do so in future; likely future threats from species that are not present yet in the site, but for which there are pathways of introduction.

Prioritising PA Management: Mainstreaming of IAS management would ensure that

(5) Management to address or prevent IAS is appropriately incorporated into overall PA management prioritisation.

Developing PA Management Strategy and /or PA Management Plan: Mainstreaming of IAS management would ensure that :

(6) PA Strategic Plan and/or PA Management Plan incorporate all aspects of addressing IAS (including risk assessment, early detection and rapid response, prevention, eradication and /or control, awareness raising etc..)

(7) IAS management receives sufficient resources out of overall PA management resources

Implementation Of PA Management Plan: the day to day programmes, projects, activities and tasks that PA personnel carry out. It can also include activities carried out by visitors and by stakeholders, such as neighbouring land owners or communities. Mainstreaming of IAS would ensure that:

(8) All PA decision makers, managers and staff incorporate appropriate IAS related activities in their day to day work e.g. all field staff know to report "unusual/probably new" species (part of fortuitous early detection) and all managers obtain input from someone with IAS expertise as and where needed in their planning or decisions. Training and up skilling of personnel should foster this approach.

(9) All implementation activities / tasks / outputs have IAS issue component as relevant e.g. visitor information material, guided tours and educational displays include the threats from invasive species, and ways to prevent them or to fight back, as well as specific steps that individuals can take to help with this.

Monitoring And Evaluation (M&E). An important part of effective adaptive management in protected areas is the monitoring and evaluation of outputs and outcomes of management programmes and projects. This allows managers to keep track of whether management is achieving the desired goals, and hence whether the protected area objectives are being met. An important reason to mainstream IAS issues into M&E is:

(10) to include an assessment of invasion risks caused by the implementation of PA management itself. In other word, to evaluate activities, and assess the risks of introduction of IAS caused by activities carried out in the park, by visitors, other users, as well as personnel, in order to take action to block any pathways for biological invasion. For instance: increasing the number of visitors, opening up remote areas, construction of facilities, changes in stakeholder access for grazing or harvesting, using alien species within the park for stocking or revegetation, all carry risks of introducing IAS that need to be assessed. Review of management may include the addition of better cleaning protocols (e.g. to clean equipment before coming into the PA), restriction of grazing routines (to avoid the introduction of invasive weeds in dung), developing of alternatives such as the use of native species (e.g. for sports fisheries or erosion control).

10 SCOPING SOLUTIONS: DEVELOP AND FOSTER CAPACITY FOR EFFECTIVE IAS MANAGEMENT AT SITE OR SYSTEM LEVEL

10.1 Adaptive Management Approach

Successful IAS management has several general requirements: good planning; good understanding; appropriate methods; adequate institutional support; stakeholder support; monitoring of outcomes, evaluation and feedback, and review as required. The complexities that can be encountered when addressing IAS make it very important that an adaptive management approach is applied (Fig 10.1). For more details, see e.g. Wittenberg and Cock (2001) and Tu *et al.* (2001).

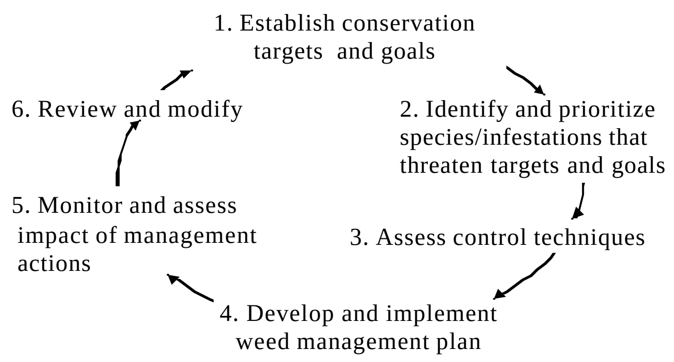

Figure 10.1 : adaptive management approach to alien plant control (after *Tu et al.* 2001): The same approach can be applied to other taxa of IAS.

10.2 Prevention, risk assessment, early detection and rapid response

Prevention is the first line of defence. In most cases, even if an invasive alien species is already present in the country, or even invasive in some types of habitats, it will be possible to target prevention on high value sites, such as PAs, and prevent the arrival of such species in the PA sites. This will be most effective if the most likely pathways are targeted by which IAS would arrive. In first instance, the use of alien species in the PA itself should be avoided where possible (e.g. it is preferable to use native species for erosion control, stocking fishing ponds for recreational purposes, planting around visitor facilities etc.). Where the use of native species is not possible, any use of alien species should be made subject to strict risk assessment. Restrictions on the introduction of alien species into protected areas can be implemented in many ways, at different levels of authority (e.g. see box 10.2).

Prevention of unintentional introductions is also important. Pathogens may be transferred by tourists in clothing or on boots, seeds of IAS plants may be brought on construction equipment, animals may be "hitchhiking" in people's belongings, vessels or vehicles. These pathways can be addressed through requirements for boot cleaning, equipment cleaning, requirement for de-ratting certificates (before allowing access to islands) etc. For example, in Stirling Range National Park, Australia plant species are under threat from a plant disease caused by the introduced pathogen *Phytophthora* *cinnamomi* ('dieback disease'). It is spread by transport of infected soil, mainly by foot access. Prevention measures hence include the provision of boot-cleaning stations designed to reduce the spread of the pathogen via trampers (Watson and Barret 2003) For more on prevention see e.g. Wittenberg and Cock (2001) or Owen (1998).

The progression of management options (and increasing costs and difficulty) with time since introduction / IAS population size are illustrated in 10.2

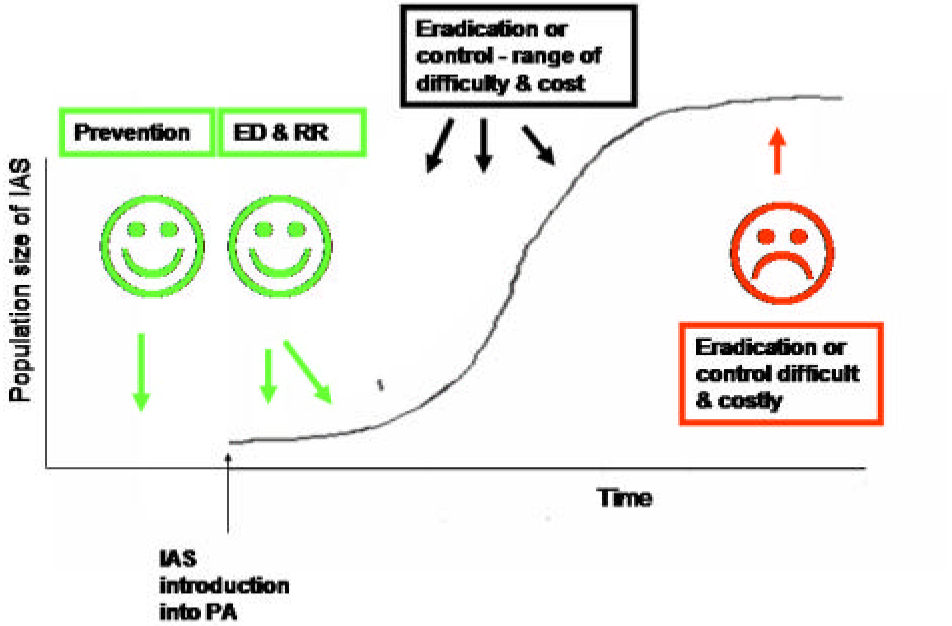

Figure 10.2 The progression of management options over time. EDRR = early detection and rapid response.

A specific challenge for managers is that there is a profound lack of awareness, about the importance of prevention. Prevention is the most cost effective approach to protecting current PA values, and in addition it is a *sine qua non* of future proofing them, especially in the face of global change. Yet, politicians, decision makers, funding agencies etc often are not aware of this.

Early Detection and Rapid Response: the second line of defence, and high priority, against biological invasion into protected areas, is the early detection of an introduced potentially IAS, allowing for rapid response (e.g. eradication before numbers have become too big, or the area of spread too vast). That way, even if a species has arrived within the site, and has survived there, it will not be able to become well established and spread. Any potential invasion can be "nipped in the bud" – avoiding impacts on biodiversity and livelihoods, and saving large amounts of management resources. Many invasive species may be almost impossible to manage once they are well established, but they can be successfully eradicated at this early stage. Fig 10.3 illustrates the exponential rise in costs for management of IAS plants, with time since establishment. While the publication refers to plant IAS ("weeds") in the New

Zealand Conservation estate, the same principle applies more generally to taxa anywhere (e.g. see Koike 2006 for a discussion on the optimum strategy for spatial management of feral raccoon in Kanagawa Prefecture, Japan).

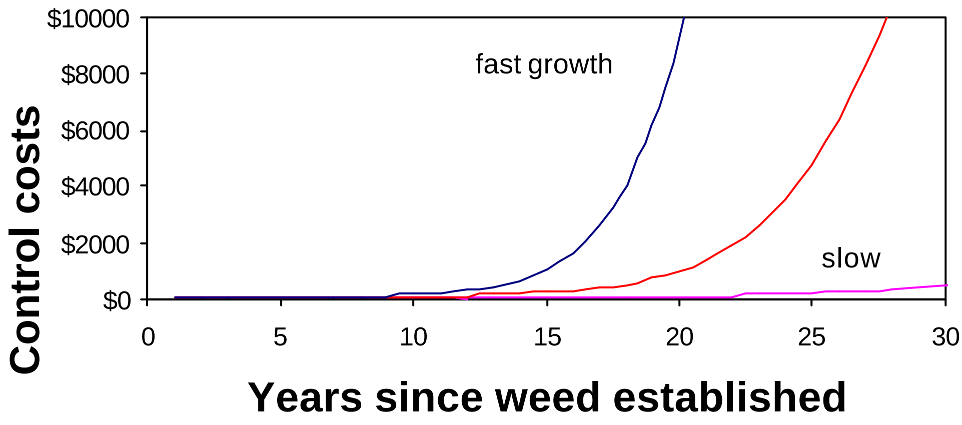

Figure 10.3; exponential rise in costs for management of IAS plants, with time since establishment (after Timmins 2002)'

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Surveillance and monitoring efforts as part of early detection systems, could focus on valuable areas within the PA sites, as well as on areas that are likely to be a point of entry – such as road ends, rubbish dumps, etc. Visitors, and the general public can also be effectively involved, especially for IAS that are relatively easy to see and recognise. The advantage of such larger involvement is that in addition to additional "eyes", it also produces aware and supportive stakeholders.

Box 10.1

Example of successful early detection and rapid response

In U Minh Thuong National Park, Vietnam, invasion by mimosa was detected early: in 2000, mimosa was found in two small spots with a total area of less than one hectare. The infested areas were quickly treated by manual methods (hand pulling and stem cutting). Park management established a weed control team, which has been patrolling the park once a month since then to monitor mimosa and other important environmental weeds. The weed was eradicated at little cost, highlighting the importance of invasion awareness and early intervention for mimosa control (Triet *et al.*2001)

Risk Assessment: Many alien species will not become invasive. But given that the impacts from alien species can be direct, indirect, cumulative and/or complex, unexpected, surprising and counter-intuitive, and that they often only show after considerable lag times, from a management perspective, every alien species needs to be managed as if it is potentially invasive, until convincing evidence indicates that it presents no such threat (McNeely *et al* 2001, IUCN 2000). The uncertainty adds to the complexity of using risk assessment to underpin prevention and rapid response. However, it is the nature of management decisions that they are taken in a context of uncertainty, and assessments of risk of invasiveness, for an alien species, should not be required to provide a perfect model of the local ecosystem – they are merely required to provide effective support for management decisions. For more on risk assessment as applied to IAS in the protected areas context see e.g. Timmins and Owen (2001), Murray and Jones (2002), Morse *et al* (2003).

10.3 Eradication and control

Eradication: Even if an IAS has established itself, eradication may still be possible, especially on islands. Where it is ecologically feasible and socially acceptable, eradication should be the preferred option over long-term control, because eradication is usually more cost effective and less risky for the environment than control. However, commitment of resources needs to be assured, as ill-considered or unsustained attempts result in certain failure. Methods for eradication of IAS vertebrates have been increasingly numerous and successful and the size of islands or other areas from which species have been eradicated is constantly growing. Important progress has also been made in eradicating or containing other IAS, including plants and invertebrates. Eradication can be a very important tool in turning back the tide of biodiversity loss. For more examples, see (Veitch and Clout 2002).

Control: Where eradication is not feasible, long-term control or containment should be considered. Several strategies for control exist, including the use of biological control agents and integrated pest management (Wittenberg and Cock 2001), and for weeds (IAS that are plants) manual eradication, mechanised removal, use of fire and herbicides. No single method is perfect and each case needs careful planning. All methods have limitations - all can be essential (Sigg 1999). The desired outcome of control should be to achieve gains for native biodiversity and/or livelihoods. As for eradication, there needs to be both management and political commitment to spend the resources required over the long term (McNeely *et al* 2001).

10.4 Prioritising

It will never be possible to manage all invasive or potentially invasive species at the same time, and being able to prioritise is a key management component at the site level as well as at the protected area system level. The aim is to decide on the best course of action with the available resources, in order to maximise the outcomes for the PA values. It will, for instance, not always be possible to eradicate or control the worst invader, if there are insufficient resources, or the available techniques are unreliable. In that case, it may be better to focus on several other IAS species that are not as far into the invasion cycle and where there is a good chance of success. It is also important to incorporate stakeholder concerns in the prioritising – management of IAS will almost certainly fail without stakeholder support, so even if a particular project is technically and financially feasible, it may have to be given a low priority if there is stakeholder opposition to it. In general factors to be considered are grouped in four categories: (1) current and potential extent of the alien species on or near the site; (2) current and potential future impacts of the species; (3) value of the habitats/areas that the species infests or may infest; and (4) difficulty of management (technical aspects as well as social aspects). For examples of how this has been approached in "real life" see e.g.: Wittenberg and Cock (2001), Owen (1998), Benjamin and Hiebert (2004), Morse *et al* (2003), Thorp (1999), Murray and Jones (2002).

10.5 Other issue of importance to IAS management at site level

Ecosystem context: management of IAS needs to be put in an ecosystem context. The management is never for the sake of managing a particular species of IAS – but for the sake of the expected biodiversity or livelihood outcome that will result from this management. Moreover, the ecological context of eradication and control is sometimes very complex e.g. where sites are affected by multiple invaders (Zavaleta *et al.* 2001, Zavaleta 2002).

Stakeholder participation: Another, critical, challenge is to ensure that stakeholders are properly involved and informed. If they are not involved, and don't agree with the management project, the management will almost certainly fail. For instance, in Idaho Craig Mountain Wildlife Management Area a programme of hand spot-spraying of yellow star thistle (*Centaurea solstitialis*) was stopped by a court injunction which resulted from a suit brought by the Northwest Coalition for Alternatives to Pesticides.

"Dual Personality Species": A special challenge is posed by alien species that are desirable and important to livelihoods in parts of the landscape but damaging to protected area values in other parts of the landscape. This is the case for instance in New Zealand, Brazil, and many other Southern Hemisphere countries with *Pinus spp.* or other plantation trees. These require management strategies that minimise the risk of spread from areas of cultivation to areas where they are unwanted, for instance through design and siting of plantations, removal of wilding seedlings through intensive grazing of land surrounding plantations, hand pulling or application of herbicide on sites with high conservation value, etc. (Rouget *et al.* 2002, DOC 2004).

In the marine environment, deliberate introductions of marine species for cultivation have often brought positive benefits to the economies of many coastal communities worldwide, but some of these introduced species have established themselves in the wild and displaced native marine life, while others have brought disease organisms and parasites with them that have proceeded to infect or parasitise local marine life, compromising not only the native biodiversity but also future production and ecosystem health. It is clear that addressing marine IAS will need to involve all interests and all stakeholders, and needs to include the MPA itself as well as surrounding areas.

Box 10.2

Example: stakeholder participation and landscape approach

Prosopis juniflora is another example of a species on which there can be divergent views. In the Sariska tiger reserve, the *Prosopis juliflora* plantations raised around the Reserve in the past have started posing serious problem to the eco-systems of Sawai Mansingh Sanctuary and Keladevi Sanctuary (*http://projecttiger.nic.in/sariska.htm*).
Rauf (pers. comm.) gives more examples of the complexity of managing this species in the Point Calimere Wildlife Sanctuary (Tamil Nadu, India) where *Prosopis* has invaded inside the sanctuary, and is destroying the habitat preferred by the Blackbuck (*Antilope cervicapra*), for which the reserve was originally created. Mwangi and Swallow (2005) illustrate some of the stakeholder issues surrounding this species in Kenya.

In India and Nepal, invasive alien weeds that exhibit such "dual personality" include *Chromolaena odorata* and *Mikenia micrantha* which are environmentally damaging and often "weeds" in the agricultural sense as well, while on the other hand also playing a role, in the absence of native vegetation, in conservation of soil, water and nutrients on steep hill slopes. Ramakrishnan (in prep a,b) discusses possible control measures for *Mikania micrantha* through a community participatory landscape management plan, involving Traditional Environmental Knowledge(TEK).

Box 10.3

Examples of different stakeholders implementing prevention

Prevention of intentional introductions into protected areas can be achieved via law or regulations at several levels:

- **At national level, through law:** Argentina prohibits the introduction, transportation and propagation of alien species in all protected areas (Law no. 22,321 of 1980) (Shine *et al*. 2000) Bulgaria forbids the introduction of alien species into the nation's protected areas, which include national and nature parks, reserves, managed reserves and protected sites (Bern Convention Group of Experts on Invasive Alien Species 2005)
- **At national level, through Protected Area Management Plans**: The Royal Government of Bhutan has declared 26% of the country as protected areas. The management plans of protected areas prohibit the introduction of any invasive alien species into the protected areas, and heavy penalties are imposed for defaulters. Before introducing any new species in to protected areas, the species has to be thoroughly screened and tested for its potential negative impacts on the ecology or on economic local plants (Pallewatta *et al.* 2003)
- **At sub-national level:** One of the outcomes of the Italian EU established LIFE Nature project Conservation of priority plant species in Aeolian was the inclusion of specific measures to avoid intentional introductions of exotics, in the species management plans. The Lipari municipality, beneficiary of the project, issued an ordinance to ban the introduction of exotic animals and plants in the entire archipelago (Scalera and Zaghi 2004)
- **At Agency level:** Regulations issued by the National Oceanic and Atmosphere Administration (USA) prohibit the introduction or release of any exotic species of plant, invertebrate, fish, amphibian or mammal into the Florida Keys National Marine Sanctuary. (Shine, *et al*. 2000)

11 SCOPING SOLUTIONS: DEVELOP AND FOSTER AWARENESS

11. 1 Awareness raising is a critical component of IAS management

Awareness building is crucial and can start at the local level - protected area sites and their surrounding areas: schools, villages, local communities. This does not necessarily require large funds or extensive logistics – one or two motivated people can make a tremendous difference for stakeholder relations, especially if they can deal with the protected areas IAS issues in an ecological and appropriate cultural context (Togia 2003). Awareness of IAS problems leads to support of management and to helping with prevention and other tasks. For instance, if communities understand the threats posed by IAS, they are usually willing to ensure that their gardens do not become "jump-off" points from where weeds or other IAS can get into a site. In cultures where removal of vertebrates may be controversial (e.g. for religious or ethical reasons), it is even more important to explore various alternative methods with the stakeholders (lethal vs. non-lethal), and it is important to ensure awareness on the positive outcomes for biodiversity and/or livelihoods that will follow from IAS management. For instance, it is not a "kill rats" or "kill weeds" programme for the sake of it, but it is a "protect our endemic species" or "protect our cultural heritage, or livelihood" project. Livelihood benefits can take many forms – from eradication or reduction of invasive species that impact crops or pastoral activities, to eco-tourism, or a renewed understanding of traditional values and traditional uses of biodiversity - including medicinal use of plants, carving, etc. (See Togia 2003 for an inspiring case study in the American Samoa National Park). Awareness raising will ensure that stakeholders can understand the link between managing IAS and such livelihood benefits.

11.2 Awareness at all levels

Awareness needs to be fostered at all levels: if politicians or decision makers do not understand the gravity of the issue, funding and other support will not be made available, and national strategic approaches will not be developed. If decision makers within the PA system are not aware of the issues, then IAS management at site level will not be sufficiently resourced or funded. If international funding entities do not understand the relevance of IAS management (including prevention) to the conservation of biodiversity and the maintenance of ecosystem functioning, it will be impossible to obtain the external finance that often will be required for particular management projects at the PA system or site level. Even within the international conservation (and sustainable development) community awareness needs to be improved.

A specific challenge for PA managers, especially where they are seeking to obtain funding from "external" sources such as international funders, is that those funding entities currently often do not understand the relevance of IAS management for the conservation of biodiversity or livelihoods. It will be very important to increase overall understanding and awareness at the level of funders – including about the benefits of early detection and rapid response and especially about prevention. Prevention is the most cost effective approach to protecting current PA values, and in addition it is a *sine qua non* of future proofing them, especially in the face of global change. However, effective prevention literally "has nothing to show" and as such funders, politicians and decision makers still too often fail to see its attraction. A major victory for awareness raising would be a situation where "we still do not have Red Imported Fire Ant in our Reserves" is understood to be among the most significant conservation and livelihood outcomes one can leave as a legacy for future generations.

11.3 Monitoring and Evaluation and awareness

There is an important lesson here: the biodiversity (or livelihood) outcomes of practical IAS management at site level must not only be monitored and evaluated in order to improve IAS management - as part of adaptive management; It is equally important that such information is circulated and publicised widely. The experiences of effectively rolling back the tide of biological invasions at site level must be shared to contribute to growing awareness and positive attitudes at all levels of decision making.

11.4 The importance of Attitude

Attitude is indeed another aspect of awareness and capacity that often is pivotal in managing IAS. As a result, closely linked with the need to improve awareness is the need to encourage a change in attitude as can be illustrated with the following quotes:

Shenandoah National Park, Virginia, has a total of 1,363 plant species listed to date. Included are 318 non-native. That's 23%! It's easy to feel hopeless with such a view. But let's look again. ...We can take courage,[] in knowing we may focus on minimizing new disturbances and keeping infestations from spreading....working smart and strategically tackling invasives is another way of engendering hope. (Åkerson 2003).

A 'can do' attitude is essential...[] Project teams must understand and agree with an eradication plan, know the importance of their role and how integral the effort of each and everyone of them is to achieving a successful outcome.....[whereas] a 'can't do' attitude by higher level management could have serious implications for resourcing (Cromarty *et al*. 2002)

11.5 Conclusion

Awareness and attitude are critical factors in addressing impediments to IAS management in protected areas. They need to be addressed at all levels – but a lot can be achieved at the site level even with minimal resources.

12 SCOPING SOLUTIONS: DEVELOP CONSOLIDATED INFORMATION SOURCES ON IAS THREATS AND MANAGEMENT IN PROTECTED AREAS

12.1 Availability of Information

There is quite a lot of information on IAS in individual sites, with some indication of their impacts, management implemented to address it and outcomes of that management "out there", but it is very spread out, and dissipated (see section 3); Useful information is often found in internal reports rather than in publicly available documents. Material will be in many languages other than English. The nature and diversity of information that is available at site level is illustrated in the records in the Pilot sample, GISD query and Ramsar query. Combined they contain information on 487 PA sites in 106 countries, and on 326 invasive alien species that are reported in protected areas (see Fig. 12.1).

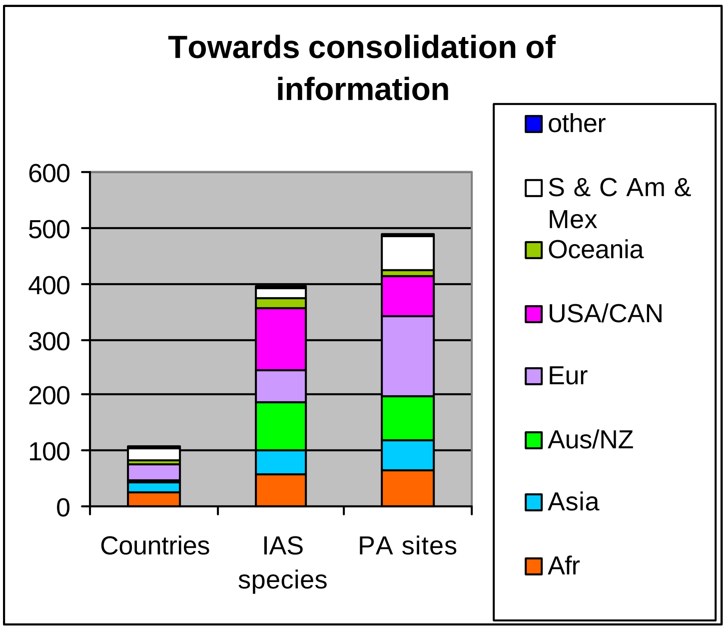

Figure 12.1: combined information in the records of the Pilot sample, GISD query, Ramsar query.

This is only the tip of the iceberg of information that could be accessed, given sufficient time and resources.

12.2 Consolidated information for higher level overview

The lack of access to consolidated information on IAS issues in protected areas, at global, international or regional scale perpetuates the problem of lack of knowledge, lack of awareness and consequently, lack of supportive action, at national or international level. The development of an easy to use source of consolidated information about IAS in PAs will make it easier to understand the international scale of IAS threats to protected areas and hence to convince those in control of resources for PA management to make them available for IAS management. It also would make it possible to assess trends over time, and to evaluate whether efforts to address the problem are paying off.

Currently, standardised information at an international level on the presence of IAS as a threat to protected areas is included in the reporting to Ramsar. It may be possible to develop linkages to sources external to Ramsar that have additional material (e.g. on the IAS species, impacts or management). It may also be possible to develop a system of information sharing (including on line) that can access the information on IAS in the WDPA, Ramsar, World Heritage, and Biosphere and PALNET websites (to name just a few), as well as relevant information provided to the CBD Secretariat. This should also access relevant information from other efforts, such as the GISP IAS Target 10 work in the context of the Convention on Biological Diversity's Global Plant Conservation Strategy, national and regional inventories of IAS/PAs etc. The result would be an emerging global picture of the status of invasive alien species in protected areas.

There is further scope here to also integrate, as possible, with sources of information on the impact of IAS on endangered species; ISSG is cooperating with other SSC entities to develop such footprint analysis of the role of IAS as a threat to such species.

12.3 Information source in IAS in PAs for site level practitioners

At the same time, there is also need to globally access and share information and expertise at practitioners level. Sharing lessons learned, on the ecology, impacts on PA values, and practical management of invasive alien species (successes and failures of approaches and projects) is a priority for successful management at local and site level. In addition, knowledge of past invasiveness of IAS elsewhere is critical information for use in risk assessments underpinning prevention, early detection, and prioritisation (De Poorter and Browne 2005).

Further discussion and brainstorming is required, including user analysis to determine what information is the highest priority to make available to practitioners. Information could be included in the IAS profiles on the Global Invasive Species Database (GISD) but this is resource intensive and at the it is limited to incorporation some PA locality data when new IAS species profiles are created. To regularly add new information on impacts or management projects at the PA-location level, and/or to actively source such information would require additional resources. The advantage of using the GISD is that it is closely associated with other "vehicles" for exchange of information on IAS that are managed or under development by ISSG, such as the developing Register of IAS Management Projects, the Global Register of Invasive Species (GRIS), the international listserv Aliens-L, and the wider networks of experts of ISSG and IUCN's WCPA. All these information exchange mechanisms adhere firmly to the concept of the "Conservation Commons" which promotes free and open access to data, information and knowledge for conservation purposes. In future, such information held will also be available to the Global Invasive Species Information network (GISIN), which is being developed.

13 CONCLUSION

As part of this scoping we found records of 487 protected area sites with IAS recorded as an impact or threat, including more than one in six of the Ramsar sites. We found IAS recorded as a threat for protected areas in 106 countries, and 326 species were reported as invasive alien species for protected area; yet, these numbers are only the absolute tip of the ice berg.

The key impediments and challenges to dealing with invasive alien species impacts in protected areas include lack of capacity for mainstreaming IAS management into PA management overall as well as lack of capacity for site based IAS management; lack of awareness, of the impacts of IAS, of the options for fighting back, and of the importance of prevention and early detection; lack of consolidated information and lack of information at site level; lack of funding and other resources; clashes of interest; and lack of institutional, legal, and other high level support.

The key ways to start addressing these challenges are:

(1) Develop and/or foster capacity for mainstreaming of invasive alien species issues into all aspects of protected area management (including site assessment, recognition of future threats from species that have not yet reached their invasion potential in or near the site, and management effectiveness evaluation).

(2) Develop and/or foster capacity at site level for all aspects of effective invasive alien species management (including risk assessment, prevention, early detection and rapid response as well as eradication and control).

(3) Develop and/or foster awareness at all levels, from site managers to decision makers and politicians, and also including the international conservation community, and funders.

(4) Foster development of consolidated information source(s) at national, international and global level, on invasive alien species impacts, threats and management in protected areas

There is much hope-inspiring progress in achieving the key protected areas management outcomes of biodiversity conservation and poverty alleviation (through sustainable livelihoods) but biological invasions, if left unchallenged, would defeat these objectives. Protected areas can not be seen as safe and sound places that, once designated, can be "left for nature to get on with things". On the contrary ongoing intervention is required to safeguard their ecological integrity. Without management to prevent and address invasive alien species, protected areas' ecosystem functions and biodiversity will inevitably be eroded sooner or later. Far from leading to despondency, however, this threat should be an incentive to fully arm protected area managers with the resources and capacity to effectively fight back. Prevention, early detection and rapid response, at the site level (or PA system level) are the key to future-proofing protected areas, the values they contain, and the services they provide. Eradication and control can be deployed to the maintenance or recovery of biodiversity and livelihood values.

In conclusion, while the underlying causes of invasive alien species threats to protected areas are significant and global in nature, protected area managers are far from helpless. Provided there is awareness, capacity and resources, the global threat from biological invasions can be effectively dealt with at the local site level.

14 CASE STUDY

CASE STUDY: INVASIVE ALIEN SPECIES IN PROTECTED AREAS – INDIA

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NATIONAL SCENARIO

Alien invasive species got introduced in India both unintentionally through crop and other material supplies from foreign countries, and intentionally, by the government forest departments, for controlling desertification by attempting to reclaim the so called wastelands (saline and marginal lands, including the grasslands); or at times to control diseases like malaria (fishes: guppies). Till as late as late as nineteen sixties to, in some cases, early eighties, the long-term and even the short-term adverse impacts were not even considered/envisaged while introducing these alien species having invasive characteristics.

The situation is quite different now, as considerable attention is paid to the IAS largely due to the associated detrimental impacts emanating out of these species that has started affecting the livelihood of the rural poor, as in the case of *Prosopis juliflora* mainly in the states of Gujarat and Rajasthan, the *Micania micrantha* affecting high value cash crops in the states of Kerala, or the infestation of *Lantana camara* affecting public access to the forests and suppressing the regeneration of native plant species. Public awareness on the issues of IAS still largely seems to be restricted towards the 'problems causing species' largely relating to the economic (*Prosopis, Lantana, Micana* etc.) and the health concerns (*Parthenium hysterophorus*, etc.). Combating/managing alien invasive species in India still is a very difficult task because of the lack of awareness at decision makers' level, though a fair understanding now exists among the scientific community about its ecological/biological impacts. Lack of proper initiatives and availability of funds for control of aliens species is largely the major constrain in India, compounded by the lack of awareness in dealing with the management of these species.

In the context of protected areas, the work on assessment and monitoring of invasive species has largely been missing in most of the PAs. In some cases like Kaziranga in the northeast and BR Hills in the south India attempts have been made lately by the forest department and the independent scientific / research communities. There have been specific local attempts on mapping, monitoring, management / restoration, including the studies on chemical contents and exudates of alien species have also been attempted in some case. Ecological studies are also available from some PA areas to assess the consequences of alien species on overall species diversity of the region. Some of the key government organizations like Kerala Forest Research Institute, (KFRI), Banaras Hindu University, National Botanical Research Institute (NBRI), National Botanical and Plant Genetic Resources (NBPGR) and the private research institutions like Ashoka Trust for Research in Ecology and the Environment (ATREE) have been focusing attention on the issues related to the biodiversity conservation. These studies have revealed that plant species like *Lantana camara*, *Mikania micrantha*, *Parthenium hysterophorus*, *Prosopis juliflora*, *Chromolaena odorata*, *Mimosa invisa*, *Ageratum conyzoides*, *Galinsoga parviflora*, Wattle (*Acacia mearnsii*), and Water Hyacinth (*Eichhornia crassipes*) etc. are among top-invader plant species in India. Among animal species, various rats, such as *Rattus exulans* as well as many varieties among fishes *Balanus amphitrite, Salmo trutta fario* have got introduced which are posing threat for the other species.

At the national level, however, there has been singular attempt by ATREE for mapping potential niches of the common invasive plant species that are the native of Central and South American region. ATREE has used the modern information technology tools including the GIS and RS based Niche Modelling to map the potential distribution of the species and has identified the PAs that are under potential threat of invasion form respective invasive plant species in the Western Ghats. The work is still on going for ground validation and for improving the accuracy of the modelling effort, in collaboration with institutions like the Centro De Referência em Informação Ambiental (CRIA), in Brazil and The University of Kansas, USA which are active in the similar efforts in the South and Central Americas. with the international. Biological control and a few other techniques are being attempted. Leadership and co-ordination, policy support and setting up priorities are some of the issues that need to be resolved. No systematic database currently exists for providing detailed information on the invasive species. ATREE is currently working on launching focused information of the invasive species through a comprehensive web-based Invasive Species Information System (ISIS) that would cater to the information needs entirely free of cost for the conservation and management of biodiversity as part of the ecoinformatics centre. It would also share the maps of the potential regions that might be under potential threats of invasives to assist timely prevention.

India holds a strong infrastructure capacity for generating primary database on invasive species and is currently engaged in researching the methods to develop suitable management policy. Awareness among local people and awareness at decision makers' level is of significant importance. Government currently holds very limited funds for management of invasives in protected areas, which is one of the major hurdles. There are stray instances of success stories that have been demonstrated to work at local scales, but up-scaling still remains a major challenge at the national level. Adequate policy framework and support infrastructure therefore is the need of the hour. Scientific community has long been voicing concerns and asking for establishment of national invasive species council that as an independent agency would look into the development of legal, institutional and infrastructural frameworks for generating database and developing ideas for managing these issues at the national level. Directorate of Biological Control and the KFRI are among the few government agencies that are experimenting on the use of integrated pest management strategies to control the invasives, without being very successful.

India already has a well established 'plant quarantine' as part of the National Bureau of Plant Genetic Resources (NBPGR) that applies control on the introduction of alien species and conducts tests to determine invasiveness and invasive characteristics in the introduced species.

OVERVIEW OF PROTECTED AREAS IN THE CONTEXT OF IAS:

Central Himalayan Foothills (Terai Arc and Bhabar Landscapes):

protected areas in the Himalayan foothills running along the east west plains (known as Terai Arc and Bhabhar regions) have been infested widely with *Lantana camara* that almost dominates the understory of the dry deciduous and moist deciduous forests, scrub forests and exposed degraded lands. In the entire landscape regardless of PA status, invasives such as bhant (*Clerodendron viscosum*), *Lantana camara*, Vasaka (*Adhatoda vasica*) and *Tiliacora acuminata* (in Dudhwa NP) dominate the understorey. These invasives figure in the top three shrubs of most Forest Divisions. Bhant and lantana occupy 21% and 17% of 1150 plots respectively. On an average, there were 2 ± 6 bhant (mean ± SD) and 1 ± 5 lantana plants per plot. The extent to which such invasives alter plant species diversity, productivity and diversity of dependent fauna needs to be investigated (Johnsingh et al. 2004). Centre for Environmental Management for Degraded Ecosystems (CEMDE) has attempted restoration of *Lantana camara* dominated landscapes in Corbett National park. As a part of ecological restoration of weed infested landscapes in protected areas, a pilot study was carried to try a new eradication strategy for *Lantana*. The restoration work is still under progress.

North-Eastern Mountain Regions:

The majority of the mid elevation protected areas of North Eastern India are currently under severe threats of invasion by species like *Mimosa invisa, Micania micrantha* whereas the low elevation protected areas are replete with invasion of *Lantana camara, Chromolaena odorata* and *Ageratum conizoides*. The International Fund for Animal Welfare (IFAW) and the Wildlife Trust of India (WTI) have announced plans to remove the invasive weeds from the Kaziranga National Park, which is the only refuge left of the Asian Rhino. The weeds have been choking the grasslands and an estimated 120 hectares of the park have been affected by it. IFAW has committed US $ 15,000 for this purpose and work along with the WTI and the Assam Forest Department has already started (Source: The Statesman, 23rd November, 2002).

Central and Eastern Plateau Regions of India:

The protected areas of the Central Plateau are largely affected by the invasion of the *Lantana camara*, *Parthenium hysterophorus* and *Chromolaena odorata* that is occupying the moister suboptimal habitats mainly the understory of the dry deciduous forests systems. Whereas the tropical thorn forest ecosystem is largely invaded by *Prosopis juliflora* that invariably has taken over all the human disturbed areas within most protected areas.

There are no properly chalked out strategies on the control and management of the invasives apart from time to time clearing of the *Lantana* undergrowth for better visibility. The activities largely are *ad hoc* based on the availability of funds and initiatives of the individual forest manager. Lantana has been observed to severely affect the habitat requirements of the spotted deer and other antelopes that form the main prey species of tiger and other large carnivores in the Central Indian landscapes. Lack of awareness about the control strategies and methods at the lowest level forest officials and guards has been reported to be the main stumbling block.

Western Semi Arid and Arid Regions

The drier parts of western Indian landscapes are invariably dominated by the invasive *Prosopis juliflora* that has taken over almost all of the protected areas in the western states including the states of Panjab, Haryana, Rajasthan and Gujarat. Central Arid Zone Research Institute (CAZRI) being the premier institute catering to the needs of natural resource management of the arid zone of India and also the main propagator of the *Prosopis juliflora* as the wonder plant has carried extensive research in all aspects of the species. However, the species has drawn wrath from the local pastoralist communities who largely depend on the cattle rearing as the mainstay occupation for their livelihood.

Prosopis juliflora has been found growing unabated in most of the protected areas destroying both, the lakes / water bodies, and the grassland habitat. It is feared if the rampant growth of *Prosopis juliflora* is not checked, the system might change from a wetland to a scrub habitat. The forest department has concerns following the recent ban on removal of anything from within the boundaries of the protected areas.

Western Ghats Landscapes

The landscape of the Western Ghats shows similarity to the north-eastern Himalayan regions. Almost all the protected areas have been reported with infestation from a variety of invasives that dominate the understory ranging across the ranging habitat types. *Lantana camara*, *Mikania micrantha*, *Parthenium hysterophorus*, *Chromolaena odorata*, *Mimosa invisa*, *Ageratum conyzoides*, Wattle (*Acacia mearnsii*) and also the *Prosopis juliflora* can be seen in different protected areas. Various scientific studies have been conducted on the effects of *Lantana camara* on the species composition and regeneration in select protected areas. Scientists have worked on mapping invasive species on select locations. It was found that *Mikania micrantha*, *Lantana camara* are of the highest nuisance value in the landscape. In parts of Karnataka, species of *Ageratum*, *Chromolaena*, *Mikania*, *Parthenium* have already invaded most of the natural habitats. Sankarn and Sreenivasan (2006) studied distribution and invasion by *Mikania micrantha*. It was found that the species was abundantly found in the moist deciduous forests of entire Western Ghats, very dominant in Kerala and also spreading into the adjoining regions of Karnataka, Tamilnadu and Maharashtra.

No systematic study on the control and management exists that would prevail across the administrative boundaries of the states. Different states have different priorities, different norms and approaches to the problem that seems to be the biggest hurdle to a single comprehensive plan for the management of invasives. The landscape is also one of the Global Biodiversity Hotspots and invasives pose increased challenge to the conservation of the biodiversity.

Andaman and Nicobar Islands:

The Great Nicobar Biosphere Reserve (GNBR) is one of the biologically richest tropical evergreen forest ecosystems and the hottest of hotspots. The Centre for Environmental Management for Degraded Ecosystems (CEMDE) has been focusing its work on the ecosystem functions and dynamics in region. They have been able to record presence of 12 exotic species with known invasive characters elsewhere. While the research on the management and control of such species is already on, not much has significantly been attained due to paucity of resources, awareness, and information on management of such species.

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Appendix 1

IAS SPECIES MENTIONED FOR SPECIFIC PA-SITES OR MULTIPLE PA SITES OR FOR PA-SYSTEM FOR THE REGIONS (Note: species names as in sources used – not checked for taxonomical synonyms)

ASIA (43 species)
Acacia mearnsii
Acacia nilotica
Adhatoda vasica
Ageratum conizoides
Annona glabra
Aulacaspis yasumatsui
Axis axis
Bubalus bubalis (feral)
Cervus timorensis
Cervus unicolor
Chitala ornata
Chromolaena odorata
Cirsium vulgare
Clerodendron viscosum
Clidemia hirta
Dioscorea sanibariensis
Egeria densa
Eichhornia crassipes
Elephas maximus (feral)
Eupatorium sp
Imperata cylindrica
Lantana camara
Micania micrantha
Mikania sp.
Mimosa diplotricha
Mimosa invisa
Mimosa pigra
Mimosa pudica
Muntiacus muntjak
Najas marinus
Nelumbo nucifera,
Oncorhynchos mykiss
Pomacea sp.
Opuntia dillennii
Parthenium hysterophorus
Procyon lotor
Prosopis juliflora
Salvinia molesta
Salvinia sp
Spartina sp.
Sus scrofa
Tiliacora acuminata
Ulex europaeus

SOUTH, CENTRAL AMERICA & MEXICO (18 species)
Cinchona pubescens
Didemnum spp.
Felis catus
Impatiens walleriana
Limnoperna fortunei
Melanoides tuberculata
Mustela vison
Perna viridis
Pinus spp.
Pinus taeda
Rana catesbeiana
Rattus norvegicus
Rubus ellipticus,
Rubus moluccanus, ,
Rubus rosifolius
Rubus spp.
Sus scrofa
Tamarix gallica

OCEANIA (19 species)
Adenanthera pavonia,
Boiga irregularis
Bos taurus,
Canarium harveyi,
Capra hircus,
Castilla elastica,
Cinnamomum vernum,
Clidemia hirta,
Coccinia grandis,
Equus caballus
Merremia peltata
Miconia calvescens
Paraserianthes falcataria, ,
Piper arithrium,
Psidium cattleianum,
Rattus exulans
Rattus rattus
Scheflera actinophylla
Spathodea campanulata,

OTHER (4 species)
Brassica rapa,
Cynodon dactylon
Holcus lanatus,
Phormium tenax,

AUSTRALIA/NEW ZEALAND (87 species*)*

Achatina fulicata
Acanthaster planci
Acridotheres tristis
Ageratina riparia
Agrostis capillaris
Alternanthera philoxeroides,
Alysicarpus vaginalis,
Ammophila arenaria,
Annona glabra
Anoplelis gracilipes
Anredera cordifolia
Araujia sericifera,
Asparagus scandens
Beak and Feather Disease Virus (BFDV)
Berberis darwinii
Brachiaria mutica,
Brassica tournefortii
Bubalus bubalus
Bufo marinus
Calluna vulgaris
Canis familiaris,
Canis lupus
Capra hircus
Cenchrus ciliaris
Cervus elaphus,
Chrysanthemoides monilifera .
Clematis vitalba
Codium fragile tomentosoides
Cortaderia selloana,
Cyprinus carpio
Cytisus scoparius
Eichhornia crassipes,
Equus caballus
Euphorbia hirta,
Felis catus,
Gambusia affinis
Gambusia holbrooki,
Glyceria maxima
Gunnera tinctoria
Hedychium spp.
Hemidactylus frenatus
Hieracium spp
Hydrocotyle bonariensis
Hyptis suaveolens
Iris pseudacorus
Juncus acutus
Lantana camara
Linepithema humile
Lycium ferocissimum
Mimosa pigra
Mus musculus
Mustela erminea
Opuntia stricta
Myriophyllum aquaticum
Oryctolagus cuniculus
Passer domesticus
Passiflora foetida

AUSTRALIA/NEWZEALAND (ctd)

Pennisetum ciliare
Pennisetum polystachion
Pinus contorta
Pinus spp.
Poa annua
Rattus exulans
Rattus norvegicus
Rattus rattus,
Rubus fruiticosis
Rumex spp.
Salix cinerea
Salix fragilis,
Salix spp
Salvinia molesta
Schizoporella errata
Sida acuta,
Sida cordifolia,
Spartina spp,
Sus scrofa
Tamarix aphylla
Tradescantia fluminensis
Trichosurus vulpecula
Typha orientalis
Typha sp.
Ulex europeas
Undaria pinnatifida
Vallisnaria spiralis
Vulpes vulpes,
Xanthium pungens
Zizania latifolia

AFRICA (58 species)

Acacia cyclops
Acacia dealbata
Acacia mearnsii,
Albizia lophantha,
Argemone mexicana
Azolla filiculoides
Bidens pilosa
Boerhavia diffusa
Broussonetia papyrifera
Caesalpinia decapetala
Caesalpinia pulcherrima
Canna indica
Carcinus maenas
Cardiospermum halicacabum
Cassia didymobotrya
Cervus timorensis
Chenopodium ambrosioides
Chromolaena odorata
Cirsium vulgare
Cocculus hirsutus
Cotoneaster spp.
Cylindropuntia exaltata
Cyprinus carpio,
Datura stramonium
Eichhornia crassipes
Eucalyptus camaldulensis
Gomphrena celosioides
Ipomoea purpurea
Ligustrum robustrum
Lonicera japonica
Macaca fascicularis
Melia azedarach
Nicotiana glauca
Optuna monocantha
Opuntia aurantiaca
Opuntia stricta
Oreochromis mossambica
Oreochromis mossambicus
Paspalum vaginatum
Pennisetum clandestinum
Pinus patula
Pinus spp.
Pistia stratiotes
Populus canescens
Psidium cattleianum
Rattus norvegicus
Rattus rattus
Rubus cuneifolus
Salix babylonica
Salvinia molesta
Senna didymobotrya
Sesbania punicca,
Sesbania punicea
Sus scrofa
Tagetes minuta
Tecoma stans
Tilapia sparrmannii
Tinca tinca

EUROPE (58 species)

Abies sp.
Acer negundo
Acer pseudoplatanus
Ailanthus altissima,
Ambrosia artemisifolia,
Amorpha fruticosa,
Aster lanceolatus
Capra hircus
Carpobrotus edulis
Caulerpa taxifolia
Cyprinus carpio,
Echynocystis lobata,
Fallopia japonica
Fascioloides magna
Felis catus
Fraxinus pennsylvanica
Gaulteria shallon
Hedychium gardnerianum
Helianthus tuberosus
Herpestes javanicus auropunctatus
Hyphthalmichthys molitrix,
Impatiens glandulifera
Juniperus communis
Lepomis gibbosus
Linepithema humile
Lonicera japonica.
Lupinus polyphyllus
Lupinus sp.
Mustela furo
Mustela vison
Neogobius spp
Nyctereutes procyonoides
Opuntia stricta
Orconectes limosus
Oryctolagus cunninculus
Picea abies
Picea sp.
Pinus mugo
Pinus radiata
Pinus sylvestris,
Platanus spp.
Populus deltoides
Populus hybrida
Populus nigra
Populus x canadensis
Populus x Euroamericana
Procambarus clarkii
Prunus mahaleb
Prunus serotina,
Quercus rubra,
Rattus norvegicus
Rhododendron ponticum
Robinia pseudacacia
Solidago gigantea
Stenactis annua
Tenopharyngodon idella
Thuja occidentalis
Trachemys scripta elegans

USA/CAN (109 species)

Nelumbo lutea,
Acer platanoides
Agropyron cristatum,
Ailanthus altissima,
Albizzia julibrissin,
Ammophila arenaria.
Avena spp.
Axis axis
Bos taurus
Brassica tournefortii
Bromus inermis
Bromus rubens
Bromus tectorum,
Cakile edentula,
Cakile maritima
Capra hircus
Carduus nutans
Casuarina equisetifolia
Celastrus orbiculata,
Centaurea maculosa
Centaurea repens
Centaurea solstitialis
Ceratophyllum demersum
Chrysanthemum leucanthemum,
Cirsium arvense
Cirsium vulgare
Citellus undulatus,
Cortaderia jubata
Cytisus scoparius
Dicrostonyx groenlandicus
Eichhornia crassipes
Elaeagnus cuneata
Equus asinus
Equus caballus
Euphorbia esula,
Felis catus
Halogeton glomeratus
Holcus lanatus,
Hordeum spp.
Hydrilla verticillata
Iguana iguana
Imperata cylindrica
Iridomyrmex humilis
Lepidium latifolium
Ligustrum sinense,
Ligustrum spp.
Linepithema humile
Lonicera japonica
Lygodium microphyllum
Lythrum salicaria,
Melaleuca quinquenervia,
Melaleuca sp.
Melia azedarach,
Mesembryanthemum chilense,
Microstegium vimineum
Microtus oeconomus
Myocastor coypus
Myrica faya,

USA/CAN (ctd)

Myriophyllum spicatum,
Myriophyllum spp.
Nicotiana glauca,
Oncorhynchus mykiss
Oreamnos americanus
Oryctolagus cuniculus
Ovis aries,
Paratachardina lobata
Passiflora mollissima
Paulownia tomentosa
Pennisetum setaceum
Phleum pratensis
Phoenix spp.
Phragmites australis
Pinus elliottii
Pinus radiata
Polygonum cuspidatum
Populus alba,
Pueraria lobata
Rangifer arcticus
Rangifer tarandus
Rattus exulans,
Rattus norvegicus
Rattus rattus
Robina pseudo-acacia
Rosa multiflora,
Rubus discolor
Rubus spp.
Salsola kali,
Salvinia minima
Sapium sebiferum
Sargasso muticum
Schinus terebinthifolius
Schismus barbatus
Senecio jacobaea,
Senecio sylvaticus,
Sisymbrium altissimum
Solanum tampicense
Sorghum halepense,
Spartina alterniflora
Sus scrofa,
Tamarix aphylla,
Tamarix ramosissima
Tamarix spp.
Taraxacum officinale
Trifolium spp.
Ulex europaeus
Undaria pinnatifida
Verbascum thapsus
Vulpes vulpes
Washingtonia filifera,

Appendix 2

IAS SPECIES MENTIONED FOR SPECIFIC PA-SITES OR MULTIPLE PA SITES OR FOR PA-SYSTEM OVERALL (REGIONS COMBINED) (Note: species names as in sources used – not checked for txonomical synonyms)

Abies sp.
Acacia cyclops
Acacia dealbata
Acacia mearnsii
Acacia nilotica
Acanthaster planci
Acer negundo
Acer platanoides
Acer pseudoplatanus
Achatina fulicata
Acridotheres tristis
Adenanthera pavonia,
Adhatoda vasica
Ageratina riparia
Ageratum conizoides
Agropyron cristatum,
Agrostis capillaris
Ailanthus altissima,
Albizia lophantha,
Albizzia julibrissin,
Alternanthera philoxeroides,
Alysicarpus vaginalis,
Ambrosia artemisifolia,
Ammophila arenaria,
Amorpha fruticosa,
Annona glabra
Anoplelis gracilipes
Anredera cordifolia
Araujia sericifera,
Argemone mexicana
Asparagus scandens
Aster lanceolatus
Aulacaspis yasumatsui
Avena spp.
Axis axis
Azolla filiculoides
Beak and Feather Disease Virus
Berberis darwinii
Bidens pilosa
Boerhavia diffusa
Boiga irregularis
Bos taurus,
Brachiaria mutica,
Brassica rapa,
Brassica tournefortii
Bromus inermis
Bromus rubens
Bromus tectorum,
Broussonetia papyrifera
Bubalus bubalis (feral)
Bufo marinus
Caesalpinia decapetala
Caesalpinia pulcherrima
Cakile edentula,
Cakile maritima
Calluna vulgaris
Canarium harveyi,
Canis familiaris,
Canis lupus
Canna indica
Capra hircus,
Carcinus maenas
Cardiospermum halicacabum
Carduus nutans
Carpobrotus edulis
Cassia didymobotrya
Castilla elastica,
Casuarina equisetifolia
Caulerpa taxifolia
Cenchrus ciliaris
Celastrus orbiculata,
Centaurea maculosa
Centaurea repens
Centaurea solstitialis
Ceratophyllum demersum
Cervus elaphus,
Cervus timorensis
Cervus unicolor
Chenopodium ambrosioides
Chitala ornata
Chromolaena odorata
Chrysanthemoides monilifera .
Chrysanthemum leucanthemum,
Cinchona pubescens
Cinnamomum vernum,
Cirsium arvense
Cirsium vulgare
Citellus undulatus,
Clematis vitalba
Clerodendron viscosum
Clidemia hirta
Coccinia grandis,
Cocculus hirsutus
Codium fragile tomentosoides
Cortaderia jubata
Cortaderia selloana,
Cotoneaster spp.
Cylindropuntia exaltata
Cynodon dactylon
Cyprinus carpio
Cytisus scoparius
Cytisus scoparius
Datura stramonium
Dicrostonyx groenlandicus
Didemnum spp.
Dioscorea sanibariensis
Echynocystis lobata,
Egeria densa
Eichhornia crassipes
Elaeagnus cuneata
Elephas maximus (feral)
Equus asinus
Equus caballus
Eucalyptus camaldulensis
Eupatorium sp
Euphorbia esula,
Euphorbia hirta,
Fallopia japonica
Fascioloides magna
Felis catus,
Fraxinus pennsylvanica
Gambusia affinis
Gambusia holbrooki,
Gaulteria shallon
Glyceria maxima
Gomphrena celosioides
Gunnera tinctoria
Halogeton glomeratus
Hedychium gardnerianum
Hedychium spp.
Helianthus tuberosus
Hemidactylus frenatus
Herpestes javanicus auropunctatus
Hieracium spp
Holcus lanatus,
Hordeum spp.
Hydrilla verticillata
Hydrocotyle bonariensis
Hyphthalmichthys molitrix,
Hyptis suaveolens
Iguana iguana
Impatiens glandulifera
Impatiens walleriana
Imperata cylindrica
Ipomoea purpurea
Iridomyrmex humilis
Iris pseudacorus
Juncus acutus
Juniperus communis
Lantana camara
Lepidium latifolium
Lepomis gibbosus
Ligustrum robustrum
Ligustrum sinense,
Ligustrum spp.
Limnoperna fortunei
Linepithema humile
Lonicera japonica

OVERALL (ctd)

Lupinus polyphyllus
Lupinus sp.
Lycium ferocissimum
Lygodium microphyllum
Lythrum salicaria,
Macaca fascicularis
Melaleuca quinquenervia,
Melaleuca sp.
Melanoides tuberculata
Melia azedarach,
Merremia peltata
Mesembryanthemum chilense,
Micania micrantha
Miconia calvescens
Microstegium vimineum
Microtus oeconomus
Mikania sp.
Mimosa diplotricha
Mimosa invisa
Mimosa pigra
Mimosa pudica
Muntiacus muntjak
Mus musculus
Mustela erminea
Mustela furo
Mustela vison
Myocastor coypus
Myrica faya,
Myriophyllum aquaticum
Myriophyllum spicatum,
Myriophyllum spp.
Najas marinus
Nelumbo lutea,
Nelumbo nucifera,
Neogobius spp
Nicotiana glauca,
Nyctereutes procyonoides
Oncorhynchos mykiss
Optuna monocantha
Opuntia aurantiaca
Opuntia dillennii
Opuntia stricta
Orconectes limosus
Oreamnos americanus
Oreochromis mossambicus
Oryctolagus cuniculus
Ovis aries,
Paraserianthes falcataria, ,
Paratachardina lobata
Parthenium hysterophorus
Paspalum vaginatum
Passer domesticus
Passiflora foetida
Passiflora mollissima
Paulownia tomentosa
Pennisetum ciliare
Pennisetum clandestinum
Pennisetum polystachion
Pennisetum setaceum
Perna viridis
Phleum pratensis
Phoenix spp.
Phormium tenax,
Phragmites australis
Picea abies
Picea sp.
Pinus contorta
Pinus elliottii
Pinus mugo
Pinus patula
Pinus radiata
Pinus spp.
Pinus sylvestris,
Pinus taeda
Piper arithrium,
Pistia stratiotes
Platanus spp.
Poa annua
Pomacea sp.
Polygonum cuspidatum
Populus alba,
Populus canescens
Populus deltoides
Populus hybrida
Populus nigra
Populus x canadensis
Populus x Euroamericana
Procambarus clarkii
Procyon lotor
Prosopis juliflora
Prunus mahaleb
Prunus serotina,
Psidium cattleianum
Pueraria lobata
Quercus rubra,
Rana catesbeiana
Rangifer arcticus
Rangifer tarandus
Rattus exulans
Rattus norvegicus
Rattus rattus
Rhododendron ponticum
Robinia pseudacacia
Rosa multiflora,
Rubus cuneifolus
Rubus discolor
Rubus ellipticus,
Rubus fruiticosis
Rubus moluccanus, ,
Rubus rosifolius
Rubus spp.
Rumex spp.
Salix babylonica
Salix cinerea
Salix fragilis,
Salix spp
Salsola kali,
Salvinia minima
Salvinia molesta
Salvinia sp
Sapium sebiferum
Sargasso muticum
Scheflera actinophylla
Schinus terebinthifolius
Schismus barbatus
Schizoporella errata
Senecio jacobaea,
Senecio sylvaticus,
Senna didymobotrya
Sesbania punicea
Sida acuta,
Sida cordifolia,
Sisymbrium altissimum
Solanum tampicense
Solidago gigantea
Sorghum halepense,
Spartina alterniflora
Spartina spp,
Spathodea campanulata,
Stenactis annua
Sus scrofa
Tagetes minuta
Tamarix aphylla
Tamarix gallica
Tamarix ramosissima
Tamarix spp.
Taraxacum officinale
Tecoma stans
Tenopharyngodon idella
Thuja occidentalis
Tilapia sparrmannii
Tiliacora acuminata
Tinca tinca
Trachemys scripta elegans
Tradescantia fluminensis
Trichosurus vulpecula
Trifolium spp.
Typha orientalis
Typha sp.
Ulex europaeus
Undaria pinnatifida
Undaria pinnatifida
Vallisnaria spiralis
Verbascum thapsus
Vulpes vulpes,
Washingtonia filifera,
Xanthium pungens
Zizania latifolia