

Biosecurity and quarantine for preventing invasive species

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1.1 Introduction

The saying ‘prevention is better than cure’ applies to the entry of invasive species but this is difficult to achieve, particularly in the absence of physical or ecological barriers to the movement of invasive species, or where human activities and vectors provide pathways for their entry. For the purposes of this chapter, the term ‘invasive species’ applies to those that enter and establish in a new area and have the ability to spread aggressively, to intrude or overwhelm other organisms. This can apply to organisms affecting human food safety, human health and culture, and agricultural, natural terrestrial, and aquatic ecosystems. *Biosecurity* includes all policies and measures that a country implements to minimize these harmful affects, ranging from preventing the entry of unwanted species into an area to their management if they do enter. Biosecurity is a broader concept than *quarantine* (system), but at times these terms are used interchangeably. Together they are usually integrated measures that cross over all sectors that relate to the protection of the environment in general.

Internationally the term *quarantine* is used in several ways. In the broad sense it refers to all activities aimed at preventing the introduction, and/or spread, of a species of concern. In a narrower sense, it is the official confinement of organisms that have a risk of invasiveness (FAO 2007a). In this chapter, the broader sense of quarantine refers to a quarantine system and the narrower sense refers to a quarantine facility, quarantine procedure, or quarantine measure. All of these systems or measures are tools used to reduce the likelihood of entry of invasive organisms.

We stress that accurate identification of the species involved is critical to all aspects of biosecurity and invasive species management to enable appropriate decisions or actions.

1.2 Invasiveness and impacts

The impacts of invasive species range from negligible to extremely high and they can be difficult to understand. Certain components are clearly quantifiable, such

2 | Invasive species management

as the loss of human lives (e.g. West Nile disease) and financial losses (e.g. direct loss of agricultural production or increased cost of control measures). Many other impacts are less easily quantified, including environmental impacts (e.g. loss or change of biodiversity), impingements on human lifestyle, and amenity losses. In general, if invasive species can be prevented from establishing in an area, the resources used in prevention are usually significantly lower than those needed for eradication, containment, long-term control, or the consequences of doing nothing. Hence, where an invasive species does enter and is detected, it is essential to have well organized and implemented emergency management procedures to minimize the risk of widespread establishment and the subsequent need for an eradication campaign. Eradication can be difficult to achieve and often entails fairly severe measures that may need to be maintained over lengthy periods (see Chapter 4).

Many organisms that enter a new or endangered area either do not establish or necessarily become pests even if they do establish. Other species will establish but do not appear to have a significant impact, at least initially, because the populations are small in size and initially not problematic. However, some species, after several to many generations—which may take months to years—the population can reach sufficiently high levels to become problematic. Invasiveness may increase with a change in conditions, ranging from broad-scale climate change resulting in more available habitat, to a single event such as the introduction of a more efficient plant pollinator resulting in greater seed set. Such changes may result in previously benign species becoming invasive with unacceptable impacts. In addition to exotic species, previously benign native species can invade, through habitat modification such as the introduction of new nutrient resources (e.g. new hosts), to such an extent that they require control.

A critical aspect of all aspects of biosecurity, particularly at the border, is the great difficulty of predicting which species will be invasive. There is no single set of characteristics that determine if a species will be invasive, although certain characteristics increase the likelihood that a species is more likely to be successful in establishing and possibly becoming invasive. A general formula for invasiveness = [Nutrition availability (food or niche availability) + capacity to spread + sensitivity (ecological and human) of ecosystem to change/impact] × Constraints (climate requirements, parasites, disease, reproductive constraints etc.)

There are many texts on this subject with greater or lesser details with many predictive models available that have varying degrees of usefulness. The major requirement for a species to establish and invade in an area is the availability of suitable nutrition, which ranges from host organisms (e.g. parasites) to niches on the landscapes. Once established, other constraints that determine the extent of impact include: its dispersal capacity either by its own means such as flight, or mediated by other means such as passive wind dispersal or attachment to bird feathers or mammal coats; tolerance of different environments; lack of competition at the site of invasion; presence/absence of predators, disease, or parasites; abundance of high value nutrition; host suitability; reproductive capacity; climate; coincidence of

climate and host life stages; niches availability and disturbance levels (e.g. change of landscape by humans).

1.3 Legislative frameworks

1.3.1 International framework

When considering the establishment of quarantine systems/measures there are many issues to be taken into account. At the broadest level there are obligations to international conventions and intergovernmental organizations to which governments are members or contracting parties. The principle conventions and intergovernmental organizations that deal with invasive species are the International Plant Protection Convention (IPPC), World Organisation for Animal Health (OIE), Convention on Biological Diversity (CBD), Codex Alimentarius, Ballast Water (International Maritime Organisation, IMO), and the Convention on International Trade in Endangered Species of Wild Flora and Fauna (CITES). These international agreements provide a framework of principles to guide a country in developing mechanisms/measures to reduce the threats from invasive species (see Chapter 8).

The agriculture sector has been developing procedures, methodologies, and tools to lower the likelihood of entry of organisms of concern for many years. The first international plant health agreement was signed in Bern, Switzerland in 1881, as a response to spread of a plant pest, *Phylloxera*, on grape vine planting material. It was called the Convention on measures to be taken against *Phylloxera vastatrix* (now renamed *Daktulosphaira vitifoliae*). This agreement was the forerunner of the current IPPC. Over the past 12 years international phytosanitary standards (ISPMs) have been developed within the framework of the IPPC, to provide guidance on a range of plant quarantine issues covering plant pests—under IPPC definitions the term plant pest includes plant pathogens, insect pests, and weeds (FAO 1997, 2004a–c, 2005a, 2007a,b; IPPC 1997) These standards are generally adaptable across all sectors. The risk assessment standards have been unofficially adapted for use by some scientists for invasive species in areas other than agriculture, e.g. aquatic species.

1.3.2 National frameworks

These agreements, international standards, and frameworks are often administered through different national mechanisms, usually implemented by different sectors of government, and hence not necessarily applied in a unified or coordinated manner.

National issues that can impact on a country's capacity to implement quarantine systems/measures include the national economic status, effectiveness of governance, social and political stability, and the well-being of a populace. If major social problems prevail—such as poverty, famine, civil unrest, or war—then the prevention of entry or deliberate introduction of potential invasive species is likely to have

a relatively low national priority. That is, the short-term imperatives of human issues are likely to have higher priority than establishing quarantine measures despite the potential longer-term consequences of not doing so.

1.4 Pathways

Apart from the biological characteristics of invasive organisms, many other factors need to be considered during the implementation of quarantine measures. In particular are the pathways via which organisms can enter new areas. There are three broad categories of pathways of introduction:

- 1) Species that spread naturally either passively by water or wind, including extreme events such as cyclones, or actively flying, crawling, or swimming.
- 2) Species that are accidentally introduced hitch-hiking or vectored on/by something for example, during trade; movement of material during emergency relief or conflicts; traditional movement of people; movement of plants, animals, or soil; scientific materials; traveller's personal effects; movement of contaminated agricultural, military, or industrial equipment; ships, including ballast water.
- 3) Species that are deliberately introduced, e.g. new genetic stock, biological control, hunting, pets, or ornamental trade. These may be introduced legally or illegally (smuggled) into an area. A further layer of complexity arises when one community considers an organism invasive and another community (often in the same country) considers the species beneficial.

The volume of human-facilitated movement of goods and organisms, and people travelling around the globe is huge and increasing every year. These movements provide pathways that are possibly the most significant sources of potential invasive organisms. Every traveller and item of goods that are imported into a country potentially provides a pathway for an invasive species. The following describes some data of known movements of people and goods in two countries with relatively well-controlled borders, the USA and Australia. They give some idea of the magnitude of the task of minimizing the risk of invasive species entering a country. Both the USA and Australia have invested heavily in the prevention of entry of invasive organisms, as well as in management of pest incursions. The USA has a mix of long land borders and sea borders. Australia is entirely surrounded by sea with only one area in close proximity to another country.

The USA intercepted about 325,000 pests between 1991–96, and inspected over 315,000 ships. In 1996, they inspected over 66 million passengers (APHIS web facts). Australia intercepted about 140,000 pests between 1993–2003. In the year 2006–07 there were 1.6 million sea cargo containers inspected; rising to 1.8 million in 2007–08—an increase of over 10% in one year. Currently 12 million air passengers are screened each year and around 45,000 items of quarantine concern are seized every month and about a quarter of these are undeclared—there

are 3,300 staff (inspection and non-inspection) in the agency that manages the international border. Hence, to complement the effectiveness of the work done by government agencies, there needs to be a high level of cooperation by a greater part of the populace

1.4.1 Natural spread and host range extension

The Queensland fruit fly (*Bactrocera tryoni*) exemplifies the combination of natural spread and host range extension resulting from human modification of the environment. It is native to south east Queensland, Australia, where it originally lived on native fruit. When exotic horticultural species of fruit and vegetables were introduced into its native range, *B. tryoni* was exposed to a novel host range to which it readily adapted. It subsequently expanded its distribution to wide areas of eastern Australia where it has severe consequences for some crops. High levels of control and monitoring are required to ensure that major production areas are kept free from this native, invasive species.

1.4.1.1 Natural disasters

Natural disasters affect the entry of invasive species. Cyclones (hurricanes) can result in the movement of organisms over abnormally long distances. Similarly, large-scale disturbance of landscapes can create conditions in which invasive organisms can establish, e.g. the spread of insect vectors or large-scale destruction of land cover creates opportunities for establishment of weeds. In addition, natural disasters often generate emergency relief actions and the rapid importation of largely uncontrolled goods. The associated quarantine risks often lead to accidental introductions (see Section 1.4.2).

1.4.2 Accidental introductions

There are many historical examples of accidental introductions, e.g. rodents via ships, weeds in fodder, and European woodborer in furniture. More recent examples include aquatic diseases introduced through ornamental fish and hyper-parasites introduced with biological control agents. The impacts of such accidental introductions can rival those of deliberate introductions. For example, there are many documented examples of rodents causing at least local extinction of certain bird species.

Most accidental introductions enter via contaminants of commodities or organisms. They can also result from the deliberate introduction of another species upon which they are parasites, e.g. parasitic mites of bumblebees introduced into Japan for pollination purposes where the parasitic mites moved from the imported species to native species where they have had a negative impact (Goka *et al.* 2006).

1.4.2.1 Trade

Trade is the major pathway for short- and long-distance movement of small-to-large quantities of materials and goods. Over recent decades, there have been vast

improvements in the capacity to rapidly move greater volumes, and an increased variety, of material. Organisms associated with trade goods no longer need to survive for as long a period as they previously needed to in order to arrive in a viable condition at a destination. Hence, there is a significant increase in the potential for trade to be a source of invasive species. As the primary objective of trade is profit or economic benefit, this often involves moving goods as fast as possible from source to outlet. This need is frequently in conflict with quarantine measures designed to lower the likelihood of entry of invasive species, because the measures may be seen to impede the speed of movement of goods. This can result in a tendency to avoid these measures. Therefore, there is a need to develop pragmatic quarantine measures, in conjunction with stakeholders, which are commensurate with the threats posed by the trade. If possible, these measures should be undertaken as close to the entry point into a country and as efficiently as possible.

If the quarantine measures are integrated into normal practices, there is a greater probability of a high level of compliance than if the measures cause change to normal practices. However, there are circumstances where changes to normal practices are unavoidable to achieve the required level of protection. It is important to remember that not only the goods themselves are potential pathways for invasive alien species, but also the conveyances by/on which they are transported, e.g. wood borers in packing crates.

1.4.2.2 *Traditional movement of people and goods*

Traditional movement of people and goods are pathways that have existed for a considerable time, particularly between countries with land borders. These pathways can allow the entry of invasive alien species, including both accidental introductions such as cattle diseases, and purposeful introductions such as food crops with weed potential. When establishing a quarantine system these movements should be given consideration but with an understanding that some may be difficult to manage. The objective is not necessarily the complete exclusion of traditional movements, which often encourages illegal trade. Rather, the need is to look at what goods (animals, foodstuff, plant material, and conveyances) are involved, the areas through which they pass, the risks involved, and the available management options. Communities should be engaged to increase awareness of the risks and develop appropriate quarantine measures to reduce the risks.

1.4.2.3 *Emergency food, disaster relief, and development aid*

Emergency food and disaster relief, and development aid, can be a source for the introduction of invasive species, e.g. stored product pests such as larger grain borer (*Prostephanus truncatus*), aquatic species, and weed seeds. Such aid often involves the rapid deployment of people, vehicles, goods, and products, and in many cases quarantine or preventative measures are intentionally or unintentionally ignored. Often there are few, if any, controls enforced when people, vehicles, and goods

enter a country. Political interference can over-ride justified safety measures. Thus, the risks of the introduction of invasive species are often substantially increased during such a process. It is predicted that the need for food aid is likely to increase with the effects of global warming with a resulting increase in risk of invasions. The application of controls in source countries probably has the greatest potential to lower the likelihood of entry of invasive species into recipient countries.

1.4.3 Deliberate introductions

Deliberate introductions of alien species for any purpose, including pasture and genotype improvement, new crops, biological control, land rehabilitation (e.g. for erosion control or post-mining activities), leisure activities (e.g. gardening), the pet trade, hunting, research, agricultural or horticultural purposes can have wide reaching, and often unexpected, consequences. Hence, there should be careful consideration of impacts beyond those of the immediate focus of the introduction programme when undertaking a risk analysis before importation.

A large number of invasive species have been human assisted at least in the first instance, a process that has been going on for thousands of years. During the colonization of the New World, especially in the 1800s, there were proactive moves to introduce a greater range of species into new areas for food or utility, for ornament, as pets, or for hunting (acclimatization societies) to make the new lands 'feel like home'. Birds were often introduced to control insect outbreaks and later on, mammalian predators were introduced to control outbreaks of the previous 'useful' introductions. A few of those introduced to Africa, Australia, and New Zealand include common mynahs (Aves: Sturnidae: *Acridotheres tristis*), rabbits (Mammalia: *Oryctolagus cuniculus*), foxes (Mammalia: Canidae: *Vulpes vulpes*), stoats (Mammalia: Mustelidae: *Mustela erminea*), weasels (Mammalia: Mustelidae: *Mustela nivalis*), European starlings (Aves: Sturnidae: *Sturnus vulgaris*), sparrows (Aves: Passeridae: *Passer domesticus*), deer (Mammalia: Cervidae: *Cervus* spp.), lantana (Magnoliopsida: Verbenaceae: *Lantana camara*), prickly pear (Magnoliopsida: Cactaceae: *Opuntia* spp.), pasture grasses (Liliopsida: Poaceae), goats (Mammalia: Bovidae: *Capra hircus*), and pigs (Mammalia: Suidae: *Sus* spp.). Many of these introductions, especially food plants, have been critical to the new colonies. Some introductions, when undertaken with appropriate consideration of the potential off-target impacts, can be highly beneficial, such as biological control agents.

A major trap for those proposing to import new organisms is that most species are normally not considered invasive in their home range. When introduced to a new range, these same species, by adaptation to new hosts or niches, have resulted in drastically altered habits and ecosystems, including the extinction of some native species. The consequences of many of the above introductions still have major impacts today.

1.4.3.1 Biological control

Biological control usually involves the deliberate introduction and release of new organisms into areas, often in a repetitive manner. The objective of quarantine

systems is to prevent the entry of new organisms that can have a negative impact and, as such, the release of biological control agents is contrary to most quarantine measures. Just because an organism is labelled as a biological control agent does not automatically mean that it will be safe or beneficial in all circumstances. Even though an organism may have been used successfully and safely as a biological control agent in a particular target area, it does not necessarily mean it will be safe in another ecological area. An example of this is with the highly successful use of the prickly pear moth, *Cactoblastis cactorum* in Australia to control prickly pear (Dodd 1940), where, even 70 years after initial release, it is still controlling prickly pear in that country. This same species of moth has accidentally entered the USA where it is an invasive pest (Hight *et al.* 2002; Viguera and Portillo 2002; Zimmermann *et al.* 2002), and threatens species of cacti in their area of origin and livelihoods of subsistence farmers. This does not discount from the usefulness of this species as a safe biological control agent, provided appropriate non-target testing has been undertaken as well as consideration of the possible affects of this species in areas outside of the release areas, i.e. ability of this species to disperse (or be transported) to other geographic areas. Hence, when releasing biological control agents, if a country has land borders with another country or is in close proximity to another country, then potential impact of the biological agent in those areas should be considered.

1.4.3.2 Plant introductions

Plants have been introduced around the world in an attempt to improve productivity in many areas. However, significant numbers of these plants have either not been particularly useful or become invasive weeds. For example, in northern Australia, 463 pasture species of legumes and grasses were introduced for pasture improvement between 1947 and 1985; only four species proved useful with no invasive consequences, 17 species were proved useful as well as having weedy characteristics that caused problems for some sectors, and a further 60 species are considered invasive and as having no useful characteristics (Lonsdale 1994).¹ Other examples of species introduced for commercial reasons include pines, acacias, and eucalypts, which form the basis of commercial plantation industries in many countries. However, in some areas outside of their native ranges, these introduced species have become invasive. For example, in South Africa in climatically suitable areas all three groups have become invasive (Rouget *et al.* 2002).

Many ornamental plants that have been deliberately introduced into various areas around the world have become highly invasive. Some continue to be promoted in various areas as ornamental species. Part of the problem is that the combination of hardiness and attractiveness makes them desirable in horticulture because they require little maintenance to produce sometimes spectacular floral displays. One

¹ These findings eventually resulted in a weed risk assessment system for the introduction of plants into Australia (Pheloung *et al.* 1999).

such species is *Lantana camara*. This species originally came from Central and South America, it now occurs throughout most tropical and subtropical areas in the world (e.g. Asia, Australia, the Pacific islands, Africa). *Lantana camara* has attractive flowers and thrives in a broad range of temperatures, soil types, and rainfall ranges. It is a major weed of disturbed areas including agriculture and areas of significant environmental value. It is tolerant of slashing and chemical controls and hence is difficult to control. It has been the subject of biological control efforts for many years; these have, at best, only achieved partial success. It continues to expand its range and become denser in areas where it already exists. It is difficult to eradicate and takes considerable persistence to do so, and vigilance to prevent reinfestation.

The recent trend for introducing biofuel crops raises the spectre of new weed invasions, especially onto marginal land in the tropics or the encouragement of the clearing of virgin forests to plant alien species, hence creating significant areas of ecological disturbance.

1.4.3.3 *Smuggling*

Deliberate illegal introductions can have significant consequences, not only from the species smuggled, but also other pests and diseases entering with the material. This can be because of ignorance of the consequences or deliberate avoidance of extremely strict quarantine regulations. Hence, to lower the likelihood of such instances there is a need to facilitate movement of material wherever possible, and where this is not possible to work with people and provide reasons and information as to why it is so. Therefore, the engagement of populace and good communication is critical to a robust quarantine system and indeed all aspects of biosecurity.

Another factor that complicates the issue of quarantine or biosecurity is the possibility of malicious or deliberate introduction of species in an attempt to create damage or fear e.g. the possible release of zoonotic diseases or widespread distribution of crop diseases. This risk should be considered when conducting the overall risk analyses of threats to a country.

1.5 Actions

The types of action that can be taken to reduce the risk of entry/establishment of invasive species fall into three broad categories. These are: pre-border actions—those actions taken outside a country or region; border actions; and post-border emergency actions. Each category has two main components—physical (e.g. infrastructure, materials, finance) and human (e.g. legislation, procedures, skills). It should be noted that to establish and maintain a quarantine system takes the ongoing commitment of physical and human resources.

The objective of quarantine systems is usually to lower the risk or prevent the entry of identified unwanted organisms. When a quarantine system is developed, various aspects should be considered. These include understanding of the degree

of natural biological isolation of the country, infrastructure capacity, the legal and political situation, available technical expertise, communication capacity, and personnel capabilities. There are generic similarities between most quarantine systems, but every quarantine system should be developed specifically for the particular circumstances that prevail within a country. In the case of plant quarantine systems, ISPM 20 (FAO 2004b) provides general guidance for the elements of an import system for plants—these are applicable to most systems and can be adapted to lower the risk of entry of invasive species. See Fig. 1.1 for a diagram of assessment and management of risks associated with invasive species

In quarantine systems, actions with regards to particular species can take place before the border (pre-entry), at the border (entry), or as a reaction to the detection of an invasive species (emergency actions).

1.5.1 Pre-entry

There is a need to identify the organisms or groups of organisms that pose risks and assess their potential impacts. This will enable appropriate guidance and contingency resources for detecting or controlling them should they enter or escape. When undertaking a risk analysis or assessment, issues that are useful to consider include those mentioned in Section 1.1, in particular the pathway/s via which an organism is most likely to arrive. Control of pathways of entry of invasive organisms provides the best opportunity to prevent the entry.

Risk mitigation measures prior to entry include: pre-export inspection; pre-export treatments; field treatments; selection of material from areas free of the invasive species or areas where there is low populations of the invasive species of concern; or treatment of goods that may provide a pathway for the target invasive species at discharge at the airport/port of entry.

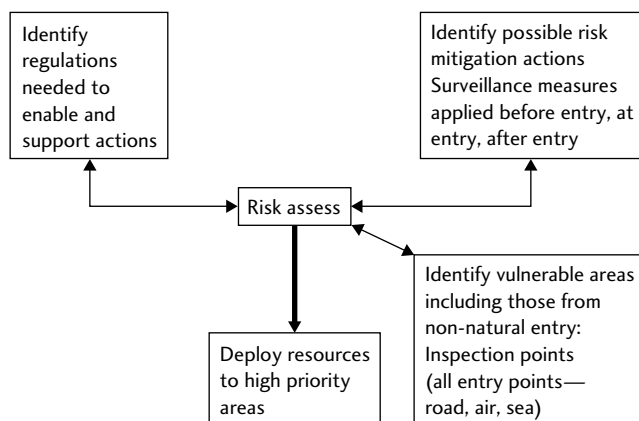


Fig. 1.1 Assessment and management of risks.

1.5.2 Entry (border)

Risk mitigation measures include: inspection of goods; checking that goods meet conditions of entry; treatment if required (heat/cold treatment, chemical treatment) including holding in a containment facility for observation; and either release or destruction or re-export if unable to meet conditions of entry. Quarantine facilities should be built to cope with the highest risk organism likely to be handled by the facility (Boxes 1.1 and 1.2). This may be a highly specialized facility or laboratory, or general facility that houses a wide range of organisms likely to be vectors for invasive species. Items possibly needing such facilities include, for example, agricultural crops such as cuttings, insect pathogen vectors (plants or animals), farm animals or pets carrying diseases or weed seeds, pets, and potential biological control agents.

Box 1.1 Notes on inspection facilities and processes

Inspection processes have inherent risks arising from various areas, but with careful management and competent inspections they can be minimized. Risks arise in several areas such as: lack of appropriate facilities to contain potential risks; poor staff knowledge and skills; poor procedures or lack of appropriate application of procedures such as opening sealed containers.

Actions to mitigate risks

Inspection facilities should be sited on appropriate terrain largely immune from natural disasters such as earthquakes. They should be located near the country entry point to minimize movement of material and the potential for escape. They also need to be as far as possible from suitable habitats/hosts such that in the event of an escape the likelihood of establishment is lowered.

Potentially invasive organisms (and risk goods) need to be examined in a secure area where they cannot escape. The quarantine containment rooms or laboratories need to be perceived, and function, as though biologically isolated from the surrounding country, with a system of physical and procedural barriers that lead out into the country. The physical isolation of the facility must be complemented and reinforced by operational procedures and systems established to run it.

Facility components

The floor plan of a facility and installation of equipment should make operational procedures flow smoothly and have efficient practices. Otherwise, staff may adopt practices that potentially compromise the integrity of the quarantine facility/system. The design and operation of the facility should focus on controlling pathways of biological organisms into and out of the facility (including by hitch-hiking on humans or materials used in the facility). This type of design often contradicts standard design and construction used for other types of buildings or facilities where the focus is often economy, aesthetics, and/or

people-friendly functionality. To have a facility that operates well, it is imperative to have highly competent staff, otherwise there is a high likelihood of system failures. A minimum standard should be a fully enclosed room with solid floor, walls, and ceilings made of impervious materials and sealed joints, as well as with sealed or screened vents, and appropriately sealed water supply, drainage, waste disposal, and power supply.

The safeguards/measures used in a facility should be appropriate to its function and be independent from each other such that each safeguard/measure has a different mode of action. Hence if one fails, all safeguards are not compromised (e.g. a series of sealed doors with vestibules in-between and one with a light at one end to attract organisms back towards it). The degree of security needs to reflect the acceptable level of risk of material likely to be held. All procedures need to reflect a similar degree of security.

Particularly vulnerable areas of quarantine facility rooms/buildings need biologically-secure structural designs, and procedures include: specialized doors, non-opening windows, appropriate air vents and drains, and sealed light fittings. The materials of ceilings, floors, walls, and all joints should be impervious without crevices where organisms can lodge. All surfaces should be capable of being decontaminated. Facilities should have contingency procedures to contain escapes within the facility or emergency action taken if something is detected outside a facility in close proximity.

Traceability

Traceability is critical to control and rectification of problems. It requires the ability to track goods backwards to the point of origin or likely area(s) of contamination, and any subsequent points where the contaminated goods may have released unwanted organisms. This includes knowledge of the source and country of origin or production of the goods, where they entered the country, and their subsequent fate and destinations. If there is an incursion, this information can assist in enabling the implementation of containment controls, and in preventing further introductions. Components of tracking systems often have to have regulatory and administrative elements to ensure compliance.

Disposal of hazardous waste

Disposal of hazardous waste requires the ability to prevent a potential invasive species escaping. Hence the need to have a system that enables the safe disposal of quarantine wastes. It is preferable that the waste is not transported over long distances as this is a vulnerable point in the system and introduces factors that increase biosecurity/quarantine risk.

Procedures and work instructions

These should describe how to check identity of goods and organisms; check the exterior of conveyances for contamination; examine goods and organisms for contaminants, parasites, disease. They need to include information about all of the data collection required.

Box 1.2 Some of the tools and equipment for general bench inspections

Inspections are undertaken in many situations. In general a large quantity of commercial goods (or a sample taken from a container of goods) or personal goods involve examination at the border on a bench or table. However, other situations include inspections in ship holds, aircraft holds, of animals in holding areas, or field inspections prior to entry. The following is a guide to tools and equipment to enable adequate bench inspections. Some of these tools and equipment are used in other forms of inspection—all require adequate lighting for inspection of goods.

- Inspection bench dimensions (for one-person work area): height 900mm, width 1 metre and length 2 metres; with an impervious, white surface. The bench should be sturdy, level, and stable, and have adequate fluorescent lighting along the entire length. The surface of the bench should lend itself to easy cleaning and sterilization where necessary. Power outlets should be located in close proximity to the inspection bench to enable the use of microscopes and supplementary lighting.
- Microscope (binocular dissecting microscope with a minimum magnification of 30×)—if possible mounted on a flexible arm to enable greater access to material to be inspected.
- Microscope light (preferable cold light—however, need to consider ability to obtain replacement lamps).
- Tweezers/forceps (fine).
- Specimen jars or tubes for collection of samples in a range of sizes e.g. 30mL, 60mL, 100mL with some of larger size—the jars or tubes need to be leak-proof and not be affected by the preservation fluid. There should also be the ability to apply some form of labelling; this could be comprised of a label written with alcohol (preservation fluid) -proof pen inserted into the tube with the specimens or an external label applied to the jar/tube such that it will remain attached without the writing being affected by the preservation fluid.
- Preserving medium (often 70% ethanol) with appropriate handling facilities if preserving fluids are toxic.
- Capacity to kill samples or specimens effectively and efficiently where necessary, such as access to a freezer (−18°C or below) or other methods.
- Sealable plastic bags for material preserved by sealing or needing to be sent off-site for further diagnostic examination or testing (it is preferable the material is a non-viable state).
- Brushes (fine bristle or camel-hair brushes size 00 for collecting very small organisms; larger size 15 or 20 for brushing down items to detect specimens).
- Hand lens/magnifier (for example, folding 10× and 20×).

- Magilamp (magnifying lens at least 4× with associated lighting) on adjustable arm.
- Sheets of white paper (for disposal after each inspection) or large white trays on which to work.
- Large flat, white inspection trays.

1.5.3 Emergency actions

Knowing how to respond if an invasive species is detected can minimize the impact that the species has on an area and maximize the potential to control or eradicate it. Hence the development of *contingency response plans* should be part of the overall risk assessment process. Contingency plans can be developed as overall generic plans with supporting documents for specific situations.

Organisms are usually detected after the national border via systems of inspection (including regular inspection of fields by farmers), surveillance, monitoring, or sample testing. Systems need to be in place to enable effective and efficient reporting of the incident to the persons responsible for initiating control actions. The options that are available on detection of an invasive species are: emergency management to prevent establishment; containment; eradication; or no action.

It is useful to undertake full-scale exercises/simulations on a theoretical or potentially real invasive species threat to: test the ability of the functionality of the components of a system; train personnel as to their roles and responsibilities in the event of a real detection of a pest/invasive species; and make necessary adjustments should they be found not to be effective or practical. The overall management of an incident must focus on the outcome(s) and ensure that that procedures and processes support the effective and efficient achievement of that outcome. To this end, a response plan should contain an explanation of why these actions are needed and the goals that are desirable to achieve. It should identify the individuals responsible for particular activities, and the regulations that enable these activities. It should clearly state at what point the response plan will be activated. The response plan should also:

- Detail the scope of the actions, work plan, and lines of communication and expected interactions between whom, and when, or at what points in a incident.
- Detail the hierarchy of reporting, and information flow, and define the types of documentation needed through all stages of the incursion.
- Identify the resources and equipment required to execute the plan and who/which organizations are to provide them (this includes technical advice and support).
- Define the types and numbers of personnel needed and allow for appropriate rotation of personnel to avoid fatigue.

- Include the training schedules for all staff, and records of the training undertaken.
- Stakeholders need to be identified and their responsibilities stated where appropriate.
- As the response progresses a large amount of information will accumulate and the plan needs to detail its management.
- There needs to be mechanisms for review and assessment of the plan, both during an incident and following an incident. The plan itself should state how and when changes are to be implemented.

A minimum set of (at least generic) equipment should always be accessible and available—otherwise delays to the initiation of actions may occur.

Administrative support for emergency actions is essential for efficient functioning of the plan and it is useful to identify the following: who is going to provide the administrative support for the process; what degree of confidentiality is required of the personnel involved in response; what potential conflicts of interest could arise. As part of the overall plan it should contain strategies of how, when, and why stand down of actions should occur. Triggers for stand down could include:

- Eradication of the invasive species has been achieved as per pre-agreed definition of level on non-detection.
- A move into a containment phase.
- Or, if neither eradication nor containment are achievable with resources available, then move to management of the invasive organism as it spreads.

Such plans should be developed taking into account a country's or authority's capacity to take actions, including the ability to make and enforce exclusion zones; carry out treatments, and elimination or species—these could be because of legal limitations, resource limitations, or physical (environmental) barriers to undertaking actions. There is no single way of doing this, and authority to undertake actions can vary between states, provinces, or regions within national borders.

An example that provides guidance on overall structure of documentation and possible processes can be found in AS ISO 10013–2003 (Australian Standard on Guidelines for quality management system documentation). The plans that have been based on this structure are Aquavet (<http://www.daff.gov.au>), Plant plan (<http://www.planthealthaustralia.gov.au>), and Ausvetplan (<http://www.animalhealthaustralia.gov.au>). The following is a brief summary of stages of a response:

- Investigation phase—determine if there is a possible problem.
- Alert phase—provide concerned parties with information that a potential situation exists.
- Activation—initial meeting/communication of all decision makers as per contingency plan; summaries of information of current situation; prognosis for immediate and long term provided; clarification of objectives of response plan; execution of actions as per plan; coordination of plan; communication of incident.
- Stand down—response concluded as per plan, review of plan, incident, and actions.

1.6 Summary

Organisms can be introduced into an area many times, but never become established or invasive, yet for others a single event is all that is needed. The establishment of an invasive species is therefore the end point of a combination of many coinciding events and conditions.

Islands that are isolated by significant stretches of water (sea) and areas isolated by significant biological or geographic barriers, such as deserts, have distinct advantages in their ability to control the entry of terrestrial invasive organisms. Under such circumstances the prevention of entry of invasive species can be a realistic option. However, where there is limited or no biological or geographic isolation then to have a system totally focused on the prevention of the entry of invasive species is fraught with practical difficulties. Under such circumstances, prevention in combination with other strategies, such as very good early detection and management systems, are more likely to lead to a more robust system that lowers the number of invasive species establishing and becoming problematical. This combination of strategies implemented in both non-biologically isolated and biologically isolated areas will provide the greatest opportunity to minimize the impacts of species that do enter. Measures that involve early detection, with contingency plans for eradication/containment of invasive species that can be efficiently implemented, are more likely to have a higher cost/benefit outcome.

The same situation exists for aquatic or marine invasive species—where there are significant biological barriers or isolation, there is the potential to develop workable quarantine measures. However, complicating factors in aquatic systems are that there is little biological separation when water is the vector and by practices such as the discharge of ballast water by vessels and the fouling of hulls of vessels. A history of invasiveness and patterns for specific species in the Pacific region can be found on the PIERS database for the Pacific region (<http://www.hear.org/pier/index.html>).

Invasive species occur in most taxa, a few examples of species in various taxa and broad categories of introduction are given in this chapter. Table 1.1 summarizes general problematic organisms associated with broad categories.

Table 1.1 Summary of potential quarantine issues associated with organisms.

Organism type	State	Potential quarantine/ invasive issues
Terrestrial plants	Live	<ul style="list-style-type: none"> • Invertebrate pests • Diseases • Weed potential • (Soil associated with plants carry further risks)
	Dried foliar (non-viable)	<ul style="list-style-type: none"> • Disease
	Dried stem (or thicker	<ul style="list-style-type: none"> • Diseases
	plant parts)—non-viable	<ul style="list-style-type: none"> • Invertebrate pests

Table 1.1 (Con't.)

Organism type	State	Potential quarantine/ invasive issues
Aquatic plants	Seeds	<ul style="list-style-type: none"> • Weed potential • Diseases • Invertebrate pests—particularly insects
	Live	<ul style="list-style-type: none"> • Invertebrate pests • Diseases • Weed potential
	Dried foliar (non-viable)	<ul style="list-style-type: none"> • Diseases
	Dried stem (or thicker plant parts) non-viable	<ul style="list-style-type: none"> • Diseases
Terrestrial and aquatic invertebrates	Seeds	<ul style="list-style-type: none"> • Invertebrate pests • Diseases • Invertebrate pests • Weed potential
	Live	<ul style="list-style-type: none"> • Pest potential • Diseases • Parasites
Terrestrial and aquatic vertebrates	Dried/dead (non-viable)	<ul style="list-style-type: none"> • Stored product pests • Diseases
	Live	<ul style="list-style-type: none"> • Pest potential • Diseases • Parasites
Fungi	Dried/dead (non-viable)	<ul style="list-style-type: none"> • Diseases • Stored product pests
	Live	<ul style="list-style-type: none"> • Invertebrate pests • Parasites (other fungi and diseases) • Spores—propagative material—invasiveness potential of species • Hyperparasites
Biological control agents	Dried (non-viable)	<ul style="list-style-type: none"> • Invertebrate pests • Parasites (other fungi and diseases) • Spores—propagative material—invasiveness potential of species
		<ul style="list-style-type: none"> • Potentially all types of organisms—hence issues associated with all other organism
Bacteria		<ul style="list-style-type: none"> • Contaminants
Viruses		<ul style="list-style-type: none"> • Contaminants

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