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Review of non-native species policy

Report of the working group

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Introduction

When non-native species become invasive they can transform ecosystems, and threaten native and endangered species. All terrestrial and marine natural and semi-natural habitats are affected. Invasive non-native species also damage economic interests, such as agriculture, forestry and infrastructure, and can threaten public health. Thus the problems caused by invasive non-native species are serious; so serious that the introduction of invasive non-native species is identified as one of the main causes of biodiversity loss worldwide. This includes the loss of the distinctive local biodiversity that makes each area special. With increasing global trade and world travel, these problems are likely to continue to grow.

The United Kingdom has international obligations to address invasive non-native species issues, principally the Convention on Biological Diversity (CBD) and including the International Plant Protection Convention (IPPC), the Bern Convention on Conservation of European Wildlife and Habitats and the EC Habitats Directive. The sixth CBD Conference adopted a series of Guiding Principles for States to take into account in when developing their policies.

Defra set up a Review Group in March 2001 to review policy and legislation on non-native species throughout Great Britain[1]. This is the report and recommendations of that Group. The CBD Guiding Principles have been taken into account in this report and are reflected in its recommendations.

This report recognises that many non-native species do not become *invasive* nor cause problems. Many non-native species provide considerable benefits to society, for example as agricultural, horticultural and forestry crops, or in the pet industry. The recommendations therefore aim to address the threats posed by *invasive* non-native species without hindering legitimate activities. The Review Group also accepted that the natural ranges of many species will change in future, and this needs to be recognised in policy development.

Key recommendations

The Review Group considered current arrangements for dealing with the introduction, establishment and spread of non-native species, and assessed the main pathways through which non-native species are introduced and spread. The report makes eight key **recommendations** to improve measures to limit the ecological and economic impact of invasive non-native species in Great Britain. More detailed recommendations are included in the main body of the report.

The key recommendations follow the three-stage hierarchical approach proposed by the CBD Guiding principles. This approach emphasises that measures to prevent introduction of invasive non-native species are generally far more cost-effective and environmentally desirable than measures taken following their introduction and establishment.

[1] The terms of reference and membership of the Review are in Annex 1 and 3 respectively.

- The first stage is to give priority to measures to prevent introductions of invasive non-native species.
- The second stage concerns detection of newly-introduced invasive non-native species and, where appropriate, rapid action to prevent their establishment.
- The third stage concerns longer-term mitigation measures, such as containment or control, for established invasive non-native species.

It is essential that the approach is prioritised to address the most serious threats. It is also acknowledged that some long-established non-native species are valued by society and are here to stay.

To accord with the CBD guiding principles, the rationale for future policies dealing with invasive non-native species should be developed using the precautionary approach. This assists in balancing the freedom and rights of individuals and organisations with the need to reduce the risk of adverse effects to the environment or other interests.

Responsibility for non-native species issues

Responsibility for non–native species is spread across several Government Departments and agencies. There is no single contact point and, although a variety of statutory powers and non-statutory measures exist to address non-native species issues these are unco-ordinated and focus on individual sectors.

The Review Group believes that the lack of a co-ordinating body in Government is the greatest constraint to drawing up effective, coherent policies to address invasive non-native species issues. The Review's Terms of Reference specifically acknowledge the need for co-ordination. It is necessary to focus the political responsibility for this issue by designating or creating a single lead co-ordinating organisation. Even though environmental policy is devolved, the nature of the issue is such that the Review Group strongly recommend that the lead co-ordinating organisation has a Great Britain-wide remit.

Specific expertise already exists within a range of organisations. The challenge will be to marshal and develop that expertise, and target efforts and resources towards agreed priorities. The co-ordinating body should liaise with all the relevant sectors (within and outwith Government), and provide advice on implementing appropriate measures. The Group is aware of the Cabinet Office study into Government structures and functions to tackle the illegal import of products of animal origin, non-animal origin (food), trade in endangered species, plants and plant products and non-native species. The Group considers that there are clear linkages between invasive non-native species issues and animal and wildlife disease issues and suggests that the Government should assess the opportunities for synergy with any other new biosecurity initiatives.

- **Key Recommendation 1: The Government should designate or create a single lead co-ordinating organisation to undertake the role of co-ordinating and ensuring consistency of application of non-native species policies across Government.**

Prevention measures

Introductions of many non-native species into Great Britain are regulated by licensing arrangements under the Wildlife and Countryside Act 1981 and other legislation (*e.g.*, Plant Health legislation, the Import of Live Fish Act 1980). All intentional introductions to the wild should be subject to proper consideration of the issues and specific consents (improvements in the coverage of plants are proposed in Key Recommendation 5). To enable this, satisfactory risk assessment procedures are required.

Many introduced non-native species do not become invasive and action must be targeted towards species likely to cause problems, based on thorough, transparent risk analyses. This should include impact assessment, cost estimation and cost-benefit analyses to agreed criteria (economic, biodiversity, social, animal welfare, animal and human health considerations). These analyses should provide criteria from which to prioritise actions for different species. Risk assessment procedures should identify potential problem species (*i.e.* those not yet introduced into Great Britain or a part of it) and will target and prioritise preventative action. They should also inform management decisions when invasive non-native species are discovered to be present in the wild. These procedures must be robust, so action taken is justifiable and widely accepted.

The internationally accepted risk assessment procedures used for plant health under the International Plant Protection Convention could form the basis for non-native risk assessment procedures.

- **Key Recommendation 2: Develop comprehensive, accepted risk assessment procedures to assess the risks posed by non-native species and identifying and prioritising prevention action.**

Codes of conduct

In addition to intentional introductions, many introductions of non-native species arise unintentionally as the result of legitimate activities, and preventative action to reduce these is needed. The group identified a number of different pathways by which non-native species can be introduced unintentionally into Great Britain.

Some of these pathways are already the subject of action, such as the International Maritime Organization's work to address the introduction of non-native species in ballast water. It is recommended that codes of conduct or best practice be drawn up with stakeholders in relevant sectors, to prevent introductions. Risk assessment procedures will be useful in prioritising areas for action. Codes of conduct can be adapted to specific industries or pathways and are relatively easy to update and amend. They should be given a statutory underpinning. It is recommended that codes of conduct be developed to address all relevant intentional and unintentional introduction pathways.

- **Key Recommendation 3: Develop codes of conduct to help prevent introductions for all relevant sectors in a participative fashion involving all relevant stakeholders.**

Raising awareness

Many problems posed by invasive non-native species stem from a lack of public, commercial and institutional understanding of the legislation prohibiting their release, and of the costs and consequences of their establishment. Better information and education, and improved public awareness of these issues are therefore all required. This should take account of translocation of native species outside their natural range within Great Britain, which can also become invasive. This approach should help to prevent problems arising and increase the public acceptance of measures taken to address existing problems. Management of invasive non-native species and eradication programmes are more likely to succeed if supported by an informed and co-operative public. Reducing the number of inadvertent introductions will allow agencies to concentrate on more productive actions, such as supporting codes of conduct. Different approaches will be needed to reach different audiences, for example, the general public, enforcement agencies, industries and trade professionals, conservation groups, scientists and policy makers.

- **Key Recommendation 4: Develop a targeted education and awareness strategy involving all relevant sectors.**

Existing legislation provides many of the powers required to implement an effective policy for invasive non-native species. However, there are specific areas where the existing legislation is inadequate to address the problems posed by invasive non-native species and this requires revision.

Key areas to improve prevention measures include improvements to Section 14 of the Wildlife and Countryside Act 1981, to rationalise the treatment of plants and animals and to enable the more regular update of Schedule 9 to ensure that problem species are included. A statutory basis for the codes of conduct set out in Key Recommendation 3 is also recommended.

Non-native bird species are afforded protection under the Wildlife and Countryside Act 1981, along with native species, due to the broad definition of wild birds used in that Act. This impedes management of invasive non-native bird species and these provisions should be revised, or a licensing solution found.

Fines for criminal offences in respect of invasive non-native species are very low in comparison to the potential costs of damage, control and repair. These remedial costs are typically met by the taxpayer, or the interests affected. The Review Group suggests that the level of fines available does not constitute a deterrent and recommends that where a release constitutes a criminal offence or wilful negligence then the "polluter pays" principle should be available, *i.e.* courts should be able to impose fines bearing some relation to the cost of reparation.

The statutory framework could also be revised to assist the capacity to undertake mitigation measures. Powers of compulsory access to undertake management or eradication of problem species are provided under some existing legislation, *e.g.* the Destructive Imported Animals Act 1932. However, there is no general provision in respect of non-native species, which would enable emergency control of a newly-discovered non-native species before it becomes firmly established and much more difficult and expensive to remove.

- **Key Recommendation 5: Revise and update existing legislation to improve handling of invasive non-native species issues.**

Detection and capacity for mitigation action

To detect and control non-native species, it is necessary to have sound information on their numbers and distribution. Surveillance at points of entry and in the wild is needed to inform management and control decisions. An enormous amount of wildlife monitoring is undertaken in Great Britain, although there are few nationwide arrangements specifically aimed at non-native species. Many existing national and local monitoring schemes provide some information about non-native species or could be adapted to do so. However, there are many gaps and improvements are required.

- **Key Recommendation 6: Establish adequate monitoring and surveillance arrangements for non-native species in Great Britain.**

Where non-native species are detected there must be the capacity to undertake management or eradication of invasive non-native species. This applies equally to newly-discovered and more established invasive non-native species. A structured approach must be developed to assess the impact and management of individual species. Control should not be the automatic response; this would be prohibitively expensive and publicly unacceptable. The policy should accommodate a range of options from acceptance of that species' presence and future review, through mitigation such as containment or control, to eradication. Such arrangements should make use of the capacity of existing organisations. The current capacity for action is greatest in those areas where economic interests are threatened, and least where biodiversity is threatened. A contingency capacity is needed to deal with newly-discovered non-native species to prevent them from becoming established.

- **Key Recommendation 7: Policies should be established with respect to management and control of invasive non-native species currently present or newly-arrived in the wild, and operational capacity be developed to implement these policies.**

Key Recommendation 4 will also support these measures, in terms of public acceptability of control and encouraging detection and reporting of non-native species. Key Recommendation 5 is also relevant, *e.g.* to enable access to land in order to undertake control operations.

Other supporting measures

Invasive non-native species are an international problem and the Government should continue to work though international mechanisms to address the issues and to contribute through information sharing. These include the Convention on Biological Diversity, the International Plant Protection Convention, the Bern Convention, the work of the International Maritime Organization and the International Civil Aviation Organisation, and the European Commission's consideration of how EC Wildlife Trade Regulations might address invasive non-native species issues.

Implementation of recommendations

It is essential that stakeholders are fully engaged in the development of policies and actions to address invasive non-native species. This should include all those who have an interest; such as conservationists, the wildlife trade, agriculture and horticulture, scientists, and animal welfare bodies. A consultative forum must meet regularly, to develop good understanding of the issues, and to ensure that the relevant sectors become engaged. Its remit should include consultation on policy issues, assisting with development of codes of conduct and assisting with public education and awareness work.

- **Key recommendation 8: Stakeholders should be fully consulted and engaged in development of invasive non-native species policies and actions through a mechanism such as a consultative forum.**

These key recommendations will require adequate funding if they are to be effective. This funding will need to be met from improved use and targeting of existing resources combined with some enhancement of resources in the areas of co-ordination and the development of monitoring, risk assessment and control measures.

Progress in addressing invasive non-native species issues must be maintained and the Review Group recommends that Government reviews progress towards meeting these recommendations after five years.

1.1 Introduction

Biological diversity faces many threats throughout the world. One of the primary threats to native biological diversity is biological invasions caused by invasive non-native species. The impacts of invasive non-native species are very serious and, on a global scale, may be as damaging to native species and ecosystems as the loss and degradation of habitats (CBD & IUCN (2002)).

Before the growth of human populations, the natural barriers of oceans, mountains, rivers and deserts provided the isolation essential for unique species and ecosystems to evolve. These barriers have been overcome by human activities that have combined to help species travel vast distances to new habitats, where they are removed from their co-evolved predators, competitors or other factors that control their abundance and distribution, and become invasive non-native species. The globalisation and growth in the volume of trade and tourism provide more opportunities than ever before for species to be spread accidentally or deliberately. Customs and quarantine practices, developed previously to guard against human and economic diseases and pests, are often inadequate safeguards against species that threaten native biodiversity. Thus the inadvertent ending of millions of years of biological isolation has created major ongoing problems that affect many countries.

In a local context, biodiversity has particular importance in giving distinctive character to an area whether it be chalk downland, estuary, woodland or mountain. Even in towns and cities, oases of wildlife habitat make an important contribution to the quality of life. However, the world is losing biodiversity at an ever-increasing rate as a result of human activities, with many species and habitats in danger of disappearing, especially at the local level, thereby risking the loss of the distinctive local character that makes each area special and unique.

Non-native species do not necessarily become established when they are introduced to a new ecosystem, and only a small proportion go on to become invasive and cause problems. However, when they do become established and invasive, the scope of biological non-native invasions is global and serious, in both ecological and economic terms. Invasive non-native species are found in all taxonomic groups: they include introduced viruses, bacteria, fungi, algae, mosses, ferns, higher plants, invertebrates, fish, amphibians, reptiles, birds and mammals. They have invaded and affected native biota in virtually every ecosystem type on Earth. The World Conservation Union (IUCN) estimates that hundreds of extinctions have been caused by invasive non-native species. The ecological cost is the irretrievable loss of native species and ecosystems, including loss of characteristic local distinctiveness.

In addition, the direct economic costs of invasive non-native species is likely to run into many billions of pounds annually. For example, invasive non-native animals such as grey squirrels and muntjac deer cause damage to agriculture and forestry, invasive non-native plants degrade catchment areas and freshwater ecosystems creating flood hazards; pests and pathogens of crops and forests reduce yields and increase control costs and so on. The discharge of ballast water together with hull fouling has led to unplanned and unwanted introductions of harmful aquatic organisms, including diseases, bacteria and viruses, in marine and freshwater systems.

For example, well-known invasive non-native species that have caused problems in Great Britain include: Japanese knotweed (crowds out native flora and impacts on other wildlife such as insects, causes problems in respect of flood management and damage to property, even growing through tarmac); American mink (a voracious predator that has had serious impacts on the declining native population of water voles); signal crayfish (has seriously impacted on the native globally-threatened white-clawed crayfish through spread of disease); Chinese mitten crab (damages flood management measures by burrowing in estuarine banks); Zebra mussel (smothers native bivalves and causes fouling of pipes resulting in costs for industry) and grey squirrel (major damage to forestry and has completely displaced the native red squirrel from most of England and Wales).

More detailed case studies demonstrating particular issues are included within this report. The case studies illustrate different species groups causing problems and different introduction pathways, and also some of the costs associated with invasive non-native species.

Species that are native to one part of a country can also become invasive if they are introduced to an area, such as an island, beyond its natural range. An example of this is the introduction of hedgehogs into the Outer Hebrides, an area where they have not historically been present and are causing serious conservation problems by predating on eggs of ground-nesting birds. Evolutionary isolated ecosystems such as island ecosystems can be particularly vulnerable to invasion by non-native species.

In contrast to these costs, many non-native species also give considerable benefits, both social and economic. For example, benefits can be accrued through the use of non-native species in activities such as agriculture (most commercial species are non-native species or genotypes), horticulture, forestry, ornamental wildlife collections, game-rearing, the pet industry, fisheries, mariculture and other sectors. It is worth bearing in mind that a large proportion of non-native species do not cause problems and action therefore needs to focus on addressing those species which are invasive. It is also acknowledged that many long-established non-native species are valued by society and are here to stay, for example those plants termed as archaeophytes (*i.e.* plants introduced by humans before 1500 such as the poppy).

The implications for biodiversity conservation make a compelling case for the need for action. If Britain does not take sufficient action, it shall suffer both economic, cultural and spiritual loss. Moreover, we shall hand on to our successors a planet which is markedly poorer than the one we were privileged to inherit. There is therefore a need for practical and proportionate policies to address effectively the threat posed by **invasive** non-native species. In the past, there has been a poor appreciation of the potential magnitude and economic costs of the problem. International agreements, primarily the CBD, require States to take action to address these threats. The Government has recognised the significance of this issue and commissioned this review of invasive non-native species policy.

Invasive non-native species present in Great Britain have historically been introduced by all sectors including government agencies, conservation groups, animal rights groups, industry and members of the public. Decisions that led to species introduction and distribution in the past were generally made in line with the custom and practice of the time. Few, if any, were introduced with the deliberate intention of causing harm to native biodiversity or other interests. The responsibility for introducing invasive non-native species is therefore shared across many sectors.

It is also the case that the impacts and costs are spread across many sectors. Overall costs to Britain currently caused by invasive non-native species are extremely difficult to quantify as the costs often arise from *ad hoc* action on a local basis and are spread over many different sectors from central and local government, and statutory agencies through to business, NGOs, landowners and managers, and the general public. However, the costs are considerable in both financial and biodiversity terms.

A glossary of terms is given at Annex 4.

CASE STUDY: Japanese knotweed *(Fallopia japonica)*

Category of introduction: intentional (imported deliberately for horticulture), but also released accidentally, at least in part.

Reason(s) for introduction: Japanese knotweed, and its related species and hybrids, were highly valued as ornamental garden plants from the mid-nineteenth century and were imported for the horticultural trade. Japanese knotweed has also been planted to stabilise spoil heaps and banks.

Pathway for the introduction: importation of plants by the horticultural trade from China and Japan.

Problems caused by the introduction: Japanese knotweed creates a vigorous monoculture of canes which grows densely and excludes the vast majority of British flora, with subsequent impacts to the associated fauna. It can colonise most habitats and is regarded as a troublesome pest in many parts of the country because of its rapid invasion and domination of habitats. It appears to have no natural enemies in Britain and is difficult and expensive to control. In addition to affecting native biodiversity, the species also causes problems in terms of flood management. It increases the risk of riverbank erosion when the dense growth of the plant dies back in the autumn exposing bare soil and can also create a flooding hazard if the dead stems are washed into the streams clogging up the channel.

Japanese knotweed can also damage property, for example by growing through tarmac or even the floors of houses, and therefore needs to be cleared from development sites. To prevent its further spread Japanese knotweed, and soil contaminated with it, is treated as controlled waste. The development industry is currently suffering considerable expense from Japanese knotweed management on brownfield sites, which are often severely infested.

Legislation exists to prevent further spread by human activities (including that it must be treated as controlled waste) but the species is now well established in the wild and is expanding its range as shown by Figure 1 which shows the increase in number of 10km squares where the species has been recorded since 1960. The actual area of infestation is unknown.

Japanese knotweed is difficult and expensive to control using current techniques. Assuming 0.5% of the total land area of Britain may be affected by Japanese Knotweed =1200 km^2 (and this is likely to be an underestimate), the cost of control is approximately **£1.56 billion**.

Trevor Renals ©

Native bluebells and other woodland flora can be swamped by Japanese knotweed.

Figure 1: **Spread of Japanese knotweed: 10-km squares in which the species was first recorded before 1960 are shown in light green; 10-km squares in which the species was first recorded after 1960 are shown in dark green.**

Data source: Vascular Plant Database, collated for the New Atlas of British and Irish Flora.

1.2 Nature and extent of the issue

When introduced into new environments, invasive non-native species can affect native species in a number of ways: for example by direct predation (such as American mink preying on water voles); including herbivory (such as muntjac deer affecting bluebells); competition for resources (food and territories); habitat alteration or degradation (*e.g. Crassula helmsii* shading out native plants,); spread of disease (*e.g.* crayfish plague, Dutch elm disease and perhaps the decline of red squirrels); and loss of species through hybridisation (such as between native red deer and introduced sika deer). The problem is largely as a result of, or exacerbated by, the absence of natural enemies, such as predators, pests and diseases, which prevent species being invasive in their native habitats.

The majority of non-native species which are introduced have little impact on native species but a small fraction have caused major problems. Great Britain has perhaps been fortunate that to date only a minority of non-native species established in the country have caused serious problems. Williamson (2002) estimated that, as a rough rule-of-thumb for British invaders, for every 100 imported plants, only 10% become casuals, and of these casuals only 10% become established and self-sustaining and of these only 10% actually go on and become invasive pests. Of course this a crude assessment and does not take into account different life strategies and the varied vulnerability of habitats to invasion, but it is a satisfactory rule of thumb that begins to give some perspective to the scale of the problem. It is therefore a minority of species which cause problems but predicting which species will become invasive is fraught with difficulty.

There is little evidence that non-native species have so far caused extinctions in Great Britain, as has happened in other countries. It has been suggested that British ecosystems are, in general, less susceptible than those which have evolved on isolated islands or continents, for example because Britain is larger and/or less biologically diverse than most tropical or sub-tropical islands where severe impacts have occurred. However, there are invasive non-native species that have caused considerable problems such as local extinctions of species such as red squirrels from most of England and Wales. Further examples are given in case studies throughout the report.

The appropriate response to non-native species will need to remain flexible, as predicted changes in climate may increase the risk of invasive non-native species becoming established in Great Britain, especially if such changes stress habitats and make them more vulnerable to invasion (Gregory *et al* (2001)). A whole range of factors cause climate changes across Europe, and in most instances it would be inappropriate (and probably impractical) to prevent range changes resulting from climate change occurring.

CASE STUDY: Grey squirrel *(Sciurus carolinensis)*

Category of introduction: intentional.

Reason(s) for introduction: recreational and aesthetic (probably the desire to see what was regarded as a harmless and attractive squirrel resident in Britain).

Pathway for the introduction: adults imported to Britain from North America and deliberately released.

Background to the introduction: at the time of the introductions to Britain (late nineteenth to early twentieth century) there was less knowledge of the possible harm likely to result from releasing non-native mammals. At this time, the movement of plants and animals around the world was regarded favourably by many people. There was a perception that non-native species were welcome exotic enhancements to familiar native flora and fauna, rather than potential problem species.

Problems caused by the introduction: The grey squirrel is a long-established invasive non-native species which has impacted significantly on native wildlife and also causes significant economic damage. Following introduction, grey squirrels spread rapidly in the lowlands and are now common throughout most of England and Wales and southern Scotland, displacing the native red squirrel *(Sciurus vulgaris)*. They are still absent from parts of north-eastern and north-western England, a few parts of Wales and much of highland Scotland. Their spread has everywhere been accompanied by a reduction in numbers of the red squirrel. Competition between the two species is thought to be one factor in this but recent research has suggested that the grey squirrel may act as a carrier for a virus disease (parapox) to which red squirrels are extremely susceptible. Extinction of the red squirrel in England and Wales is a likelihood in the foreseeable future, although it is more secure in Scotland.

The decline of the native red squirrel is the most serious conservation damage caused by the spread of grey squirrels. However they also cause significant economic damage to tree crops by stripping bark from a wide range of broadleaved and coniferous species. The risk of severe damage may discourage landowners from planting broadleaved trees in parts of Britain and this hinders achievement of government objectives for expanding the area of native woodland in the lowlands.

Grey squirrel damage to woodlands is a cause of major concern to landowners. The Forestry Commission has made various estimates of the loss of timber value to British forests. This is a difficult process because damage is cumulative and accurate data scarce. A 1999 study calculated losses in revenue in state-owned forests in England and Wales as £2m at the end of a rotation. In 2000, a GB-wide study put the total cost to the British timber industry of damage to beech, sycamore and oak as £10 million at the end of the current rotation (both studies assumed the worst-case scenario that damaged timber had no value).

Currently, the control of impacts can only be achieved through controlling the squirrel population by killing animals. Public acceptability needs to be considered in respect of methods of control of mammals and other techniques have been investigated. Experimentation with immuno-contraception has given disappointing results after a promising start. Methods of damage limitation by silviculture or habitat manipulation are either impractical or remain aspirational.

Grey squirrels are well established in most of England, Wales and southern Scotland, and have also colonised many urban areas. As far as woodlands are concerned, the grey squirrel is probably the most damaging non-native species that Britain have had to contend with. It seems certain that Britain will have to continue to live with it.

Forestry Commission ©

Native red squirrel: Populations of red squirrel in the UK have suffered markedly over the last 50 years with the introduced grey squirrel (Sciurus carolinensis) replacing the species throughout most of England and Wales. Reds are usually displaced within 15 years of the arrival of greys.

The costs of invasive non-native species can be considered in a variety of different ways. There are the costs of preventing their entry into the country, of monitoring and licensing those already present, the damage they cause to economic activities and, harder to quantify, the damage to biodiversity. Management also has particular costs, either for containment or eradication. Lastly, it should not be overlooked that many non-native species have benefits for biodiversity and the economy.

No estimates of the total costs in Britain are available. Total costs exist for other countries, for instance a Cornell University report for the US Department of Agriculture's, Animal and Plant Health Inspection Service estimates costs of $138 billion annually for damage, control programmes and research projects (www.aphis.usda.gov/oa/invasive/invasive.html).

1.3 The current regulatory framework

At present, the responsibilities for dealing with non–native species issues are spread across different Government Departments and Agencies. There is a variety of statutory powers under different legislation and also non-statutory measures in place to address invasive non-native species problems. However, these are unco-ordinated and tend to focus on individual sectors. This sectoral approach has evolved over time as different Government Departments and Agencies took action in their respective policy areas to address particular threats specific to those areas. The control measures are most developed where invasive non-native species affect economic interests.

There are a large number of international instruments and much European and domestic legislation dealing with non-native species issues. There are as many as twenty-nine domestic Acts, Orders and Regulations which have relevance to non-native species. Often these instruments consider non-native species only indirectly, for example, in terms of preventing economic damage.

Perhaps the most important international instrument is the Convention on Biological Diversity (CBD). This Convention requires contracting parties (of which there are 184), as far as possible and as appropriate, to prevent the introduction of, control or eradicate, those alien (*i.e.* non-native) species which threaten ecosystems, habitats or species. The CBD has done much to provide an over-arching international framework for action, including the development of a set of guiding principles, considered in further detail in Chapter 2. A number of other international conventions and agreements, for example, the Bern Convention, address non-native species to some extent, although they can be rather general in nature.

The main areas of relevant European Union legislation include the EC Habitats Directive, the EC Birds Directive, the EC Wildlife Trade Regulations, the EC Plant Health Directive, and the Forest Reproductive Material Directive.

EC Habitats Directive – this Directive requires Member States to regulate deliberate introductions of non-native species so as not to prejudice natural habitats or wild native fauna and flora, where necessary prohibiting such introductions. In Great Britain, this is transposed into domestic legislation by Section 14 of the Wildlife and Countryside Act 1981.

EC Birds Directive – this Directive contains similar provisions in respect of prohibiting introductions of species of birds, also transposed by Section 14 of the Wildlife and Countryside Act 1981.

EC Wildlife Trade Regulations – these Regulations implement the Convention on International Trade in Endangered Species (CITES) within the EU. The Regulations also contain provisions in Article 4(6)(d) to regulate import and sale of species which present an ecological threat to native species. These provisions are not widely used and currently prohibit import of two invasive non-native species.

EC Plant Health Directive – this Directive guards against import of organisms such as pests, parasites and diseases. The EC Forest Reproductive Material Directive can allow restrictions on use of specific imported provenances of regulated tree species (to avoid use of problematic non-native genotypes).

In addition there is a large body of legislation on animal health relating to farmed animals, relevant to import of animals, animal products, pathogens and carriers of animal pathogens. Although there are some similar issues, this falls outside the remit of this review and has not been considered.

The main piece of domestic legislation regulating the release of non-native species in Great Britain is Section 14 of the Wildlife and Countryside Act 1981. Under Section 14(1) of this Act it is an offence to "release or cause to escape into the wild" any animal which:

a) is of a kind which is not ordinarily resident in and is not a regular visitor to Great Britain the wild state; or

b) is included in Schedule 9 Part I (this includes established invasive non-native species of birds and other animals).

Under Section 14(2) of the Act, it is an offence to "plant or otherwise cause to grow in the wild" any plant listed on Schedule 9 Part II (which includes some species of established invasive non-native plants).

There is therefore a general prohibition on the introduction of all non-native animal species, but only for specified plant species. In addition, fungi, lichens and micro-organisms are not covered. Releases do not have to be deliberate or intentional to be prohibited, although Section 14(3) provides a defence if the defendant can show that all reasonable steps were taken and all due diligence exercised to avoid committing an offence.

Guidance issued by the Government states that, in addition to releases into the open environment, "releases or allows to escape into the wild" should be taken to include semi-confined situations, such as greenhouses, because animals can and often will escape from such situations. Under the 1981 Act, licences can be granted giving exemptions from Section 14. The penalties available to the courts for Section 14 offences have been recently increased to include custodial sentences of up to two years.

However, this legislation is considered to have been largely ineffective in preventing further introductions and is difficult to enforce. There have been very few successful prosecutions. This has been partly because of the difficulty in interpreting the legislation, (for example, there is no definition of "the wild") and partly because many introductions are likely to be unintentional or accidental, and may be covered by the defence at Section 14(3). Furthermore, in itself it does little to address the problems posed by invasive non-native species which have already become established in this country.

There is a variety of other domestic legislation which has relevance to aspects of the non-native species issue. This legislative framework has developed on an *ad hoc* basis over the years. Most of it is not intended to address the over-arching issue of invasive non-native species but rather to protect specific sectors or interests. As a result the legislative framework is rather incoherent and inconsistent, with some areas such as plant health having a relatively sophisticated regime in place and other areas less so. The legislation, with varying degrees of relevance, includes the Import of Live Fish Act 1980, the Import of Live Fish (Scotland) Act 1978, the Destructive Imported Animals Act 1932, the Zoo Licensing Act 1981 and the Deer Act 1991.

Local authorities also have some relevant powers. Section 215 of the Town and Country Planning Act 1990 provides local authorities with a discretionary power to require landowners to clean up 'land adversely affecting the amenity of the neighbourhood' which could be relevant to control of invasive non-native species such as Japanese knotweed. Local authorities also have the power to undertake clean-up works themselves under Section 215 and to recover costs from the landowner. The decision whether to take action in individual cases is a matter for the local authority concerned, which will need to take into account all the local circumstances. Also, the Local Government Act 2000 introduced a broad enabling power for local authorities to promote the economic, social or environmental well-being of their area. It would be relevant in allowing local authorities to spend money on invasive non-native species if they chose to do so.

Further details of the legislative review undertaken on behalf of the Review Group can be found in *Review of Non-native species legislation and guidance*, Fasham and Trumper, 2001, Defra.

In reaching its conclusions, the Review Group has had regard to the outcomes of the 6th Conference of Parties of the Convention on Biological Diversity (CBD). The CBD is the world's largest international conservation agreement with 184 contracting parties. Article 8(h) of the CBD places obligations on contracting parties to take action in respect of invasive non-native (or "alien") species. It states:

"Each Contracting Party shall, as far as possible and as appropriate prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species."

The CBD has been considering implementation of Article 8(h) and the 6th Conference agreed a set of Guiding Principles on invasive non-native species. While each country faces unique challenges and will need to develop context-specific solutions, the Guiding Principles provide clear direction and recommend an overall approach. They can be found on the CBD's website (http://www.biodiv.org).

2.1 The CBD three-stage hierarchical approach

The CBD Guiding Principles set out a three-stage hierarchical approach to address the issue of invasive non-native species. The Review Group has adopted this overall approach.

The three-stage hierarchical approach proposed by the CBD Guiding principles is summarised as follows:

- The first stage is to give priority to measures to prevent introductions of invasive non-native species.
- The second stage concerns detection of newly-introduced invasive non-native species and, where appropriate, rapid action to prevent their establishment.
- The third stage concerns longer-term mitigation measures, such as containment or control, for established invasive non-native species.

The first stage is prevention. Preventing introduction of invasive non-native species is generally far more cost-effective and environmentally desirable than measures taken after the introduction and establishment of the species. Priority should therefore be given to preventing the introduction of invasive non-native species. The Review Group has considered the pathways by which non-native species may be introduced (both intentionally and unintentionally) and considered what action is necessary to improve prevention measures. The prevention measures recommended are set out in Chapter 4.

However, prevention measures will not always be successful and some invasive non-native species are already present. The second and third stages of the approach relate to detection of non-native species and the capacity to undertake mitigation measures. The second stage occurs where a new invasive non-native species, not currently known to be present, is detected and rapid action may be able to prevent its establishment. The third stage is where it has not been possible to prevent the establishment of an invasive non-native species, in which case it is necessary to consider mitigation measures. This could accommodate a range of management options from acceptance of that species presence and future review, through to mitigation measures such as containment, control or eradication.

To address the second and third stages, the Review Group has considered the surveillance requirements required to detect and monitor non-native species and also the current capacity to undertake mitigation measures. The measures recommended to improve detection of non-native species and the capacity to undertake mitigation measures are set out in Chapter 5.

2.2 Overarching principles – the precautionary approach and an ecosystem approach

2.2.1 Precautionary approach

In accordance with the Guiding Principles, the rationale for future policies should be developed in accordance with the precautionary approach, sometimes referred to as the precautionary principle.

The precautionary approach is a formal recognition of the act of being cautionary when making decisions. The precautionary approach is described in the preamble to the CBD and in Article 15 of the Rio Declaration.

Rio Declaration Principle 15:
"In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."

CBD preamble:
"Noting also where there is a threat of significant reduction or loss of biological diversity, lack of full scientific certainty should not be used as a reason for postponing measures to avoid or minimize such a threat."

Guiding Principle 1 on the Precautionary Approach then further describes it as it may relate to invasive non-native species. It states that:
"Efforts to identify and prevent unintentional introductions and decisions relating to intentional introductions should be based on the precautionary approach described in principle 15 of the Rio Declaration and in the CBD preamble.

Additionally, lack of scientific certainty about the various implications of an invasion should not be used for postponing or failing to take appropriate eradication, containment and control measures."

The precautionary approach is also referred to in the EC Treaty (where it is called the precautionary principle) for the purpose of protecting the environment. There is a detailed European Commission communication elaborating on the precautionary principle. This can be found on the Commission's web site: http://europa.eu.int/comm/dgs/health_consumer/library/pub/pub07_en.pdf

This document outlines the Commission's approach to the precautionary principle and acknowledges the difficulty in balancing the freedom and rights of individuals, industry and organisations with the need to reduce the risk of adverse effects to the environment and to find the correct balance so that proportionate, non-discriminatory, transparent and coherent actions can be taken.

Miscellaneous Recommendation 1:

The precautionary approach is fundamental to dealing with issues arising from invasive non-native species and should always be taken into account in policy development and decision-making.

2.2.2 Ecosystem approach

Although less fundamental to invasive non-native species issues than the precautionary approach, in accordance with the Guiding Principles, an ecosystem approach should be taken into account specifically in respect of decision-making on eradication, containment or control measures. It is set out in detail in Decision V/6 of the CBD, the preamble of which is reproduced below.

Preamble to CBD Decision V/6 – A description of an ecosystem approach

An ecosystem approach is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. Thus, the application of an ecosystem approach will help to reach a balance of the three objectives of the CBD: conservation; sustainable use; and the fair and equitable sharing of the benefits arising out of the utilization of genetic resources. An ecosystem approach is based on the application of appropriate scientific methodologies focused on levels of biological organization, which encompass the essential structure, processes, functions and interactions among organisms and their environment. It recognizes that humans, with their cultural diversity, are an integral component of many ecosystems.

This focus on structure, processes, functions and interactions is consistent with the definition of 'ecosystem' provided in Article 2 of the Convention on Biological Diversity: '"Ecosystem" means a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit.' This definition does not specify any particular spatial unit or scale, in contrast to the CBD definition of 'habitat'. Thus, the term 'ecosystem' does not, necessarily, correspond to the terms 'biome' or 'ecological zone', but can refer to any functioning unit at any scale. Indeed, the scale of analysis and action should be determined by the problem being addressed. It could, for example, be a grain of soil, a pond, a forest, a biome or the entire biosphere.

An ecosystem approach requires adaptive management to deal with the complex and dynamic nature of ecosystems and the absence of complete knowledge or understanding of their functioning. Ecosystem processes are often non-linear, and the outcome of such processes often shows time-lags. The result is discontinuities, leading to surprise and uncertainty. Management must be adaptive in order to be able to respond to such uncertainties and contain elements of 'learning-by-doing' or research feedback. Measures may need to be taken even when some cause-and-effect relationships are not yet fully established scientifically.

An ecosystem approach does not preclude other management and conservation approaches, such as biosphere reserves, protected areas, and single-species conservation programmes, as well as other approaches carried out under existing national policy and legislative frameworks, but could, rather, integrate all these approaches and other methodologies to deal with complex situations. There is no single way to implement an ecosystem approach, as it depends on local, provincial, national, regional or global conditions. Indeed, there are many ways in which ecosystem approaches may be used as the framework for delivering the objectives of the CBD in practice."

CBD Decision V/6 sets out a number of guiding principles on an ecosystem approach.

3.1 The case for a lead co-ordinating organisation

A wide range of activities can give rise to invasive non-native species problems and a wide range of interests can be affected. The issue therefore inherently cuts across many policy interests.

At present, the executive responsibilities for non–native species issues are devolved and administrative responsibilities are also spread across different Government Departments and Agencies in each part of Great Britain. There is a variety of statutory powers under different legislation and also non-statutory measures in place to address invasive non-native species problems. However, these are unco-ordinated and tend to focus on individual sectors. This sectoral approach has evolved over time as different Government sectors took action in their respective policy areas to address particular threats specific to those areas. The regimes are most developed where invasive non-native species affect economic interests. There is currently no single Government contact point or lead co-ordinating organisation.

The Review Group has considered the arrangements in place in the United States, New Zealand, Germany and Italy to see what lessons might be learnt (note: some new measures may have been taken in these countries since this work was carried out at the start of the review process in 2001). The arrangements in these countries are reviewed in a consultant's report to the Review Group, Review of Non-native species legislation and guidance, Fasham and Trumper, 2001, Defra. This covers various constitutional arrangements including federal states with powers devolved to the regions, analogous to Great Britain.

The issue has the highest priority in New Zealand where invasive non-native species are considered to be a grave threat to both the economy and the country's natural heritage. New Zealand has many endemic species which have developed in isolation and are therefore particularly vulnerable to introduction of new species. It is one of the countries most affected by invasive non-native species. In recent years it has developed one of the most extensive and well-integrated approaches on the basis of the three-stage hierarchical approach. The lead organisation is a Biosecurity Council, comprising representatives from the relevant Government departments which have invasive non-native species responsibilities. A Biosecurity Technical Forum provides the Council with technical and policy advice.

In the United States, there has been progress in recent years with the establishment of a National Invasive Species Council to oversee and co-ordinate the activities of all the federal agencies involved. The publication of a National Invasive Species Management Plan has laid the foundations for a much more co-ordinated and comprehensive approach to problems caused by invasive non-native species in the US. The Council is intended to provide national leadership on invasive species, oversee implementation of the work programme, ensure that Federal agency activities are co-ordinated, encourage planning at all levels in co-operation with stakeholders and existing organisations, develop recommendations for international co-operation, develop guidelines and co-ordinate monitoring and surveillance activities.

Germany and Italy, like the UK, currently have a fragmented, sectoral approach, with some areas, such as plant health, well covered but others, particularly threats to native biodiversity, much less so. This is perhaps partly because European countries either have not yet faced, or have yet to perceive, the same magnitude of costs arising from invasive non-native species as New Zealand and the United States.

This indicates the benefits of centrally co-ordinated policies, driven by a co-ordinating body, and the problems associated with a lack of co-ordination.

3.1.1 Review of existing organisational capabilities and responsibilities

This section reviews existing organisations undertaking management and control of established invasive non-native species, those with statutory responsibilities for control, and those undertaking research to directly support control. Environmental policy is a devolved matter, so Defra, the Welsh Assembly and the Scottish Executive each have policy responsibilities in England, Wales and Scotland respectively for the overarching issues of invasive non-native species and for the main legislation governing it (the Wildlife and Countryside Act 1981). Organisational details and summaries of activities are contained in Annex 10.

Existing organisations dealing with the control of invasive non-native species fall into three categories, those with legislative responsibilities including licensing; those providing research/technical support and advice; and those undertaking inspection/enforcement/ control activities. This model is most evident in the more mature areas where there are clear legislative responsibilities and international obligations. The Defra Plant Health Service provides such an example, including Defra Plant Health Division, Central Science Laboratory Plant Health Group together with the Defra Plant Health and Seeds Inspectorate which fulfil the policy, research and implementation roles respectively for England and Wales. This structure is reflected in Scotland by the devolved administration equivalent, comprising, SEERAD: Plants, Environment and Pollution Division, Plant Health: Plants, Horticulture & Potatoes, the Scottish Agriculture and Science Agency and the Agricultural Staff Group. Legislative frameworks and formal structures exist to support Plant Health with both national and international commitments to combat invasive non-native invertebrate pests and pathogens. A recent Economic Evaluation of the MAFF (now Defra) Plant Health Programme (available at http://www.defra.gov.uk/research/econeval/planth/index.htm) includes case study examples of both the costs of control together with the net social benefit of different plant health issues. These suggest cost-benefit ratios of between 3:1 and 30:1 for six example plant health case studies

Another example from an economically important area is provided by fish and shellfish and the Import of Live Fish regime, for which there are also structures in place to protect these interests. These established areas are motivated by economic concerns with biodiversity taking an increasing but secondary role. They are also limited to those species impacting on a particular interest.

The widest statutory responsibilities are carried by the three conservation agencies, English Nature (EN), Scottish Natural Heritage (SNH) and Countryside Council for Wales (CCW). Their responsibilities under the Wildlife and Countryside Act 1981 include the protection of biodiversity across all species groups and therefore all invasive non-native species. However, their role does not cover the economic or cultural impact of non-native species, nor a variety of related international agreements. In conjunction with the Joint Nature Conservation Committee (JNCC) they advise Government on which species should be listed on Schedule 9 of the Wildlife and Countryside Act 1981.

The research and technical support element is similarly fragmented, typically focussing on particular species groupings. A number of organisations have co-ordinated groups, for example the Institute of Arable Crop Research's Centre for Aquatic Plant Management, The Central Science Laboratory's Plant Health and Countryside Management Groups together with the Centre for Environment, Fisheries and Aquaculture Science (CEFAS) Fish Health and Freshwater Teams. However, a wide range of other organisations and Universities have expertise on particular species.

Inspection, enforcement and control activities are similarly mixed between species groups. Inspection and enforcement responsibilities are most apparent in those areas covering the protection of economic interests, for example the Plant Health & Seeds Inspectorate, The Forestry Commission's Inspection Service and the CEFAS Fish Health Inspectorate. In a number of other areas of primarily conservation interest there are often no identified organisations with responsibility for these activities. The statutory conservation agencies (EN, SNH, CCW, JNCC) have broad responsibilities for the protection of biodiversity across species groupings but no formal inspection or enforcement role. Where viable invasive non-native material may exist within waste material, the Environment Agency has an enforcement role in England and Wales under Sections 33 and 34 of the Environmental Protection Act 1990.

The control of invasive non-natives is again split along economic and species lines. There are established programmes, methods and criteria available to protect economic activities including plant and tree health and fish movements. These include both the control of established pests, but also the surveillance of species entering the country together with co-ordinated responses to prevent their establishment. This contrasts with the measures to protect biodiversity where species entering the country often receive protection from standing legislation and specific measures must be undertaken to demonstrate that they pose a threat before control can be initiated. For example, a non-native bird establishing itself in Great Britain after a release would receive protection under the Wildlife and Countryside Act 1981. As a consequence there is little work to prevent invasive non-native species that threaten biodiversity from establishing populations and most control is of established species that have already impacted on native biodiversity.

The nature of the different organisations undertaking control to protect biodiversity reflect the characteristics of the species concerned. For example, given the site-specific problems they cause, invasive non-native aquatic weeds are controlled by a wide variety of organisations and contractors. Invasive non-native birds and mammals are more mobile and control programmes for these typically contain a regional or national element requiring greater coordination.

Invasive non-native species do not, by definition, respect national or international boundaries. Coordination and a unified approach between national agencies within Great Britain is clearly required for effective management. Similarly, coordination between the United Kingdom and Republic of Ireland, with mainland Europe and beyond is required. A number of structures for European coordination already exist, for instance the Bern Convention and the European and Mediterranean Plant Protection Organisation (EPPO).

In summary, few organisations demonstrate capabilities or responsibilities across different species or economic groupings. While some areas, particularly those protecting economic activities, have mature legislative, support and control functions conducted by well-established organisations, others appear to have little established expertise or coordination. No single organisation has the existing capabilities to fulfil either the policy, research or implementation role for more than one or two species groupings although there is a considerable volume of expertise spread between existing organisations. There is no co-ordinating body to bring together interested parties, set priorities or standardise procedures.

3.1.2 Experience of other countries

A number of other countries have recently reviewed their approach to the invasive non-native species issue and established new legislative and administrative frameworks to deal with these issues. These provide a number of useful examples and frameworks for this country. Descriptions of the experiences of the United States and New Zealand are discussed in this chapter. Within Europe there are also a series of ongoing initiatives, for example the Bern Convention on the Conservation of European Wildlife and Natural Habitats has recently published a 'Contribution to a European Strategy on the Invasive Alien Species Issue (T-PVS (2001)12 Revised) (www.nature.coe.int/cp21/tpvs12rev.doc).

3.1.3 Conclusion

The legal status, inspection, research and management responsibilities for invasive non-native species are currently spread across a range of organisations on species and sectoral grounds. There is currently no one organisation with capacity or responsibility for dealing with invasive non-natives. Coordination is needed at the decision making level and in terms of management to make best use of existing sectoral capabilities and to fill identified gaps. While ensuring coordination, this should also take into account and accommodate existing capabilities and responsibilities. Existing capabilities also need to be extended to cover sectoral gaps and ensure a broad response capability.

The Review Group believes that the lack of adequate co-ordination of government functions is the greatest single weakness in drawing up effective and coherent policies to address invasive non-native species issues. Where many parties are involved in activities relating to non-native species, without sufficient co-ordination, these activities' effectiveness can be hindered by insufficient co-operation, prioritisation and information sharing unless there are clearly defined responsibilities.

The current piecemeal approach has resulted in inconsistency of approach and serious gaps in control and potentially inefficient duplication of effort. This could be addressed by seeking to improve co-ordination between agencies but it is recommended that it is necessary to focus the political responsibility for this issue by designating or creating a single lead co-ordinating organisation.

It is acknowledged that environmental policy is devolved. However, the nature of the issue is such that it is strongly recommended that the lead co-ordinating organisation has a remit for Great Britain. It is intended that the designated co-ordinating body will liaise with all the relevant sectors both within and without Government providing advice, ensuring a coherent approach, prioritising action and implementing appropriate measures.

The Review Group is aware of current work on exotic plant and animal diseases, such as the Illegal Imports Forum. The existing organisational structures in this policy area are complex and the Cabinet Office is undertaking a study into how the various parts of Government tackle the illegal import of products of animal origin, non-animal origin (food), trade in endangered species, plants and plant products and non-native species. It is recommended that the Government consider whether there are opportunities for synergy with other biosecurity initiatives arising from that initiative.

The options for better co-ordination between existing relevant organisations and sectors should be considered. The Review Group recommends that the best option is to focus the political responsibility for this issue by designating or creating a single lead co-ordinating organisation.

- **Key Recommendation 1: The Government should designate or create a single lead co-ordinating organisation to undertake the role of co-ordinating and ensuring consistency of application of non-native species policies across Government.**

One way to support improved co-ordination would be to convene an advisory committee with representatives of government, research, NGOs and industry to consider the protection of biodiversity, health and economic interests related to non-native species. An example of such a model is the Partnership for Action Against Wildlife Crime (PAW). Such a committee or forum could support a lead organisation and this idea of a stakeholder forum is developed further in Chapter 6.

3.2 Functions of a lead co-ordinating organisation

The Review Group has identified a series of functions that require better co-ordination and which could be undertaken by a lead co-ordinating organisation. This section briefly considers the main themes, including for completeness those that clearly fall to central government such as revision of legislation. These themes, and the supporting arguments, are fully considered and developed throughout this report rather than in this section.

Consideration of the functions to be undertaken will assist in devising the most appropriate format for such a body, or other mechanism to achieve the desired result. The Plant Health model provides one possible structure, with a policy component in the central government department, a scientific component and an implementation (including inspection and enforcement) component. Another model would be conservation policy with the policy component retained in the central government department, with statutory conservation agencies which undertake both the scientific and implementation components. The exact division of responsibilities functions between the different components would need to be determined in due course.

Clearly, devolution will also be a key issue in considering structures. Environmental policy is devolved and therefore one central government department alone cannot undertake the function as a lead co-ordinating organisation on a GB-basis.

3.2.1 Functions

The overarching function would be **co-ordination**; to liaise with all sectors with an interest in non-native species issues, both within and beyond government, ensuring provision of information and advice, coherence of cross-cutting areas and consistency of approach. It would provide a single point for provision of advice and information to all parts of government, industry, conservation, the public and other interests on all non-native species issues.

This role would also involve issues such as international information sharing on invasive non-native species and assisting in developing international information networks. Another important issue is ensuring a mechanism such as a forum for stakeholder engagement and consultation. Other specific functions to be undertaken are:

Risk assessment:

Once a risk assessment system has been developed setting common standards, undertaking of actual risk assessments will require the involvement of specialists in the specific species groups being considered. This is a scientific function.

Acting on risk assessments:

Prioritising the areas requiring action on the basis of risk assessments relating to non-native species and their introduction pathways would be a key task. It will be necessary to develop policies on the required actions on the basis of such risk assessments.

Codes of conduct:

Engagement with industry and other relevant sectors to develop Codes of Conduct to address threats from particular species or introduction pathways will be a key task.

Education and awareness strategy:

Development of a targeted education and awareness strategy, involving all the relevant sectors, will be a key task. This will need to operate on various levels from the general public to scientists to other relevant professionals.

Management/control of invasive non-native species:

Development of a structured decision-making process for control and management will be a key task. Once developed it will be necessary to implement this decision-making process, including making use of existing expertise and capacity by liaising with existing organisations. There is a need for capacity to undertake management to be further developed.

Revisions to legislation:

Developing proposals to revise legislation will clearly be a function for central government departments (including the devolved administrations in their respective areas), although advice from relevant sources may be instrumental in developing proposals.

Monitoring and surveillance:

The statutory conservation agencies are already the lead point for government on wildlife monitoring, are involved in a number of programmes covering different species groups and have links and contacts with monitoring and surveillance undertaken by NGOs. This role could be adapted better to address non-native species surveillance needs and the information fed back to inform the other work streams. This function should include monitoring the effectiveness of management strategies.

"Prevention is the first and least costly line of defence"

Global strategy on invasive alien species, 2001

The three-stage hierarchical approach sets out that measures to prevent introduction of invasive non-native species are generally far more cost-effective and environmentally desirable than measures taken following introduction and establishment of such species. Prevention is better than cure when dealing with troublesome invasive non-native species, in saving money lost through the depredations of invasive species, by reducing damage to characteristic native biodiversity and in reducing the costs of undertaking mitigation/control measures should an invasive non-native species become established. Increasing concerns over the use of pesticides and the withdrawal of treatments mean that prevention of pest invasions is increasingly necessary. This chapter sets outs the recommendations on improvements to prevention measures. Prevention measures should be considered to be the highest priority.

Prevention measures should be deployed in the most appropriate combination, as part of a national strategy for dealing with invasive non-native species. The Review Group has considered existing prevention arrangements, identified relevant introduction pathways and reached a series of recommendations for improvements. It is recommended that a combination of new codes of conduct and public education campaigns backed up by improved legislation and better surveillance, will be most effective in reducing the number of damaging invasive non-native species that become established here. The measures summarised in this report will need to be discussed more widely with those sectors concerned with non-native species issues. It is also essential that the measures suggested here are deployed in a consistent and co-ordinated way. Their implementation should be based upon the wise use of the precautionary approach, coupled with careful risk assessments. It is the view of the Review Group that the co-ordination necessary to deliver these measures will require clearer organisational responsibilities to be defined than has previously been the case in Great Britain.

CASE STUDY: Chinese mitten crab *(Eriocheir sinensis)* and Zebra mussel *(Driessena polymorpha)*

Category of introduction: unintentional.

Pathway for the introductions: likely to have been introduced unintentionally by ballast water transfer or hull fouling, introducing species to marine, estuarine and riverine environments.

Problems caused by the introductions: These species can both affect native species and cause economic damage.

The Chinese mitten crab *(Eriocheir sinensis)* is a native of East Asia, introduced into Europe in the 1930s. It is thought to have been transported to Britain in ships' ballast water (juvenile crabs and larvae) or perhaps by adult crabs clinging to ships' hulls. The species has six larval development stages and it is understood that for complete development the larvae need to migrate to the open sea. Dispersion of the species is assisted by the pelagic larvae and mobile adults. Adults live in freshwater migrating to river estuaries and coastal regions to breed.

Its distribution in Britain includes the Thames, Humber and Medway estuaries and numerous rivers. Factors influencing the distribution and spread of the Chinese mitten crab include currents taking the larvae along the coasts of Europe (Clare *et.al*., 1994). Chinese mitten crabs have been recorded all along the east coast of Britain but so far there are no records from the west coast.

The mitten crab is a voracious predator and many native species are thought to be threatened by the species, including threatened native crayfish populations. It also damages estuarine banks by burrowing and fishing nets by cutting mesh (Ingle, 1986). In high population densities it causes erosion of soft sediment banks and is therefore a cause for concern in terms of flood defence measures. In the Thames estuary, it has been found to aggregate in locations near warm water outflows.

A project is planned to provide bank protection in the Thames estuary as a consequence of mitten crab damage. This aim is to install hard defences rather than control of the species (costs are not yet available). It should be noted that such measures to remedy problems caused by an invasive alien species could affect other species using that habitat. Newcastle University is currently undertaking a project studying the spread of the species in North East England and possible management measures for controlling its breeding patterns.

Zebra mussels are native to the Black Sea and Caspian Sea basins. They were first reported in the British Isles in Surrey docks, London in 1824. By 1850 they had spread by canals and rivers over most of central England. Zebra mussels were first documented in Ireland in late 1996 and early 1997 in the Lower Erne and Lough Derg. Zebra mussels attach to hard surfaces including other bivalves and can rapidly reach high densities. It has a planktonic larval stage which can be present in the water column throughout the year.

Zebra mussels are filter feeders and in high densities will significantly reduce the phytoplankton and zooplankton levels, which may have a direct effect on fish populations in terms of decreased food availability for juvenile fish and increased predation due to greater water clarity. Zebra mussels also smother native freshwater urionid bivalves leading to decreases and removal of native bivalve populations (Ricciardi *et.al*, 1995, 1996, 1997). However, a particular concern is the extent to which the species causes fouling in pipes. In many instances this has resulted in major additional costs for industry (*e.g.* cooling water) and water supply agencies, requiring the installation of expensive filtration or sterilisation systems (Claudia & Mackie, 1994). No estimate is currently available with regard to cost implications for Britain.

Problems caused by species in marine or other aquatic environments can be particularly difficult to remedy. This demonstrates the importance of effective prevention measures to avoid introduction of new species by known introduction pathways, for example measures to avoid unintentional transfer of species with ballast water.

Adrian Bicknall ©

Measures are needed to prevent accidental introduction of non-native species, for example mitten crabs being accidentally introduced by means of ballast water exchange.

4.1 Overview of prevention measures

4.1.1 Summary of recommended prevention measures

The Review Group has considered the types of available prevention measures and developed a strategy to prevent problems from invasive non-native-species arising in the first place. The areas in which recommendations on prevention measures are made are as follows.

- Risk assessment (Chapter 4.2)
- Codes of best practice/conduct (Chapter 4.3)
- Public awareness and education (Chapter 4.4)
- Improvements to legislation, specifically prevention measures (Chapter 4.5)

Risk Assessment:

Following a thorough and transparent risk assessment, the success of any strategy crucially depends on the prioritisation and targeting of measures to manage invasive non-native species that are known, or are likely to cause significant economic or environmental problems. Those species that are considered to be of lower risk should continue to be monitored, and their status regularly reviewed. Risk analysis and assessment issues are covered in Chapter 4.2.

Policy, legislation and practice should adhere to the principle that prevention is the preferred option and warrants highest priority. Rapid action to prevent the introduction or spread of known problem species (whether intentionally or unintentionally introduced) needs to be undertaken even when there is significant scientific uncertainty about the long-term outcomes of a particular invasion. A comprehensive risk assessment of known pathways for the introduction of non-native species should be carried out for both intentional and unintentional introductions, with a parallel exercise to assess how both intentional and unintentional introductions may best be prevented.

Some examples are provided by the prevention case studies in this report. The risk assessments for known pathways should be used to inform the development of codes of conduct and legal mechanisms designed to prevent damaging introductions of invasive non-native species in future and to ensure quick action to tackle the introductions that do occur.

Codes of conduct: The Review Group places great emphasis upon reaching the optimum balance between using codes of conduct/incentives and legislation/enforcement to prevent the future establishment of damaging invasive non-native species in Britain. While there are some differences of view on the balance between adopting a regulatory rather than a voluntary approach to deal with a particular issue or problem, there is strong agreement that assessment of the prevention measures which should be adopted must be based on the best available judgement of what will work. Factors to be taken into account include (i) gaining the support of key groups through discussion and dialogue to reach agreement on contentious issues and (ii) ensuring legislation is implemented through effective surveillance and enforcement. In addition, there should be a clear understanding of the respective roles of voluntary and regulatory approaches and how they should work together. In each case, a precautionary approach should be adopted that is based upon consistent risk assessments for each pathway.

Having identified relevant introduction pathways, the Review Group recommends that codes of conduct or best practice need to be devised to remove the risk of unwanted introductions or reduce that risk to an acceptable level. All significant intentional and unintentional pathways should be covered by a code. These should be prepared in co-operation with all relevant stakeholders and should be used to define the standards of reasonable behaviour and the duty of care for owners or keepers of specimens to prevent those escapes that might cause problems.

Codes of conduct have a number of attractive features as they can be targeted to a specific industry or pathway and can incorporate recognised international standards, for example, Food and Agriculture Organisation (FAO) Aquaculture guidelines on the use and introduction of non-native species. Further discussion on Codes of conduct and recommendations are in Chapter 4.3.

Codes of conduct are preferable to import bans or other trade prohibitions which may have legal and practical limitations. The UK's international obligations as a member of the European Union and of the World Trade Organisation govern actions in respect of import and trade even where those actions might be seen as desirable in preventing the introduction of invasive non-native species. The EC Wildlife Trade Regulations include the provision to restrict the trade in, the holding or the movement of species known to constitute an ecological threat to indigenous native fauna and flora if they are introduced into the wild. Currently, restrictions on trade have only been established for two invasive non-native species under the EC Wildlife Trade Regulations, though trade in a large number of commodities which may harbour invasive non-native species are covered by the EC Plant Health Directive. Due to the growing recognition of the threat to global biodiversity posed by invasive non-native species, there is ongoing consideration at EU-level to determine how best to apply EC Wildlife Trade Regulations to assist in combating the threat posed by invasive non-native species. Controls on imports and sales might be appropriate methods to tackle the most serious risks where

codes of conduct are thought to be insufficient to prevent introductions of certain invasive non-native species by these pathways.

Public education and awareness: Many of the problems, both potential and actual, posed by invasive non-native species stem from a public and institutional ignorance of the costs and consequences of their establishment and of the law as it stands at the moment. Invasive non-native species have historically been introduced by all sectors including government, conservation groups, animal rights groups, industry and individuals. Decisions that led to species introduction and distribution were made in line with the custom and practice of the time. Few, if any, were introduced with the deliberate intention of causing harm to native biodiversity or other interests.

Better information, education and improved public awareness of these issues is therefore required by all sectors of society. This should be aimed at enabling everyone in all sectors to do the 'right thing'. Better information on, and heightened awareness of, the subject must be readily available to the general public, commercial and conservation interests as well as government officials and agencies (both at the policy and executive level). This approach will not only help to prevent problems arising in the first place but control and eradication programmes of problem species are more likely to be successful if supported by an informed and co-operative public. The issue of public education and awareness is covered in more detail in Chapter 4.4 which supports Key Recommendation 4 on developing a targeted public education and awareness strategy.

The aim of promoting awareness of the issues should be to achieve well-informed support for policies and this will in turn improve compliance. Reducing the number of inadvertent offenders will allow enforcement agencies to concentrate on the deliberate, repeat systematic offender. Different approaches will be needed to reach different audiences.

Improvements to legislation: Legislation has a key role to play in preventing introductions, through the control and regulation of the release and spread of invasive non-native species. The law is only as good as its enforcement, but current enforcement is hampered by ineffective legislation. There are a number of weaknesses in the current legal framework in Great Britain which means the law is hampered in addressing the threat posed to native fauna and flora, and other interests, from invasive non-native species. Recommendations to improve prevention measures are set out in Chapter 4.5.

4.1.2 Other prevention issues

Natural colonisation processes will continue within marine, freshwater and terrestrial environments, possibly assisted by climate change. It would be impossible to attempt to prevent such future colonisations, although it may be necessary to intervene to prevent some species becoming established (for example, invasive species such as the Indian house crow or geranium butterfly). It is necessary to recognise that the distribution of plants and animals changes naturally over time, that not all changes are harmful or undesirable and that attention should be concentrated upon adopting those prevention measures that will be effective at halting the human-induced arrival and spread of those invasive non-native species most at risk of causing major economic damage, severe health problems or losses of native characteristic biodiversity.

There are some special concerns regarding micro-organisms. While detailed consideration of measures to prevent the arrival and establishment of micro-organisms are beyond the remit of the Defra Review of Non-native Species Policy, there are some important aspects that the Review Group wishes to flag up. Micro-organisms are more difficult to detect and deal with than larger organisms, and their occurrence and distributions are very imperfectly known. However, they can be transported by the same pathways and vectors as other organisms, they occur in combination with other organisms (often within plants or animals as diseases) and they can cause major problems when they are translocated into Britain, as the recent outbreak of foot and mouth disease has shown. Therefore, it makes sense to consider briefly the consequences of adopting the prevention measures proposed in this report upon the future arrival of non-native micro-organisms.

Government commissioned a number of reports in the wake of the outbreak of foot and mouth disease (The Policy Commission on sustainable food and farming, the Royal Society Inquiry and the Lessons to be Learned Inquiry). The published reports concur that a key requirement must be to step up efforts to prevent the introduction of disease into the country. They recognise that the risk cannot be eliminated but it can be reduced. They make recommendations for a number of measures to be taken forward for preventing and deterring the entry of disease. These are encompassed in the Government's action plan to tackle illegal imports of products of animal origin and plants and was published on 28 March 2002 (www.defra.gov.uk/animalh/illegali/actionplan.pdf). These include:

- Commissioning a risk assessment, the results of which will help to inform decisions about priorities for deploying enforcement capability
- Increased public awareness through radio, TV and other outlets for showing public information videos, plus advisory literature, etc
- Improved intelligence gathering and sharing to assist anti-smuggling measures
- Improved co-ordination and co-operation with and among enforcement agencies
- Investigating the use of practical measures, *e.g.* a pilot study into the use of dogs to detect meat and fish carried in passengers' bags
- Better legislation
- Initiating discussions within Europe and the wider international community with a view to encouraging a uniform approach to tackling the issues.

The existing organisational structures are complex and the Cabinet Office is undertaking a study into how the various parts of Government tackle the illegal import of products of animal origin, non-animal origin (food), trade in endangered species, plants and plant products and non-native species.

There are links between preventing the establishment of animal diseases and the work programme proposed in this report and, at the conclusion of the Defra Review of Non-native Species Policy, it would be worthwhile considering how implementing the recommendations should be linked to dealing with non-native micro-organisms and disease control.

4.2 Risk assessment

Risk assessment procedures are employed in Britain for particular groups of non-native organisms, such as plant pests. However, for most non-native species, no risk assessments are undertaken, and the risks and consequences of the arrival and establishment of these species are not assessed, quantified or prioritised for remedial action. The Review Group therefore advocate the development of a universally-applicable risk assessment system, which can cover all non-native species, and consider the effects on receptor habitats and species.

This may be based on the existing schemes developed by European and Mediterranean Plant Protection Organisation (EPPO), which appear to us to be a valuable starting point. Such a scheme should apply to all taxa, regardless of their intended purpose (agriculture, horticulture, forestry or fisheries for example), and regardless of whether the release into the environment is intended or accidental. The Review Group offer seven detailed recommendations to address this area. These are aimed at supporting Key Recommendation 2:

- **Key Recommendation 2: Develop comprehensive risk assessment procedures to assess the risks posed by non-native species and identifying and prioritising areas for other prevention action.**

The aim should be to use risk assessments to develop a list of problem species for priority action, whether prevention or mitigation. Information identifying problem species and strains should be made readily available to all sectors. A definitive list of invasive non-native problem species should be developed, maintained, updated and made publicly available. Chapter 4.5 also considers the development of a list of non-native species that have not previously caused problems when introduced into Britain, or to other countries with similar climatic and ecological conditions (especially western Europe).

Jonathan Briggs ©

High densities of Zebra mussels smothering the native swan mussel.

CASE STUDY: Crayfish plague (Disease caused by the fungus *Aphanomyces astaci*)

Category of introduction: unintentional, but the direct consequence of poorly considered deliberate releases.

Reason(s) for introduction: the disease was accidentally introduced with stocks of non-native crayfish species (long-clawed or Turkish crayfish *Astacus leptodactylus* and the North American signal crayfish *Pacifastacus leniusculus*) imported for aquaculture (for human consumption).

Pathway for the introduction: importation of crayfish that were not screened for diseases, and without a risk assessment of the possible dangers of the escape or release of these non-native crustaceans and any associated pathogens, despite evidence of serious problems elsewhere in Europe.

Background to the introduction: There are many cases of the importation of non-native diseases of fish and other aquatic organisms, both into Britain and elsewhere in the world which have been both commercially costly and environmentally damaging.

Prior to the introduction of signal crayfish for farming in 1976, promoted under the *Food from Britain* campaign, there was a lack of clarity in the legislation to prevent such establishments. Coupled with the differences in view between those parts of Government responsible for supporting the food industry and protecting native wildlife, this resulted in substantial environmental damage for negligible commercial returns.

Problems caused by the introduction: the native white-clawed or Atlantic stream crayfish, *Austropotamobius pallipes*, has declined in range and abundance in Britain as the result of the effects of crayfish plague (which causes a very high level of mortality) and also from the results of competition with the non-native crayfish species.

How the introduction might have been prevented: proper risk assessment, taking into account the harsh lessons in continental Europe prior to the 1976 introduction of signal crayfish, would have prevented the subsequent losses of native crayfish. This demonstrates the need for proper risk assessments before importing non-native species for aquaculture, coupled with a code of conduct for the industry to raise awareness of the problems and the need for compliance by the commercial interests involved.

The lack of an authority to assess the evidence from opposing viewpoints (those in favour of crayfish imports as a source of revenue for food versus those against crayfish import and release on the grounds of introducing a new disease) demonstrates the need for accountable decisions to be made that take into account risk assessments and relevant evidence.

Increased publicity for the problems caused by non-native species, particularly the introduction of non-native crayfish and associated crayfish plague elsewhere in Europe, might have changed perceptions about the risks involved and reduced support for the proposed introductions.

4.2.1 Introduction

Risk assessment procedures have a key role in the appraisal of environmental issues (DETR, 1998), and are central to the formulation of policy on invasive non-native species. Their use provides justification and support for actions taken; ensuring that resources are targeted to the highest risks and preventing ad hoc decisions from being taken (DETR, 2000). Risk assessment procedures are in place for intentional introductions licensed under the Wildlife and Countryside Act 1981 but, since formal risk assessments are not consistently applied to all non-native species and the procedures which are available are designed to assess the risks posed to particular receptors, *e.g.* crops, the Review Group decided that it would be helpful to describe the risk assessment process in detail. In order to provide an insight into the extent to which it is possible to construct a risk assessment system which can be used for all categories of non-native species, the Review Group tested a scheme developed by the plant health sector using a variety of non-native species. The Review Group also give examples of schemes and tools which can be employed to assist in the production of risk assessments and recommend further work to improve their accuracy and consistency.

Risk assessments are employed to determine: (i) the **likelihood** of an event occurring, *e.g.* the entry and establishment of a particular non-native plant in an area, and (ii) the **impacts** of this event. For non-native species, they are useful when there is uncertainty about the likelihood of the introduction and the magnitude of the impact. Further objectives are (iii) to determine the mechanisms or pathways by which the risk may be realised and (iv) to help identify and evaluate actions to manage the risk.

However, risk assessment and risk management may be undertaken in several stages. Initially, risk assessment can be used to identify and rank hazards of most concern. These assessments can be used as a basis of risk screening, identifying priorities for further more detailed risk assessment and risk management decisions. More detailed risk assessments may involve greater quantification and/or be supported by further research. In the context of non-native species, risk screening can be applied to determine which species represent the greatest risk to particular defined receptors or which pathways represent the greatest risk of introduction of non-native species. Alternatively, receptors can be identified and screened to highlight those which are at greatest risk from invasive non-native species. Risk screening and prioritisation help to reduce unnecessary effort and the chance that potentially important risks are overlooked.

Non-native species risk assessments are most commonly used to assess the risks posed by a particular non-native species. Such species may be known to have adverse consequences for particular receptors (for example within the existing range of the non-native species or from previous experience in the area of concern). Alternatively there may be a suspicion based on the taxonomic relationships or knowledge of the ecology of the species.

Receptors that are at risk from invasive non-native species include agricultural, horticultural and forestry crops, commercial and amenity fisheries and aspects of societal amenity. Invasive non-native species may present a particular threat to native biodiversity, and may impact on the ability of conservation agencies to meet particular objectives associated with the conservation of native species and habitats. Less obvious receptors may include the reputation of a company or regulatory body that is associated with the introduction or failure to control the establishment of nuisance invasive non-native species.

On completion, risk assessments can be used by those responsible to manage the risk, to ensure that resources are used efficiently by applying measures which are proportional to the magnitude of the risk, taking actions which are most likely to prevent the events occurring, protecting the most vulnerable targets and targeting risks with the highest priority. Having identified possible management options, it may be advisable to undertake a risk assessment of the proposed management strategy to determine the likelihood, magnitude and extent of a successful outcome.

4.2.2 Objectives of risk assessments for non-natives

Risk assessments can be carried out for non-native species, for pathways of introduction, for receptors potentially at risk of harm from non-native species and to assess the likelihood of success of management actions. The particular purpose of a non-native risk assessment will be determined by the interests and responsibilities of those seeking to understand and manage the risk posed by non-native species. Annex 8, on the EPPO risk assessment scheme, outlines the components and stages of non-

native species risk assessments. These can be used to meet a wide variety of purposes, and are consistent with Defra guidelines on environmental risk assessment (DETR, 2000). Particular applications are outlined in more detail in this chapter and also Annex 9 on a prototype risk assessment scheme.

4.2.2.1 Non-native species

Assessments can be carried out in order to determine the risks posed by particular non-native species. Such species may be identified because they represent a known or potential threat, for example as an agricultural pest species. Non-native species risk assessments may be undertaken to determine (i) the safety of intentional introductions, *e.g.* for the purposes of biocontrol, or (ii) the likelihood of unintentional introductions occurring and causing significant harm to species, habitats and ecosystems in an area.

4.2.2.2 Pathways

Risk assessments can also be undertaken on the pathways which may unintentionally allow non-native species to enter an area. This may allow the risk assessor to distinguish, from all the non-native species associated with a particular pathway, those that represent the greatest risk. An additional objective may be to identify those pathways that represent the greatest risk to one or more receptors. In these cases it would be necessary to determine the likelihood that particular non-native species will be associated with the pathway(s), and the magnitude of the impacts associated with each species upon one or more receptor.

4.2.2.3 Receptors

Risk assessments can also be carried out from the viewpoint of the receptors, *i.e.* by determining the likelihood of invasive non-native species adversely affecting a particular receptor. Potential receptors may include agricultural crops, other commercial interests, or human health. Of particular interest will be the threat posed by invasive non-native species to native species of wildlife, groups of species, habitats or ecosystems within an area. The highest priority in such assessments will generally be on the risks to threatened species, habitats and ecosystems, keystone species and other species of particular importance to people. In principle, it would also be possible to ask the question, "What are the risks posed by invasive non-native species to the overall success of the UK Biodiversity Action Plan?".

4.2.2.4 Management actions

In many cases a risk assessment will conclude that the risk posed by non-native species is negligible. For example, the species may be unable to survive or reproduce within the area defined by the risk assessment. In such cases no action may be required. However, where the risk is determined to be significant, risk management options need to be considered. A variety of options may be available, and the identification of these options will be facilitated by a good risk assessment. These management options may be considered separately or in combination, and each will inevitably have different attributes in terms of cost, practicality, their impact on reducing risk and probability of success in bringing the risk down to an acceptable level. These attributes can be

examined through further iterations of the risk assessment approach, building upon information gained from the initial risk assessment.

Detailed information on the factors that need to be considered before starting a risk assessment and the various ways that such assessments can be triggered are set out in Annex 6 – Initiation of Risk Assessments.

4.2.3 Types of risk assessment

4.2.3.1 Qualitative and quantitative risk assessments

Risk assessments are generally classified into two types: qualitative and quantitative. Qualitative risk assessments may include quantitative elements but generally rely on expert opinion. Expert opinion may be quantified by scoring responses from 1 to 9 or from low to medium to high. Such scores have greatest value when responses from many similarly conducted risk assessments can be compared. Quantitative risk assessments, which may also be described as probabilistic risk assessments, attempt to calculate the probability of an event occurring and the cost in monetary terms or environmental indices of the impacts which result. However, since assessments of the risks posed by non-native species contain numerous uncertainties and risks which are very difficult to quantify, fully quantitative non-native species risk assessments have rarely been prepared. The quantifications which are most often attempted include maps and calculations of the area endangered by a non-native species (based on, for example, knowledge of climate and suitable habitat) and costs to individual enterprises whose gross margin budgets can be readily obtained.

4.2.3.2 Risk assessments for species, pathways, policies and receptors

Risk assessment procedures for intentional introductions, unintentional introductions, pathways, policies and receptors will all be different, but ultimately they all come down to detailed assessments of the responses by non-native species to the living and non-living environment in the area under consideration together with estimates of the harm which they may cause.

As noted above, risk assessments should be fit for purpose, responding to the requirements of risk managers, communicators and policy makers while taking into account the time, information and resources available, the complexity of the situation and the prospect of a dispute arising.

Risk assessments for **intentional** introductions will not need to identify and analyse the pathways by which a species can enter an area, but will focus on its capacity to spread and establish in unintended areas and habitats where damage might occur.

Risk assessments for **pathways and management actions** begin with the compilation of lists of organisms with the potential to be associated with the pathway or which are known to have been detected at some point within a pathway or are either known or suspected to be influenced by actions and changes to policies. A screening process should be carried out to ensure that the list is restricted to non-natives, and to prioritise the organisms which have not previously been assessed according to any information

which gives indications of the extent to which they are likely to travel along the pathway or be influenced by actions. The screening process should also ensure that time is not wasted on species which have already been assessed or are already widespread and shown not to cause harm.

When conducting risk assessments for **receptors**, although the risk assessment should consider the types of non-natives to which the species, habitat or ecosystem is likely to be particularly vulnerable, the assessment will again lead to a detailed consideration of the pathways which could introduce non-natives to the area where the species, habitat or ecosystem occurs and the risks posed by each non-native species which might be able to travel along the pathway. To select the receptors which are likely to be most vulnerable to invasive non-natives, analyses of past introductions to the area and elsewhere are valuable. Some habitats and ecosystems, *e.g.* islands, lakes, edges of water bodies and disturbed ground, are known to be particularly vulnerable to non-native invasions.

4.2.4 Short cuts to risk assessment

For some non-native species groups, organisms which have very high or very low risks may have already been identified in legislation or explanatory leaflets. The Wildlife and Countryside Act 1981 and Plant Health (Great Britain) Order 1993 both list high risk non-native species. Defra (MAFF, 1997) published an explanatory leaflet on importing invertebrate plant pests under the Plant Health (Great Britain) Order 1993. Stressing that no non-native species may be released, it identifies certain arthropod orders, genera and species which may be imported, kept, sold, exchanged or given away because they pose only a low risk.

The Review Group considered whether it might be possible, a priori, to identify 'high risk' invasive non-native species by taxonomic groups. A review of taxa based on an audit of non-native species in Scotland (Welch *et al.* 2001) showed that this is not likely to be a fruitful approach, at least for vascular plants. Williamson (1996) confirmed the difficulty of making generalisations which are valid for all species groups, noting that the most robust predictions are based on propagule pressure, habitat matching and previous success at invasion. Williamson & Fitter (1996) found that, in the British flora, invasion success is related more to their distribution in the area of origin and morphology than their life history and reproductive behaviour.

Sub-recommendation 2.1:

Although it is clear that, for many taxa, there are no easy short cuts to risk assessments, further analysis of the attributes of species successfully invading Great Britain should be undertaken.

4.2.5 Risk assessment schemes

As noted above, once a screening and prioritisation process has been undertaken, risk assessments for pathways, policies and receptors also require assessments of the risks posed by one or more individual non-native species.

Three fundamental questions have to be answered in assessing the risks posed by non-native species:

- can the species **enter** the area concerned and how?
- can the species **establish** viable populations in the area concerned, and what does it require to do so?
- can the species cause significant economic and/or environmental **impacts** in the area concerned and how does it do so?

As noted above, for intentional introductions, the first question is irrelevant, and for species which are established, only the third question may be important.

Many subsidiary questions can also be asked to assess, for example, whether the organism can follow at least one pathway to reach the area, whether the abiotic and biotic environment is suitable for establishment, whether aspects of its biology, such as reproductive ability and adaptability, make successful colonisation more likely, whether it can spread and reach population densities known to exceed damaging thresholds and whether biodiversity and endangered species in particular will be harmed.

To standardise the production of risk assessments, several attempts have been made to construct schemes which can be used for many different organisms. Plant protection organisations have made the greatest efforts in putting together such schemes because risk assessments are required under the World Trade Organisation's Sanitary and Phytosanitary Agreement to justify all phytosanitary measures. International standards for risk assessment (FAO, 1996, 2001) have been generated and schemes following this standard have also been created, *e.g.* by the European and Mediterranean Plant Protection Organisation (EPPO, 1997), to assess the risk posed by quarantine pests (primarily invertebrates and plant pathogens) to plants. Recent attempts by the CBD (Convention on Biological Diversity) to agree guiding principles on invasive non-native species have led to requests for the International Plant Protection Convention (IPPC) to explore the extent to which IPPC procedures can assist the implementation of the CBD guiding principles. The IPPC has confirmed that pests of all plants, whether cultivated or unmanaged, are covered by the convention and that both direct and indirect pests are included. Following this confirmation, efforts are being made to adapt existing risk assessment procedures so that they also work with indirect pests, such as weeds and other invasive organisms.

4.2.5.1 The EPPO Risk Assessment Scheme

There are several risk assessment schemes already available which are designed to assess the risk posed by one type of invasive non-native species, namely crop pests. Some of these are in the process of being adapted to cover a much larger range of non-native species which directly or indirectly harm plants. To assess whether crop pest risk assessments might form a useful template for more generalised risk assessments, the Review Group decided to test one of these schemes against a variety of organisms. Four species were selected, representing a range of circumstances:

- *Azolla filiculoides* (water fern)
- *Corvus splendens* (Indian house crow)
- *Muntiacus reevesi* (muntjac deer)
- *Uncinia rubra* (New Zealand hooked sedge),

The EPPO (1997) scheme was chosen for this test, and a risk assessment prepared by Cannon (2001) for *Arthurdendyus triangulatus* (New Zealand flatworm) was used as a template to show how the scheme should be followed for non-native species.

The EPPO Risk Assessment Scheme starts with an initial questionnaire to ensure that the organism has the characteristics of a harmful, invasive non-native pest before continuing with the detailed section of the scheme. The main part of the scheme (see Annex 8) contains 46 questions which are scored from 1-9; high scores represent high likelihood or impact. The Review Group's conclusions on the value of the EPPO Risk Assessment Scheme for the above four species can be found in Annex 8.

In summary, the EPPO Risk Assessment Scheme provides a good substantive basis for non-native risk assessment, but would benefit from development in order to meet a wider variety of purposes. Further development is already being undertaken within the EPPO system.

Sub-recommendation 2.2:

Plant health risk assessment standards and schemes should be used as a basis for constructing a general risk assessment scheme that can be applied to all non-native species. Plant health risk assessment procedures are widely applied and already recognised by the World Trade Organisation. Their use as a basis for generic risk assessments is likely to increase the speed with which they are accepted and adopted.

4.2.5.2 Receptor and pathway initiated risk assessment scheme

A prototype receptor-based risk assessment scheme was developed and investigated. The risk assessment scheme developed the six stages identified in Annex 9.

i. Problem formulation.
All risk assessments start with a specific statement of the problem to be assessed. As an example of a receptor-based problem, the Review Group posed the question *'What is the risk posed by non-native mammal species to the conservation of certain breeding bird populations in the Western Isles'*?

ii. Receptor definition.
For this particular assessment the starting point is the definition of the nature and geographical distribution of the receptor(s) of concern or potentially at risk from non-native species. In this case the problem was defined by those responsible for managing the risk to a particular group of receptors. The breeding birds might include populations of redshank, snipe, corncrake, and species of tern that nest in areas of the Western Isles, whether they are nesting in specifically designated protected areas or not.

iii. Pathway identification.
The objective of this stage is to identify and characterise the different pathways of concern, by which non-native species might be introduced to the particular sites and receptors defined in stage ii. In this particular case the starting point for identifying possible pathways for the introduction of non-native species was determined by concern about particular receptors thought to be vulnerable to introduction. For other problems, the starting point could be concern about risks posed by particular non-native species or groups of species, or concern about particular sources of non-native species.

iv. Hazard identification.
The objective of this stage is to identify and characterise the non-native species that may represent a potential risk to the receptors identified in i. above. In this case, because the assessment starts with a definition of the receptor, it may only be possible to outline the nature of the non-native species in broad terms, based on an understanding of the nature of the receptor. For example in this case 'Species of woody plant able to colonise and establish coastal meadows, coastal sand dune slacks, and machair and alter their suitability as nesting habitat by breeding bird species' might form one group of potential invasive non-native species. Other areas of vulnerability to invasive non-native species (*e.g.* reduced breeding or hatching success through predation or reduced opportunities for feeding) might help identify other broad groups of invasive species. Nevertheless, the assessment may guide the assessor to identify particular non-native species that represent a particular risk.

v. Preliminary risk assessment.
This stage involves bringing together information stages i.-iii. above and forms the basis of an initial risk assessment, including estimates of the probability of exposure of receptors to invasive non-native species hazards via particular pathways, and estimates of the magnitude of the consequences for the receptors. The objective of this stage is to facilitate risk screening and prioritisation of the receptors, pathways and non-native species. For a receptor-initiated assessment, it may neither be possible nor desirable to do more than conclude which receptors are most vulnerable, or which pathways represent the greatest risk of introducing non-native species. Nevertheless, monitoring and other risk management actions can be based on these conclusions if appropriate.

vi. Generic non-native species risk assessment.
This stage entails a more detailed, possibly semi-quantitative, risk assessment. Where particular non-native species have been identified as potential hazards, this part of a receptor-based risk assessment might use a modified and developed version of the EPPO risk assessment scheme discussed earlier. Where, in a receptor-based assessment, the hazards can only be identified in a generic way, the purpose of this stage would be to characterise better the risks and reduce the uncertainty represented by non-native species to vulnerable receptors, the extent of that vulnerability in terms of possible consequences, and probability of exposure via different pathways.

Sub-recommendation 2.3:

High priority should be given to developing and publishing a risk assessment scheme suitable for all non-native species. To foster best practice this would ideally be presented in the form of a manual supported by guidance, examples of best practice and a tool kit identifying, for example, suitable reference material.

It is anticipated that priority for undertaking risk assessments would be afforded to potential or new introductions. A retrospective trawl through all long-established non-natives is unlikely to be productive and hence is of lower priority.

4.2.6 Results of risk assessments

The results of such risk assessments may be used to generate lists of invasive non-native species which are known or are likely to have harmful consequences. It has been suggested that these might form a 'High Risk List', or list of the 'nation's least wanted' species, but careful thought is still required about the precise way to develop and publicise such lists. If the public is to be aware of the 'least wanted' species, they should be few in number and of high consequence. (*e.g.* Colorado beetle). However, for the policy, scientific and conservation sectors, the list should be a comprehensive catalogue of high-risk species. It would need to be considered how native species outside their range would fit into this system.

High priority should be given to the creation of a 'High Risk' or 'nation's least wanted' list of invasive non-native species of all taxa.

Developing a high, medium or low system, where species are clearly assigned to one of three risk categories, will greatly assist with a wider understanding of the problems resulting from the importation and release of invasive, damaging non-native species. At the same time, those non-native species that do not pose risks to the environment, or to human activities, will not distract attention or divert resources from those problem species that require action.

A definitive list of invasive non-native problem species should be developed, maintained, updated regularly and made publicly available. This should be cross-referenced to Schedule 9 of the Wildlife and Countryside Act 1981. This 'High Risk List' should be used by other implementation tools, including legislation, codes of conduct and best practice guidance. Species on this list could be considered for regulation of import and sale. After work has been carried out to identify 'High Risk List' species, there will be species where there is some information to indicate that there may be potential problems with their importation and release, but insufficient evidence for a complete ban on importation and trade. These would be placed in the next category, described in the following paragraph.

The 'Medium Risk List' would comprise those species for which further work would be required to demonstrate whether there is a significant risk of them becoming invasive and causing problems. Adopting a precautionary approach for these species would involve prohibiting their importation and release until evidence has been obtained that they are benign. The 'Medium Risk List' species should be evaluated quickly, but thoroughly, with the aim of moving these species to the 'High Risk List' or 'Low Risk List' within a reasonable timescale.

In addition, an indicative list of non-native species that have not previously caused problems when introduced into Britain, or to other countries with similar climatic and ecological conditions (especially western Europe) should be compiled. This third list, of species assessed as being very unlikely to cause problems (a 'Low Risk List'), should be published, together with the evidence on which the assessments have been based. The

great majority of non-native species that have been imported into Britain hitherto, without causing any problems, would be placed on this list. These 'Low Risk List' species would be allowed to be imported and traded without any (or very limited) specific conditions, and would include many species of agricultural and commercial importance that are important economically or are grown in gardens or kept as pets. Should new evidence emerge that any of these 'Low Risk List' species are causing problems in Britain, or other similar countries, then the species concerned would be transferred to the 'Medium Risk List' for further evaluation. After review, they would be placed either on the 'High Risk List' or restored to the 'Low Risk List'. Any change in risk status would be given wide publicity to alert organisations and individuals to the change.

In some cases, it will be necessary to define conditions under which invasive non-native species may be traded or kept in order to prevent them causing problems in Britain, with this risk management process being implemented by codes of conduct and legislation as appropriate.

The decisions on the status of non-native species with respect to these three lists should be made on the basis of the best available information (including prior practical experience) to generate risk assessments for each species, with judgements on the level of risk involved being based upon an agreed level of precaution to prevent potentially damaging introductions, while at the same time not preventing legitimate activities that do not pose significant risks to the environment or human interests. When environmental conditions change (for instance, as a result of climate change), and as species change through evolution over time (for example, by developing frost tolerance), there will be a requirement to review the placement of species on these three lists, by seeking evidence where significant changes are happening. Review could also be needed when there is a change of use for a non-native species that might alter the chance of damage being caused.

The evaluation of the level of risk that different non-native species pose should be carried out in conjunction with international organisations and other countries tackling problems associated with invasive non-native species under the auspices of international conventions, for instance, the Convention on Biological Diversity and the Ramsar Convention. There are already international lists which draw attention to certain categories of problem species, such as direct pests of plants, which could be utilised when developing and implementing the 'risk list' protocol. Work is already underway in Plant Health to add to the lists of direct crop pests by compiling a database of species which indirectly injure plants. One priority should be to obtain lists of perceived problem species in neighbouring countries.

The Review Group was not unanimously supportive of the concept of a 'low risk' list. Serious reservations were raised about the prospect of such a system, as it might be construed to give implicit approval for the release of these species into the environment, which may cause as yet unforeseen problems, and could be illegal *e.g.* the release into the wild of a non-native animal. There are dangers that the consequences of an introduction would be very difficult to predict and that species thought to be harmless may go on to cause problems. Invasive species can go through a lag phase whereby there is a delay, perhaps for many years, before the population booms and they become invasive. For example, decades passed after the introduction of the ruddy duck before it was recognised as the most serious threat to the long-term survival of the globally-threatened white-headed duck.

If a 'Low Risk List' is to be developed, any publicity associated with this list should be handled with great caution. It would be necessary for any 'Low Risk List' to make allowances for climate change and species adaptation, such as frost tolerance.

Sub-recommendation 2.4:

In the light of consultation with interested parties outlined in the two sub-recommendations (2.5 & 2.6) below, a list of problem species should be developed for priority action including licensing and even exclusion from Britain (a 'High Risk List'), a list of species where more evidence is required as to their potential to cause problems (a 'Medium Risk List') and possibly also a list of species assessed as not being known to cause problems (a 'Low Risk List')

Sub-recommendation 2.5:

Further consultation is needed with the horticultural industry and other interested parties to determine the extent to which it would be practicable to require risk assessments on all new imported and introduced plant taxa.

Sub-recommendation 2.6:

Further consultation is needed with the horticultural industry and other interested parties to determine whether the creation of lists of non-native species known and demonstrated to have no negative effects ('low risk' or 'harmless' lists) would be achievable and beneficial.

Sub-recommendation 2.7:

Comparative assessments should be undertaken of the risks of introducing non-native species to Great Britain by a variety of importation pathways, as a basis for prioritising resources to the detection, monitoring and management of non-native species entering Great Britain.

4.3 Codes of conduct

In contrast to intentional introductions subject to licensing arrangements, many introductions of non-native species arise unintentionally as the result of legitimate activities, and preventative action to reduce such unintentional introductions is needed. The group identified a number of different pathways by which non-native species can potentially be introduced intentionally and unintentionally into Great Britain.

Some of these introduction pathways are already the subject of international action, such as the International Maritime Organization's work to address introduction of non-native species in ballast water and the International Civil Aviation Organisation's work to assess unintentional transport of non-natives by air. For other relevant sectors and activities, it is recommended that codes of conduct or best practice be drawn up with the stakeholders, to prevent unintentional introductions. Risk assessment procedures will be useful in prioritising areas for action. Such codes of practice can be adapted to

specific industries or introduction pathways and have the advantage of being relatively easy to update and amend. Such codes should be given a statutory underpinning so that failure to comply with a code would expose the offender to the risk of prosecution.

Intentional introductions may also require codes of conduct or best practice, to ensure that there are no detrimental effects as a result. Codes of practice should therefore be developed to address all relevant introduction pathways, whether intentional or unintentional.

- **Key Recommendation 3: Develop codes of conduct to help prevent introductions for all relevant sectors in a participative fashion involving all relevant stakeholders.**

CASE STUDY: Australian swamp stonecrop, also known as New Zealand pigmyweed *(Crassula helmsii)*

Category of introduction: intentional and unintentional (imported deliberately, but released accidentally, at least in part).

Pathway for the introduction: importation of plants by the horticultural trade from Australasia for use as an ornamental aquatic plant. Also probably partly introduced as a contaminant with other imported plants

Background to the introduction: Australian swamp stonecrop is a water plant imported for growing in aquaria and outside water bodies, still on sale today. It was first recorded as naturalised in the mid-1950s. There is currently no prohibition on import or trade in this species.

Problems caused by the introduction: Australian swamp stonecrop is an aggressively invasive species in ponds and ditches. It rapidly excludes other water plants and marginal vegetation where it becomes established. This results in losses of the native water plants and their associated invertebrates. This reduces biodiversity and can threaten rare native plants. Where waterways become choked with this species, flooding can result and also amenity activities, such as fishing, can be restricted. It is now widespread in southern Britain and has colonised many sites farther north.

Where it becomes a problem, effective control of the species is very difficult. Control of the species using mechanical methods is not recommended as even small plant fragments produced by cutting and tearing can re-grow. Mechanical control can therefore lead to spreading the infestation downstream. Using herbicides can be more effective although it is costly and is not always appropriate for use in watercourses. Use of chemicals and herbicides can have serious impacts on other wildlife, creating an impoverished environment for an extended period.

The species therefore causes serious problems once it becomes established and remedial measures are very difficult. Other aquatic invasive plants also cause similar problems, such as floating pennywort and parrot's feather.

CAPM ©

Dense mats of Australian swamp stonecrop that can reach depths of 3 metres, choke native plants and create a poor oxygen depleted habitat. Codes of conduct for retailers of garden and ornamental plants should reduce the chance of such invasive pond plants reaching the wild.

4.3.1 Codes of conduct

Relevant groups for all sectors and activities should devise codes of conduct or best practice. All pathways should be covered by a code. These should be prepared in co-operation with all relevant stakeholders and should be used as a determinant of standards of reasonable behaviour and the duty of care of owners or keepers of specimens to prevent escapes.

Codes of conduct have a number of attractive features as they can be targeted to a specific industry or pathway and can incorporate recognised international standards, for example, FAO Aquaculture guidelines on the use and introduction of non-native species. Some sectors already have codes of conduct in which invasive non-native species issues could be addressed, such as the UK Forestry Standard and Biodiversity Guidelines. Also, avicultural guidelines in respect of keeping of waterfowl are being developed by the African Eurasian Waterbird Agreement.

While all efforts to minimise the entry and impact of invasive non-natives will require underpinning by legislation, codes of conduct should play a very valuable role. To do so they must be recognised by the courts as the basis for determining reasonable conduct and/or a duty of care. If so recognised, they would be legally binding upon the actions of individuals and organisations and hence be recognised as 'having teeth'. In order to increase the incentives for complying with codes of conduct, those organisations or individuals found to have behaved in ways that conflict with a code should be liable to prosecution and if found guilty, subject to appropriate penalties.

Some guiding principles for the development of these codes are outlined below:

- Each code will be required to meet certain minimum criteria before recognition by the proposed co-ordinating body;
- Each code will incorporate a precautionary approach to the introduction of non-native species, based upon an agreed risk assessment process for known pathways for both intentional and unintentional introductions;
- Codes must be sectorally based and call on the administrative, legal, practical, theoretical and commercial expertise of all stakeholders concerned with a particular activity;
- By drawing on such a breadth of expertise the codes will be scientifically rigorous, practical, proportionate and cost effective;
- By involving all stakeholders in their production and maintenance they may achieve the greatest possible "buy in" and partnership;
- Codes will be underpinned by the law to encourage compliance and allow for legal sanctions to be applied where there is negligence or deliberate flouting of their provisions;
- They will be relatively easily altered as situations or conditions demand;
- The codes will be used to inform decisions on purchasing, planning, stocking etc., even in the absence of detailed rules particular to a species being formulated;
- New codes will be prepared as and when new pathways emerge or gaps, in coverage of current activities, are identified;

- Non-native species and native species outside of their range in Britain or native species supplied from elsewhere may cause problems. The nuances of each situation should be taken into account in codes;
- Codes will adhere to international standards such as the International Maritime Organization's guidelines on ballast water and sediment discharges;
- Monitoring should be built in to codes of conduct. This may take two forms: monitoring and surveillance of the sector for non-native organisms and, perhaps more importantly, of the effectiveness of the code of conduct.

Codes should ideally be developed involving all relevant stakeholders. The methods used to develop a code of conduct for the horticulture industry in the United States may be a valuable model on which to develop such codes.

4.3.2 Pathways for entry and establishment of non-native species

Pathways for the entry and establishment of non-native species are similar for both unintentional and intentional introductions, although the measures needed to prevent their establishment are different. The growth of international trade, combined with reduced border controls within the European Union and the increased diversity of sources of supply for many organisms (including sales via the Internet), make regular re-evaluation of pathways and their associated risks essential.

Unintentional introductions may, by their very nature, be harder to prevent because they may not be the result of choices or decisions that can be debated, influenced or made the subject of legislative controls. However, risk assessments of pathways for these introductions can reveal techniques and controls to reduce the risks of unintentional introductions taking place in future. Unintentional introductions can be hard to detect, particularly when small species are translocated in large volumes of water or in materials such as compost. Prevention measures may depend upon detailed inspections procedures, often coupled with improved prophylactic treatments designed to kill the organisms or their propagules.

Intentional introductions follow decisions to translocate a species; when a decision is taken publicly there will be the opportunity for stakeholders affected by the decision to become involved in the prior debate. This involvement is not possible when the decision is taken by an individual or group who chooses not to engage others in any prior discussions, instead making the decision and carrying out the introduction clandestinely. Prevention measures depend upon gaining the support of the stakeholders concerned, with a balance to be struck between education and codes of conduct to set standards and improve practices on the one hand and appropriate legislation and enforcement on the other.

Some of the principal pathways for the entry and establishment of non-native species are summarised in Annex 5 (Table 1 and Table 2), together with the relevant prevention measures designed to deal with each pathway. **Each pathway should be "owned" by a code of conduct as the means of engaging key stakeholders in practical prevention measures. In each case education and publicity will be needed to raise awareness of the problems and to gain the widest possible support for preventing either unintentional or intentional introductions.**

It should be borne in mind that invasive non-native species cannot only be species not native to Britain, but they can also be species native to only part of Britain. In the latter case, species can be regarded as non-native if they are outside their current or recent historical natural range. Preventing the unintentional or intentional translocation of species native to part of Britain provides several different challenges and complexities compared with species not native to Britain. This comes about first as a consequence of the perception that species native to Britain are indigenous to the entire geo-political area, and hence not likely to cause problems when translocated, and second because there are difficulties drafting clear and effective codes of conduct or legislation to prevent the establishment of these species beyond their natural range in Britain. The requirement to prevent translocations into areas where these species are not present means that it is essential to define and communicate the location of these areas unambiguously. This must be supported by suitable education programmes and surveillance measures to ensure wider understanding and public support for effective implementation of codes of conduct.

CASE STUDY: New Zealand flatworm *(Arthurdendyus triangulatus)*

Category of introduction: unintentional.

Reason(s) for introduction: through lack of precautionary measures to prevent the introduction of non-native invertebrates and other organisms in soil imported as a growing medium for living plants.

Pathway for the introduction: as multiple introductions, probably arriving in the UK during the 1960s in association with a specimen plant sent from New Zealand to a botanic garden.

Background to the introduction: the New Zealand flatworm was only occasionally found over a period of many years, but by the early 1990s the species was becoming of greater concern because of repeated findings in Scotland and Northern Ireland, as well as in Northern England. There is evidence that New Zealand flatworm has limited tolerance of climatic variations and in consequence it may only be a problem in areas that have a similar climate to its native habitat.

Problems caused by the introduction: the species is significant because it eats earthworms, potentially causing their local extirpation, and hence poses a threat to native earthworms and the ecosystems dependent on earthworms, including agricultural production. There is much debate about the extent of any damage that may be caused and the degree to which earthworm populations are adversely affected in Britain.

How the introduction might have been prevented: had there been knowledge of the species and the risk of its introduction, some trade measures may have been deemed appropriate to prevent introduction from New Zealand in planting material, for example by only allowing bare rooted plants or requiring growing media accompanying plants to be sterile. Additionally, a good level of awareness of the risk of moving it in plant material could have limited its spread once introduction had taken place. Defra's Plant Health Service produces publicity, partly in order to assess the extent of spread of the pest, and as guidance for professional and amateur gardeners on measures to detect and control New Zealand flatworm. However, the species is now so well established in Northern Ireland and parts of Scotland that eradication from the UK is not feasible.

The New Zealand flatworm was imported unintentionally in soil and threatens native earthworms, an important part of the ecosystem. Sharing of information and use of risk assessments should help prevent unintentional introductions such as the New Zealand flatworm in the future.

4.4 Public awareness and education issues

The Review Group has considered the issues of public awareness and education as they relate to invasive non-native species policy and practice.

Many of the problems, both potential and actual, posed by invasive non-native species stem from a lack of public and institutional understanding of the costs and consequences of their establishment, and of the current legislation prohibiting release of non-native species. Better information, education and improved public awareness of these issues are therefore required with the aim of reducing unintentional introductions of non-native species. This approach will not only help to prevent problems arising but will increase the public acceptability of measures taken to address existing problem species. For example, management and eradication programmes are more likely to be successful if supported by an informed and co-operative public. Furthermore, reducing the number of inadvertent offenders will allow enforcement agencies to concentrate on systematic criminal offenders. It is noted that different approaches will be needed to reach different audiences, for example, the general public, enforcement agencies, relevant industries and trade professionals, conservation groups, scientists and policy makers.

For example, green fly-tipping of plants by domestic gardeners has been identified as a cause for concern. A large proportion of such activities occur through genuine ignorance of the harm it can cause. An outreach campaign to gardeners indicating solutions such as composting may help overcome this problem. A good example of the effectiveness of publicity in mobilising a community response to discover and report the presence of a harmful invasive non-native species is illustrated by the numerous reports of Colorado beetle which have been made by the general public.

There is an urgent need to develop a greater understanding of the issues surrounding invasive non-native species, which is far less developed in the UK than in many other countries, such as New Zealand and the United States. The activity to develop this increased level of public awareness is a complex, multifaceted task which will require substantial and clear planning, and which represents a major area of work for the future. It must also recognise that such work has a role in assisting with prevention, remedy and control, and monitoring and feedback reporting.

Measures to tackle invasive non-native species will benefit from wide public understanding and support, especially any programmes to control such species as action may be necessary before widespread damage has occurred. It is important that the precautionary approach is accepted and that the issue of invasive non-native species becomes better understood. There is the need for a programme of targeted educational programmes to achieve this. This should be based on an understanding of what the various constituencies believe, to allow messages to be delivered appropriately to influence opinions. Opposition to control of invasive non-native species might, for example, be based on factors other than simply a lack of knowledge or understanding of the issue.

The Review has examined these issues carefully. First, it has developed an analysis of the different sectors which should be addressed. Second, it has identified the issues most relevant to each of those sectors. Third, it has raised a number of issues related to the public appreciation of the issues generally: the development of the culture of understanding of invasive non-native species issues and problems, and finally, it makes

suggestions on the means of delivery of some of the key information. Each of these is considered in turn below.

The key aims of all communications, to whatever sector, should be to promote:

- understanding of the issues
- support for the aim of preventing the introduction and establishment of invasive non-natives in the wild
- engagement in helping prevent problems
- awareness of the issues, and by so doing promote behavioural and decision-making patterns (personal, commercial, legislative and government) that help achieve this aim *i.e.* let people know how they can do the "right thing"

Information should be disseminated using different media, making full use of available technologies. This might include the creation of a website dedicated to the issue of invasive non-native species. This would complement information being disseminated in other forms such as through manuals, databases, scientific journals and popular publications.

CASE STUDY: Preventing the establishment of Colorado beetle *(Leptinotarsa decemlineata)*

Category of introduction: unintentional.

Reason(s) for introduction: this would be accidental within food or horticultural products, or possibly as strays within vehicles arriving from continental Europe.

Pathway for the introduction: as adults or immature individuals within consignments of plants or in containers imported from continental Europe.

Background to preventing the introduction: Colorado beetle is not established in the UK, although it is widely established in much of continental Europe, having first arrived in Bordeaux in 1922. The larvae of this beetle feed on leaves of potato, typically in large numbers, thereby causing substantial damage to the plants and great loss of crop yields. The species has been extending its range possibly in response to climate change, and so the risk of it becoming established in Britain is increasing.

Colorado beetle is a listed quarantine pest in UK plant health legislation and poses a threat to potato production. One hundred and sixty three outbreaks of this beetle have been eradicated in the twentieth century, the most recent in 1977 in Kent. The beetle has been kept away from the UK through vigilance by Plant Health and Seeds Inspectors, Customs inspectors and private operators, coupled with widespread, albeit low key, publicity over many years. This publicity has established Colorado beetle in the public conscience, and every year the public report findings of the beetle in foodstuffs and elsewhere, such as in cars recently returned from the continent. There have been occasional reports of findings close to possible outbreak sites, but on investigation no outbreaks have been detected.

Given the legal status of the pest, exporters of vegetables and other products to the UK are obliged to take action to prevent movement to the UK, but there are still repeated findings, especially in products such as parsley and potatoes from the south of the EU. Importers and wholesalers of these products have shown vigilance and co-operation in protecting the UK from these pests and such people are key in assisting government inspectors. In the event of an outbreak, Defra has contingency measures to detect and eradicate any infestation.

The successful exclusion of Colorado beetle demonstrates the need for a high level of awareness of how to recognise non-native pests amongst the public and traders, coupled with adequate systems to prevent introduction.

Problems that would be caused by the introduction: the Colorado beetle could cause many millions of pounds of damage to potato crops grown in Britain. If it were to become established as a resident pest, there would also be significant environmental effects from control measures used to reduce numbers, and hence damage, caused by this beetle.

The successful exclusion of the Colorado beetle from the United Kingdom demonstrates the effectiveness of public awareness campaigns.

4.4.1 Target audiences and key issues

The target audiences for improving public awareness in relation to the problems of invasive non-native species must be well-defined.

First, some of the issues and information need to be addressed specifically to members of the general public, such as the risks of unwanted introduction of invasive non-native plants through dumping of garden waste. There is also a need for the general raising of awareness of the issues though formal and informal education.

However, there is also a section of the public which is well-informed on such issues and is able to contribute by way of reporting and feedback on the spread of non-native species. This section comprises those naturalists who are interested in recording the occurrence and distribution of plants, fungi and animals throughout Britain. This is a key audience which can provide huge amounts of valuable information on the distribution and spread of a large number of non-native species. The way in which information is disseminated to them is quite different from the general levels of information required by the general public, and particular effort should be made to build the levels of co-operation and information provision from this group.

Second, there are a number of 'professional groups' with important roles to play. These may be policymakers themselves, ministers and civil servants. They include operational professionals whose decisions may permit or prevent the spread of invasive non-natives (agriculture, forestry, landscape or planning professionals, for example). They may be professionals in other fields whose actions or advice may influence the actions of the public, such as horticulturists or pet-trade professionals. The activities of each of these groups, and the guidance and advice they provide to the public, will be instrumental in raising awareness or causing problems.

The mind map (below) represents an attempt to classify these groups, and to identify the main issues relevant to each. It does not claim to be comprehensive: it is intended to emphasise the complexity of public awareness issues in this field, and to emphasise the need for thorough analysis, co-ordination and targeting of efforts to raise public awareness across all sectors of the British public.

The Review Group recommend urgent action to develop a strategy to promote public understanding of the issues surrounding invasive non-native species, which are poorly-

developed in Great Britain. This will require thorough analysis, co-ordination and targeting of efforts to raise public awareness across the many different sectors of the British public.

- **Key Recommendation 4: Develop a targeted education and awareness strategy involving all relevant sectors.**

Further more detailed recommendations on the approach to Key Recommendation 4 are set out below.

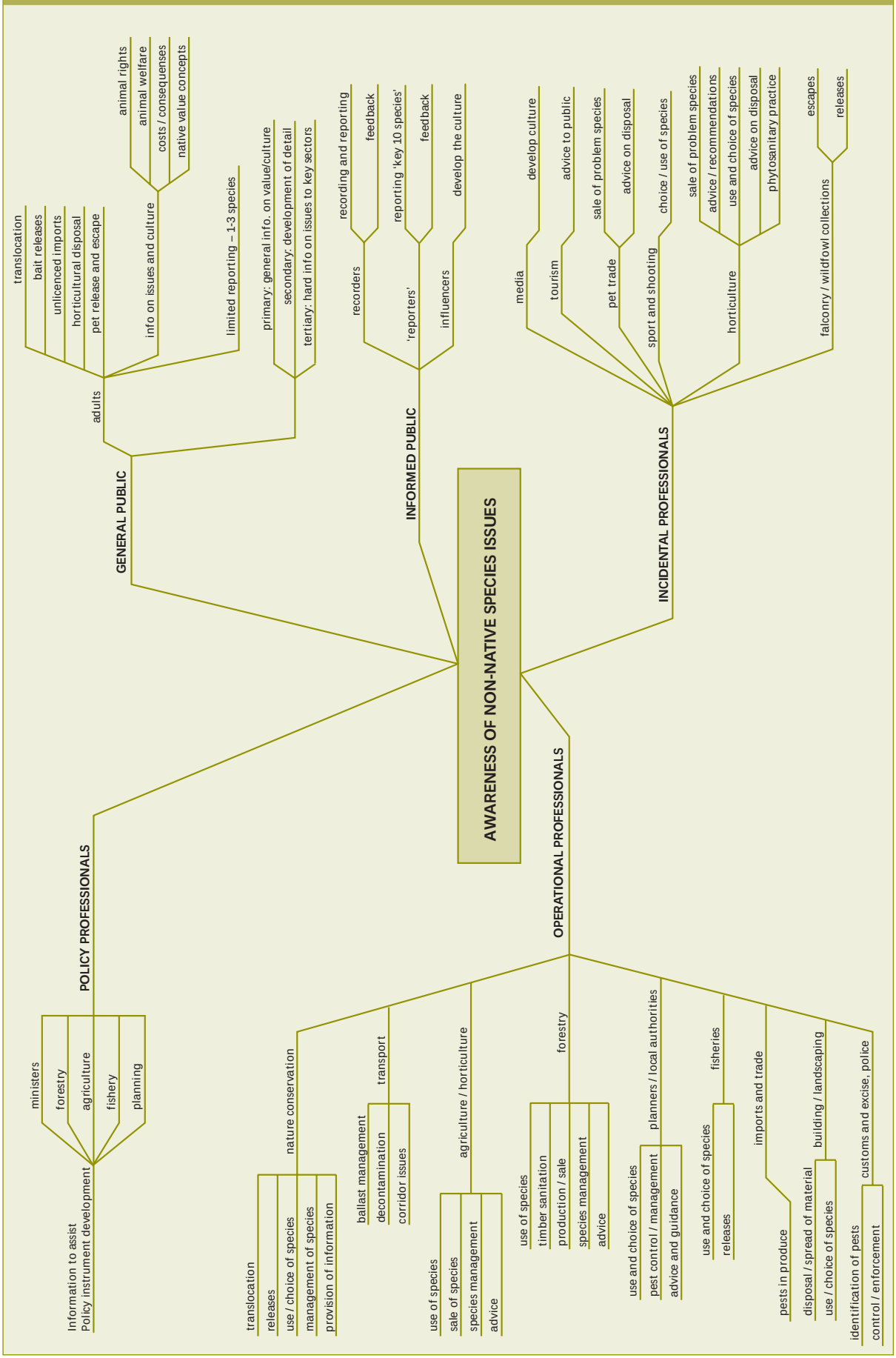
4.4.2 Developing the culture

The Review Group considered that an early priority for public awareness work on invasive non-native species should relate to the development of a greater understanding of the issues by the public: **"the development of an awareness culture"** so that people are aware of the risks posed and problems caused by invasive non-native species, and aware of the value of native biodiversity. This must encompass an understanding of the ecological, economic and social costs and benefits of non-natives. Such work will have to give careful consideration of the messages to be propagated, and how to maximise the effectiveness of this work.

In the view of the Review Group, it will be necessary to offer a small number of key messages about invasive non-natives if the development of awareness is to succeed. The Review Group suggest that some key basic messages are to ensure that the public:

- is aware of the potential risks of releases and escapes into the environment;
- understands the consequences of moving plants and animals around Great Britain;
- understands the risks and consequences of introductions especially to islands, remote areas, freshwaters;
- understands the concepts of the values of native biodiversity, and the term 'native';
- is aware of the potential risks of what they bring back from abroad;
- appreciates the ecological, economic, social and landscape costs associated with a small number of the most harmful established invasive non-natives;
- understands the need for the control and management of invasive non-natives, and understands the risks of failure;
- also understands that only a minority of non-natives cause problems and that many have and will continue to enrich peoples' lives.

Figure 2: Target audiences and key issues: mind map analysis



Long-established and accepted non-native species, for example those plants termed archaeophytes, could also be considered in the context of developing the culture. It will be important that the public understands that policies are aimed at addressing the problems caused by the "invasiveness" of species and that species are not necessarily bad simply because they are non-native. Also, biocontrol agents may be considered to be beneficial non-native species where they have been released after prior evaluation, designed to ensure that they will reduce the populations of pest species, while at the same time not damaging non-target species.

In developing the means to promulgate these key issues, there are several key considerations. These include:

- ensuring the simplicity of the message, to build understanding;
- avoiding the use of words that have had negative associations with human activities, thus using, for example, the term 'non-native' rather than 'alien';
- advance planning to address concerns about animal welfare ahead of any control measures, recognising that control measures should be undertaken to high standards that ensure the welfare of the animals;
- developing an awareness culture where the risk of invasive non-native species is considered a legitimate concern, ensuring that those undertaking any actions have a 'licence to operate';
- dealing with any public assumption that reporting a non-native species will automatically lead to its death or removal;
- overcoming professional and scientific concerns about scientific accuracy to convey a message effectively: it is important to strike the right balance.

Sub-recommendation 4.1:

Messages about invasive non-native species which are promoted to the public revolve around a small number of key concepts, and should use simple, understandable terminology, and plan in advance to deal with controversial aspects of the issues.

A consortium of interested groups perhaps led by Defra and following the Partnership for Action Against Wildlife Crime (PAW) model could assist in developing the awareness culture. This is discussed more fully in Chapter 6.3 on a Stakeholder Forum.

4.4.3 Means of delivery

It is clear from the above that many means of delivery of information are required, tailored to fit the sectors being addressed. In the time available to conduct this review, it has proved impossible to detail these sector by sector. However, the Review Group offer comments related to each sector by way of illustration:

4.4.3.1 The general public

A key to delivery here is to make the public aware through easily accessible media: *e.g.* television, radio and the press, and through media targeted to key areas, activities and locations, such as garden centres, pet shops, airports (even information on the back of airline tickets?). The Review Group are conscious of the long-running poster campaign on Colorado beetle, and the Review Group suggest this might be adapted and extended to encourage the reporting of a small number of the most threatening or highest-risk invasive non-native species. Similar good work has been done by a collaborative partnership, the Cornwall Knotweed Forum, to encourage the reporting by the public of Japanese knotweed in Cornwall, for example. One suggestion to simplify the message is that it may be useful to pick a single plant (*e.g.* Japanese knotweed) and a single animal (*e.g.* mink) to explain why species become invasive.

Sub-recommendation 4.2:

A general information campaign should be undertaken to inform the general public of the issues surrounding invasive non-native species, through easily accessible media such as television, radio and the press, and through media targeted to key areas, activities and locations, such as garden centres, pet shops, and airports.

4.4.3.2 The informed public

A different approach will be required with naturalists, ecologists and the informed public. More detailed information can be provided in the specialist press, and non-government organisation and specialist society publications. Discussions with specialist societies will be necessary to enhance the reporting systems which already exist for most taxa, to encourage them to report effectively on non-native species. Consideration should be given to the development of E-mail reporting of non-native species, and the development of web-based information, to provide the vital feedback to encourage ongoing reporting of problem species. It should be borne in mind that most recording schemes rely almost entirely on volunteer reporting.

Concerning formal education, the most important approach will be to ensure the inclusion of information on invasive non-native species within core curricula in primary and secondary education, and in the curricula in key subject areas in tertiary education. The latter includes ecology, agriculture, forestry, planning and land management amongst others.

Sub-recommendation 4.3:

Detailed discussions should commence with specialist societies and recording schemes, with the aim of enhancing the reporting systems which already exist for most taxa, to provide effective reporting of non-native species. Consideration should be given to the development of E-mail reporting, and the provision of web-based feedback on non-native species. Formal education courses should include information about non-native species issues where appropriate.

4.4.3.3 The 'incidental' or advisory professionals

This group comprising sectors which could give rise to incidental releases, *e.g.* pet trade, horticulture, should be considered in two ways. There is the need to provide professional quality information through their trade media, courses and the like, to equip them to understand the issues as they are affected by their work. However, they also have an information and advisory role, and careful consideration should be given to the provision of public information which they can display and dispense.

4.4.3.4 Operational professionals

This group may also have such dual roles, though the priority for this group is more likely to be the provision of professional quality, technically-based information geared more directly to their work, so they can act in ways which mitigate the inadvertent spread of invasive non-native species. For example, the Cornwall Knotweed Forum, in collaboration with Duchy College has created a training course for Japanese knotweed control and herbicide use.

4.4.3.5 Policy professionals

Policy professionals will require clear professional and scientific analysis of the issues associated with invasive non-native species, presented in terms appropriate to non-scientists, and in ways which can enhance policy development and application.

Sub-recommendation 4.4:

Carefully targeted material should be produced to cater for the information and advisory needs of the range of professionals likely to have an impact on invasive non-native species issues. This will differ between sectors, and should include detailed professional and scientific analysis of the issues associated with invasive non-native species, material presented in terms appropriate to non-scientists and the public, as well as material appropriate to the scientific and research communities.

4.4.4 Native species beyond their natural range

There have been significant problems for nature conservation in Britain following the introduction and establishment of species which are native to parts of Britain into areas beyond their natural range. For example, the introduction of hedgehogs to the Outer Hebrides (page 60) has caused a substantial reduction in important wader populations, and the introduction of several fish species into Loch Lomond has caused major alterations in the fish fauna. Consideration of whether legislative change is needed is covered in Chapter 4.5. However, one key prevention measure is to highlight the damage caused, and to enlist the support of the public to be vigilant in preventing such introductions occurring.

CASE STUDY: The introduction of hedgehog *(Erinaceous europaeus)* to the Uist Islands, Outer Hebrides

Category of introduction: intentional.

Reason(s) for introduction: Hedgehogs were not recorded on the Uists prior to 1973. Introduced deliberately to South Uist for purposes of garden slug control: confirmed introductions were 4 animals in Autumn 1974 and a further 3 in Spring 1975. It is possible that further introductions occurred but were not recorded.

Pathway for the introduction: via the ferry service from mainland Scotland to the Outer Hebrides.

Background to the introduction: while it is well known amongst ecologists and conservationists that mammalian predators can have a serious impact on island birds, awareness of these problems among the general public and island residents is currently low, (although probably now much higher in the Outer Hebrides and other parts of Great Britain following recent initiatives and media reporting of eradication proposals). Though hedgehogs were introduced to the Uist islands deliberately, it is likely that it was done in ignorance of the potential impacts on indigenous wildlife.

Problems caused by the introduction: the hedgehog population has increased to in excess of 5,000 now resident in South Uist and Benbecula, with smaller numbers on North Uist. They are continuing to spread, with about 10,000 young born each year. Hedgehogs are generalist predators and can take substantial numbers of birds' eggs during the breeding season (though eggs generally form only a small portion of the overall diet of hedgehogs). The Outer Hebrides, support internationally important populations of breeding waders (dunlin, redshank, ringed plover, snipe, lapwing, oystercatcher) that are vulnerable to egg predation. Since their establishment in the mid 1970s, egg predation by non-native hedgehogs has resulted in steep declines in wader populations on the Uists, with some species reduced by over 50% in less than 20 years in areas supporting hedgehog populations.

Recent studies have investigated the nature and scale of the problem, as well as possible control measures. The complete removal of hedgehogs from the Uists might be feasible; assessment of this will require large-scale removal trials. Complete eradication, if feasible, would be an expensive and lengthy exercise. The alternative route to safeguarding and restoring the wader populations would be a continuous programme of hedgehog population control. Either of these is likely to be controversial given the views of many people about hedgehogs.

How the introduction might have been prevented: Three scenarios could have prevented the introduction of hedgehogs to the Uists. The first would have been the generation of awareness amongst the public of the dangers of introducing non-native species to new areas, to such an extent that people naturally avoid such actions. This would have required an effective education and public awareness campaign prior to the mid-1970s, but would only be likely to have happened if an adequate risk-assessment had identified the risk. The second scenario would have been the implementation of legislation, prohibiting such introductions prior to the mid-1970s. Again, this would need to have been underpinned by education and information programmes to raise awareness of the problems associated with importing any species, particularly predators. The third is early detection, which could have enabled their rapid removal, ideally against a backdrop of awareness-raising of the issues amongst the UK public and island residents.

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Even British species can be invasive non-native species if introduced outside their natural range. For example, hedgehogs have been introduced to British islands, where they are not native, and had negative impacts on the vulnerable island ecosystems particularly on internationally important bird populations.

Sub-recommendation 4.5:

There is a need to raise awareness of the problems caused by introducing native species beyond their natural range so as to prevent their impacts in future.

Problems with non-native genotypes

There can also be problems associated with introduction of native species of non-native provenance, with different genetic composition from the local stock. An example would be importing hedge plants of appropriate local species, for example into southern England, from sources on the continent. Although the species will be the same, genetic differences might result in a different capacity of the stock to survive in the British environment, or a different palatability to native insects. If the genes of this introduced stock became widespread then there could be consequent impacts on biodiversity. As similar issues may apply to herbaceous plants, shrubs and trees, native plants of local provenance should be stipulated for use in commercial, conservation or amenity planting schemes, particularly within or near areas of conservation interest. A second, pertinent, example of the potential problem is the introduction of non-native salmon from non-UK waters as brood stock, which could cause problems if released into the wild. Interbreeding between introduced fish and the local wild populations may result in offspring being less resistant to disease, and parasitisation, as a result of interference in their normal genetic signature. This could cause problems at a very localised level due to the salmon's adaptation to spawning in rivers in which they hatched.

The Forestry Commission is developing ways of promoting greater use of native genotypes for planting of native species. For example, the Forestry Commission already stipulates the provenance of Scots pine to be used in grant-aided planting schemes in areas with native Scots pine, to protect the genetic diversity of the species, and there are examples of Spanish provenance Scots pine faring very badly in Britain as a result of pests and climate. There is a need to raise awareness of the problems caused by

introducing native species beyond their natural range, and by planting schemes using non-native genotypes, thus preventing their impacts in future, using codes of conduct and legislation together to tackle these problems

Sub-recommendation 4.6:

The issue of use of non-native genotypes of native species is important and requires further consideration, building on existing initiatives such as those by the Forestry Commission and Flora Locale. There is a need to raise public awareness of this issue.

4.4.5 Need for a campaign

The Review Group agrees that there should be a campaign geared towards "the development of the culture" of understanding about invasive non-native species, and to an appreciation of the cultural heritage of native biodiversity. Given the above commentary, the way in which this is developed should be the subject of professional planning. Such an education programme should also inform government bodies, local authorities, landowners, business interests and the public of the threats and costs associated with invasive non-native species and the need for management.

Sub-recommendation 4.7:

There should be a public campaign to "develop an awareness culture" considering the problems that can be caused by invasive non-native species, and to increase appreciation of the cultural heritage and value of native biodiversity. This should be planned professionally, resourced appropriately, and it should be expected to be a long-term process and avoid an over-simplified message of native equals good, non-native equals bad.

4.5 Legislation – prevention measures

Legislation has a key role to play in preventing introductions, through the control and regulation of the release and spread of invasive non-native species. The law is only as good as its enforcement, but current enforcement is hampered by ineffectual legislation, in some sectors, specifically Section 14 of the Wildlife and Countryside Act 1981. The current regulatory framework is explained in chapter 1.3. There are a number of weaknesses in the current legal framework in Great Britain which means the law is hampered in addressing the threat posed to native fauna and flora, and other interests, from invasive non-native species.

Section 14 of the 1981 Act attempts to create a blanket prohibition on releases of non-native animals and partial prohibition for plants. However, it is considered to have been largely ineffective for preventing further introductions and is difficult to enforce. This is partly because of the difficulty in interpreting the legislation, (for example, there is no definition of "the wild" – does it include gardens or semi-confined areas from which there is the possibility or probability of escape?) and partly because many introductions are likely to be unintentional or accidental, and hence potentially covered by the defence. For example, there has been argument as to whether allowing free-flying of

non-native birds from aviaries which the owner fully expects to return to the aviary constitutes a release within the meaning of the prohibition in Section 14. This lack of clarity has meant that there have been few prosecutions.

Also, Section 14 in itself does little to address the problems posed by invasive non-native species that have already become established in this country. Schedule 9 of the Wildlife and Countryside Act 1981 lists invasive non-native species which are already established in the wild and prohibits them from further releases. However, the Schedule has not been updated for some years. Regular review and updating of this Schedule is important if it is to be effective.

The Review Group was concerned that, in practice, fines for criminal offences in respect of invasive non-native species are very low in comparison to the potentially huge costs of damage, control and repair and that this did not constitute an effective deterrent. Following the Countryside and Rights of Way Act 2000, custodial sentences are now available to the courts but only in England and Wales. There is therefore a need for similar updating of sentencing provisions in Scotland.

Further issues include:

- Unequal treatment of plants and animals in law (the 1981 Act prohibits introduction of all non-native animals but only named plants);
- The general lack of powers to prohibit the sale of non-native species (especially where this involves sale via the internet and possibly import). Powers are available under the EC Wildlife Trade Regulations but are currently only used for two species;
- Out of date lists of relevant species. (Schedule 9 of the Wildlife and Countryside Act 1981 has not been updated since 1997);
- Lack of duty of care placed on any sector;
- No consideration of threats from unintentional introductions via new developments (for example by soil contaminated with Japanese knotweed, or use of non-native plants or genotypes);
- Lack of enforcement powers, for example, a right of entry to check for species or to undertake control and the need to ensure that agencies and local authorities are accountable for taking action with respect to relevant named species (the Police are the statutory enforcement authority for offences under Section 14 of the Wildlife and Countryside Act 1981).

- **Key Recommendation 5: Revise and update existing legislation to improve handling of invasive non-native species issues.**

Sub-recommendation 5.1:

Reform legislation to: ensure plants and animals are treated equally in law; ensure the correct list of species are targeted with legislative action, which should include a ban on the sale of relevant species; define duty of care by legal underpinning for codes of conduct and incorporate into EIA legislation for risk assessment for major developments that could lead to unintentional introductions of problem invasive species; provide for suitable powers and responsibilities for enforcement where required.

4.5.1 "Polluter pays" principle

The costs of damage, control and repair work are typically met by the taxpayer, or economic or other interests affected. The Review Group considered that the level of those fines available do not constitute a deterrent and recommended that where such releases constitute a criminal offence or wilful negligence then the "polluter pays" principle should be available, meaning that the courts should have the option of imposing fines bearing some relation to the cost of reparation. The costs of inspection, monitoring or management are open to the 'polluter pays' principle and consideration needs to be given to the benefits of a legal framework for imposing and collecting fines, or imposing an insurance requirement. In different circumstances these might include imposing the cost of management on those responsible for the release or introduction of a damaging invasive non-native species. The potential costs of control may provide the basis for determining financial costs.

Sub-recommendation 5.2:

Consideration should be given to identifying those circumstances where responsibility for management or its costs should lie with those responsible for the illegal introduction of the non-native species. Consideration should also be given to providing a legal basis for imposing fines on the 'polluter pays' principle.

4.5.2 Native species beyond their natural range

There have been significant problems for nature conservation in Britain following the introduction and establishment of species which are native to parts of Britain into areas beyond their natural range. For example, the introduction of hedgehogs to the Outer Hebrides (see case study page 60) has caused a substantial reduction in important wader populations, and the introduction of several fish species into Loch Lomond has caused major alterations in the fish fauna. Such problems could be countered by amendment to existing wildlife legislation, as the current wording in the Wildlife and Countryside Act 1981 refers to species 'not normally resident in, and not a regular visitor to, Great Britain in a wild state'. Amendment of the legislation should be given careful consideration, especially in respect of the introduction of species onto islands within Great Britain.

Sub-recommendation 5.3

Careful consideration should be given to amendment of the wildlife legislation in respect of the introduction and establishment of species which are native to parts of Britain into areas beyond their natural range. This is of particular relevance in respect of the introduction of species onto islands within Great Britain.

4.5.3 Release to the wild

Release to the wild is a separate issue from the importation pathways that result in organisms arriving in Britain. While Section 14 of the Wildlife and Countryside Act, 1981 prohibits the release of all non-native animals, the wording of Section 14 is much weaker for plants and does not cover micro-organisms. Only those invasive non-native

plants listed on Schedule 9 to the Act are prohibited from release.

A position previously advocated by the statutory conservation agencies has been to seek harmonisation of the law such that it would be an offence to release, allow to escape, or cause to grow in the wild, any plant or micro-organism which is not ordinarily resident in, or a regular visitor to, Great Britain in a wild state. Exclusions or general licences could be issued to cope with releases of certain categories of non-native plants or micro-organisms where these do not pose significant threats.

Under the proposed 'risk list' system for classifying non-native species according to their likely risk of becoming invasive and thereby causing damage, all non-native species (animals, plants and micro-organisms) would be placed in one of three categories. According to this system, only those species where there is clear evidence of likely harm would be prohibited from release to the wild, and possibly importation ('High Risk List' species), species where the evidence is equivocal or insufficient would be placed on the 'Medium Risk List' and would be banned until they could be cleared (to the 'Low Risk List') or definitively banned (to the 'High Risk List'), and low risk species would be placed on the 'Low Risk List', with no hindrance on them being kept or released to the wild.

There has also been difficulty in defining what constitutes 'the wild'. For instance, the spread of Japanese knotweed has been linked to the fly-tipping and inappropriate disposal of garden waste following its planting as an ornamental and there have been successful prosecutions for such fly-tipping. However, allowing the plant to spread naturally from land is unlikely to be covered by the Wildlife and Countryside Act 1981 offence. The legislation could be amended to ensure that garden plants are contained within the curtilage of the property or amenity area, although this would be a significant new burden on landowners/occupiers. An educational programme on the environmental impact of green waste fly-tipping is also necessary. Improved information on, and provision of composting and green waste disposal facilities would also address this issue. Garden centres could be encouraged to host these facilities, thus encouraging good practices and providing a resource for their customers.

What constitutes 'the wild' may be different for different groups of organisms, depending upon their biology and the reasons for their importation into Britain. Defining 'the wild' may be best achieved by a tight specification in each code of conduct, to ensure the most effective application in each case.

Further consideration of legislative measures, specifically covering management issues, is set out in Chapter 5.3 on Legislation – Remedy and Control measures.

The CBD's three stage hierarchical approach stresses that prevention is generally far more cost-effective and environmentally desirable than measures taken following introduction and establishment of an invasive non-native species, and that therefore prevention, the first stage, should be given priority. However, prevention measures will not always be successful. If an invasive non-native species has already been introduced then further measures will be necessary.

This chapter addresses the second and third stages of the CBD approach. It considers the monitoring and surveillance requirements to gain sufficient information on the presence of non-native species and also the capacity to take mitigation measures to eradicate or control invasive non-native species. Surveillance of non-native species at points of entry and in the countryside is needed to make informed decisions about their management and control. It is also important that where invasive non-native species are detected there is capacity to undertake management, and if necessary eradicate invasive non-native species. This is relevant in respect of both newly discovered non-native species and established non-native species. A structured approach should be developed to assess the impact and management of individual non-native species. Control should not be the automatic response to the presence of a non-native species; such a policy would be prohibitively expensive and publicly unacceptable. The policy should therefore be able to accommodate a range of management options from acceptance of the presence of the species and future review, through to mitigation measures such as containment or control.

5.1 Monitoring and surveillance

5.1.1 Overview

General monitoring schemes for most taxa are well-established in Britain, but very few of these have specifically-designed elements to monitor non-native species, and few monitor changes in distribution or numbers at a rate appropriate to cater for invasive non-native species. Monitoring must cover all stages of assessment of non-native species, from identifying those with potential to invade Britain, to assessing the effectiveness of control measures, and the Review Groups' assessment suggests there are a number of gaps in this network. The Review Groups' Key Recommendation from this area is that there needs to be a comprehensive review of the monitoring capacity for non-native species in Great Britain, followed by the development of adequate monitoring systems at all stages of management of invasive non-native species. This work should not halt urgent action on priority species.

The Review Group offer sixteen detailed recommendations to address this area – set out in this section – all aimed at supporting Key Recommendation 6.

- **Key Recommendation 6: Establish adequate monitoring and surveillance arrangements for non-native species in Great Britain.**

5.1.2 Classification of species

The Review Group concluded that it would be essential for work on invasive non-native species to have a commonly agreed set of definitions of the terms to be used. In the past, use of contradictory, overlapping and contrasting definitions has caused confusion, and definitions need to be clarified, preferably those which have international currency. The Review Group has used the definitions in the glossary, which are derived from the Global Invasive Species Programme (GISP) definitions, (see Annex 4).

A first priority is to develop an agreed set of assumptions and classification of non-native species. Great Britain holds species which are believed to be native, and which have occurred in Britain since the last glaciation, species which were introduced millennia ago, species which have recently been introduced, and species whose origins are simply unknown. A range of other categories simply compound the confusion over the status and "legitimacy" of species in Great Britain. A proper understanding of the status of the species present in Great Britain will provide substantial and vital information to guide policy decisions on priorities for action on invasive non-native species. For example, it is likely to be more important to address the rapid spread of recently-arrived species, rather than widely-distributed species which were introduced centuries ago, such as rabbits and those plants termed archaeophytes.

The Review Group believe that the classification of the status of all organisms on the British List is a key task, but note that there is no clear view on the way in which criteria should be set. The definitions of 'neotaxa' and 'archaeotaxa' used by plant ecologists may be a useful concept, but further research is necessary to determine how these might be applied to other groups. The Review Group further note that work to classify the status of all organisms that occur in Britain will take some time.

Non-native species are not currently defined specifically in British law. The Wildlife and Countryside Act 1981 currently refers to prohibiting introductions of species "which are not ordinarily resident in" or "a regular visitor to Great Britain in a wild state", coupled with a prohibition on release of established problem species (listed on Schedule 9) which would otherwise fall outside this definition.

Sub-recommendation 6.1:

Work should be undertaken to classify the status of all macro-organisms in Great Britain. This is a key task to underpin work on non-native species. The Review Group notes that there is no clear view on the way in which criteria should be set, and recommends that further research is necessary to determine how these should be applied.

Sub-recommendation 6.2:

Measures to develop monitoring systems for non-native species should not be delayed while classification work is completed, since the need for monitoring will remain, even if the list of species and habitats which require monitoring may require further modification.

An alternative to such detailed study would be for government to take practical decisions about the definition of non-native species. This might avoid the need for comprehensive scientific work to classify a wide range of established species that are not candidates for control or management and are therefore not priorities in policy terms. The Wildlife and Countryside Act 1981 seeks to prevent introductions of new species plus a list of specified established invasive species. This approach could be refined. An alternative is setting a cut-off date. Species introduced before that date are accepted as native with those introduced after that date being classified as non-native. This approach would recognise that it will not be possible to remove the vast majority of long-established non-native species, nor would it necessarily be appropriate to attempt to do so.

5.1.3 Monitoring of non-native species

The Review Group has considered the role of monitoring in the understanding of the status of non-native species and their economic and nature conservation impacts. A survey consists of observations made using a consistent method. Surveillance is the act of undertaking repeated surveys. Monitoring is surveying against a standard, to determine subsequent actions etc. But for the purposes of this report, the Review Group has taken "monitoring" to include surveys, surveillance and formal monitoring programmes, recognising that one approach may be more appropriate during a certain stage of colonisation than another. The Review Group have assessed the monitoring which is required for each stage of the process: from the period before the arrival of an organism (when it is just a theoretical possibility), to its management, or eradication, if appropriate.

In undertaking this review, the Review Group emphasise that all monitoring must have a clear purpose, which will vary according to the policy needs and the status of the species being monitored. Examples of the need are:

- Recording the presence/status of all non-native species. Usually, this can be undertaken as part of monitoring of native biodiversity, often by keen and knowledgeable members of the public;
- Proactive reporting of key invasive non-natives of concern (*i.e.* those that are considered to pose a significant risk). This could be undertaken by dedicated surveys, supported by records from wildlife enthusiasts and, if appropriate, the general public;
- Monitoring of a species that is known to be causing serious damage, probably undertaken intensively as part of a management strategy.

No Great Britain-wide schemes are designed to monitor the status of non-native species. There are, however, a small number of regional schemes (*e.g.* the aquatic and riparian invasive database in Environment Agency's Thames Region) and statutory surveillance programmes that support the enforcement of plant pest regulations, although these are 'spot checks' and coverage is, inevitably, incomplete.

However, a considerable amount of biological monitoring is undertaken. Britain is fortunate, indeed is the envy of many countries, in having a reasonable knowledge of its native biodiversity. Such has been these islands' social history that biological recording of many elements of fauna and flora have been maintained for more than

100 years. This information has been collected almost exclusively by keen, enthusiastic individuals in their spare time. The Review Groups' knowledge of past and current status of many species is thanks to this network of volunteers.

Efforts to map the arrival, establishment and spread of non-native species should be made in the context of enhancing knowledge of native wildlife. Techniques to better understand the status of non-native species should build on existing schemes, not develop alternative schemes.

5.1.4 What should be monitored?

The Review Group considers that high quality data are required for each stage of an organism's movement into Great Britain. This section analyses the monitoring requirements and the existing capacity to fulfil these, and recommends measures to enhance monitoring to levels sufficient to allow meaningful risk analyses to be made. The approach to each stage differs, but in most cases it is possible to build on monitoring and surveillance that are already *in situ*; the Review Group emphasises that a relatively small amount of core funding of established schemes could greatly assist the amount and quality of data on non-native species.

5.1.4.1 Potential

There is a need to identify the 'next generation' of species that may cause serious damage to economic or conservation interests. It is difficult to predict which of the millions of organisms from outside Great Britain could arrive, be likely to become established and cause problems and it would require almost limitless resources to monitor their status at multiple exit and entry points around the globe. However, through a network of international contacts, responsible authorities should monitor the presence of species associated with the pathways from Britain's principal trading partners. This, combined with a risk assessment, should identify the most likely contenders, and provide an 'early-warning system'. This is already in place for plant pests, but requires extending to include invasive non-native species that may cause different types of problems.

5.1.4.2 Identifying potential arrivals

Part of the risk analysis process requires the identification of key features in the life-cycle or behaviour of a species that suggest it could be likely to invade semi-natural habitats. Only a small proportion of the millions of species in the world are likely to become established in Britain, and it would be inefficient to undertake detailed risk analyses for all species that do not occur here.

Sub-recommendation 6.3:

A group of experts should be formed to collate scientific information on those species which are considered to have the highest potential for arrival and establishment in Britain, and which may cause conflicts.

5.1.4.3 Monitoring status and impact outside Great Britain

Knowledge of the impact of non-native species in other parts of the world is critical to making the most effective use of risk assessments, since it is based on real experiences. A core function of any co-ordinating body should be to support the development of international information networks, which would track contemporary knowledge of the status and the impacts of species that have the capacity to become established and invasive in Britain.

Sub-recommendation 6.4:

Britain should play a key role in supporting the development of international networks on invasive non-native species, in order to improve the flow of information about the impacts of invasive non-native species in climates similar to that in Britain.

5.1.4.4 Arrival

The arrival phase is considered to include the journey from a species' native range to its arrival in a semi-natural habitat in which it has the potential to survive. There is a need to maintain surveillance through the principal pathways and at the points of entry, though this is clearly more difficult for those species that are native to one part of Great Britain, but not another. As a result of previous risk analyses, surveillance of some pathways is already undertaken, at least for agricultural, horticultural and forestry pests that could cause considerable economic damage. However, there is currently no systematic method to record all organisms at the point of entry, or any system by which to draw together the datasets from each industrial sector.

5.1.4.5 Monitoring non-natives around principal pathways

Britain should take a lead in further developing networks of international contacts with whom to share information and knowledge about the distribution of problem species and the biodiversity/economic impact of species outside their range.

Sub-recommendation 6.5:

Priority should be given to developing information exchange with Britain's principal trading partners, by air and sea. It may, for example, be useful to know which invasive non-native species are present in and around the source of major trading pathways.

5.1.4.6 Surveillance around points of entry

Some surveillance mechanisms (*e.g.* Customs & Excise, Plant Health and Seeds Inspectorate) already exist at the points of entry of some economic pests which are considered to be high risk. With training, the role of staff employed in this work could be broadened to record other non-native species which are found during routine searches. Such information could be passed to a nominated expert or body, who would confirm the identification and take responsibility for ensuring its reporting into the relevant monitoring scheme.

The Review Group note that surveillance schemes are not designed to be complete in their coverage, and that spot-checks will only pick up a proportion of the non-native species that are transported outside their natural range. The Review Group also note that there is almost no surveillance of the movement of native species outside their natural ranges *within* Britain.

Sub-recommendation 6.6:

The role of existing surveillance inspectors should be broadened to include all non-native species and it is suggested that consideration should be given to putting in place surveillance of movements of non-native species within Britain, in tandem with enforcement and public awareness measures, for invasive species that are causing serious damage.

There is strong evidence that organisms arriving in ships' ballast water are a particular problem, threatening both conservation and economic interests, potentially on a large scale. There is little to discriminate between the arrival and establishment phases for these species.

Sub-recommendation 6.7:

Priority should be given to developing specific mechanisms to monitor the arrival and establishment of marine/aquatic invasive non-native species around British ports.

5.1.4.7 Establishment and spread

Monitoring the establishment and spread of non-native species is challenging. There is a need to identify the presence of a species outside a contained environment, to confirm that it is propagating/breeding, and to monitor the rate and geographic scale of its increase. As mentioned above, the voluntary network of naturalists and wildlife enthusiasts is a vital source of information on non-native species. Such is their interest that there is a high likelihood that the **establishment** of a non-native species will be noted and that the information will be provided to a national recording scheme. However, few schemes are able to adequately monitor the **spread** of non-native species on a timescale suitable to inform risk assessments or to plan control programmes. This is because many of the specialist schemes collate records, rather than being programmes designed to determine the change in range or population of a species or taxon.

Each recording scheme, inevitably, varies in the extent to which it can maintain wide geographic coverage, dictated by the location of the recorders involved (in general, most taxa are better recorded in south-east England than north-west Scotland). Not surprisingly, different taxonomic groups attract different levels of interest: only a few dozen people have the interest and skills to record each group of Coleoptera, compared to thousands of people who are capable of recording birds or mammals. The Review Group analysis (Annex 7) of current biological recording schemes indicates that few of the recording schemes have been designed to monitor non-native species, but the Review Group believe that many could do so with minor changes.

The assimilation, collation and analysis of biological data is a huge task. However, monitoring the status of non-native species can usually be achieved through existing schemes, many of which are run by Non-Governmental Organisations (NGOs), academic institutions or enthusiastic individuals. The Review Group suggest that the most significant contribution that government can make is to support the continued gathering of these datasets in the long term, especially to develop the capacity of monitoring schemes to recruit and train additional volunteers.

5.1.4.8 Monitoring audit

While the Review Group have endeavoured to be thorough in evaluation of existing schemes, the Review Group do not pretend that it is complete. It does not, for example, consider the capacity of recording schemes to be modified to account for the needs of policy development on non-native species, nor the likely response from volunteers in being asked to expand their role.

Sub-recommendation 6.8:

A full audit should be undertaken to determine where the most significant 'gaps' lie in the capacity to monitor the spread of non-natives. In assisting the development of these schemes, it is suggested that priority should be accorded to those schemes covering taxa or habitats that are known to be vulnerable to invasion by non-native species.

5.1.4.9 Plugging the gaps

Analysis of an audit of the type described above should identify groups of species that possess invasive qualities for which there is currently insufficient means to monitor their establishment and spread. The Review Group note, for example, that for some organisms, especially micro-organisms, there is no volunteer capacity to monitor status.

Sub-recommendation 6.9:

Government should seek to support the development of recording schemes for taxa that possess invasive qualities for which there is currently insufficient means to monitor their establishment and spread, through capacity building of appropriate NGOs or volunteers.

5.1.4.10 Comprehensive recording

If monitoring of non-native species is to be achieved through existing networks, there is a need to ensure that data are 'captured' in a consistent format and are made available in a timely manner. The statutory conservation agencies, as 'partners' or sponsors in many of the schemes, should assist NGOs and volunteers in developing common standards for data collection.

Sub-recommendation 6.10:

Government should encourage the organisers of all biological recording schemes to gather data on the status of non-native species.

Not withstanding the comments on classification and the definitions of non-native in Section 4, the Review Group strongly suggest that the measures recommended above, to equip monitoring systems to gather data on non-native species, should be put in place quickly.

5.1.4.11 Coordination of data

Such is the scale of recording effort that a single 'gateway' contact point would greatly assist the assimilation and communication of the potential wealth of data. If public attention is sought in the monitoring of biodiversity (native and non-native), there would be considerable value in having a single high-profile 'clearing-house' through which data could be provided.

Sub-recommendation 6.11:

Recommend the National Biodiversity Network is the obvious route through which data on non-native species from across Great Britain can be made available.

5.1.4.12 Collation and analysis of data

Once data are collated by the organisers of biological recording schemes, there is a need to extract the subset of non-native data in a timely manner, to update knowledge of the spread of species. There is a need for the co-ordination of this data selection, though the Review Group see no reason why this has to be undertaken by the same body responsible for implementing invasive non-native policy activity. The Review Group suggest that this would be a suitable role for the statutory conservation agencies, since they already have strong links to the various recording schemes.

Sub-recommendation 6.12:

A single organisation should have responsibility for co-ordinating the collation of data on non-native species to ensure that they are used in revisions of risk assessments and strategies for the control or management of problem species.

5.1.4.13 Provision of data to the public and interested parties

Where the volunteer capacity exists, organisers of biological recording schemes should be encouraged to publish regular reviews of non-native species (at least as additions to their current publications). The Rare Breeding Birds Panel has set a good benchmark, by producing an annual report on attempted and successful breeding by non-native birds (see, for example, British Birds 94: 518-522). This provides an annual overview of the status of many species, enabling interested parties to evaluate the speed of expansion in population and range. This is particularly valuable because it is usually published little more than a year after the breeding season concerned.

Sub-recommendation 6.13:

Support should be provided to enable biological recording schemes to produce regular reviews of the status of non-native species.

5.1.4.14 Evaluating spread and distribution

Most biological recording schemes gather sightings; some involve systematic recording in certain areas; but few are able to provide regular 'snapshots' of the countrywide distribution of a species. Detailed distribution maps for non-native species have been produced only recently for plants and butterflies, and even fewer taxa (*e.g.* breeding birds) have the benefit of regular reporting against which comparisons can be made. Producing such atlases is time-consuming, but is essential to maintain a realistic assessment of biological change. It was suggested that this process would be assisted if established invasive non-native species were deemed notifiable by law. However, this is not a recommendation of the Review Group.

Sub-recommendation 6.14:

Statutory conservation agencies and NGOs should collaborate to ensure that biological atlases include data collection on non-native species, and that government funding is available to support their production.

5.1.4.15 Impacts

Evaluation of the impacts of a non-native species is critical to any case being made for management measures. Invasive non-native species that cause significant impacts are normally assessed by the visible effect on a crop, a structure, a native species or a biotope, but the scale of the impact is often only appreciated once the non-native species is well established. There is a need to identify and monitor the impacts of non-native species as early as possible in their establishment phase in order to increase the likelihood of implementing successful management measures.

Where an invasive non-native species threatens the status of native wildlife, data are most likely to be obtained through autecological studies of the declining native species or its habitat. These kinds of detailed ecological data is often only acquired during the latter stages of a species' decline, by which time the cost and effort required to remove the invasive non-native species or protect the native species is prohibitive. As a result, absolute proof of damage often comes only once it is too late to undertake any meaningful action. Instances of direct impact (such as predation, competition for food, competition for breeding areas, weakening of flood defences) are easier to identify than changes made to ecological processes and habitats, which generally occur more slowly.

5.1.4.16 Dedicated monitoring of impacts

The monitoring of the impacts of non-native species should be a priority where an assessment of a receptor (*e.g.* a native species, a crop, a semi-natural habitat *etc*.) identifies a high risk of impact. Resources should be directed towards monitoring the impacts on those native species and habitats that are a high priority under the UK

Biodiversity Action Plan, and on habitats that are known to be a major pathway or receptor for non-native species (*e.g.* freshwater habitats, offshore islands).

Sub-recommendation 6.15:

Resources should be directed towards monitoring the impacts of invasive non-native species on the most threatened species and habitats.

5.1.4.17 Control

Regular monitoring of the range and effectiveness of control measures is essential in order to evaluate progress against pre-determined objectives and models of eradication, containment, management or mitigation. This iterative process enables the management approach to be refined and enhances the efficient use of available resources.

5.1.4.18 Monitoring control measures

A well-planned programme to control or eradicate an invasive non-native species must have good population demographic data and good monitoring to determine the effectiveness of the management measures. The precise nature of the research and monitoring required will vary according to the management measures employed and the life cycle of the species and habitats concerned. Monitoring should not only evaluate the numbers or biomass of an organism removed, but also the effect of this removal in reducing the impact on the species, habitat or land-use concerned.

Sub-recommendation 6.16:

Control programmes should always include resources to monitor the population demography of the target species, and the effectiveness of control programmes. This should continue beyond the end of management measures, in order to determine that further invasion has not occurred and that the problem has been resolved.

5.2 Management and control policy and capacity

5.2.1 Introduction

To implement the second and third stages of the three-stage hierarchical approach, it is important that where invasive non-native species are detected there is capacity to undertake management, and if necessary eradicate invasive non-native species. This is relevant in respect of both newly discovered non-native species and established non-native species.

A structured approach should be developed to assess the impact and management of individual non-native species. Control should not be the automatic response to the presence of a non-native species; such a policy would be prohibitively expensive and publicly unacceptable. The policy should therefore be able to accommodate a range of management options from acceptance of that species' presence and future review, through to mitigation measures such as containment or control.

Such arrangements should make use of the capacity of existing organisations where possible. An example is the Deer Initiative, supported by the Forestry Commission, and its work to bring together those involved in deer management with the aim of a sustainable well-managed deer population (including both native and non-native species). It is noted that the current capacity for operational action is currently greatest in those areas where economic interests are threatened and least where biodiversity interests are threatened. It is also noted that a contingency capacity for such action will be needed to deal with newly-discovered non-native species to prevent them from becoming established.

The legal status, inspection, research and management responsibilities for invasive non-native species are currently spread across a range of organisations on species and sectoral grounds. As set out in Key Recommendation 1, coordination is needed at the decision-making level and in terms of management to make best use of existing sectoral capabilities and to fill identified gaps. While ensuring coordination, this should also take into account and accommodate existing capabilities and responsibilities. Existing capabilities also need to be extended to cover sectoral gaps and ensure a broad response capability.

- **Key Recommendation 7: Policies should be established with respect to management and control of invasive non-native species currently present or newly arrived in the wild, and operational capacity be developed to implement these policies.**

Detailed consideration of this issue, and a further set of detailed recommendations to support Key Recommendation 7, is set out in this chapter.

CASE STUDY: Ruddy duck *(Oxyura jamaicensis)*

Category of introduction: unintentional, but as a consequence of deliberate importation of the species.

Reason(s) for introduction: recreational and aesthetic for ornamental wildfowl collections.

Pathway for the introduction: birds escaped from wildfowl collections and the species became established in the wild. It was therefore introduced as a direct result of deliberate imports of the species. After escaping from captivity, Ruddy ducks first bred in the wild in 1960 and increased to about 5,000 birds by 2000. The birds are beginning to spread across Europe.

Problems caused by the introduction: The North American ruddy duck has been identified as the primary threat to the long-term survival of a European species. The white-headed duck *Oxyura leucocephala* is a globally threatened species. Its Western Mediterranean population is recovering from a historical minimum of 22 birds counted in Spain in the 1970s. Over 20 years of active conservation efforts have resulted in a population increase in Spain to over 4,000 in 2001.

However, in the mid-1980s, a new threat to this species appeared from the ruddy duck. Ruddy ducks from the feral UK population began to reach Spain and to breed aggressively with white-headed ducks, giving rise to fertile offspring with predominantly ruddy duck characteristics. Without control, ruddy ducks are therefore expected to colonise continental Europe and threaten the white-headed duck with extinction through hybridisation and competition.

Action taken: An international white-headed duck action plan prepared by BirdLife International and endorsed by the Bern Convention on Conservation of European Wildlife and Habitats and by the European Commission highlights the need for control, and ultimately eradication, of both wild and captive populations of ruddy ducks (particularly the UK source population) in order to safeguard the future of the white-headed duck.

A number of countries are working to implement this action plan. The UK Government has undertaken a regional control trial of ruddy ducks, to investigate the feasibility and cost of a national eradication programme for this species, and is considering next steps.

The control trial concluded that the UK ruddy duck population can be reduced to very low numbers at a cost of £3.6 million to £5.4 million over four-six years. This demonstrates the high cost and difficulty of undertaking control or eradication programmes once invasive non-native species have become established. Such control measures may also be unpopular with the public, hence the need for greater public understanding of the issue including the importance of not allowing introduction of further new species.

English Nature ©

The spread of introduced North Amercian ruddy ducks from the UK across Europe threatens the survival of a globally-threatened species.

5.2.2 Development of practical control measures

It is necessary to consider the development of practical control measures for invasive non-native species. Established non-native species and incoming non-native species are considered in turn.

5.2.2.1 Management of established non-natives

There are many hundreds of non-native species already established as self sustaining populations, ranging from those identified from just one or two locations, to others with a Great Britain-wide range. These species also vary from the damaging, to the benign, to those with benefits for other aspects of biodiversity or economic activity. To develop a practical approach to the control of non-natives, there is a need to produce a standard set of criteria against which to compare the issues raised by different species. **Control should be seen as the response to a particular set of criteria rather than the universal response to the presence of an established non-native.**

Figure 3 presents a decision tree outlining a possible route by which established non-natives might be assessed and different end-points of remedy or control derived. This starts with the assumption that the species is established, although it does not preclude undertaking risk assessments or cost-benefit analyses in anticipation of establishment.

For established non-natives, the decision tree allows species to follow four separate pathways. Firstly, a species may remain in the loop of periodic review, undergoing assessment for its impact on biodiversity, health or economic activities and cost-benefit analysis, but with no active management or control.

Secondly, a species may be identified as having detrimental effects, but eradication is not considered appropriate. In this case the decision tree proposes the production of a management plan to suppress, restrict or limit the species or its impact as appropriate.

Thirdly, eradication may be desirable but not currently feasible or cost-effective. In this case management should be considered to contain the species while researching improved or more cost-effective techniques.

Lastly, a species can move to the eradication pathway, where an iterative process of review allows the progress and continued desirability of this aim to be assessed.

The tree also requires three separate procedures to be standardised and common criteria to be developed. These include impact assessment, quantifying the costs of control, and cost-benefit analysis. The issue with all three is to identify methods of comparing between different currencies of measurement. In particular, systems should assess the implications of the species or its management on economic, biodiversity, social, welfare and health interests. Areas of consideration include:

Economics
The existing and potential costs of the species to economic interests.
The economic benefits of the species.
The costs of control.

Biodiversity
The existing and potential impact of the species on native biodiversity.
The international status of the non-native species and any inherent conservation value.
The impact of control on native biodiversity.

Social
The perception of the social value of the species, either positive or negative.

Welfare
The animal welfare implications of control.

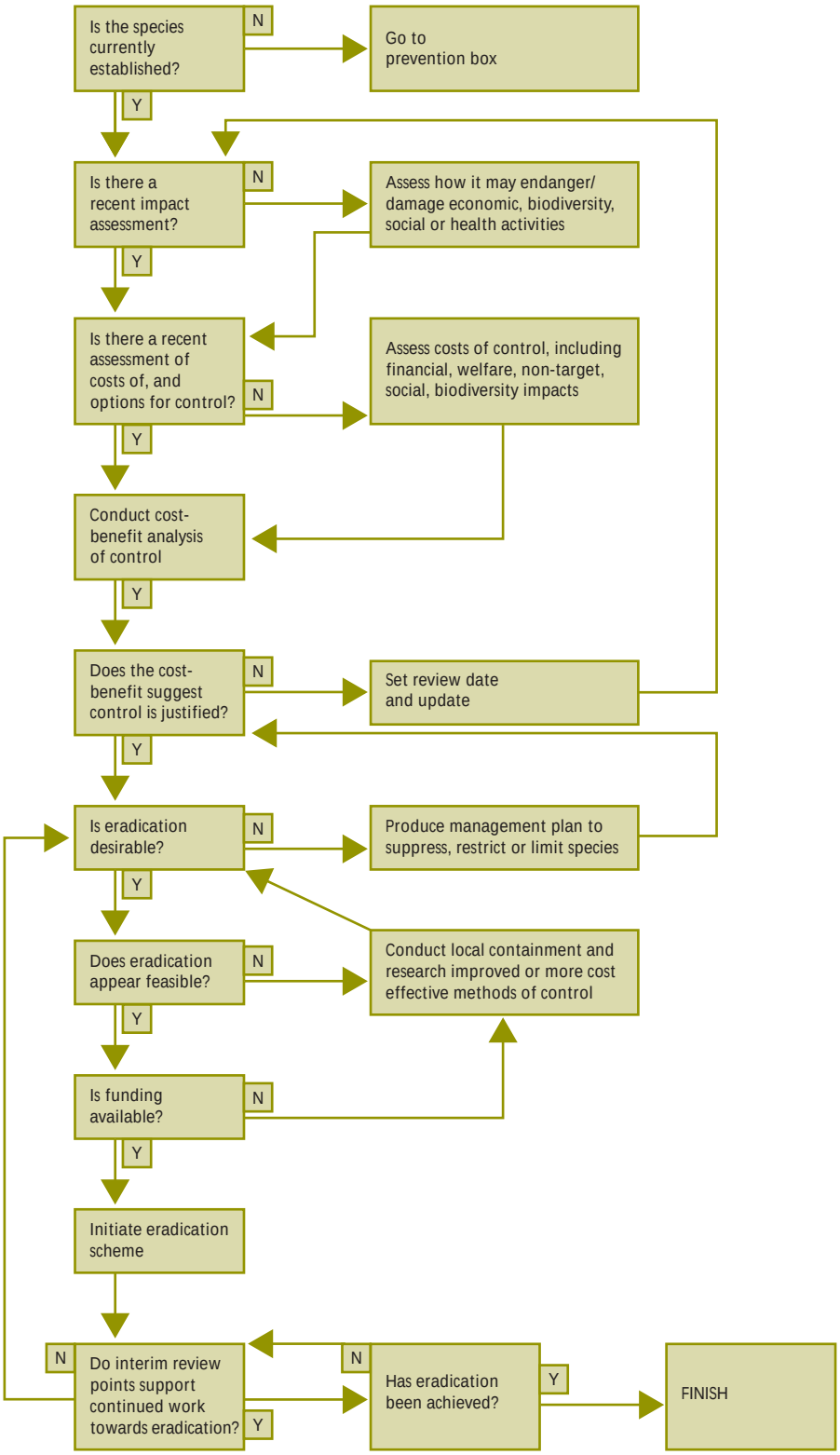
Health
The effect of the species on human and animal health.
The implications of control for human and animal health.

Sub-recommendation 7.1:

A structured approach to assess the impact and management of individual invasive non-native species should be developed. This should include impact assessment, cost estimation and cost-benefit analyses to agreed criteria. The output should accommodate a range of management options from review through limitation to control. These methods should include economic, biodiversity, social, animal welfare and animal and human health considerations. These analyses should provide criteria from which to prioritise actions relating to different species.

One possible means to address this might be through management plans. The CBD Decision VI/9 (a Global Strategy for Plant Conservation target 10) recommends conserving plant biodiversity by implementing management plans for at least 100 alien species that threaten plants, plant communities and associated habitats and ecosystems.

Figure 3: Decision tree to assist with assessment of established non-natives



5.2.3 Management of incoming non-native species

The opportunity for control of non-native species is clearly greatest and the costs lowest when they first arrive. The interception and control of new species at the point of establishment would require the assumption that they should be managed prior to them demonstrating any detrimental effects on national interests, as would be supported by the precautionary approach. The principle should be that such species should not be allowed to establish unless a risk assessment can be produced to suggest otherwise.

The implementation of such a policy would clearly be aided by the prediction of which species are most likely to enter the country based on the experience of other nations, information on the likely extent of trade or other movements and the *a priori* production of risk assessments and contingency plans to deal with them on their arrival. Such an approach has recently been adopted with regard to the control of non-native fish species under the Import of Live Fish Act, 1980 (ILFA). In particular this should allow for the appointment of agencies or other bodies to take responsibility for particular species or species groups, their monitoring and management should they arrive.

While the production and agreement of contingencies and risk assessments prior to the arrival of particular species will clarify actions and responsibilities, it is also likely that species will establish in an unpredictable manner. A robust system for dealing with incoming non-native species must include the prospect of species arriving with no prior warning or pre-existing risk assessment. It should also accommodate response mechanisms where the species falls outside of existing areas of sectoral expertise and responsibilities. Assuming that there is a centralised policy group for non-native species, there will also be a requirement for agencies to be designated which could be called upon to undertake control on behalf of the decision-makers where no one else has responsibility or capacity to do so. A critical test of the effectiveness of a co-ordinated management system will be the ability to make decisions rapidly, in order that the impact of an invasive non-native species can be minimised.

Invasive non-native species are, by definition, an international issue. For some groups there already exist international agreements, definitions, standards, information transfer and monitoring programmes to deal with invasive non-native species, particularly those that affect economic interests and trade. Similar arrangements are required to cover other species groups better and to protect biodiversity interests.

Sub-recommendation 7.2:

Co-ordinated methods of risk assessment and control should be established with other countries and across sectoral groupings to assess future risks, limit spread of damaging species and share expertise.

This sub-recommendation supports Key Recommendation 2 (to develop comprehensive Risk Assessment procedures to assess the risks posed by non-native species and identifying and prioritising areas for other prevention action) set out in Chapter 4.2.

5.2.4 Cost effectiveness of control

Available finances will limit the efforts that can be made to manage invasive non-native species. Funds therefore need to be effectively managed, their uses prioritised and more efficient methods of both prevention and control developed. The present sectoral responsibilities for different invasive non-native species groups are not adequately co-ordinated and there is clear scope to increase coordination. For example, if a plant health risk analysis concludes that a new non-native species poses no economic or environmental threat, no further action can be undertaken under plant health regulations. However, release of any non-native animal or of a plant included on Schedule 9 would contravene the Wildlife and Countryside Act, 1981. Coordination of responsibilities is required to ensure information transfer and avoid duplication of effort. Information exchange is also important to improve coordination of efforts and dissemination of results to other workers, policy makers and the general public. A useful current example is the work on Japanese knotweed (www.cornwall.gov.uk/environment/knotweed). On a broader scale, the Global Invasive Species Database implemented by the IUCN Invasive Species Specialist Group (http://www.issg.org/database) is a prototype system to disseminate information on invasive non-native species, their ecology and control. The success of control and eradication programmes may depend upon the continuing availability of effective pesticides.

The costs of control can also be a major consideration, and lack of effective and selective control methods is likely to make the costs of control prohibitive for many established invasive non-native species. For example, the estimated cost of eradicating Japanese knotweed *(Fallopia japonica)* with current methods exceeds £1 billion while other species such as *Impatiens glandulifera* might only be controlled with unacceptable levels of damage to the native hedgerow communities in which it is found. The development of more cost effective control methods, such as biological control, could greatly reduce these estimates and alter any cost-benefit analysis. A biological control proposal for Japanese knotweed has been costed at £500,000, and early results indicate a high probability of success for this project (http://www.cabi-bioscience.org/html/japanese_knotweed_alliance.htm).

Other areas of potential improvement include the development of species specific baits, antigens or chemicals for the immunological, contraceptive or direct control of established invasive non-native species. In other areas current control may be cheap but unselective, for instance the management of plants through use of broad-spectrum herbicides. The development of more specific methods, such as species-specific mycoherbicides for stump-treatment, would increase the potential for their use.

Improved modelling and understanding of the dynamics of invasions, invasive non-native species and vulnerable systems will also increase the cost effectiveness of management. For instance, improving our understanding of how invasive non-native species spread through the application of spatial and climatic models would improve cost effectiveness, as would a clearer understanding of human factors (*e.g.* levels of trade). Predicting which species may become invasive or impact on national interests would increase the efficient targeting of resources. Understanding the characteristics of those ecological systems most vulnerable to invasion, for instance through disturbance or nutrient enrichment, may allow more effective preventative methods to be developed.

Sub-recommendation 7.3:

Individual agencies should be nominated to produce and implement management plans for dealing with particular invasive non-native species. Risk assessments and contingency plans should be prepared for species identified as likely to enter the country or to pose particular risks in advance of their arrival. Agencies should be empowered to act in advance of the species entering the country to ensure a rapid and co-ordinated response before the species becomes established. These agencies should also include a contingency capability to deal with the unexpected occurrence of species or species that cross existing sectoral responsibilities.

Sub-recommendation 7.4:

Strategic funding should be made available to support the development of novel control techniques for invasive non-native species and the establishment of centres of excellence for such methods.

Sub-recommendation 7.5:

Research should be conducted into the restoration of habitats or communities following the removal of invasive non-native species to restore their original biodiversity or economic value.

Sub-recommendation 7.6:

Methods of information transfer should be developed, through web-sites, e-mail discussion groups, workshops and conferences, to disseminate information on effective control methods, both nationally and internationally.

This last recommendation overlaps with the proposed role of a lead co-ordinating organisation as envisaged in Key Recommendation 1 and also the need for public education campaign and provision of information envisaged in Key Recommendation 4.

CASE STUDY: Muntjac deer *(Muntiacus reevesi)*

Category of introduction: Intentional

Reason(s) for introduction: Similarly to grey squirrel, the species was deliberately introduced around 1895 before the impacts of non-native species were understood.

Pathway for the introduction: Deliberate importation from China and a series of releases.

Problems caused by the introduction: Muntjac deer can have a severe effect on native ground flora and also cause significant economic damage to forestry. They are small deer (up to 50 cm at shoulder) originating in China. The current British population is still concentrated in south and central England though records extend to Wales and Scotland. Model predictions suggest a probability of some further spread into areas around the current distribution.

Where they do occur, muntjac can have a severe and deleterious effect on ground flora in woodland. One threat is to bluebells, which can be virtually extirpated in unprotected woods; orchids are also at risk. By browsing on young trees, muntjac can cause significant economic damage in forestry. They also damage agricultural and horticultural crops. Road traffic accidents involving deer are a significant and increasing cost-factor in some parts of Britain.

As with all deer, current methods to reduce impact rely on killing animals and protecting target vegetation with barriers such as fencing which may be expensive (*e.g.* £3-5 per metre). Methods such as immuno-contraception are not currently practical. The only practicable and legal method of population management for muntjac in the UK is by shooting. However, compared to other common deer species, muntjac are particularly difficult to control by shooting because of their solitary habits, small size and preference for dense cover. Public acceptability for lethal methods of controlling mammalian species also needs to be considered.

Muntjac deer therefore pose a significant threat to woodland biodiversity that can only be limited by persistent, and possibly unpopular, control measures. It should be noted that these problems apply to most British species of deer including all the native species, although muntjac are arguably more damaging to native ground flora than native deer.

For control and eradication activities, the table below includes a range of estimates for the containment or eradication of a selected list of established invasive non-native species. These include examples from recent or ongoing projects, together with estimates of the costs of eradicating a range of currently established species. The costs can be very high and this highlights the importance of both initial prevention measures and also having the capacity to take early action when an invasive non-native species is first discovered.

Table: Cost of control or eradication

Species		Notes
New Zealand flatworm	*Arthurdendyus triangulatus*	Current costs of survey and containment (£0.1m)
Ruddy duck	*Oxyura jamaicensis*	A current project (£0.8m) is quantifying the costs and feasibility of national eradication. It is estimated that national eradication would cost approximately £5m.
Coypu	*Myocaster coypus*	This species was eradicated from East Anglia in the 1980s at a cost of circa £10m at current value
American mink	*Mustela vison*	An ongoing project (£1.6m) aims to eradicate mink from the Uists and reduce numbers in Harris. A further, larger project would be required to eradicate mink throughout the Hebrides
Melon thrip	*Thrips palmi*	Eradication of local outbreak (£0.1m)
Wild boar	*Sus scrofa*	An ongoing project (£0.3m) is surveying numbers, distribution and population ecology
Grey squirrel	*Sciurus carolinensis*	Estimated current annual control costs for timber protection (£3m)
Water fern	*Azolla filiculoides*	Costs of eradication from 200 sites nationally has been estimated at between £0.2 and £2m over a three to five year period
Australian swamp stonecrop	*Crassula helmsii*	Costs of eradication from 200 sites nationally has been estimated at between £1.8 and £4m.
Japanese knotweed	*Fallopia japonica*	The cost of control in riparian areas, where approximately 10,000 km of watercourse is estimated to be affected is calculated at £52 million. This assumes both banks are affected to a width of 2 m from the edge of the water on both banks. Assuming 0.5% of the total land area of Britain, this is only 1% of every square affected and is likely to be an underestimate. 1200 km^2 may be affected by Japanese knotweed, the cost of eradication is approximately £1.56 billion.
Giant hogweed	*Heracleum mantegazzianum*	Current annual control costs are estimated at £0.1m, costs of eradication likely to be in the order of £100m
Floating pennywort	*Hydrocotyle ranunculoides*	Costs of eradication estimated at between £0.2 and £0.7m
Himalayan balsam	*Impatiens glandulifera*	Costs of eradication estimated at over £1m
Parrot's feather	*Myriophyllum aquaticum*	This species present in approximately 150 sites in the UK. Assuming an average infestation size of 0.2 ha, the total cost of chemical control is estimated to be approximately £250k over 3 years. The total cost of eradication using mechanical control is estimated to be between £900k and £3 million.

5.3 Legislation – remedy and control measures

In addition to the legislative measures proposed in chapter 4.5, this section sets out additional proposed improvements to legislation to address remedy and control issues more effectively.

5.3.1 Appropriate enforcement and support measures

Legislation needs also to facilitate control programmes for existing invasive non-native species. The management of many species will require access to land and there are clearly situations where compulsory access may be required. If management of an invasive non-native species is being undertaken then lack of access to land may be inconvenient but may not prevent the management measures being effective. However, in the case of an eradication programme, access to land might be absolutely vital for that policy to succeed.

Powers of compulsory access are available under existing legislation, for instance, The Weeds Act (1959) and The Destructive Imported Animals Act (1932), although these only relate to certain species, rather than all invasive non-natives. These powers should be available for the management or inspection of invasive non-native species in general. However, it is recognised that this must be balanced against the rights of landowners/occupiers and such powers should only be invoked under specific circumstances and any empowering legislation framed in terms compatible with The Human Rights Act (1998). The right of entry currently granted under Section 42(3) Environmental Protection Act provides a further precedent.

Sub-recommendation 5.4:

Consideration should be given to providing powers of compulsory access, compatible with The Human Rights Act 1998, to allow the control of non-native species by statutory bodies, with guidelines produced to ensure that these are used sparingly and as a last resort for effective control.

A further problem arises as established non-native bird species are afforded protection by default under the Wildlife and Countryside Act 1981, along with native species, due to the broad definition of wild birds used in that Act. This is an impediment to management of invasive non-native species as licences are required to undertake control, as in the case of the invasive non-native ruddy duck.

It is recommended that such provisions be revised, or a licensing solution found, to avoid affording protection to non-native species by default in this way, while still ensuring their humane treatment. One view is that a licensing solution may be preferable. Currently all birds are protected and so removal of protection for non-native species might result in inappropriate control measures taking place, for example resulting in disturbance to other bird species during the breeding season. Another alternative might be to remove protection for non-native bird species during the winter only (similar to the position for huntable species listed on Schedule 2 Part II of the Wildlife and Countryside Act 1981), to minimise disturbance to other bird species during the breeding season as a result of control measures.

Sub-recommendation 5.5:

Existing legislation should be reviewed to identify areas where protection is inadvertently given to invasive non-native species by default, and that consideration should be given to inserting an exemption for non-native species, whilst providing animal welfare safeguards in relation to the methods by which they may be controlled.

These legislative recommendations all feed in to Key Recommendation 5 (to revise and update existing legislation).

There are a number of other issues raised during the Review process which warrant either further recommendations or discussion. These are set out in this chapter.

6.1 International work

Invasive non-native species are by definition an international issue and the issue is being considered in an increasing number of international fora as the profile of the issue increases. The Review Group recommends that the Government should continue to work through international mechanisms to address these issues and to consider how best to contribute in terms of international information sharing. In some cases, these initiatives seek to provide a broad framework for addressing invasive non-native species problems and in others the initiatives are very focused to addressing a specific issue. Some of the important international initiatives are set out below, although this should not be considered an exhaustive list.

The work of the Convention on Biological Diversity is very important to provide an international framework for action on invasive non-native species issues. The Government should continue to support and input into the CBD's work programme, engaging with the Global Invasive Species Programme (GISP), and consider how best it can take forward such issues as international information sharing. The Bern Convention for Conservation of European Wildlife and Natural Habitats has been working to develop a European regional strategy to address invasive non-native species issues. Also, the Global Strategy for Plant Conservation, adopted at CBD COP6 in April 2002, stated that management plans should be developed for major invasive non-native species that threaten plants, plant communities and associated habitats and ecosystems.

Ballast water exchange has been identified as a major threat in terms of unintentional transfer and introduction of non-native species into the marine environment. It is estimated that about 10 billion tonnes of ballast water are transferred globally each year, potentially transferring species of sealife from one location to another. On release into the new environment, these species may prove ecologically harmful.

The Review Group recommends that the Government continue to work through the International Maritime Organization (IMO) to introduce international measures to address unintentional introduction of marine non-native species through ballast water transfer. The IMO is working on developing draft new regulations for ballast water management to prevent the transfer of harmful aquatic organisms in ballast water. Species, such as algae and molluscs, can also attach themselves to ship's hulls and be transported around the world, increasing the ship's fuel consumption and potentially being introduced to new environments and becoming invasive. Anti-fouling paint is used to prevent this occurring. The Government should support the IMO's work on environmentally safe anti-fouling paints. The Government should also seek to work through the Convention for the Protection of the Marine Environment of the North-East Atlantic (the "OSPAR Convention"). The OSPAR Convention will be considering what action may be needed to address the issue of invasive non-native species in the marine environment.

There is an increasing body of international work on Plant Health which assists in tackling invasive non-native species issues, under the International Plant Protection Convention, the European and Mediterranean Plant Protection Organisation and other regional plant protection organisations. The Government should continue to contribute to these efforts.

The International Civil Aviation Organisation (ICAO) is currently considering the issue of unintentional introduction of non-native species via aircraft. The Review Group had identified this as a potential pathway for unintentional transfer of non-native species. Some procedures already exist to prevent unintentional transfer of species such as insects via aircraft but further consideration is needed to identify the level of the threat posed by this pathway. The ICAO is undertaking a survey of contracting parties to gain further information, before deciding on whether further action is needed.

On a European scale, the Government should continue to assist the Bern Convention's work to draw up a European regional strategy for dealing with invasive non-native species. The Government should also continue to work with the European Commission and other EU Member States. The EC Wildlife Trade Regulations include the provision to restrict the trade in, or holding or movement of, species for which it has been established that they would constitute an ecological threat to indigenous native fauna and flora if they were introduced into the wild. Currently, restrictions on trade have only been established for two invasive non-native species. Due to the growing recognition of the threat to global biodiversity posed by invasive non-native species, there is consideration at EU-level as to how best the EC Wildlife Trade Regulations can be used to assist in combating the threat posed by invasive non-native species. Such import and sales controls might be appropriate to address the most serious risks where codes of good practice are not thought sufficient to prevent introductions of certain invasive non-native species by this pathway. The Government should contribute constructively to this consideration.

The Review Group briefly considered the issue of preventing species being exported from the UK and becoming invasive non-natives elsewhere in the world. It was noted that this issue could be partly addressed through codes of conduct for exporters if appropriate and through international information sharing mechanisms. This issue will need to be considered further in future.

Although, the geographical remit of the review of non-native species policy is Great Britain, the Review Group felt that its conclusions would be relevant to UK Overseas Territories. Many of the UK's Overseas Territories are small islands with isolated ecosystems, thereby making them particularly vulnerable to invasive non-native species.

It should be noted that the UK's international obligations as a member of the European Union and of the World Trade Organisation do govern and may constrain some of the actions which might be seen as desirable in preventing the introduction of invasive non-native species.

Miscellaneous recommendation 2:

The Government should continue to work through international mechanisms to improve the regulatory and policy framework for dealing with invasive non-native species issues. This should include input to the Convention on Biological Diversity, the International Plant Protection Convention, the International Maritime Organization's work to address unintentional introduction of marine non-native species through ballast water transfer, the International Civil Aviation Organisation's consideration of unintentional introduction of non-natives via aircraft, the Bern Convention's work on a European approach and also the European Commission's work to consider how the EC Wildlife Trade Regulations might best be used to address invasive non-native species issues.

6.2 Release of rehabilitated non-native species

The Review Group noted that one area of current difficulty is that of rehabilitation and release of invasive non-native species currently listed on Schedule 9 of the Wildlife and Countryside Act 1981.

There are circumstances where invasive non-native species may be injured and brought in to wildlife hospitals by concerned members of the public. In such cases, there is an animal welfare dilemma in that such animals cannot be lawfully released back into the wild as this would contravene Section 14 of the Wildlife and Countryside Act 1981. Potentially this leaves the wildlife hospital treating an animal which they cannot release if it recovers. Although most people might deem it acceptable to put down an injured animal which has no chance of making a successful recovery, putting down animals which could recover is likely to be considered less acceptable. Against that is the detrimental ecological consequences of releasing a species listed on Schedule 9.

Recognising the dilemma, when muntjac deer were added to Schedule 9, a licensing system was established allowing a limited re-release of muntjac deer in certain areas subject to certain conditions. Such regulatory control, rather than prohibition, may help to minimise the risks of illicit and inappropriate release of invasive non-native species.

Miscellaneous recommendation 3:

Consideration should be given to licensing arrangements for the rehabilitation and release of certain invasive non-native species where this can be undertaken without risk of significant adverse consequences.

6.3 Stakeholder forum

The issues surrounding introduction and establishment of invasive non-native species affect a wide range of different interests and stakeholders. Some, but not all, of these sectors are represented within the Review Group. The Review Group considers that it is essential that stakeholders be fully engaged in development of policies to address invasive non-native species. This should include all of the sectors, both within and beyond Government, who have an interest and wish to be involved; such as conservation interests, wildlife trade and other relevant industry interests, horticulture, scientific interests, animal welfare interests etc.

There should be wider discussion to ensure wider understanding and ownership of the issues and how they may best be tackled. There may be several ways of achieving this but one mechanism would be the establishment of a consultative forum which could take place on a regular basis. It would enable good understanding of the policy issues, hopefully ensuring that the relevant sectors become engaged, thereby increasing buy-in to the policies adopted and having knock-on benefits such as improved profile and public understanding, increased compliance with measures adopted and even in terms of public reporting of sightings of non-natives. Its remit should include consultation on policy issues, scientific input, assisting with development of codes of conduct across the various sectors, assistance with enforcement and assisting with the public education and awareness part of the work programme.

- **Key recommendation 8: Stakeholders should be fully consulted and engaged in development of invasive non-native species policies and action through a mechanism such as a consultative forum.**