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Convention on Biological Diversity

WCPA
WORLD COMMISSION ON PROTECTED AREAS

Assessing and Managing Invasive Species

Within Protected Areas

A Quick Guide

FOR PROTECTED AREA PRACTITIONERS

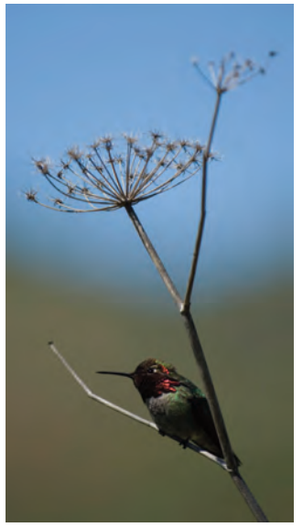
Introduction

One of the most severe threats to Protected Areas around the globe is invasive alien species (IAS). IAS are non-indigenous species that may spread quickly and aggressively when introduced by humans to areas beyond their normal ranges and can decrease native biodiversity and cause dramatic environmental changes. In fact, IAS are widely recognized as posing threats to biological diversity second only to direct habitat loss and fragmentation, and have been implicated in the decline of endangered species worldwide (Baillie et al. 2004; Wilson 1992). It is therefore imperative to address IAS threats to preserve the values and functions of Protected Areas, and the biological wealth and support they provide to the livelihoods of millions of people.

Preventing new invasions is the most efficient approach to addressing this threat, followed by quickly detecting and eradicating or containing new IAS that do become established. New invasions should be treated as urgent problems because although they can be eliminated or contained with relatively small efforts, they will cause far greater damage and become increasingly expensive and perhaps impossible to control if they are allowed to expand. A comprehensive strategy to effectively manage Protected Areas from the IAS threat therefore requires addressing IAS at the level of site/Protected Area, Protected Area system, and via national and international-scale policies, including:

- Awareness of invasive alien species threats
- Assessment of current and potential threats and pathways
- Prevention practices and policies
- Early detection and rapid response
- Management, control and restoration
- Secured and maintained funding

In February 2004, 188 countries committed to the Convention on Biological Diversity's "Programme of Work on Protected Areas," an ambitious set of activities aimed at establishing and maintaining comprehensive, effectively managed, and ecologically representative national and regional Protected Area terrestrial systems by 2010 and marine systems by 2012. The CBD recognizes the importance of invasive alien species as a 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)). At the 2008 CBD Conference of the Parties (COP-9) in Bonn, Germany, a number of countries committed to specific invasive species prevention and control actions and funding. Provided that there is awareness, capacity and sustained resources, IAS threats to Protected Areas can be abated. This quick guide was written to provide Protected Area managers with guidance on how to create a comprehensive assessment and strategic plan for IAS, as a basis for action.



Contents

overview of

invasive species impacts and issues

What are Invasive Species?

Invasive alien species (IAS) are non-indigenous plants, animals and microorganisms that have been deliberately or accidentally introduced to new areas beyond their native ranges, and which then spread beyond cultivation and human care to impact biodiversity. IAS can alter vital ecosystem processes such as fire, hydrology and nutrient cycling, kill, suppress, compete with or displace native species and communities, or alter gene pools through hybridization (Chornesky & Randall 2003). IAS can occur in terrestrial, freshwater and marine habitats across the globe, altering the lands and waters that native plants, animals and communities need to survive, hurting economies and threatening human well-being (McMichael & Bouma 2000; Pimental et al. 2005; Wilcove 1998). IAS can cause dramatic environmental changes that lead to significant declines in native populations. The most harmful invaders can transform diverse and productive ecosystems into nearly sterile lands and waters with completely different ecosystem processes (Drake et al. 1989; Mack et al. 2000; Mooney & Hobbs 2000; Usher 1988).

SCOPE OF THE PROBLEM GLOBALLY

Invasive species are spreading around the world at an accelerating rate (Kolar & Lodge 2000; Mack 2003; Ruiz & Carlton 2003). Rapid increases in global trade and travel are enabling more animals, plants and diseases to be transported from their native environments into new territories (Figure 1). The successful prevention and management of IAS threats is an integral component to Protected Areas management effectiveness (Goodman 2003; Pomeroy et al. 2004).

Additionally, IAS can harm human livelihoods and exacerbate poverty by altering ecosystem services, reducing sustainable uses of biodiversity and replacing natural resources traditionally used by individuals and communities. Economies and public health may be harmed by IAS which can clog waterways, damage powerlines and reduce energy production, decrease agricultural and timber output, depress tourism and spread diseases to people, domestic animals and cultivated plants (McNeely 2000; Naylor 2000).

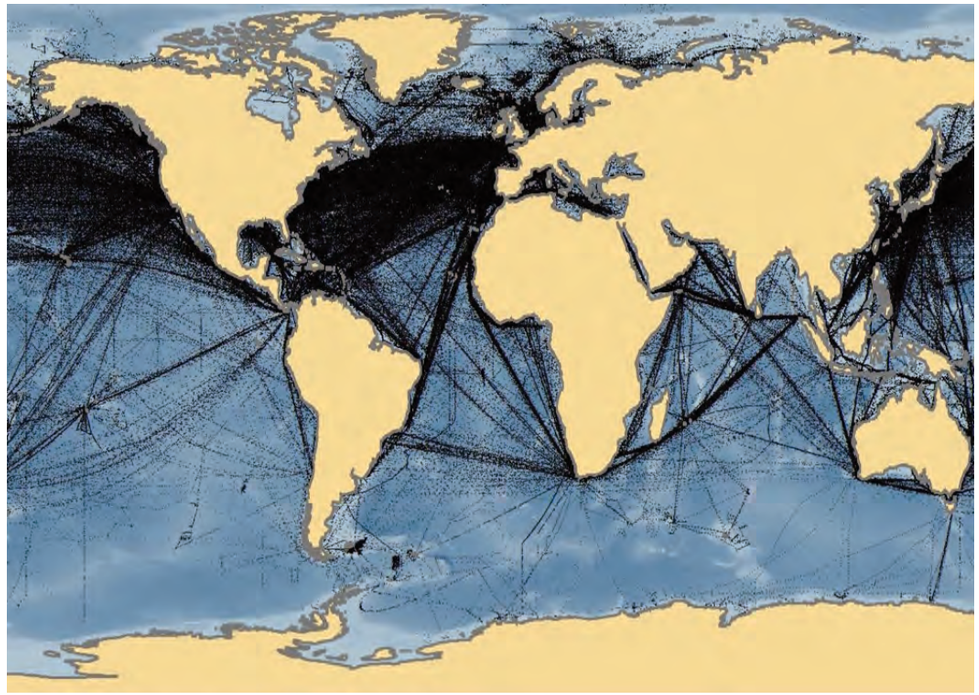


Figure 1. Map displaying major ship and barge traffic worldwide. Each single dotted-line represents the route travelled by one ship over one calendar year from Oct 2004-2005. © TNC

Degree of IAS Threats Within Protected Areas

IAS can have negative impacts at the species, population and community levels, and the most damaging significantly alter ecosystem functions and processes. Conditions can rapidly deteriorate when one IAS facilitates and accelerates invasions by others. Negative impacts of IAS on biodiversity include (Chornesky & Randall 2003; D'Antonio 2000; De Poorter et al. 2007; GISP 2006, 2008; Mooney & Hobbs 2000):

COMMUNITY & POPULATION LEVEL IMPACTS

- Predation, parasitism & disease
- Resource competition and reduced recruitment (altered succession)
- Competition for pollinators, seed dispersers and other mutualists
- Population reductions and eliminations
- Alterations in community composition and vegetation structure
- Vector pathogens and pests, and other IAS
- Hybridization with native species

ECOSYSTEM LEVEL IMPACTS

- Alterations in disturbance regimes (e.g. fire, hydrology, etc.)
- Geomorphologic processes (erosion, sedimentation)
- Soil chemistry (nutrients, nutrient cycles, pH)

goals of Protected Area IAS programs

Optimally, each Protected Area management plan should have IAS strategies integrated into their overall plan. In order to abate IAS threats, the major strategies that should be included are to:

1. Assess invasive species threats (existing and potential),
2. Prevent new invasions and the spread of established invaders,
3. Control high priority IAS in high priority places, and
4. Restore/rehabilitate native species and communities in high priority places.

Note that having a thorough assessment precedes all other strategies, so that *what* and *where* to prevent, detect and control is prioritized. There are simply too many invasive species and too many sites to protect, so there must be focus and priorities. Monitoring all efforts in each step is essential, to measure progress and to determine when to transition from one strategy to another.

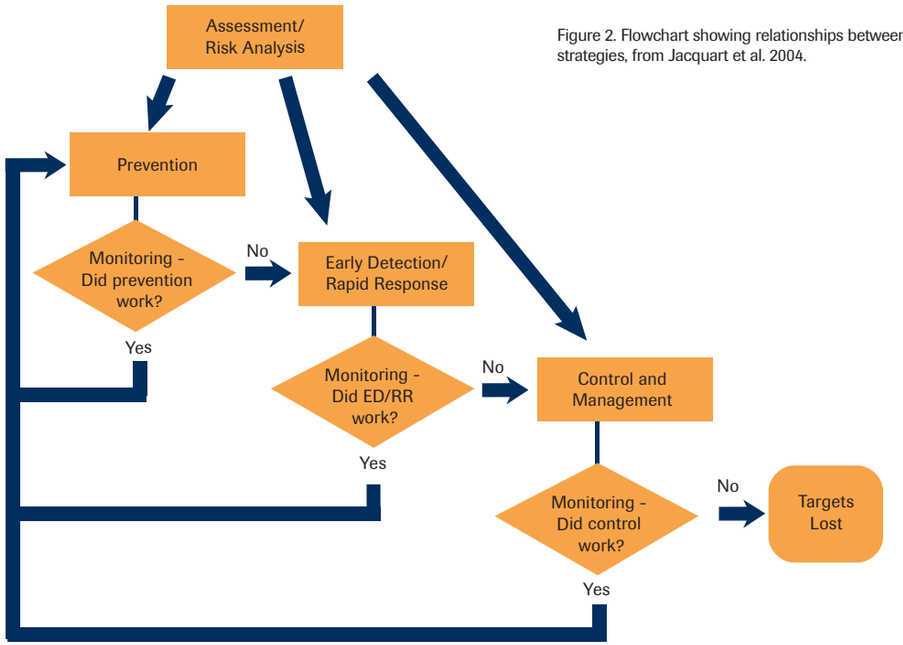


Figure 2. Flowchart showing relationships between strategies, from Jacquart et al. 2004.

assessing invasive species threats

What is an Assessment of IAS Threats?

An assessment of IAS threats identifies and determines IAS that currently threaten values within the Protected Area or Protected Area system. Complete assessments identify potential sources and pathways of entry for new IAS (Goodman 2003; Pomeroy et al 2004). A thorough assessment should also identify the capacity and resources available and needed to mitigate IAS threats (e.g. labor, technical skills, knowledge and training, equipment and funding).

The purpose of completing an IAS assessment is to assist in the:

- Identification of needs and gaps in IAS management,
- Development of Protected Area and Protected Area system prevention and control plans,
- Prioritize prevention and management activities, and the allocation of resources,
- Establishment of a baseline to determine effectiveness of management interventions, and to
- Monitor and evaluate trends.

What should be included in a Protected Area IAS assessment?

There are several methods for evaluating the overall threat of IAS for a Protected Area or a Protected Area system. Good ones should clearly state:

- The exact area covered,
- The conservation goals (values to be protected including target species and communities) and management objectives,
- The IAS which are currently present/absent and mapped locations (if possible);
- The IAS which have impacts on conservation goals and management objectives;
- The important pathways/vectors for IAS entry and dispersal,
- Prediction of future spread and impact of IAS if not controlled,
- Capacity of existing staff and resources to adequately prevent and control IAS and the damages they cause; any extra capacity that may be needed (including partnerships), and gaps in policies and programs to prevent IAS (at the level of the Protected Area, Protected Area system, state and nation)

How can you get assessment data and information?

Data and information on the IAS present on and near a Protected Area or Protected Area system can be gathered from (Salafsky et al. 2003; Wittenberg & Cock 2001):

- Field surveys,
- Literature and internet database searches,
- Collection records,
- Remotely-sensed data, and
- Experts and local professionals (academics, partners, etc.).

Assessing IAS threats within the context of a Protected Area management assessment and plan – Case Study from KwaZulu-Natal Protected Area, South Africa (Goodman 2003)

SUMMARY: An assessment of management effectiveness for Protected Areas within the KwaZulu-Natal Wildlife system identified problematic management issues and key threats to Protected Area values across the system. It identified IAS (especially plants) as the top threat in the system. Based on the results of this assessment, strategies for abating IAS threats were integrated into all future conservation planning and implementation in the system.

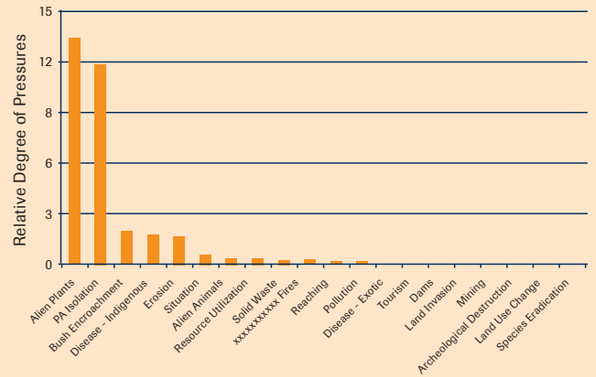


Figure 3. Results from the threat assessment across the KwaZulu-Natal Wildlife system.

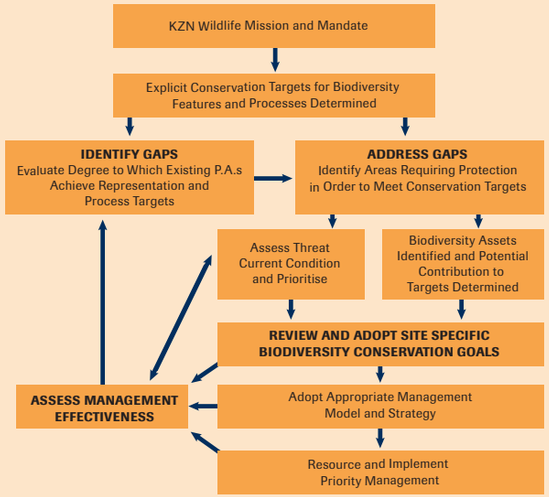


Figure 4. Illustrates how threats and management effectiveness measures can be incorporated into conservation planning and implementation.

GOING DEEPER –APPROACHES TO ASSESSING POTENTIAL IAS RISKS

Risk assessments and predictive modeling can be used to identify potential and future IAS threats (Andow 2003; Orr 2003). These types of predictive assessments use information about a species' biology, life history and ecological characteristics or evaluates entry pathways to:

1. Identify those species that are likely to expand their ranges into the Protected Area or become invasive in a region,
2. Identify those sites and habitats that are vulnerable or have a high likelihood of becoming invaded, and
3. Estimate the risk of each pathway for IAS entry and dispersal.

Several approaches to assessing potential new IAS risks are described below, as well as some introductory guidance on how to carry out each type.

SELECTING AN APPROPRIATE APPROACH

The choice of assessment approach depends largely on the scale of work. For most site-based Protected Area managers, identifying the following two items is a sufficient first step towards understanding the problems and causes of IAS:

a) The IAS species that are present in your Protected Area or that are nearby and have a high likelihood of entering it and causing damage;
b) The places in your Protected Area where IAS are most likely to invade and to become established.

In many terrestrial Protected Areas, sites along roads, around trailheads and other disturbed areas are among places new IAS are most likely to appear.

Different approaches:

1. IDENTIFY IAS THAT ARE LIKELY TO EXPAND THEIR RANGES INTO YOUR PROTECTED AREA, OR BECOME INVASIVE IN YOUR REGION.

What it is: This type of assessment seeks to

a) Identify those species that are known to be invasive, are nearby and likely to invade the Protected Area, and/or
b) Identify non-native species that are already present in the region or Protected Area which have not yet become troublesome invaders but which are deemed likely to do so.

Purpose: To establish priorities for the places and species to focus resources on in order to quickly detect new invaders and non-native species that begin to spread, so that actions can be taken to eliminate or contain them before they become abundant and widespread.

How to do it:

- Identify IAS already present on your Protected Area, using field surveys or by talking with local experts familiar with the flora and fauna in your region.
- Talk with local experts, researchers and partners to identify other potentially invasive species in your area.
- Do an online search for the IAS species (for instance, this can be done by going to *www.google.com* then look up "scientific or common name" and "invasive") to see if an IAS in your country or region is considered a serious invader elsewhere and consider what kind of impact it might have in your Protected Area, local environment and economy.

- Check online IAS databases. There are a few global databases that combine information on all taxa of IAS (*www.issg.org/database*), and some countries also have IAS databases. To see a complete list of IAS global, regional and country databases, see *http://www.gisinetwork.org/Documents/draftiasdbs.htm*
- Use a tool (such as the I3N Risk Analysis of Invasion Tool, available at *http://i3n.iabin.net/tools/web_tools.html*) to identify and prioritize high risk species.
- Additional tools such as the Australian Weed Risk Assessment (Gordon et al. 2008; Pheloung et al. 1999) to predict potential species invasiveness, or the NatureServe Protocol (Randall et al. 2008) to assess potential biodiversity impacts of existing IAS, can also be used to inform priorities.

Additional background: It is often difficult to decide if a new non-native species is likely to become a damaging invader in your area. It can also be difficult to persuade others that it is likely to cause problems if the species is not already invasive in your area, especially if it is of economic value. This is especially true of "sleeper invasives" which remain in low abundance for many years before rapidly increasing in abundance and range. Characteristics (biological life history and ecological traits) that have been identified to be highly correlated with invasiveness currently include those species that are or have (Biosecurity Australia 2003; Gordon et al. 2008; Grotkopp & Rejmánek 2007; Randall et al. 2008; Reichard & Hamilton 1997):

- Been documented as invasive elsewhere
- Large natural ranges, and are tolerant of a wide range of environmental conditions
- High relative growth rates, typically short juvenile period
- High rates of reproduction, ability to reproduce both sexually and asexually, and
- Generalist feeder (if animal), no special food requirements.

2. IDENTIFY SITES AND HABITATS THAT ARE VULNERABLE OR HAVE A HIGH LIKELIHOOD OF BECOMING INVADED

What it is: This assessment type seeks to identify those sites or habitats most susceptible to new or expanding invasions.

Purpose: To identify the sites and habitats most vulnerable to new or expanding invasions, so that they can be given priority for early detection and rapid response activities.

How to do it:

- List the IAS most likely to spread to your area, which might be present nearby. Talk with local experts that are familiar with your regional flora and fauna.
- Identify pathways most likely to carry each IAS (or group of IAS) to your area.
- Identify and map sites and/or habitats in your area that are most likely to be invaded. This includes mapping pathways identified in the step above, and places that are frequently disturbed (old fields, roadsides, trailheads, etc.).
- Use a Geographical/Geospatial Information Systems (GIS) application to analyze and map these disturbed sites and pathways, and overlay with high priority areas within the Protected Area.
- Use a tool (such as the I3N Risk Analysis of Invasion Tool and Climate Matching Module, both available at *http://i3n.iabin.net/tools/web_tools.html*) to identify and prioritize high risk species and vulnerable sites at a regional scale.
- Do predictive modeling using GIS tools or commercially available climate-invasives matching tools (such as CLIMEX).

Additional background: This assessment type typically uses data from previous or existing invasions to inform its predictions. There are widely-varying opinions on what makes a site prone to invasion (Rejmánek 1989; Rejmánek et al. 2005; Stohlgren et al. 2005), including:

- Highly disturbed sites (e.g. roadsides, new construction sites)
- Sites with altered disturbance regimes (fire, hydrology, nutrient cycling altered).

3. ESTIMATE THE RISK OF EACH PATHWAY FOR IAS ENTRY AND DISPERSAL.

What it is: A pathways-based risk assessment seeks to determine the degree of risk involved for known and predicted IAS entry pathway, including both intentional and accidental introductions (Andow 2003; NISC 2005; Ruiz & Carlton 2003).

Purpose: To identify those pathways of IAS entry into the Protected Area, so that prevention actions can be prioritized and implemented.

How to do it:

- Make a list of all potential pathways for the entry of IAS into the Protected Area (for example: vehicles, roads, fill-dirt, erosion control plantings, etc.), list all known IAS associated with each pathway, then prioritize and determine what can be done to close or limit each pathway, and implement changes.
- Use a tool (such as the I3N Vectors Analysis Pathways Tool available at *http://i3n.iabin.net/tools/web_tools.html*) to estimate the risk associated with each pathway or vector.

prevention & pathways

What is prevention of IAS?

The prevention of IAS is the most efficient and cost-effective approach to protect biodiversity and other Protected Area values from the harmful effects of IAS. Prevention refers to the exclusion or keeping out of IAS from a given area. It can be implemented at the scale of a Protected Area (or of specific locations within a Protected Area), a region, state, nation or even at continental and international scales. Larger scale prevention programs typically rely on import and trade regulations restrictions, border controls, inspections, etc. The success of these larger scale programs is important for preventing new invaders from ever reaching Protected Areas. Prevention programs can be targeted to stop both unintentional introductions of alien species (e.g. hitchhikers on vehicles, or ballast water) and intentional introductions of species that are invasive or have invasive potential.

Prevention is closely partnered with the identification of invasion pathways and vectors of spread - the means by which IAS or potential IAS may be transported to a new location. While there may be hundreds or thousands of non-native species that could become invasive in your area, there are relatively few pathways by which IAS can enter and become established in a Protected Area, a region or even a nation (Mack 2003; Ruiz & Carlton 2003).

The pattern of IAS spread includes 4 major phases (Figure 5): Introduction, Establishment, Invasion and Spread (Hobbs & Humphries 1995).

At the site or project scale, most IAS efforts are typically spent on management and control during the later stages of this growth curve. This is not resource-efficient over the long-term and large-scales. Expending a significant amount of resources available for addressing invasive species on preventing new invasions (the first two phases of the curve Introduction and Establishment), and on the early detection and rapid response to new invaders (typically during the second or third phases) will be more efficient and effective in protecting biodiversity in the long-term (Chornesky et al. 2005; FICMNEW 2003; Leung et al. 2002).

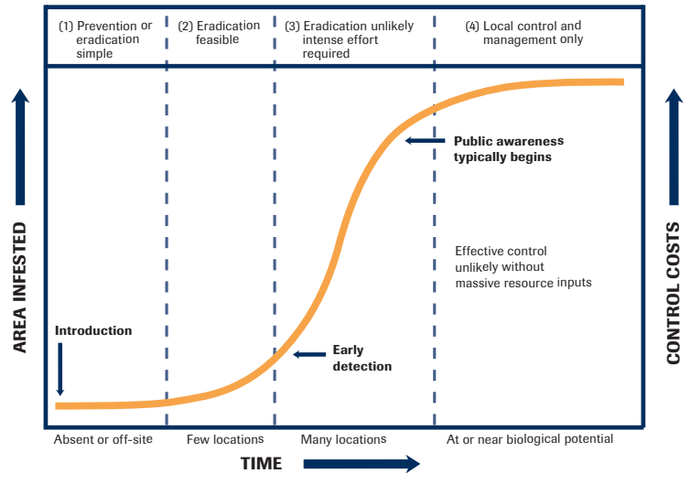


Figure 5. Different stages of invasion and management objective for invasive species (modified from Hobbs & Humphries 1995).

What are the most common pathways of IAS entry and dispersal?

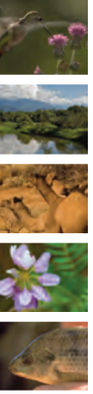
IAS can be introduced either intentionally or unintentionally. Most intentional introductions are the result of the commerce in living organisms, while unintentional or accidental introductions are generally associated with the trade, transportation and travel by humans – for example IAS may be carried in or on vehicles, equipment or packing material, or as contaminants within the cargo itself (Richardson et al. 2003; Ruiz & Carlton 2003). A few examples of important invasion pathways include:

INTENTIONAL INTRODUCTIONS

- Plants introduced for agriculture, forestry and biofuels production
- Plants introduced for soil improvements or for erosion control
- Introduced ornamental plants (horticulture)
- Birds and mammals released for hunting purposes
- Animals released as a food resource (farmed animals, fishery releases, aquaculture and mariculture)
- Pets and aquarium animals released into the wild
- Escapes from captivity such as zoos or cultivation in botanical gardens
- Biological control

UNINTENTIONAL (ACCIDENTAL) INTRODUCTIONS

- Contaminants of agricultural produce, seed or hay
- Contaminants of horticulture plants, cut flowers, or in soil
- Organisms in or on timber/wood products, wooden pallets used in shipping
- Vehicles, road building machinery, construction equipment, military vehicles and equipment, fire-fighting vehicles and equipment, building materials, etc.
- Ballast water releases, hull fouling
- Imported soils
- Tourists and their luggage/equipment



- Diseases in animals traded for agricultural and other purposes
- Hitchhikers in or on packaging material, mail, cargo, or on airplanes
- On hikers' and fishers' clothing or boots, in packs or tents, on fishing gear, etc.

Prevention Solutions

The prevention of IAS can be implemented at the Protected Area, Protected Area System, or at national and international scales. Examples of prevention strategies at different scales include (Owen 1998; Wittenberg & Cock 2001):

PROTECTED AREA (SITE-BASED) PREVENTION ACTIONS

- Require cleaning of all camping and touring equipment, vehicles, boats, boots, clothing, etc., prior to entry to the site
- Use only soils and plantings free of IAS for restoration, erosion control, forestry, etc.
- Locate trails and access roads away from known infestations of IAS
- Keep an internal transportation system to prevent external vehicles from entering the protected area and bringing in biological materials.
- Require cleaning of fire-fighting equipment and limit or restore soil disturbances caused by fire-fighting activities
- Close roads and paths that might serve as invasion pathways
- Public education and outreach regarding clean equipment, not dumping soils, aquariums, pets or other materials onsite

PROTECTED AREA SYSTEM PREVENTION ACTIONS

- Prohibit or restrict the introduction of non-native species for erosion control, stocking fishing ponds for recreational purposes, planting around visitor facilities, etc.
- Develop a process for assessing the risk of potential invasiveness of species that are to be intentionally introduced (for horticulture, agriculture, biofuels, reforestation projects, coastal erosion control, etc.) prior to introduction

NATIONAL (AND INTERNATIONAL)-SCALE PREVENTION ACTIONS

Large-scale prevention practices (national, international) can be either voluntary or regulatory. Voluntary measures are often preferred by businesses and industries, but there are no guarantees that all members of a particular industry will comply with them. Both regulatory and voluntary solutions require sufficient funding and resources to identify, prohibit and exclude, and intercept and treat any IAS. Protected Area managers can prevent future invasions by promoting and supporting stronger:

- IAS quarantine laws and regulations
- National policies to prevent new IAS
- International agreements that prevent IAS
- Policies for ballast water, shipping, etc.
- Accessibility of information on invasive organisms

early detection and rapid response

What is Early Detection and Rapid Response (EDRR)?

After prevention, the next most effective strategy for defending Protected Areas against IAS is the early detection of a new species at a given site and a rapid response to eradicate or contain the infestation before it spreads (Chornesky et al. 2005; Hobbs & Humphries 1995). Potential invasions can be quickly managed – avoiding impacts on biodiversity and livelihoods, and subsequently saving management resources (Leung et al. 2002; Rejmánek & Pitcairn 2002). Many IAS are difficult or impossible to manage once they are well established, but many can be eradicated or contained if caught at an early stage.

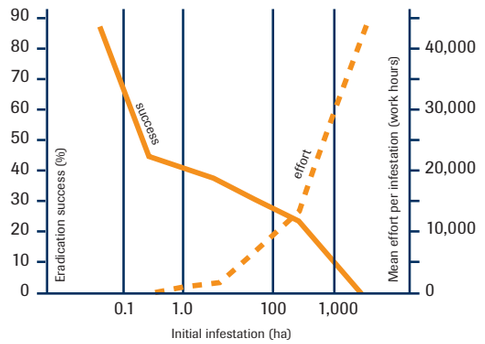


Figure 6. Showing exponential rise in effort/costs for management since establishment and decreasing likelihood of eradication over time. Rejmánek & Pitcairn 2002.

What are the necessary elements to implement EDRR into a Protected Area?

EDRR can be used at scales ranging from a single Protected Area to an entire nation. It can be implemented with limited staff resources or as part of a comprehensive program involving multiple staff and volunteers. When only one or a few staff or volunteers are available they can be given information about new IAS with potential to invade the area, and time to look for and report any they find. Where there are more staff or volunteers the additional eyes available to survey for and report new IAS allow for more thorough and comprehensive surveys. Core elements of an EDRR program include (FICMNEW 2003):

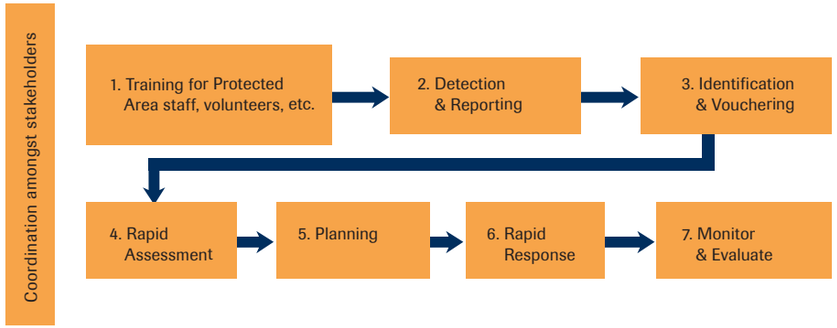


Figure 7. Elements of an EDRR program (modified from FICMNEW 2003)

Cooperating with surrounding landowners

You may choose to carry out an EDRR program entirely within the boundaries of your Protected Area. However, a cooperative effort with surrounding landowners might be well worth extra effort if it provides a significant buffer area and lessens the likelihood of invasions from nearby infestations. A cooperative effort of this sort will require coordination and communication among all stakeholders which takes time and effort. It is important that all cooperators agree on potential invaders being targeted, understand one another's survey responsibilities and regularly inform one another of the results of their surveys, especially when new invaders are detected but also when a search does not reveal any. Additionally, stakeholder involvement may be needed to develop a public outreach or communications plan to get support for the issues and planned work.

1. TRAINING FOR PROTECTED AREA MANAGERS

Creating and maintaining an effective EDRR program will usually require informing and training people who will carry it out. This may include researchers, visitors, and people from partner organizations in addition to staff and volunteers from your Protected Area. Those leading the program should know how (or consult with experts) to:

- Determine search and survey priorities;
- Determine survey and monitoring protocols, and mapping needs
- Develop short watch-lists of likely IAS (what is nearby and not yet in the Protected Area, and likely to occur);
- Determine reporting pathways (to the appropriate staff, agency or other entity), and
- Determine how and who will respond to a new IAS;

Those who will be looking for new invaders (carrying out early detection) should know:

- The most important places to look for new invaders (sites most likely to be invaded and/or sites with the highest conservation value) and survey protocols;
- Identify species on the IAS watch list and how to check the identity of species they suspect but are not sure are new invaders; and
- How and where to report new invaders

2. DETECTION AND REPORTING

If a new IAS is detected, that occurrence is reported as soon as possible to the correct authority. Everyone involved should know how to report new invasions and who is responsible for handling the reports.

3. IDENTIFICATION AND VOUCHERING

The species is positively identified by experts, and vouchered into a biological museum (herbarium, insectarium, etc.)

4. RAPID ASSESSMENT

Quickly assess the distribution of the newly detected IAS and evaluate its potential to spread further, the damage it could cause and options for eradicating, containing or controlling the infestation. Be sure that a specific person or group is responsible for completing the assessment.

5. PLANNING

Based on the information from the rapid assessment, create a plan to eradicate, contain or control the new IAS. The plan should identify the people or groups responsible for taking actions and set deadlines for those actions. Deadlines should be short enough to ensure that the new invader does not have time to spread irreversibly.

6. RAPID RESPONSE

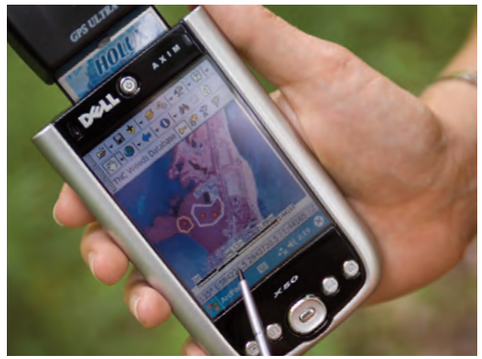
Take actions to eradicate, contain or control the new IAS. Eradication or containment of even a small population of new IAS may take many repeated treatments over many years. If you decide not to take action on the new IAS, document this decision and the reasons for it.

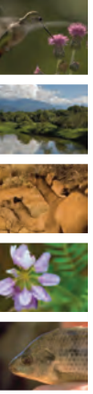
7. MONITOR AND EVALUATE

Follow the fate of the new IAS with regular monitoring after initiating actions. For plants, insects and many other types of IAS, this may require monitoring the site regularly for many years to ensure that all individuals are eliminated and that no seeds, larvae, etc. remain. Monitoring data should be quickly evaluated and plans for further treatments modified as appropriate. The data and decisions based on them should be recorded and reported. Identify the person or group who will be responsible for monitoring and evaluation and set timelines for the monitoring, evaluation of the data and reporting on results.

Additional considerations when developing EDRR into a Protected Area management plan include:

- Identify and determine staff and expert capacity, resources and constraints
- Determine need and availability of support from research institutions, NGOs and other partners
- Develop contingency plans and funding sources for the detection work (periodic surveys) and for emergency responses that would be needed if a new IAS is detected.





management, control & restoration

Even if the best prevention and EDRR measures are implemented, you will probably still need to actively manage IAS that are already established within your Protected Area. The ultimate goal of IAS management and restoration programs should be the long-term survival and viability of the target native species and communities. At the same time, it is necessary to keep in mind any risks to human health and environmental safety when deciding whether and how to manage IAS. Also keep in mind that a decision to do nothing also has benefits and costs, and these should be evaluated and recorded.

Approaches to IAS Management

The good news is that many invasions can be reversed, halted or slowed, and in certain situations, even badly infested areas can be restored to healthy systems dominated by native species, but this often requires taking action to actively control and manage those IAS, typically over the long-term. The objectives of these actions may include the eradication, containment and/or control of the IAS. (Wittenberg & Cock 2001):

1. ERADICATION

Eradication is the complete, long-term elimination of an IAS within a defined area. It is most effective when done to protect a significantly large area (i.e., to eradicate an IAS from an entire island or from a nation, rather than to locally-eradicate from a small nature park). Eradication is not possible unless all individuals of the species can be eliminated with the methods available and the risk of re-invasion is very low. However, if it is possible, it generally minimizes long-term management costs and long-term damage by the IAS. 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 continued control (Veitch & Clout 2002). Cromarty et al. (2002) identifies the three conditions that must be met in order for eradication to be successful for a given area:

1. All individuals of the target IAS can be put at risk by the eradication technique(s),
2. The targets must be killed at a rate exceeding their rate of increase at all densities, and
3. Immigration must be zero.

2. CONTAINMENT

Containment is the restriction of the distribution and spread of the IAS within some defined area (i.e., land ownership, habitat type, etc.). Containment is done to halt the spread of IAS and to prevent them from establishing within adjacent areas. It may also be done for widespread IAS if natural barriers to their spread can be exploited. In some cases containment may be used until improved control methods such as biological control become available.

3. CONTROL & MITIGATION OF IMPACTS

Control is the suppression of IAS abundance, typically to below an acceptable threshold level that still allows the values of the Protected Area to exist and thrive. Control should be thought of as a long-term continual maintenance commitment, because if it is not continued indefinitely, biodiversity and other Protected Area values will likely be impacted and suffer negative consequences. Control costs may be high in the early stages of a project when the IAS is abundant and widespread, but as its abundance and distribution in the

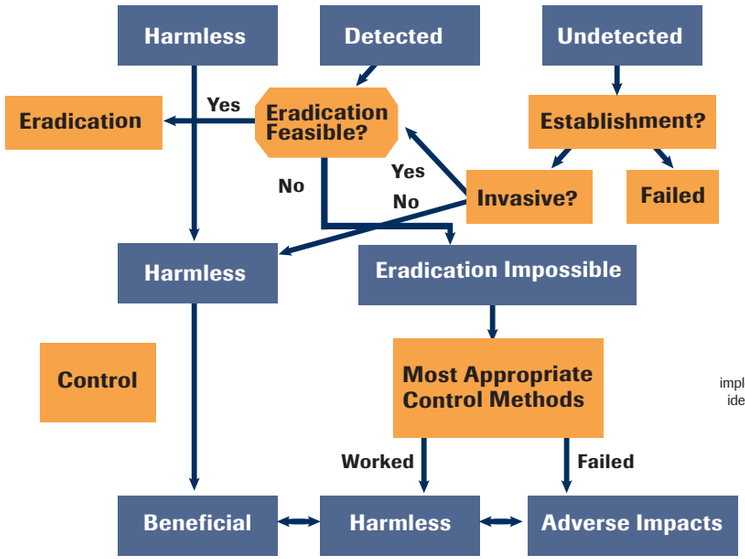


Figure 8. Management options after prevention has failed. If all steps are implemented, the alien species should be identified at the bottom of the flowchart. From Wittenberg & Cock 2001.

Protected Area decrease, control costs may decrease. Control actions are often combined with restoration efforts which can help prevent re-invasion and reestablishment of the invader as well as promoting native species and communities.

Control and Management Methods

There are many methods and techniques that can be used to manage against IAS in Protected Areas (Invasive Animals CRC 2008; Orueta & Ramos 2001; Tu et al. 2001; Wittenberg & Cock 2001). There is no one best method for every situation, and all management actions should be planned and prioritized for carefully, taking into consideration the IAS species, environmental context and resources, while being sure to benefit biodiversity and Protected Area values. Often, a combination of methods (called integrated pest management) is the best solution for a given situation, and every action should be correctly applied and timed for maximum efficacy. The following control methods are frequently used in Protected Areas:

MANUAL & MECHANICAL methods use manual labor, hand tools, and/or machinery to control the IAS. Examples include hand pulling, digging with shovels, or using light-to-heavy machinery such as mowers or earth-moving equipment to remove plants, and hunting, fishing or trapping animals. Manual and mechanical methods are usually labor intensive and costly for large-scale IAS management. However, it is often the easiest method to implement and can be used in a variety of situations. .

PRESCRIBED GRAZING uses animals (sheep, goats, cattle, etc.) to selectively graze upon those IAS (mostly plants), to benefit biodiversity. Prescribed grazing rarely eliminates the IAS, but it may help drive their abundance towards acceptable threshold levels. This method is often used with another control method (such as with chemicals) to achieve long-term control.

BIOLOGICAL CONTROL is the use of another species (generally also non-native, called 'classical biocontrol') introduced specifically to control the target IAS. For invasive plants, the biological control agents used are typically insects that feed exclusively on that IAS plant. Biological control agents are frequently used to control invasive invertebrates, but rarely work well to control vertebrate IAS. Biological control is only available for some widespread IAS. The use of biological control does not result in the eradication of the IAS, but attempts to decrease IAS abundance to acceptable levels.

PRESCRIBED FIRE is the intentional setting of fire to control the IAS (primarily plants). By itself, prescribed fire rarely eliminates the IAS, but can be an effective tool across large areas when used in combination with another technique (such as chemicals). Caution must be used whenever considering prescribed fire, as risks can be high for unintended consequences. It is therefore essential to carefully plan and have the required training for all prescribed fire activities.

CHEMICAL CONTROL is the use of pesticides to kill insects, plants, rodents, fungi, etc. It is one of the most commonly-used tools to manage against IAS, but should always be applied carefully to avoid impacts to desirable species and timed correctly to be effective. When selecting the chemical, it is important to find the one that is the most effective for the specific IAS species in its given situation and provides the least risk for unintended impacts to non-target species, human health and the environment. Follow all regulations and restrictions on the specific use of each chemical.

RESTORATION through the revegetation or reintroduction of desirable species should be considered as a major component of all treatment strategies; especially where control treatments have left newly disturbed bare ground or vacant niches. Revegetation with native or non-native (but non-invasive) vegetation can help prevent erosion as well as to prevent the reinvasion of the site by another IAS. Some reintroductions of native animals can re-establish trophic webs.

Which management approach and method(s) are most appropriate?

The choice of management approach and which method or combination of methods depends on several factors, including IAS species, the best known control methods, control methods acceptable to stakeholders, the environmental context of the invader and the habitat(s) it occupies, and available resources. In all cases, it is important to establish appropriate monitoring protocols to determine treatment progress and overall effectiveness towards management goals.

Management Method	Terrestrial Plants	Aquatic Plants	Terrestrial Vertebrates	Aquatic Vertebrates	Terrestrial Invertebrates	Aquatic Invertebrates	Other microorganisms (fungi, diseases, etc.)
Manual & Mechanical	Yes Dig, pull, mow, heavy equipment	Yes Dig, pull, harvesters	Yes Hunt, trap	Yes Fish, trap	Yes, often in combination with other methods Pheromone traps, physical removal	Yes Traps, physical removal, drain water	Yes, often in combination with other methods
Prescribed Grazing	Yes Use of sheep, goats	Yes Sterile fish to graze	No	No	No	No	No
Biological Control	Yes	Yes	Yes May include use of sterile organisms to prevent reproduction.	Yes May include use of sterile organisms to prevent reproduction.	Yes	Yes	?
Prescribed Fire	Yes Properly timed and intensity to manage vegetation	No	No	No	Yes, often in combination with other methods Cut infested trees then burn	No	Yes, often in combination with other methods
Chemical	Yes Herbicides	Yes Aquatic-approved herbicides	Yes Rodenticides, other pesticides	Yes Piscicides and other pesticides	Yes Insecticides and other pesticides	Yes Insecticides, mollus-cacides, etc.	Yes Fungicides, etc.
Restoration & Reintroduction of native species	Yes	Yes	Yes	Yes	Yes	Yes	?
Other Methods	Preventing reproduction or genetic control, using sterile cultivars, behavior modification, etc						?

Table 1. Table of possible IAS control and management methods that are often used in Protected Areas.

setting priorities

In order to be effective and efficient with available resources for IAS, you must establish management priorities as it is rare that there are enough funds or staff time to completely manage all known and potential IAS throughout a given Protected Area. The overall goal in setting priorities is to direct resources that will minimize the long-term damage caused by IAS and the overall workload necessary to achieve this. It is better to focus on a few IAS that are not as widespread and where there is a good chance of success, rather than to concentrate efforts on already widespread IAS which may be impossible to control throughout your Protected Area

What should be considered when prioritizing IAS management?

Before starting to develop priorities for IAS management:

i. Inventory, survey and determine your current IAS situation in your Protected Area (presence/absence of IAS species, exact locations, maps, etc.), as per the assessment of existing IAS threats (Assessing Threats section of this Quick Guide), and
ii. Identify the pathways of IAS entry and spread.

WHEN YOU HAVE COMPLETED THESE TWO ITEMS, THEN:

1. List your areas of highest management priority (for example, those areas with the highest biodiversity values or are in the best condition)
2. List all current (and nearby) IAS species, and their impacts on the Protected Area (high, medium or low impact),
3. List all locations where each IAS population occurs, indicating if each population is small, medium or widespread, and
4. List all nearby IAS (that are not yet present in the Protected Area), and their potential for invasion (high, medium or low risk), so that you have a watch-list of new IAS

Based on the above lists, you should then be able to start identifying those species or IAS populations that are of highest priority for active management, with an emphasis on prevention, EDRR, then control. It is best to focus on keeping uninfested areas free of any IAS, and then on those species and populations that have the most impact on Protected Area values. Therefore at a given Protected Area, high priority may be given to eliminating one or two species everywhere that they occur, and to keep several specific locations free of a larger suite of damaging invaders. The following guidelines (modified from Mazzu 2005; Owen 1998; Timmins & Owen 2001) may assist in making prioritized decisions:

HIGHEST PRIORITY FOR TREATMENT

1. Brand new IAS infestations in the Protected Area or surrounding region
2. New IAS infestations in high quality areas, or in areas not yet infested

SECOND PRIORITY FOR TREATMENT

3. Other IAS populations that are small, easy to control, or not yet widespread
4. IAS populations that threaten specific Protected Area values, such as endangered or endemic species or communities, or fragile habitats
5. Keeping large areas free of all IAS
6. IAS populations that could be a source of propagules (upstream IAS populations, trailheads, visitor centers, etc.)

THIRD PRIORITY FOR TREATMENT

7. Containment of priority IAS species where they exist in large infestations IAS infestations that occur on roadsides
8. Control and suppression of existing IAS large infestations to acceptable threshold levels.

Setting priorities for the management of IAS at a countrywide scale – Case Study from New Zealand (Owen 1998; Timmins & Owen 2001)

Summary: New Zealand's Department of Conservation (NZ DOC) is responsible for preserving and managing New Zealand's protected lands and waters, representing approximately 8 million hectares or 30% of New Zealand's total land area. In order to be effective in protecting these resources, the agency strongly promotes and implements prevention, EDRR and management programs.

Recognizing that resources for managing IAS threats are limited, all of their control and management programs must be prioritized for maximum efficiency. When setting priorities, they balance information about the IAS itself and its potential impacts on biodiversity with site values, to determine their course of action.

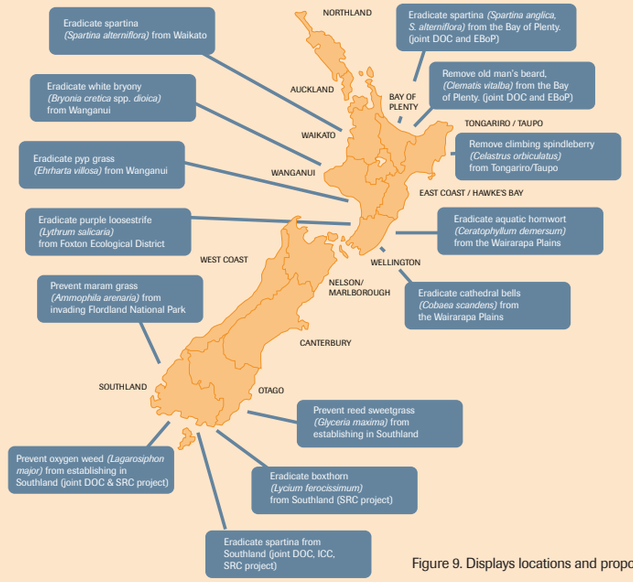


Figure 9. Displays locations and proposed actions for IAS work.

elements of a management plan

for IAS within a Protected Area

What is an IAS Management Plan?

An IAS management plan works within the context of a larger Protected Area or Protected Area System management plan (Ervin 2003a,b, Goodman 2003). It identifies those IAS that currently or potentially pose threats to Protected Area goals and values, prioritizes sites within the Protected Area and IAS species or specific populations of IAS (occurrences) for management. It also includes details on the planned management actions, monitoring, evaluating and adapting results (Pomeroy et al. 2004).

What are Necessary Elements of an IAS Management Plan?

There are numerous examples of IAS management plans, from national-scale IAS plans to a management plan for a single IAS species. Most comprehensive IAS management plans for Protected Areas consist of the following components (Hilliard 2005; Tu & Meyers-Rice 2002; Wittenberg & Cock 2001):

- Identify Protected Area goals, values and objectives
- Identify and prioritize critical current and potential IAS threats to those goals
- Conduct an assessment of IAS risks and resources to outline causal factors, key stakeholders and opportunities for successful action
- Identify and prioritize strategies for prevention and management
- Review best practices, management options and control techniques
- List specific actions planned, including:
  - Implementation of prevention practices and policies
  - Creation of an early detection and rapid response system
  - On-the-ground management, control and restoration work
  - Timeframe and implementation schedule for existing IAS infestations
  - Projected resource costs to implement plan
- Identify measures to determine whether strategies and actions are having the desired effect
- Monitor progress of implementation, and impacts of actions on Protected Area goals
- Evaluate results and adapt management as needed

What Other Factors Should be Considered When Creating an IAS Management Plan?

In addition to the above-listed elements, it is also necessary to identify and determine:

- Current resources and limitations (i.e., staff capacity, funding, political commitment, etc.)
- Stakeholder interests (are there conflicting interests?)
- Opportunities for organizational collaborations
- Key partners and roles, especially in prevention and EDRR
- Data management needs, in order to share data with partners across boundaries
- Education and outreach needs

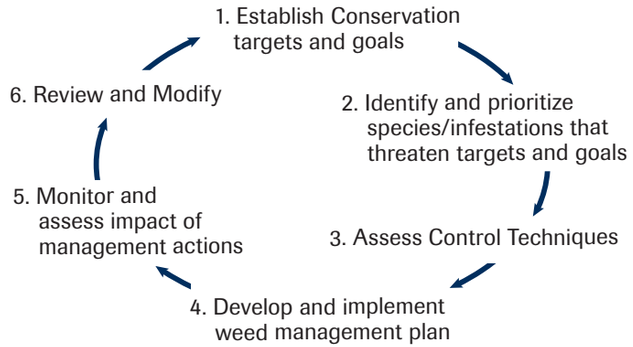


Figure 10. Adaptive weed management approach, modified from the TNC Conservation Action Planning process. From Tu et al. 2001.

10 Things all Protected Area managers must consider about IAS (modified from I. March, pers. comm.)

1. We should learn to live with the threat of IAS everywhere, including in Protected Areas. But we must determine our level of tolerance of IAS in specific areas and for particular IAS.
2. Prevention is always the best option and should involve major stakeholders with activities in the Protected Area and surrounding areas. Prevention should be planned for at several scales, with prevention measures actively implemented in "rings" of exclusion around the Protected Area.
3. Risk assessments and pathway analyses for IAS should be performed for every Protected Area in order to design effective prevention measures.
4. Active prevention, early detection and control for IAS should be included in every Protected Area management program
5. All IAS efforts should be focused on those IAS that have high impact on biodiversity and other Protected Area values (for example, focus on those IAS that are ecosystem and habitat modifiers)
6. Develop surveys and rapid assessments for the most vulnerable and fragile Protected Areas (for example, islands)
7. Work to keep islands and other fragile Protected Areas free from all IAS.
8. Budget and funding for IAS prevention and control should be secured. Ideally a Protected Area system should have a permanent vigilance system and an emergency fund for new IAS infestations.
9. Protected Area staff should have the basic training and capacity to develop vigilance activities in an Early Detection Rapid Response program.
10. The threats and impacts of altered fire regime and IAS often overlap. Integrated solutions to address both threats should be developed in the overall Protected Area management plan.

policy solutions

to invasive alien species

Many Protected Area managers might not consider the use of policy as a suitable approach to IAS, but stronger government policies could be the most effective way to prevent new invasions from establishing in the state or nation, thereby preventing them from even getting close to your Protected Area. Often policy-makers want to know more about the damage being done under current policies and how stronger policies would help. Protected Area managers have first-hand knowledge of the damage being done by IAS and often have a clear sense of how policies that prevent additional IAS could be of great benefit to them.

The use of policy to prevent new IAS and provide sustained funding directly influences on-the-ground priorities and management activities.

What is a policy solution to IAS?

Policy solutions (or interventions) to IAS include the practices, laws, agency policies and regulations, committed funding, and authorities to act, that work to prevent the introduction and subsequent impacts of IAS on Protected Areas, biodiversity and the economy (GISP 2007; Shine et al. 2000; Young 2006). These policies are typically adopted and implemented at state/province, national or international scales, and can be legally binding or voluntary.

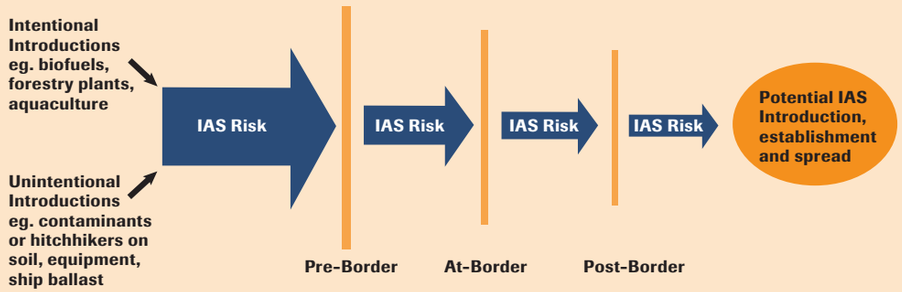


Figure 11. When prevention policies are implemented at multiple scales, there should be an overall decrease in the amount of IAS risk.

What are roles Protected Area managers can play in IAS policy?

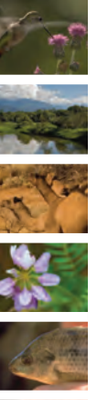
Protected Area managers have a crucial role in both Protected Area System-wide policies and practices and in national-scale policies by:

- Documenting current impacts of IAS on Protected Area values
- Documenting resources currently spent on IAS prevention and management,
- Projecting future IAS impacts and resource needs to address them
- Providing this information to policy makers
- Promoting and supporting effective policies proposed to prevent new invasions and the spread of IAS and the containment and control of high priority IAS in high priority places, and
- Promoting coordination amongst agencies, organizations and stakeholders.

EXAMPLES OF PREVENTION POLICIES

Some of the best prevention policies use pathways-based approaches (instead of species-based approaches). This approach can be applied at multiple scales, and may include (Hayden & Whyte 2003):

	PROTECTED AREA OR PROTECTED AREA SYSTEM SCALES	NATIONAL SCALE
Pre-border	• Require site-based inventories for IAS prior to ground-disturbing, road-building, or fire-fighting activities • Require the cleaning of all equipment and transports (vehicles, boats) prior to all management activities, such as earth moving or fire management activities • Require that all fill-soil be from IAS-free locations • Require that revegetation or erosion control projects use only native (or non-invasive) species • Prohibit the stocking or use of IAS for food or other production purposes (fish, forestry) • Require the use of weed-free feed and seed	• International (trade policy) agreements that include IAS pathways and risk assessments • Clean stock programs • Import IAS risk analyses • Import health standards for any imported goods, packaging and means of transport • Import permits required for live animals or other high-risk species • Use of reference lists to recognize IAS and their potential impacts • Use of a scientifically-based approach to assess IAS risk, linked to listing regulations
At border	• Require that all entering equipment and transports (cars, boats, etc.) are washed prior to entry into the Protected Area • Refuse entry to equipment and transports that are carrying soil, vegetation or water, or are suspected of having IAS hitchhikers • Prohibit the entry of all known and suspected IAS into the Protected Area	• Quarantine/biosecurity requirements and procedures and inspections at all entry pathways • Customs regulations • Pathway risk analyses and inspections of passengers, mail and cargo • Prohibit the entry of all known and suspected IAS
Post border	• Require an immediate plan and response to new IAS infestations • Provide emergency funding for the rapid response and follow-up surveillance and monitoring	• Post-border quarantine • Surveillance, detection and identification • Emergency pest and disease response • Immediate planning and management response • Information and database systems • Eradication measures • Pest management and containment

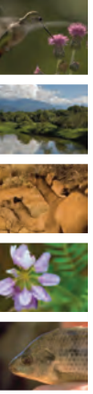


checklist of indicators for assessing invasive alien species

Protected Area management effectiveness

This checklist identifies key elements necessary in the development and implementation of a comprehensive IAS plan. It is intended as a simple rapid assessment tool to determine whether the current state of knowledge, capacity, planning, implementation and support is sufficient to abate IAS threats, and at what scale.

	Protected Area	Protected Area System	National
Capacity, institutional support and resources There is sufficient awareness of IAS threats to Protected Area values. Staff are sufficiently trained in conducting critical planning and management activities related to the assessment, prevention, detection, and management of invasive species. The infrastructure allows staff to perform critical activities related to IAS planning, implementation and monitoring. There are sufficient financial resources and institutional support to conduct critical work in IAS planning and implementation.			
Data management, communications and planning There is an effective system for tracking and monitoring IAS, impacts and management implementation. There is effective communication and data sharing among all levels of relevant staff, partners and local communities on invasive species issues. Staff and partners have access to sufficient data on invasive species to make informed and timely management decisions. A comprehensive IAS plan is included as part of the overall management plan.			
Prevention and pathways Current and potential IAS pathways and threats to Protected Area values are assessed and prioritized. Policies and guidelines are in place to prevent new invasions from multiple pathways.			
Early detection and rapid response An effective early detection system is in place. An effective rapid response system is in place, with contingency plans and identifies specific roles and responsibilities.			
Adaptive management and monitoring Critical IAS management activities are adequately implemented to maintain desirable ecosystem conditions. Results from IAS monitoring are routinely analyzed for management effectiveness, and plans are modified as necessary.			



web resources

There are many internet resources that provide information on experts, IAS impacts, management information and planning. Many of these sites contain online databases that are searchable by country or species. The below list are only a few; look to *http://www.gisinetwork.org/Documents/draftiasdbs.htm* for a comprehensive list of online invasive species databases and resources.

GLOBAL RESOURCES

Global Invasive Species Programme (GISP)
http://www.gisp.org

Global Invasive Species Database (GISD)
http://www.invasivespecies.net/

Global Invasive Species Information Network (GISIN)
http://www.gisinetwork.org

The World Conservation Union (IUCN) Invasive Species Specialist Group
http://www.issg.org/#ISSG

The Nature Conservancy (TNC)
http://www.nature.org/invasivespecies
http://tncinvasives.ucdavis.edu/

A FEW REGIONAL AND COUNTRY RESOURCES:

Argentina - http://www.inbiar.org.ar/

Brazil - *http://www.institutohorus.org.br*

China - *http://www.chinabiodiversity.com/shwdyx/ruq/ruq-index-en.htm*

Colômbia - *http://ef.humboldt.org.co/*

Costa Rica - *http://invasoras.acebio.org/*

Dominican Republic - *http://www.medioambiente.gov.do/inbidom/main/spanish/base_datos/index.html*

Inter-American Biodiversity Information Network, Invasives Information Network (IABIN I3N)
http://i3n.iabin.net/

Jamaica - *http://jamaica.paradigma.com.ar/*

Mexico - *http://www.conabio.gob.mx/invasoras/index.php/Especies*

Pacific Invasives Learning Network (PILN) - *http://www.sprep.org/PILN/Index.htm*

Paraguay - *http://www.i3n.org.py/*

Uruguay - *http://uruguayi3n.iabin.net/index.asp*

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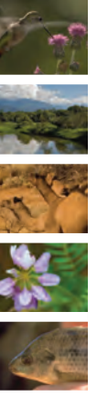

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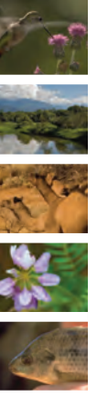

glossary

ALIEN SPECIES: A species introduced (intentionally or intentionally) outside of its natural range of distribution. Synonyms include: exotic, introduced or non-native.

CAPACITY: The ability to undertake the critical management interventions needed to protects and promote biodiversity values within a Protected Area.

CONTROL: A management intervention aimed at reducing the density and/or distribution of an invasive alien species to an acceptable level.

EARLY DETECTION: A management intervention aimed at locating new individuals, sites, or areas of establishment or spread of invasive alien species. Early detection is often done with the goal of enabling a rapid response (eradication) to that new IAS.

ERADICATION: The complete elimination or extirpation of the entire population of an IAS within a defined area.

IAS: See invasive alien species (below).

INTENTIONAL INTRODUCTION: The deliberate introduction of an alien species for a specific purpose (e.g., agriculture, ornament/horticulture, erosion control, forestry, aquaculture, hunting, etc.).

INTRODUCTION: The movement, by human agency, of a species outside its natural range. Introductions can be intentional (planned, done on purpose) or unintentional (accidental, as a contaminant), and 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).

INVASIVE ALIEN SPECIES (IAS): An alien species that is able to survive and reproduce or spread outside of human intervention/cultivation, and whose introduction and/or spread has a negative impact on biodiversity or ecological functions within a Protected Area.

MANAGEMENT INTERVENTION: Any action aimed at reducing the potential or existing impacts of IAS, including prevention, early detection, rapid response, control, eradication and mitigation.

MITIGATION: A management intervention aimed at reducing the impacts of an IAS on biodiversity and ecological functioning within a Protected Area

PATHWAY: The means by which an IAS may be transported to a new location.

PREVENTION: A management intervention aimed at keeping IAS from being introduced in the first place, through intentional or unintentional means. Prevention can be applied from site to international scales.

RAPID RESPONSE: A management intervention aimed at quickly eradicating or controlling new incursions of IAS before they become established or widespread.

UNINTENTIONAL INTRODUCTION: The introduction of an IAS through accidental or unplanned means (e.g., shipping ballast, contaminated seeds and hay, pathogens on commodities, etc.)

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