Module 6

ERADICATION

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Module 6: Eradication

6 ERADICATION

Objectives of this module:
- Define eradication
- Explain when and where eradication is the preferred management option
- Give the requisite conditions for a successful eradication
- Describe the basic principles and key steps of an eradication

6.1 Definition of eradication

Characteristics that define eradication are:

- Eradication is only achieved when the last individual has been removed
- Eradication involves high initial costs, but negligible subsequent costs
- Where eradication is feasible, it is usually the preferred management option - in association with on-going prevention activities

“Eradication” is a precise term – not to be confused with “control”, which involves reducing the numbers or containing an IAS so that its impacts are within acceptable limits (see Module 7).

Eradication is about achieving desired outcomes – such as species recovery or ecosystem restoration. Eradication is not “an end” in itself.

6.2 Requirements for eradication

Three conditions MUST be met if an eradication programme is to succeed:

1. Every individual of the target IAS must be put at risk
2. IAS must be removed faster than they breed
3. Re-invasion risks must be effectively zero
6.2.1 Putting the whole IAS population at risk

By definition eradication involves removing all individuals of a targeted population. This means the techniques employed must put all individuals in that population at risk. Where established populations are involved this will take careful planning and execution.

To be certain that all individuals are put at risk it is often necessary to use several techniques at once – or sequentially. This is most likely when eradicating a species that has different life stages (e.g. eggs, larvae and adults), and particularly when those life stages occupy different habitats.

Since plants produce seeds, putting all individuals of a targeted weed population at risk at any one time is very difficult. Seeds may continue to germinate and grow for many years after an initial eradication operation. This is why weeds which have established populations are so hard to eradicate in a single operation. A combination of methods may be required to remove seeds and seedlings, as well as adult plants. Ongoing surveillance to detect and remove seedlings will also be necessary.

As important as putting all targeted individuals at risk is the need to ensure non-target species are not exposed to unacceptable risks as a result of the eradication operation. Accidentally eradicating native species or endangering human life or health during the course of an IAS eradication is considered unacceptable.

6.2.2 Removing individuals faster than they breed

Eradication or sustainable harvesting?
The objective of any eradication operation is to lower the targeted IAS population to zero as quickly as possible. This is cost-effective, but has a second benefit: it reduces the number of individuals reproducing during the programme. Because offspring may not be exposed to eradication measures, a programme must continue beyond the time when the last juvenile could have reached the point where it is exposed to the eradication technique(s).

Reproductive rates of well-established IAS (especially mammals) tend to increase as an eradication proceeds and their population declines. In other words, the faster they are removed, the faster they breed. It is therefore not sufficient to know what the breeding rates are before eradication begins: this must be monitored and assessed during the course of the eradication program. For example, goats targeted for eradication on Raou l Island, New Zealand doubled their breeding rate as their densities decreased during the
eradication project. Hunting effort was intensified later in this operation to ensure that the mortality rate exceeded the recruitment rate.

The more that is known about the ecology of an IAS, the better are the chances of a successful eradication. Understanding the reproductive behaviour and breeding strategies of IAS is a pre-requisite for meeting this condition. It is also important to know what the population size of the IAS is. This is especially true if mechanical removal techniques are planned. Without a good understanding of numbers of individuals, it is not possible to plan the minimum removal rate required to ensure that individuals are being removed faster than they reproduce.

**Activity 6.1**

Very few plants or marine species have ever been successfully eradicated. Draw up a list of the attributes of plants and marine species that make them difficult to eradicate.

**6.2.3 Ensuring re-invasion is not a risk**

Eradication operations are very intensive and can be relatively expensive. To be justified there must be a reasonable prospect that the site will remain free of the eradicated IAS – at least for the foreseeable future. While there is always some risk of re-invasion, this must be as low as possible

The appropriate way to manage re-invasion risks is to recognise them at the outset, develop an understanding of the dispersal abilities of the IAS – and its pathways, and to put in place appropriate preventative quarantine and contingency measures.

**6.2.4 Other important factors**

Other important factors that must be taken into consideration when planning an eradication are:

- Involving only field operators who are committed to the eradication. It is when targeted IAS are at very low densities that operator commitment is most important. For example, South African hunters eradicating cats on Marion Island (in the subantarctic) spent the last three years of the project without finding a single cat. This was necessary to ensure that the eradication was successful.

- Designing an eradication operation so that it succeeds at first attempt. Failure to achieve eradication can have important implications,
including an immediate resurgence in the targeted IAS, and the presence of individual IAS which are "sensitised" to eradication methods (trap-shy, wary of people, resistant to poisons, etc). Failure can also lead to a lack of public confidence and diminished institutional or public support. In contrast, success may lead to significant ecological, social and economic outcomes, and will probably also lead to greater support for eradication elsewhere.

- It is important that monitoring is put in place to detect longer term changes so that prompt and appropriate responses may be taken. Monitoring and associated research are important for learning more about the implications of eradications and about how ecosystems function.

- Consistent and appropriate support from stakeholders - including those responsible for the operation overall, and funders. Unexpected issues are the norm in ecological management. Funding agencies, for example, should be prepared to consider applications for additional funds – or to extend the scope of the project in order to accommodate unforeseen circumstances. Planning for contingencies should begin at the outset of the project, not when budgets have already been assigned and spent!

6.3 When is eradication appropriate?

Following initial containment of a new incursion, eradication is the preferred option. The probability of carrying out a successful eradication is highest before the IAS population becomes too widespread and the reproduction rate increases too dramatically (See Figure 6.1).
The most appropriate time for an eradication to occur is during the lag phase of the invasion process. The further along the x-axis an eradication commences, the lower the likelihood of success.

Eradication is clearly the preferred objective when even very low IAS impacts cannot be tolerated. For example, if the presence of only one or two individuals of a disease vector constitutes an unacceptable risk then eradicating them is the preferred option.

By removing the IAS, its impacts, or at least some of them, are usually also removed. Thus an eradication will generally lead to important positive outcomes from the point of view of management objectives. Where mammals such as goats and rats have been eradicated from islands, for example, threatened species have recovered and some aspects of their ecosystems restored. Apart from benefits to biodiversity, eradicating IAS can also result in major economic benefits such as improved crop yields, or reduced health risks. Eradications allow the significant financial and environmental costs of on-going control operations to be avoided.

Setting goals, objectives and control measures and reporting on these are important activities in any eradication operation. These activities are covered in Module 2.

There are many important issues to consider in deciding when to proceed with eradication. At a strategic (regional or national) level such issues could include:

6.3.1 Desired outcomes for the site
Eradicating IAS is not the “end-point”, or goal, in itself. Having a site free from the impacts of one or more IAS so that desired outcomes, such as species recovered or crop yields enhanced, is the management goal behind an eradication. The desired outcomes can include ecological, social and economic factors. Restoration or rehabilitation activities should therefore be included in the eradication plan.

6.3.2 Priorities for managing this IAS
As knowledge of the impacts of IAS grows – along with the recognition that everything cannot be managed, setting priorities for managing specific IAS becomes important. For example, it might be best to prioritise managing IAS which are having or are expected to have significant impacts. It may also be necessary to prioritise eradicating species for which tried-and-tested techniques exist.

6.3.3 Available information on the target IAS
Key requirements in designing an eradication operation include previous research (such as on the breeding and feeding behaviour of the targeted IAS)
and similar projects previously undertaken elsewhere from which information is available about techniques, results and outcomes. While every eradication project is different, having such information to support decision making can give greater confidence that things are being done correctly.

### 6.3.4 Cost/benefit analysis

While significant benefits can be anticipated, a number of specific requirements must be met if eradication is to be achieved. Risks and costs associated with meeting these requirements – and in sustaining benefits will need to be carefully evaluated. Module 3 dealt extensively with risk assessments, and a cost-benefit analysis should form part of the risk assessment process for deciding on the most appropriate management option for and IAS.

### 6.4 Where is eradication likely to succeed?

**Activity 6.2**

The vast majority of successful eradactions have taken place on islands. Draw up a list if characteristics that make eradinations likely to succeed there and less likely to succeed elsewhere.

The majority of successful eradations have taken place on islands. The major reason for this is because island populations are so constrained that it is possible to put every single individual at risk virtually simultaneously. For most mainland situations, this will only be possible in the early stages of an IAS incursion.

However, there are many “insular” systems, or ecosystems that have well-defined boundaries that act as effective barriers to dispersal for the IAS. Islands need not be true islands surrounded by water. They can be islands of natural habitat reserves surrounded by a “sea” of agricultural land which serves to effectively isolate the reserve. Unless a mainland site is insular (such as a lake, mountain range or patch of habitat surrounded by agriculture) the options for eradicating are extremely limited.

A second reason behind the success of island eradactions is the relative ease with which islands can be quarantined from new propagules. There are very few opportunities for IAS to reach islands naturally, and imposing regulations has been hugely successful in limiting human-vectored dispersal.
Figure 6.2. Himalayan Tahr (*Hemitragus jemlahicus*)

In the 1930s a few Himalayan tahr escaped from a zoo on the slopes of Table Mountain. They established themselves on the mountain with their numbers peaking at about 600 in the mid 1970s. Their feeding and trampling cause extensive damage to the area’s rich endemic plant life and increases in erosion levels. This led to the initiation of a culling campaign in 1973.

This has now been expanded into a full-scale eradication programme. The eradication programme has a high chance of success for the following reasons:

- It is widely supported, including by animal-rights institutions
- Eradication of all individuals is achievable
- The target population is small and geographically isolated
- Control techniques are available
- There is a strong will to succeed on behalf of the proponents.

However, there is a vocal group of animal rights activists who oppose the eradication and have set up a lobby group “Friends of the Tahr”. They are attempting to derail the eradication by means of legal arguments and a strong public relations campaign.

Eradication is most likely to succeed when the entire IAS population is contained within a well-defined area

6.5 Feasibility assessment

The feasibility of an eradication programme will depend on ecological, logistical and social factors. Decisions to proceed with an eradication programme should be based on information about its ecological appropriateness, its logistical achievability and declared support from key stakeholders and management agencies. Feasibility assessments should be directed at addressing these issues to the satisfaction of those making decisions.
6.5.1 Ecological factors
Information on the following ecological issues will be required in order to be confident that the pre-requisites for success are met:

- The minimum viable population of the IAS. This determines the management objective
- Whether or not the IAS is still in the lag phase, or the population has begun to expand rapidly
- The dispersal ability of the IAS. Species with good dispersal abilities (e.g., birds or plants with wind-dispersed seeds) are generally more difficult to eradicate and are more likely to re-invade
- The reproductive rate of the IAS. Given that the rate of removal must exceed the IAS’ potential to breed, knowing this rate is critical
- Home range, distribution and habitat use patterns of the targeted IAS are also useful in designing an appropriate strategy
- Knowledge of social behaviours, such as territoriality and site fidelity, is useful if there is the possibility that dominant individuals could prevent subordinates gaining access to baits or traps, thereby preventing all individuals from being put at risk
- An understanding of seasonal variability can also facilitate better planning. For example, weeds may be more susceptible to sprays in periods of rapid growth, and animals may not consume toxic bait when alternative foods are plentiful.

6.5.2 Logistics
Once the techniques which can be used have been identified and ecological information obtained about the IAS, the time needed to achieve eradication can be estimated based on the predicted removal rate. Physical attributes of the site – including access to it, its terrain and vegetation will have a strong bearing on logistics. An important part of the planning for any eradication is gaining good information on physical features and developing strategies so that all parts of the site can be properly treated.

6.5.3 Social factors
An important requirement for any eradication is that legal frameworks are in place and that the agency responsible for undertaking the operation has the capacity to undertake the task. Inadequate institutional support is one of the most common reasons for IAS management projects failing to meet their objectives.

All proposed sites will have people who have a “stake” in what is being planned for the area. It is important to establish a dialogue with key stakeholders and to engage them in the planning process so that their views are properly acknowledged. The feasibility assessment process must identify all the issues and objectively evaluate their importance and how they can be managed.
Eradications can be controversial and may attract considerable public opposition. A proposed eradication of the American grey squirrel (*Sciurus carolinensis*) in Italy was abandoned following opposition by animal rights groups who won a legal battle with wildlife conservation agencies. As pointed out earlier, the attempt to eradicate the Himalayan tahr from Table Mountain attracted strong opposition from animal rights activists. Such opposition can jeopardise the success (and even the start) of an eradication operation.

*Figure 6.3. Decision-tree for an eradication programme*
Box 6.1: Revisiting decisions as technology improves

It is important to note that if an eradication programme is decided against, the option should be revisited from time to time, as conditions change. For example, in 1978 New Zealand experts considered eradicating rodents from islands over 100 ha impossible, yet by 1983, islands over 1000 ha were successfully cleared!

6.6 Planning eradications at the ecosystem level

Successful eradications can lead to significant benefits for native/endemic species. However, without sufficient planning, an eradication can have unexpected and unwanted impacts on native species and ecosystems. Undesired effects can result from eradications when IAS populations are well established, because ecosystems are complex and multiple IAS in a system can interact in unpredictable ways. When one IAS is removed, the effect on the remaining IAS may be both large and negative (for the environment). A classic example is the eradication of an invasive herbivore, which then leads to increases in invasive plant populations, with associated impacts.

In a system with an invasive predator and native and invasive prey, the eradication of the invasive prey species can lead to increased levels of predation on native species. Also, some native species may come to rely on alien plants for their existence. Eradication of those plant species could therefore cause the unintentional eradication of the native species! Clearly, while there is a need to continue developing and applying effective eradication methodologies, eradications need to be considered in the context of the overall ecosystem that is being managed. Ideally, there should be both: (1) pre-eradication assessment, to tailor removal to avoid unwanted ecological effects; and (2) post-removal assessment of eradication effects, on both the target species and the invaded ecosystem.

Planning an eradication based on a thorough understanding of the role of an IAS in the ecosystem will help prevent unexpected consequences after the eradication

Eradication methods

There are a huge number of techniques that have been used to successfully eradicate IAS. Deciding which to use will be dependent on many things, including the type of IAS, the nature of the site, the political and social environment and capacity. There is a high risk of failure if an untested method is used. Choosing the right combination of methods, their timing, and the people to apply them will be critical to the success of the eradication.
Eradication techniques fall into three general categories: mechanical, chemical and biological.

### 6.6.1 Mechanical
Mechanical methods include trapping, shooting, fencing for temporary containment and hand removal. For weeds, mechanical methods include cutting and hand-pulling – usually associated with removal or burning, as well as mechanised approaches including chainsaws, brushcutters and harvesters.

**Advantages:**
- Can be more species specific than other methods. The risks of non-target effects are usually low/negligible
- Most appropriate when dealing with individual IAS
- Can be essential when “down to the last few”, and broader-scale approaches are not effective or efficient
- Labour-intensive, which can be a means of job-creation

**Disadvantages:**
- Mechanical techniques are labour-intensive and thus relatively expensive – not desirable in many countries
- Mechanical methods are generally not practicable at remote, large or steep sites

### 6.6.2 Chemical
Chemical control involves using pesticides, herbicides or poison bait. The application of toxic chemicals has been the key to many successful IAS eradications.

**Advantages:**
- Often less labour intensive, and therefore cheaper
- Larger areas can often be covered in a shorter amount of time than with biological or mechanical methods

**Disadvantages:**
- There are widespread environmental and public health concerns about the use of chemicals
- Repeated use can result in the target species building resistance to the chemicals
- Can involve high costs
- Often considerable non-target risks
6.6.3 Biological

Biological control, or bio-control is the use of biological mechanisms to reduce the numbers of IAS. Biological control can be used against all types of IAS – including vertebrates, plant pathogens, weeds and invertebrates. (More details can be found in Module 7).

By its very nature biological control cannot achieve eradication on its own. Predator-prey and pathogen-host dynamics preclude the bio-control agent from completely destroying the IAS, which is its only resource base. However, bio-control can be used to reduce IAS numbers in conjunction with other methods as part of eradication programmes. For example, disease can be used to achieve an “initial knock-down” of a targeted IAS when it occurs at high densities. Follow-up (with mechanical and/or chemical methods) is then used to achieve eradication.

<table>
<thead>
<tr>
<th>Advantages:</th>
<th>Disadvantages:</th>
</tr>
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<tbody>
<tr>
<td>• Species-specific, when properly designed</td>
<td>• Requires more planning and more intensive initial management</td>
</tr>
<tr>
<td>• Generally involves less environmental risks compared to other approaches</td>
<td>• Requires greater understanding of the target IAS target and the system where it is to be applied</td>
</tr>
<tr>
<td></td>
<td>• Poses risks of bio-control agents becoming invasive themselves</td>
</tr>
<tr>
<td></td>
<td>• The impacts on the IAS often take longer to achieve</td>
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Whatever eradication technique is employed, it is essential to establish appropriate monitoring so that the effectiveness of each technique can be assessed as the eradication proceeds, along with anticipated changes in native species which are being affected by the IAS.

Eradications are most likely to succeed when a suite of methods is employed. Relying on only one method can be risky. In choosing eradication methods, the following procedures should be followed:

- Identify what methods could work
- Establish what methods have been used elsewhere
- Determine the opportunities and constraints of each method (e.g. will local people support the use of toxins?)
- Test and adapt likely methods - including different combinations (e.g. when eradicating rabbits, use toxins or disease to achieve a "rapid knock-down", followed by trapping and hunting using trained dogs)

6.7 Measuring change

At a fairly fundamental level, a reason for undertaking an eradication programme is to induce change (in this case, restore or rehabilitate the ecosystem). The changes include not only the “disappearance” of the targeted IAS, but also consequential changes in the environment and benefits to people. It is these responses or “desired outcomes” which justify the effort and costs of eradication. Any eradication operation should therefore measure progress towards removing the targeted IAS, as well as changes in environmental attributes that are expected to change.

6.7.1 What should be monitored?
Monitoring involves repeatedly measuring specific things in a standardised way in order to answer important questions. In eradication operations, the most important question is “When can the eradication operation be stopped?”, or put another way, “When have all target individuals been removed?”. The monitoring program must specifically set out to answer this question.

Since plant eradications can seldom be regarded as ‘successful’ until many years after the last live plant is removed, long-term monitoring and surveillance must be part of the overall strategy.

Other important questions concern the progress being made towards the eradication objective. Provided the ecology and behaviour of the targeted IAS is reasonably well understood, appropriate monitoring which will show whether things are progressing according to schedule.

6.7.2 Benefits of monitoring
Monitoring programmes are not only important for the sake of the eradication programme. They are necessary to be able to demonstrate in rational, quantifiable and understandable ways, to funders and other stakeholders, the ultimate costs and benefits of the programme.

Monitoring the outcomes of an eradication is as important as monitoring the progress of an eradication itself.
6.8 Key points of this module

- Eradication is the complete removal of a population of a targeted IAS in a set area within a defined timeframe

- Eradication involves high initial costs, but negligible subsequent costs

- Before an eradication plan can be executed, the following conditions must be met in the plan:
  - All individuals of the target species must be put at risk
  - IAS must be removed faster than they breed
  - Re-invasion risks must be effectively zero

- Eradication is most likely to succeed when the entire IAS population is 100% contained, either early on in the invasion or in an insular system

- Planning an eradication based on a thorough understanding of the role of an IAS in the ecosystem will help prevent unexpected consequences after the eradication

- Monitoring the outcomes of an eradication is as important as monitoring the progress of an eradication itself