

UK Biodiversity Research Advisory Group

STRATEGY FOR NON-NATIVE SPECIES RESEARCH

Richard Ferris and Ian Bainbridge

On behalf of the BRAG Non-Native Species Subgroup

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“There must have been plenty of them about, growing up quietly and inoffensively, with nobody taking any particular notice of them ... and so the one in our garden continued its growth peacefully, as did thousands like it in neglected spots all over the world ... it was some little time later that the first one picked up its roots and walked”

John Wyndham, *The Day of the Triffids*

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1. Introduction

Invasive non-native species (NNS) can transform ecosystems, and threaten native and endangered species (Defra, 2003). All terrestrial, freshwater and marine natural and semi-natural habitats are affected. In the 2002 Reporting Round for the UK Biodiversity Action Plan (UKBAP), NNS were cited as the third most important factor affecting delivery of Habitat Action Plans (HAPs), and the fifth most important factor affecting Species Action Plans (SAPs), limiting progress in 14 HAPs and 30 SAPs.

Invasive NNS are a global problem, identified as one of the main causes of biodiversity loss worldwide. With increasing global trade and world travel, the problems are likely to continue to grow (Defra, 2003). In view of this, UK researchers need to contribute internationally, by forming links and collaborations with overseas researchers, especially those in Europe.

Europe's size, number of countries and free trade arrangements make it essential to promote consistency and avoid unilateral national efforts being undermined by their neighbours' actions. It is with this background that the "European Strategy on Invasive Alien Species" aims to promote the development and implementation of coordinated measures and efforts throughout the region to minimise the adverse impact of invasive alien species on Europe's biodiversity, economy and human health (Genovesi & Shine 2003). The Strategy is primarily targeted at governments of Contracting Parties to the Bern Convention and aims to deliver a more integrated transnational approach to the prevention and management of biological invasions in Europe. The Strategy invokes the precautionary principle and advocates the CBD's three-step hierarchical approach of prevention, eradication, and containment.

It is important that any actions identified as part of this Strategy relate to those outlined in the European Strategy on Invasive Alien Species (Genovesi and Shine 2003). We acknowledge the links with important global initiatives. In the 1980s a considerable amount of review and research was undertaken during SCOPE's programme on the 'Ecology of Biological Invasions' (Drake *et al.* 1989). More recently, the Global Invasive Species Program (GISP), established in 1997 to address global threats from "invasive alien species," provides support to the implementation of Article 8(h) of the Convention on Biological Diversity (CBD) (for details see www.gisp.org/).

Internationally, the United Kingdom has obligations to work both unilaterally and with other nations to control the spread of NNS. However, it has particular obligations in relation to its Overseas Territories (OTs), which are nearly all small island territories that are particularly vulnerable to invasion by NNS, and to Antarctica (by virtue of the Antarctic Treaty).

2. Background and Scope of the Strategy

2.1 Focus

This Research Strategy has been developed on behalf of the UK Biodiversity Research Advisory Group (BRAG) by a specialist sub-group. Members of the sub-group were drawn from a variety of organisations, across all sectors – terrestrial, freshwater and marine, representing policymakers, researchers and practitioners. The sub-group was chaired by Dr Ian Bainbridge of the Scottish Executive. A full list of the members of the sub-group can be found in the Annex at the end of this Strategy.

Earlier work undertaken on behalf of BRAG by Just Ecology Consultants (Callaghan, 2003) was helpful in framing some of the questions to be addressed, but this Strategy is a completely new piece of work, reflecting changes that have taken place in the eighteen months since the Just Ecology review. This Strategy has also taken account of Defra's Non-Native Species Review and the policy developments that came from this (Defra, 2003).

This Strategy addresses both natural science and socio-economic research priorities, building on the generic recommendations made by the Socio-Economic Issues sub-group of BRAG in its earlier report (Perrings and Ferris, 2004).

The sub-group has considered research in relation to NNS occurring in terrestrial, freshwater and marine ecosystems, and has included wildlife pathogens within the scope of this Strategy. Pathogens affecting human health are excluded from this Strategy.

The sub-group acknowledges that while addressing NNS issues of policy relevance for England, Wales, Scotland and Northern Ireland, the latter has begun to work increasingly on cross-border collaborative projects with the Republic of Ireland. This is recognised as a logical and helpful development, and hence the focus of this Strategy is on identifying research issues for Great Britain rather than the United Kingdom.

Although aimed at Great Britain, this Strategy has implications for research in the OTs. The sub-group recommends that a research discussion would be invaluable in drafting a parallel Strategy for application to the OTs.

The sub-group recognises that research priorities were addressed in Defra's Non-Native Species Review (Defra, 2003). A Monitoring and Risk Assessment Sub-Group produced a list of research needs, a draft of which is attached as an Annex to this Strategy.

Note: throughout the Strategy, reference is made to the proposed GB co-ordination mechanism. The UK Programme Board held its first meeting in the September 2005. The Programme Board will be an ideal forum to direct this research strategy to assist in UK co-ordination.

2.2 Setting Priorities

After identifying the headline themes which constitute the main body of work undertaken by the sub-group, members were asked to make suggestions regarding their relative importance. Without attribution, the following table provides the reader with a guide to the “Top Five” priorities for research (see end column), selected from the nine broad themes identified. It is intended as an indicative guide rather than a prescription.

Table of responses by BRAG members, identifying priorities for research

This table is intended a guide to the top five priority research themes, assessed by BRAG member organisations. The themes are listed in overall priority order as assessed.

Research theme	SG1	SG2	SG3	SG4	SG5	SG6	SG7	SG8	Overall
Audit	1	1		=1	1	1	1	1	1.1
Risk Assessment		5	3		2	2	2	2	2.66
Environmental Change		4		=1	4				3.17
Autecology & Modelling	=5		1	3	5			3	3.3
Pathways & Vectors	=5	3	2	4				4	3.5
Surveillance & Monitoring	2	2		5	3	4	4	5	3.6
Management	4		4			3			3.66
Economic Costs	3		5			5	3		4
Social Perceptions							5		5

3. Specific Research Objectives

Research issues have been addressed under a series of ten broad themes, structured in order to provide a logical transition from understanding status and trends, identifying drivers and pressures, and initiating management and legislative responses.

Knowledge transfer is recognised as a key activity, integral to the overall success of actions concerning NNS, but is not specifically a research issue. For this reason, it is included in a separate section, but should not be considered any less important as a consequence, because it applies to all aspects of research.

Defining what is native and non-native

Note: alien and non-native are equivalent terms.

The CBD (2003) defines “alien species” as follows: “...a species, subspecies or lower taxon, introduced outside its natural past or present distribution” and includes “...any part, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce.” “Invasive alien species” means “...an alien species whose introduction and/or spread threaten biological diversity.” Guiding principles for the prevention, introduction and mitigation of impacts of alien species that threaten ecosystems, habitats or species. Handbook of the Convention on Biological Diversity, 2003.

3.1 Audit

Position Statement.

An audit of status and trends of terrestrial and aquatic NNS, comparable across Great Britain and the OTs.

Recommendations.

- 1. Develop unambiguous guidance regarding what is considered native/non-native.** [EPBRS 10,11,18]. Funders – Defra/SE
- 2. Undertake an audit of all NNS and subspecies present in GB (and the OTs).** [EPBRS 1,14,20]. Funders – Defra/SE/Statutory Agencies
- 3. Identify priority taxa for further investigation of status and trends.** [EPBRS 1,7,14,20]. Funders – Defra/SE/Statutory Agencies
- 4. Undertake an audit of habitats to identify the extent to which they support or are threatened by NNS.** [EPBRS 1,14,20]. Funders – Defra/SE/Statutory Agencies

Commentary.

The sub-group recommends that an integrated audit across Great Britain is a high priority. Such an audit is underway for England, and Scottish Natural Heritage commissioned such an exercise for Scotland in 2001 (Welch *et al.*, 2001). There will possibly be a need to re-examine the SNH audit in the light of the EN audit, in order to ensure consistency in approach.

As a priority, the initial focus of audit activities is on Great Britain (as this is considered achievable, and Northern Ireland and the Republic of Ireland are proceeding on an all-Ireland basis). In order for this to proceed successfully, there needs to be good collaboration between the individual Country Agencies (English Nature, The Countryside Council for Wales, and Scottish Natural Heritage), and there is a clear role for the Joint Nature Conservation Committee in facilitating this.

However, the sub-group acknowledges the need for a European perspective, widening out the geographical area, perhaps working with an EU research programme, promoted and coordinated through the European Platform for Biodiversity Research Strategy (EPBRS), or coordinated through the European Census of Marine Life (EuroCoML), which is a satellite of the Census of Marine Life (http://www.coreocean.org/Dev2Go.web?Anchor=coml_home_page&rnd=16105).

As a first step in the assessment of biological invasions, several nations have begun to undertake audits of introduced species e.g. Austria (Essl & Rabitsch 2002); the Nordic countries (Weidema, 2000); Ireland (Stokes *et al.* 2004); Scotland (Welch *et al.* 2001). Comparison between studies is hindered by variation in the degree to which marine, freshwater and terrestrial ecosystems were assessed and the range and quality of taxonomic detail.

It will be necessary to agree criteria for inclusion of each taxonomic group within the audit, possibly using an expert panel (membership could be determined by the proposed Non-native Species Coordinating Mechanism). Consideration will need to be given to the minimum criteria needed for an audit, as this will determine the success of subsequent work on pathways and vectors. It might be necessary to extend audit activities to varieties/cultivars, if these are garden escapes (only some of which are damaging).

Any audit activities must use existing or agreed data formats, standards and protocols. It will be valuable to map known records of these species and make these data available through the National Biodiversity Network (NBN).

It is important to consider the impacts that these species have had across all sectors, using this information to consider and prioritise management, surveillance and monitoring (see later section 3.9, *Biological Surveillance & Monitoring*). The sub-group recommends that a repeat audit of species is undertaken at intervals, perhaps around 10 years, although the precise interval would be informed as our knowledge progresses. This timeline is required in order to assess changes in species composition and changes in range.

3.2 Risk Assessment

Position Statement.

Assessment of environmental, economic and social risks and impacts.

Recommendations.

5. **Undertake risk assessments for a priority list of NNS (using the Defra -Funded Risk Assessment, hereafter referred to as the DFRA).** [EPBRS 14,20,22,25,27]. Funders – Defra/SE
6. **Undertake vulnerability analysis using DFRA methodology (Receptor Module), selecting particularly vulnerable species or habitats from earlier audits, and use this to refine the Receptor Module.** [EPBRS 14,22,27]. Funders – Defra/SE
7. **Develop models to forecast changes in socio-economic variables that may affect future invasion risks (there is a need to emphasise the link between trade and biodiversity).** [EPBRS 10,11,12,14,20,28]. Funders – Defra/SE/ESRC
8. **Pilot test and enhance the DFRA project manual among a wide range of national and international stakeholders (validation of the DFRA by actual case studies is a key gap to fill).** [EPBRS 20,22,27,29]. Funders – Defra/SE

Commentary.

The recently funded DFRA methodology contract highlighted that a common RA framework may be workable across taxa and habitats. Further financial support is essential to complete and validate the framework prior to any rolling-out to the user community as a functioning toolkit.

It is essential to undertake a peer-review assessment of the DFRA manual (as an international academic exercise), and to compare how rare events with large impact are evaluated as opposed to common events with a low impact. It would be helpful to examine examples of rare events that can be used in a retrospective analysis.

A key action will be to issue the manual to a range of bodies (field scientists), not involved with its development, for pilot testing (end users). This should involve testing the DFRA in the OTs. This is a priority because, if it works in GB and the OTs, then we have a tool that is valuable in an international context.

It is important to validate the model with actual examples from a representative selection of known successful and unsuccessful introductions into GB and OT ecosystems. Furthermore, retrospective analysis of past invasions may be very helpful in improving our understanding of patterns and processes.

In addition, Annex 4 of the DFRA Project Report gives a long list of research priorities (see Annex to this Strategy). It may be a useful first step to carry out the risk assessments on the priority species identified. This would be a large project, and needs to be flagged.

Statistical models should be developed to assess why, when and to what extent NNS invade GB. The information from the RA on species traits, receptors habitats and pathways should be used as input and the sensitivity of model outputs analysed for each independent variable. Differential weightings should be applied to different inputs to reflect their relative importance in determining outcomes. Importance of uncertainty in each independent variable should also be factored into risk analysis.

In addition to the DFRA, it is important to collaborate with other initiatives in Risk Assessment relevant to the UK, in order to establish a consistent approach (e.g. RA guidelines for the IMO 'Ballast Water' Convention).

The IMO Ballast Water convention sets down biological standards for the discharge of ballast water. However, the convention allows for exemptions to these standards on the basis of a risk assessment of transference of marine non-natives. Details of the RA guidelines were further progressed at the 53rd Marine Environment Protection Committee (MEPC)¹ in July 2005, but still need to be finalised and adopted. However, indications are that the guideline details will deal with species compatibility and the likelihood of establishment. This approach will consider species present in donor and recipient port, environmental parameters and species autecology to determine the risk that an unwanted marine invader could become established.

3.3 Pathways and Vectors

Position Statement:

Identification, quantification and characterisation of present pathways and vectors for the introduction of NNS into and within Great Britain.

Recommendations

9. **Quantify current pathways and vectors, based on various resumés (there is no requirement for a detailed review, as a large body of information already exists).** [EPBRS 1,14,15,20,25]. Funders – Research Councils/Defra/SE/Statutory Agencies
10. **Evaluate pathways and vectors, using and enhancing the pathway module of the DFRA system.** EPBRS 1,14,15,20,25]. Funders – Defra/SE/Statutory Agencies/Research Councils
11. **Analyse the potential changes in socio-political and environmental conditions (inc. climate change) required to forecast impacts on pathways and vectors.** [EPBRS 14,15,20,21,25]. Funders - ESRC/NERC/Defra/SE/Statutory Agencies/business/private sector
12. **Further develop novel techniques (e.g. DNA bar-coding) for tracing the origin of introductions.** [EPBRS 3,5,7,20,25,27,34,38]. Funders – BBSRC/NERC/private sector

Commentary:

It is important to distinguish between the number, frequency and origins of invasion events, in addition to making the distinction between external and internal pathways (i.e. spread following arrival). The priority here is the identification of pathways and vectors for all newly-arrived non-natives in Great Britain or the OTs. This is essential so that we can close the means of entry or minimise further entry in the future.

There is a need to review and assess the current rate of both deliberate and accidental introductions into UK. Deliberate introductions require surveys of

¹ The Marine Environment Protection Committee (MEPC) is IMO's (International Maritime Organisation) senior technical body on marine pollution related matters. It is aided in its work by a number of Sub-Committees.

Customs and Excise encounters with NNS, internet sales of plants; the pet trade, and aquaculture imports (now considered to be in the top three pathways which introduce marine NNS). Accidental introductions require assessment of contaminants of commodities, ballast water, machinery imports, soil, and EPPO interceptions. This is likely to be a major exercise aimed at assessing the scale of the problem, but will also give us a clearer indication of the feasibility of such widespread monitoring.

For the marine environment is it critical to identify the pathway into Great Britain, as it is so hard to prevent the spread of a NNS once it has arrived. The main species identified in the risk assessments should be targeted first rather than trying to cover all newly-arrived non-natives.

There are 2 priorities here:

1. To identify and quantify the relative importance of current pathways
2. Identify the most significant likely invaders and assess how (i.e. by what pathways) they are likely to invade

This theme has close links to 4.2 *Risk Assessment*. We should focus on the need for sound science to assist prevention. In order to do this, we need to have risk assessments of species which are not yet present in Great Britain and may pose an important threat. These can also be used to highlight important pathways. Prevention lessens environmental damage, since once here, invasive NNS are difficult to remove (i.e. there is an environmental cost in addition to the economic cost). See 4.8 *Management*.

3.4 Ecological research and modelling

Position Statement

Autecological and demographic studies of critical non-native taxa to develop and validate models of population dynamics, impacts and management².

Recommendations

13. **Research to identify what makes a species invasive (e.g. release from competitive interactions and natural enemies, effective dispersal mechanisms, high propagule production, rapid growth rates, ability to withstand high levels of disturbance, and susceptibility of the invaded environment).** [EPBRS 6,14,20,21,33]. Funders – BBSRC/NERC
14. **Specific research into key aspects of the ecology and life history of high risk/high impact (priority) NNS.** [EPBRS 6,14,20,21,33,38]. Funders - NERC/BBSRC/Defra/SE/Statutory Agencies
15. **Research into what makes a community/habitat prone to invasion by non-native species.** [EPBRS 5,17,19,20,21,24,33,38]. Funders – NERC/Defra/SE/Statutory Agencies
16. **Incorporate this knowledge into models of invasiveness of species and invasibility of habitats.** [EPBRS 5,6,,814,17,19,20,21,24,28,37]. Funders –

This research should be for high risk or high consequence organisms, focused on the key aspects for which knowledge is lacking. We should be at least as concerned about species that are lying dormant but which may pose a threat if conditions change. There are certainly plenty of examples of this happening.

NERC/Defra/SE

17. **Forecasting and horizon scanning of future threats. A key attribute associated with invasiveness is that the species is invasive in a similar climate zone. Assess major invasive species in similar climate zones e.g. eastern North America, Atlantic areas of Europe, Japan.** [EPBRS 13,14,15,17,18,19,20,21,25,27,33]. Funders – Defra/SE/DfID/DTi/Research Councils

Commentary:

Even for many high-impact NNS there is often a lack of information on key aspects of their basic biology and ecology in their new environment. It is crucial that there is sufficient autecological research to allow informed decisions to be taken on intervention or mitigation measures.

We need to intensify research into enhancing our ability to predict spread (natural and anthropogenic), population build-up and the attainment of densities above a threshold where economic, environmental or social damage is caused. This will require improvements to the models used, the data used to parameterise them and increased computing power to enable predictions to be generated at higher spatial resolutions (at a landscape scale below 1 km). Multi-agent systems (for modelling spread), LIDAR data (to provide a detailed 3D structure of the landscape) and grid technologies (to enhance computer processing power and interaction between institutes) are examples of the way ahead. It will be very instructive to return to past invasions and use the data collected to parameterise models.

The number of established non-natives in the UK prohibits detailed case studies for every species. Research should be targeted at relevant species-habitat combinations in order to address fundamental principles of the invasion process and subsequent impact on biodiversity. Comparative approaches assessing the performance of native and other non-native conspecifics may be especially rewarding. Experimental approaches should incorporate the large spatial and temporal scales of the invasion process and include ecosystem consequences of both the arrival NNS and their removal.

Much of the research that has been carried out internationally has been anecdotal and relates to individual species or habitats. There is only a limited amount of information that relates to the generality of which species are likely to be the most troublesome or which habitats are most open to invasion. Further generic studies, such as those of Williamson (1996), are needed in order to broaden our understanding of the ecologies of the invasion processes, both from the point of view of the invader and the invaded habitat or species.

3.5 Environmental Change

Position Statement:

Understanding the interactions between species invasion and environmental change.

Recommendations

18. **Carry out an assessment of selected NNS under various environmental change scenarios.** [EPBRS 20,21,25]. Funders – Defra/SE/Statutory Agencies

19. Improve understanding of the relationship between land- and water-use changes caused by climate change and the introduction of NNS species.
[EPBRS 14,20,21,33,38]. Funders – NERC/Defra/SE/Statutory Agencies

Commentary

Climate change is likely to be one of the main factors affecting NNS distribution and degree of invasiveness in future. An important element of this work is taking a forward look, attempting to anticipate problems. For example, research might focus on those non-native species resident but not currently problematic in GB, but which have caused problems elsewhere in the world in locations with climates similar to those which GB might experience under climate change. It might be instructive to look at species known to be invasive in our close neighbour countries in Europe; examining potential changes in temperature, pH, anthropogenic activity (chemical and physical conditions) and their impact on these “sleeper” species.

There is anecdotal evidence of climate-mediated expansion of NNS, and it is important to stress that climate change may play an important role of as a driver for new NNS, permitting them to arrive and/or expand their range in GB. There are for example marine species that have been introduced from the Far East for aquaculture, which at present do not reproduce naturally in GB. However, this may change as seawater temperatures increase with climate change. The consequences of this are largely unknown, but if such species escape and establish populations in the wild they should be termed ‘invasive non-native species’.

However, we do need to be clear that species colonising naturally, from their natural ranges, even if facilitated by climate change, should not be regarded as invasive non-natives. The distribution of many species changes naturally over time (eg collared dove, little egret), and the natural arrival of new species in GB should not necessarily be viewed as problematic; in some cases it will be celebrated.

Non-native species are therefore those species whose arrival in GB is a direct consequence of human activities, or which have spread from a range established as a direct consequence of human activities.

We should also note that in many areas of pest control, e.g. plant health, no differentiation is made between those species which have entered due to human activities and those which have arrived by natural means. If they are invasive or potentially so (i.e. pests), then control measures may have to be taken.

Different patterns of spread may be expected. Natural range increases may occur as a front, but invasions have the characteristics of epidemics. Our focus should be on addressing problem non-native species rather than all species.

We therefore need to be able to determine, or suggest how to differentiate between changes in natural ranges caused by climate change and ‘introduction’ from anthropogenic sources. It will be beneficial to undertake some autecological research on such species, as this can help inform us about traits that favour successful colonisation or invasion.

However, there is a real danger that we may focus on climate change to the detriment of other changes which may be having more immediate and profound effects .e.g. how will land use changes (which are currently in progress and likely to accelerate as CAP is reformed) impact on the distribution and spread of existing NNS or likelihood of establishment of new ones? Changes are likely to include increasing lowland woodland cover, increases in a range of novel and biomass crops, for example. These will affect the distributions of many farmland species.

We need to improve our understanding of how established NNS may respond to future environmental change (especially global warming). We face a number of important questions:

- will environmental change facilitate the establishment of new NNS that currently fail to maintain long-lived populations;
- will established but not invasive NNS increase their range and/or abundance sufficiently to become problematic;
- will the impacts of invasive NNS become more severe either directly through changes in performance or indirectly through changes in native habitat and/or species vulnerability?

3.6 Economic Costs

Position Statement:

Understanding the socio-economic dimensions of NNS, including appraisal of true economic costs and benefits, and understanding incentives to control invasive species

Recommendations

- 20. Review the overall economic costs and benefits associated with non-native invasive species in GB.** [EPBRS 8,11,12,14,32]. Funders – ESRC/Defra/SE
- 21. Evaluate the full economic costs and benefits of the introduction of selected critical non-native invasive species, including the indirect effects on ecosystem services.** [EPBRS 8,11,12,14,20,32,38]. Funders – ESRC/NERC/Defra/SE/DfID/Statutory Agencies
- 22. Evaluate the cost-effectiveness and social acceptability of alternative prevention and control strategies for critical species.** [EPBRS 10,18,22,29,32,34,38]. Funders – Defra/SE/DfID/Research Councils/private sector
- 23. Explore the alternatives to use of NNS in trade (developing new market opportunities, use of economic incentives).** [EPBRS 11,12,15,18,19,24,26,31,32,38,39,41]. Funders - Defra/SE/Statutory Agencies/DfID/DfTi/ESRC

Commentary:

The sub-group considers it a priority, in order to provide influence at a policy level, to provide broad estimates of the economic impact of NNS. If the ecosystem services, costs and values can be incorporated into these calculations, so much the better. However, there must be substantial information on the costs of damage or

preventative control measures for a wide range of non-native agricultural and forestry pests, for example, and this would be an important first step towards making an unequivocal case for action on economic grounds alone.

The importance of undertaking some case studies – perhaps 8 to 12 – in the marine, freshwater and terrestrial environments - is to provide a research focus: how can the costs of the effects of these species on ecosystem services be estimated? This requires cost-benefit analyses, bearing in mind that some NNS might have a positive economic value, whereas others have a definite adverse cost. Research needs to develop a methodology that is appropriate for accounting for all of the costs and benefits of NNS.

We suggest that it would be useful to carry out a study along similar lines to that undertaken by Pimentel (2003). Key species and pathways should be targeted in order to make this more achievable. This should be high on the agenda. The Centre for the Economics and Management of Marine Resources (CEMARE) at Portsmouth University have worked on a recent project with the Scottish Association for Marine Science (SAMS), where it was necessary to calculate values for environmental impact (or potentially ecosystem function). This has shown that it is possible, up to a point. In terms of the costs reflecting the ‘control effort’, various scenarios can be run with different levels of control built into the spreadsheet model.

3.7 Social perceptions

Position Statement:

To address social perceptions, awareness and resolution of NNS conflicts.

Recommendations

- 24. Undertake a study to establish a baseline and to monitor changes in public attitudes (and consumer behaviour).** [EPBRS 9,10,11,12,15,18].
Funders – ESRC/DTi/Defra/business
- 25. Investigate the most effective range of measures to raise public awareness and change public attitudes.** [EPBRS 9,10,11,18,29,31,32].
Funders – ESRC/Defra/DTi/DfID/SE
- 26. Explore methods for resolving different attitudes to NNS.** [EPBRS 18,19,23,26,29,30]. Funders – ESRC/Defra/DfID/DTi/Statutory Agencies

Commentary:

The key question to address through social research is “Are the public picking up the messages?” There is a need to define the different elements of the public, their potential differences in perception, and the different ways of targeting them, and be clear about which of the different “publics” we are targeting (eg. the informal general public; the informed public such as biological recorders, professionals in horticulture). Research could also explore why different attitudes are held and why social factors might hinder the implementation of policy. We also need to look at which awareness-raising measures have most impact on public attitudes and actions.

Awareness-raising activities (e.g. websites, notices at points of entry, leaflets) need to be targeted carefully, and social research may help to guide this. For example, to

back up Codes of Conduct for various sectors, a list of the top 10 (or more?) invasive species, coupled with appropriate publicity, will help to raise awareness of the problem. This is not strictly research, and such activities are discussed more fully in Section 5, *Knowledge Transfer*.

There is a need for an audit of the public perception, and then for research into the most effective ways of altering behaviour and attitudes, or reinforcing existing ones. There is some evidence that with growth in multi-ethnicity in Great Britain, the public do not like the idea of classifying species as non-native. For details, see the Black Environment Network:

[http://www.ben-network.org.uk/uploaded Files/Ben 1/Ben file 1 25.pdf](http://www.ben-network.org.uk/uploaded%20Files/Ben%201/Ben%20file%201%2025.pdf)

One crucial research task is to assess where differences of opinion may hinder policy implementation or management approaches e.g. the attitudes of some parts of the public towards eradication of hedgehogs on the Uists, local opposition to coypu control, the refusal of some landowners to allow access to their land for ruddy duck control.

3.8 Management

Position Statement

Research the most effective: approaches to management, including prevention, control and eradication strategies; and evaluation of ecosystem consequences of NNS removal.

Recommendations

27. **Identify the species that are high risk or for which there is a high likelihood of success, in terms of control or eradication (i.e. demonstrable “quick wins”).** [EPBRS 1,22,27,38]. Funders – Defra/SE/Statutory Agencies
28. **Research into ecosystem management – to improve habitat resilience to NNS.** [EPBRS 22,24,38]. Funders – Defra/SE/Statutory Agencies
29. **Identify the pathways that are high risk or for which there is a high likelihood of success. What is the most effective way of closing (specific) pathways?** [EPBRS 22,27,38]. Funders – Defra/SE/Statutory Agencies
30. **Development of decision support tools so that practitioners can gain help in deciding whether to prevent, control or eradicate.** [EPBRS 14,22,25,27,28,38]. Funders – Defra/SE/NERC
31. **Review the practicalities of existing prevention, control or eradication methods (i.e. is there an adequate, appropriate method ?)** [EPBRS 22,34,38,39,40]. Funders – Defra/SE/Statutory Agencies/private sector
32. **Develop new systems for management where method gaps exist. Specific areas for consideration:**
 - biological control;
 - control of invasive water plants, for which no effective herbicide is permitted;
 - immunocontraception / sterilisation;
 - chemical / electrical methods for treating ballast water;
 - selective delivery systems for eradication of vertebrates;[EPBRS 22,34,38,39,40]. Funders – Defra/SE/Statutory Agencies/private sector

33. **Contingency planning: review and identify potential future arrivals, and assess whether we have systems in place for rapid and effective control.** [EPBRS 1,14,15,22,25,28]. Funders - Defra/SE/Statutory Agencies
34. **Monitor control programmes, with a view to generating generic advice, including ways of proving a zero population (eradication).** [EPBRS1,14,15,22,25,28]. Funders – Defra/SE/Statutory Agencies
35. **Develop predictive modelling and monitoring of ecosystem consequences of removal, particularly where a NNS has become established and significantly altered the environment (e.g. vegetation responses to a removal of or reduction in grazing pressure).** [EPBRS 4,5,6,14,17,20,24,25,28]. Funders – NERC/Defra/SE

Commentary

Once an invasive NNS is present in a new country, there will be a brief period when its chances of establishment will hang in the balance. However, the longer it goes undetected or action is delayed, the less opportunity there will be to intervene successfully, since fewer options will remain for its control or eradication, and costs will have increased (Wittenberg and Cock, 2001).

Having relevant contingency plans and capabilities are clearly important parts of the early response to any NNS which have been detected, and which the risk assessment suggests are likely to be problematic.

Eradication is clearly a permanent solution and, in some cases, it can be a ‘quick win’. However, in too many cases eradication is not followed up by monitoring of the habitat/species /ecosystem response to the removal of the invasive species (see 4.9 *Biological Surveillance & Monitoring*). We clearly need to understand more fully the often complex relationships between NNS and the ecosystems they inhabit, and the consequences of their removal.

The CBD approach of ‘Prevention-Control-Eradication’ is strongly supported by BRAG, since it is now well-accepted and many initiatives are aligned with it. For example, it is the approach taken by the Ballast Water Convention, the ICES Ballast Water and Other Ships Vectors - and forms the basis of the DFRA.

Management research can be focused at a case or species-specific level (to tackle individual problems) or at a generic or higher level (to deal with whole areas, generic issues etc.). There is a need for both, and a good balance between the preventive side (historically under funded) and the reactive side to deal with current problems.

What do we mean by “control”?

Control can be defined as:

- preventing spread (i.e. holding the current position),
- protecting particular features of species of interest,
- suppressing damaging NNS (which might include reducing the extent of target NNS),
- reduction prior to possible eradication?

All these are possible and viable approaches, and BRAG considers that the approach taken should be tailored to meet specific conditions and objectives (including socio-economic considerations).

3.9 Biological Surveillance & Monitoring

Position Statement

We require efficient monitoring of the spatio-temporal trends in the establishment, spread and impact of NNS.

Recommendations

- 36. Undertake surveillance of established NNS.** [EPBRS 1,25,41]. Funders – Defra/SE/DfID/Statutory Agencies
- 37. Undertake a gap analysis of existing monitoring schemes for critical taxa for existing NNS, and identify methods for filling gaps.** [EPBRS 1&41]. Funders – Defra/SE/Statutory Agencies
- 38. Evaluate systems for detection of new arrivals.** [EPBRS 14,22,25,27,29,38,41]. Funders – Defra/SE/DfID/Statutory Agencies
- 39. Establish suitable schemes for monitoring pathways.** [EPBRS 1,14,15,25,41]. Funders – Defra/SE/DfID/Statutory Agencies/private sector/business
- 40. Establish a (virtual?) centre for co-ordination and collation of survey / monitoring results.** [EPBRS 1&38]. Funders – Defra/SE/NERC

Commentary:

Surveillance is an essential operation, helping to build up vitally important time-series data. There are many important examples, such as bird data (farmland bird indicator), butterfly data, and the new plant atlas and the changes recorded within it. From the research on identifying key vectors and pathways, it should be possible to target specific places or pathways for surveillance of new introductions.

A key point is that we should build on existing frameworks and schemes with which recorders, particularly volunteers, are already engaged. It is not necessary to undertake anything new, apart from in exceptional circumstances. It is vital to seek integration with existing initiatives (e.g. Ballast Water and WFD monitoring programs have the potential to overlap).

It is crucial that regular reporting is carried out in order to ensure that the necessary surveillance and monitoring is delivered. This will also help to ensure subsequent action on priority issues.

There is a need to initiate surveys, where these are required (requesting recorders to look out for particular species, for example), and to collaborate with existing surveys (*Seasearch* is a good example in the marine environment). Data collected by volunteer recording groups may be key, especially for the groups working on terrestrial plants and larger, more obvious animals; but we note that there are far fewer recording groups or individuals who specialise, for example, on fish, aquatic plants or many invertebrates.

Bodies such as the Environment Agency and SEPA, and consultancies conducting environmental impact assessments; may have a key role to play in aquatic monitoring, if their contributions can be directed so that they can add to the work on NNS.

We need to analyse the trends in how species have established in GB to see whether the origins, habitats invaded, taxa, and damage caused, have changed over time. We should also undertake comparisons with other countries, not only to provide comparisons for these trends, but also to identify possible new threats. For example, has increased trade with the Far East in recent decades meant that more species have invaded from there?

We need to set an appropriate timeframe for monitoring of NNS (producing a GB and Ireland flora every 40 years is insufficient to monitor trends of rapidly-changing species). A reasonable timeframe might be 6 or 12 years, although it will depend on the taxa involved and the intensity of survey. This would fit in with the cycle of monitoring the condition of SSSIs. Assessment of NNS could then become a module of SSSI surveillance and that might be one means of providing a reasonable early warning of the arrival or spreads of NNS in GB. The precise cycle should be determined by the 'risk' status of a particular species.

Highlighting priority species, using a "Top 20/50/100" approach for monitoring is also suggested. It would also be valuable to produce an appropriate identification guide and training where required. See earlier recommendations under section 4.1, *Audit*.

Surveillance for invertebrate pest species is often centred around ports of entry e.g. airports and harbours, but we do not know whether this is adequate for other taxa. Would surveillance of urban/suburban areas provide insight into the risk in the wider countryside?

Clearly, it is not necessary to monitor every population or 10km x 10km grid square. Thus some thought should be given to stratified sampling programmes that might give a good idea of the national picture, without necessarily mapping the entire distribution of a species. Perhaps comparison of River Habitat Surveys, Countryside Surveys, or the BSBI Monitoring Scheme might highlight how intensive monitoring needs to be. There is a need to monitor habitats as well as species. For example, the reporting of changes in condition could be the responsibility of wardens in National Parks or Nature Reserves.

Rapid assessment surveys need to be made at suitable intervals. In the marine sector, for example, experience of rapid assessment surveys indicates that whilst data (species lists) can be obtained within the order of hours or days; the assessment is skewed towards those habitats and species more easily accessible and identifiable. If a target species falls into these categories (e.g. Zebra mussel), rapid assessment surveys may be of particular use. However, where more difficult and inaccessible potential invaders are suspected (e.g. dinoflagellates), it would be difficult to pick these up in a rapid assessment survey. Consequently, rapid assessment surveys are unlikely to be adequate as a tool for monitoring new invaders, but could be of good use when targeted monitoring is considered for control or eradication programs.

3.10 Legislation and the Regulatory Context

Position statement:

Research into the effectiveness of legislation and regulatory measures

Recommendations

41. **Research the effectiveness of measures to regulate movement of species within countries.** [EPBRS 22,25,27,37]. Funders – Defra/SE/Dti/Statutory Agencies
42. **Investigate the value of formal standards set at the international level to deal with some pathways.** [EPBRS 25,32,36,37]. Funders – Defra/DfID/SE/Statutory Agencies
43. **Consider the potential effects that environmental liability regimes, depending on their formulation, could have on means of addressing invasive NNS issues.** [EPBRS 23,29,32,36]. Funders – Defra/Dti/SE/Statutory Agencies
44. **Investigate the benefits or disbenefits that regional approaches can provide to address issues on invasive NNS. eg sharing expertise and economies of scale.** [EPBRS 22,26,28,29,31,37]. Funders – Defra/Dti/DfID/SE/Statutory Agencies
45. **Assess the effects of the opening up of borders and removal of trade barriers on the controls that can act as a brake on the movement of NNS.** [EPBRS 22,29,32]. Funders – Defra/Dti/DfID/SE/Statutory Agencies

Commentary:

Decision-making should be based on firm evidence. It is important to recognise the link between the knowledge gained from the research which is outlined in many/all of the sections above, especially those topics picked out for priority development, and the feed back they can provide into governmental, European, and indeed local authority, policies. At the same time, it is pertinent to study the effectiveness of the political mechanisms used to implement the controls and management of NNS, so we recommend above a number of examples of socio-political research, aimed at helping to frame improvements to the legislation and regulation used within GB and Europe.

National legislation on non-native species is the responsibility of the UK Government administrations, but will be steered in future by the NNS co-ordinating mechanism, through the Programme Board. The co-ordinating mechanism will ensure close collaboration between government departments and agencies involved in different conventions and sectoral areas.

The review of Part I of the Wildlife and Countryside Act 1981, carried out from December 2004 to March 2005, identified a number of proposals for improving the effectiveness of national legislation on NNS. Defra and the Welsh Assembly Government are giving careful consideration to the responses received, and to how the proposals may best be taken forward. Two measures have been included in the Natural Environment and Rural Communities Bill, and will have effect within England and Wales: a prohibition on the sale of certain invasive non-native species to be listed by order; and a power for the Secretary of State to approve guidance on non-native species, which may be used as evidence in a court of law. These measures

are broadly consistent with those introduced within Scotland by the Nature Conservation (Scotland) Act 2004.

It is necessary to keep international developments on NNS under continual review. An evaluation should be carried out on potential and actual change in national and European legislation, and in international agreements on NNS. For example, an Ad Hoc Technical Expert Group (AHTEG) of the CBD Subsidiary Body on Scientific, Technical and Technological Advice (SBSTTA) has recently reported on *Gaps and inconsistencies in the international regulatory framework in relation to Invasive Alien Species* (<http://www.biodiv.org/doc/meetings/sbstta/sbstta-11/information/sbstta-11-inf-04-en.doc>). This report draws a number of main conclusions:

- Actions taken to address invasive alien species need to be taken at the right levels.
- Problems are not caused by gaps in the international regulatory framework, but actually lie with inadequate implementation at national level. Furthermore, gaps in the international regulatory framework do not necessarily limit the ability of governments to address such gaps at national level
- Collaboration among international bodies and instruments is important.
- There is a lack of international standards to address animals that are invasive alien species but are not pests of plants under the International Plant Protection Convention (IPPC).

Legislation – a question of implementation

The International Convention on the Control and Management of Ships' Ballast Water and Sediments was adopted on 13 February 2004. The Convention is not yet in force. Adoption means simply that everyone has agreed the text. For it to come into force, more States, with more tonnage, need to join (target: 30 states representing 35% world tonnage). Certain elements of the Convention are due to be reviewed in January 2006, and it seems that virtually all States have the intention of signing the Convention. It covers almost all commercial ships. There are equivalent voluntary guidelines being developed to minimise introductions from pleasure craft (i.e. ships less than 8 tonnes). Most ships have to be undertaking management or meet the standards by phased dates.

At present in the UK, nobody is obliged to take any action, and there are no legal regulations. Voluntary IMO guidelines exist, recommending that tanks are flushed out with 3x volume of oceanic water. These guidelines provided the basis for the development of the Ballast Water Convention. Hence, anything that comes into force – whether simply undertaking some management to start with, before meeting set biological standards - is better than the current situation.

In the UK, we are currently looking at the feasibility of regional management (of the northern sea areas of Europe) as a regional approach to implementation of the Ballast Water Convention. A pilot study is being proposed OSPAR, as the area broadly aligns with that.

There is a lack of formal standards set at the international level to deal with some pathways (in many cases due to a lack of a body with a mandate to develop standards recognised by the Sanitary and Phytosanitary (SPS) Measures Agreement). Controls on most pathways for invasive NNS must be implemented at the national level, as international standards do not in themselves constitute controls.

It is important to realise that liability regimes, depending on their formulation, could have positive and negative implications for addressing invasive NNS issues.

Regional approaches can provide opportunities to address issues on invasive NNS. Regional approaches allow pooling of resources and expertise, and increased efficiencies which overcome capacity limitations, but can also provide inertia through inflexibility. Regional approaches may be particularly important for the OTs, allowing problem and expertise sharing. In addition to geographic regions, there is value in having cooperative arrangements between countries facing similar issues.

The opening up of borders and removal of trade barriers have reduced some of the controls and inspections that acted as a brake on the movement of NNS in the past, and hence there is a real conflict between trade and biodiversity legislation.

It is important that parties recognise their role and responsibilities as exporters of invasive NNS, in addition to addressing the problem from an importer's perspective. To address these responsibilities, information needs to be made available on the species being exported, including notifying potential importing countries through alert lists, controlling exports where requested and, in exceptional cases, refusing to export the species.

Post-legislative assessment can be highlighted as an important area for research. In other words, after new legislation, or a change in legislation, a piece of research ought to be commissioned to assess whether or not the legislation is working as it was intended to, and whether or not there have been any 'side effects'.

4. Knowledge Transfer

This is an essential component of research, and we make a strong recommendation that provision should be made for funding of knowledge transfer activities on NNS. The internet provides a powerful tool for the dissemination and sharing of information, and offers good opportunities for raising awareness of and shaping responses to NNS.

Within the European Union, knowledge transfer is a requirement of the Bern Invasive Alien Species (IAS) Strategy, to which the United Kingdom is a signatory. Within Great Britain, this is an area that the Non-Native Species Forum could help to address.

Information systems are needed to mobilise data on non-natives, e.g. through NBN, and to make the results of research accessible. Links are needed to information systems in Europe, in order for GB to be able to identify species that may become invasive here, and for us to share information with others. We recommend that existing information exchange, notification and consultation mechanisms are used wherever possible (at a pan-European level these might include EPPO, OIE, CBD Clearing House Mechanism, Bern Convention), with new mechanisms established wherever necessary. This reinforces the view of the European Strategy (Council of Europe, 2003).

Although it is recognised that the Co-ordinating Mechanism Programme Board is yet to determine its terms of reference, it is desirable that the establishment of a Clearing House mechanism will be an important function.

5. Funding and Delivery Partnerships

Defra is to fund an audit of resources spent on NNS within Great Britain, which will inevitably include research. The effectiveness of the funding needs to be examined critically, in order to assess whether expenditure is meeting policy needs, and to look for more cost-effective mechanisms for delivery of research.

The sub-group recognises the role of the Research Councils for supporting research in this area. Where the research is more directly related to policy development, then it is the responsibility of the various government departments to provide funding. This includes all the Government administrations: Defra, the Welsh Assembly, SEERAD and DoENI (and possibly DARDNI). Where the research is more concerned with monitoring and surveillance, and with audit, then there is a clear role for the country agencies - CCW, EHS, EN, JNCC and SNH.

Consideration could also be given to the introduction of legislation which ensures 'the introducer pays' (to coin an expression from pollution work). In other words, if it can be determined that a new pathway exists because of the activities of industry X, then industry X should be responsible for paying for any research related to closing that pathway or eradicating the species that it has introduced.

Finally, where there are projects of particular interest to an NGO or a charitable trust, it is hoped that they would either fund the research or be prepared to join with others to form a funding partnership.

6. Glossary

AHTEG	Ad Hoc Technical Expert Group
BSBI	Botanical Society of the British Isles
CBD	Convention on Biological Diversity
CEMARE	Centre for the Economics and Management of Marine Resources
DARDNI	Department of Agriculture and Rural development for Northern Ireland
Defra	Department for Environment, Food and Rural Affairs
DOENI	Department for Environment for Northern Ireland
DFRA	Defra-funded Risk Assessment
EPPO	European and Mediterranean Plant Protection Organisation
EuroCoML	European Census of Marine Life
GISP	Global Invasive Species Program
HAPs	Habitat Action Plans
IMO	International Maritime Organisation
LBAPs	Local Biodiversity Action Plans
LIDAR	Light detection and ranging
MEPC	Marine Environment Protection Committee
NNS	Non-native species
OIE	Office International des Epizooties
OSPAR	The Convention for the Protection of the Marine Environment of the North-East Atlantic (The OSPAR Convention)
OTs	Overseas Territories
RA	Risk Assessment
SAMS	Scottish Association for Marine Sciences
SAPs	Species Action Plans
SBSTTA	Subsidiary Body on Scientific, Technical and Technological Advice
WFD	Water Framework Directive

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8. Annexes

8.1: UK NON-NATIVE ORGANISM RISK ASSESSMENT SCHEME USER MANUAL, Version 3.3, Dated 28.2.2005

Gaps and Areas for Future Work identified by the Consortium

Prepared by CABI Bioscience (CABI), Centre for Environment, Fisheries and Aquaculture Science (CEFAS), Centre for Ecology and Hydrology (CEH), Central Science Laboratory (CSL), Imperial College London (IC) and the University of Greenwich (UoG) under Defra Contract CR0293³

Risk Assessment

(enhancements of user-friendliness and further extensions are listed under the Electronic Toolkit section below)

- Additional examples of best practice required for all taxon/habitat combinations

Pathway Risk Assessment

- Additional examples required for all pathway types
- Provide a system for prioritising pathways in order of importance

Receptor Risk Assessment

- Additional examples required covering a wider range of organisms, habitats and ecosystems
- Extend the receptor risk assessment scheme to other sectors, e.g. tourism, social impacts
- Provide a system for prioritising receptors in order of importance

Impact Assessment

- Additional examples required
- Allow the costs of control and other drivers, e.g. climate change, to vary over time.
- Study retrospective examples, e.g. Dutch elm disease, to clarify how risks change over time.
- Enhancement of environmental (and social) impact analysis, giving guidance on how to value environmental resources
- Give more guidance for non-quantitative methods, e.g. with a “pick list” of the impacts to be expected at the five levels of severity.

Summarising Risk

- Greater clarification of the most appropriate methods for analysing qualitative/quantitative risk scores and uncertainty responses and their presentation to risk managers

- Enhancement of the ability to prioritise risk based on the production and comparison of many risk assessments
- Providing the ability to plot a species risk assessment on a graph with impacts on the x-axis and the probability of entry/establishment on the y-axis so that the risks posed by different species can be visualised together and uncertainties visualised as error bars
- Validation of the methods used, e.g. conduct a risk assessment for *Fallopia japonica* based on information available in 1960.

Electronic Toolkit

- General help for each question, aiding understanding of how it is to be interpreted
- Help and examples on specific taxon, habitat, pathway, and receptor level.
- Examples on each of the five levels of response and three levels of uncertainty to guide the assessor and help to ensure consistency
- A diagram showing where you are in the process when tackling each question
- Automatic links to related questions where key factors are relevant to both
- Automatic links to useful databases / other sources of information e.g. identification tools, monitoring and surveillance schemes such as the National Biodiversity Network
- Enhancement of the impact quantification module, and creation of other modules, e.g. To model the impact of climate change
- Allow the importation of other files from word or excel
- Allow the storage of completed risk assessments in a database to allow easy retrieval to enable comparisons and ranking of species, pathways and receptors
- Generate scores for each species, and classify them into a low, medium, high rating
- Capability of producing a report in electronic and hard copy format.

Risk Management

- Provide examples of best practice for intentional & unintentional introductions
- Provide links to the risk assessment scheme
- Explore the extent to which risk management options can be generated automatically from a risk assessment
- Provide methods for prioritising management action.

8.2: Report of the Monitoring and Risk Assessment Sub-Group of the DEFRA Review of Non-native Species Policy

RESEARCH NEEDS

As part of the review undertaken by the Sub-Group, we were asked to provide a preliminary identification of the research needs relating to monitoring, risk assessment and public awareness of non-native invasive species. For the purposes of this task, we have defined research in a wide, rather than narrow sense, to include research, survey and monitoring, and to cover socio-economic research issues as well as biological research. We deal with each of the major areas in turn below, and propose a limited number of the most urgent research projects in each area:

Priority Research associated with monitoring work on non-native species

Review of existing schemes' capacity to record non-native species

Our review of existing monitoring schemes has concluded that *ad hoc* recording of non-native species of many taxa has improved during the last decade, but surveillance on a sufficiently regular timescale to detect expanding invasive species is very patchy. This is dependent partly on the interest in the taxa by amateur and volunteer recorders, partly on their ease of identification, and partly on a range of other factors. There is an urgent need for a review of such monitoring to maximise the benefit which might be gained, and to develop protocols for regular recording of the most important taxa. This must include a full audit of coverage by existing monitoring and the capacity of volunteers to monitor at sufficient scale, to inform future decision-making about monitoring and priorities.

Investigate status, distribution, impact of 'least wanted' non-natives

When the above review is completed, there is an urgent need to carry out research into the status, distribution and impact of a 'least wanted' group of non-native species. This will be vital to enable the prioritisation of action on these 'least wanted', and should stimulate their monitoring on a regular basis.

Classify status of organisms currently present in the British Isles

A valuable early exercise would be to classify the status of all organisms on the British List according to their native ness, but there is no clear view on the way that the criteria should be set. The plant world's definition of neotaxa and archaeotaxa may be a useful concept, but further research is necessary to determine how it might be applied to other groups.

Develop systems to identify most threatening potential invasive species

There is a need to develop the systems which can identify the most likely and threatening potential invasive species, and establish the means to monitor non-native species on the geographic boundaries of the UK (not just Ireland and the near-continent, but also those ports and airports which regularly 'export' people and goods to the UK.

Priority Research associated with risk assessment work on non-native species

Development of a universally-accepted risk assessment procedure

There is an urgent need to undertake methodological research, to develop a universally-accepted risk assessment procedure, with the highest degree of commonality between taxa, habitats and pathways.

Research to identify characteristics common to problem species

One of the major problems, at least with vascular plants, has been the difficulty of predicting which taxa are most likely to cause problems as non-native invasives. It is clear that the proscription of particular groups or families of plants is an inappropriate route to follow, although for some insect groups, this may be an appropriate course of action. Research is therefore required which aims to identify characteristics common to problem species. These are likely to revolve around fecundity, dispersal mechanisms and the influence of habitat factors.

Review monitoring schemes to maximise information for risk assessment

A review of existing monitoring schemes is required, to analyse what information is not currently gathered, but which would contribute to the rapid completion of risk assessments for non-native problem species. The intention of this work would be to pave the way for discussions with the managers of recording schemes, so recorders can be encouraged to provide the necessary data for risk assessment.

Research to identify habitats vulnerable to non-native species

Research is required to identify those habitats that are particularly vulnerable to invasion and impact from non-native species (e.g. islands, lakes). This will help to set priorities for prevention and remediation work.

Research to identify key pathways for release / escape of non-natives

Research is necessary to identify the key pathways for the release of non-native species into the environment, and to quantify their effect. In particular, the work should aim to identify which pathways are common to a wide range of species. This research will also will help to set priorities for prevention and remediation work.

Autecological studies of key problem species

As well as the cross-cutting work identified above, there will be the need to undertake autecological research into those species which are judged to be a priority for action. A number of case histories of the eradication of unwanted non-native species indicate that programmes are far more likely to succeed if the demography and ecology of the species concerned is well-understood.

Public awareness and education

Monitoring of public awareness of non-native species issues will be important as the work to resolve problems takes place. In this area it is particularly valuable to gather feedback information, and we suggest a few avenues for research into this:

Monitoring of public awareness of non-native species issues

It will be important to undertake survey work to provide feedback monitoring of public awareness of, and attitudes to, the issues surrounding non-native species. This

might take the form of opinion polling, attitude surveys or focus group work, and should take the form of repeat surveys, to enable the tracking of changes in awareness and attitudes as public information messages and campaigns develop.

Research into economic and social costs of non-native species

To inform the public debate on non-native species issues, it will be important to outline the likely economic and social costs of critical or 'least wanted' non-native species. These assessments should form part of the necessary risk assessment and risk management work for these species, but it should be available for presentation to the public to demonstrate of the likely effects of inadvertent release of non-native species.

Assessment of most effective means of communication of issues

The most effective public awareness campaigns are those which target their audiences through the most appropriate media. Any media campaign should allow for the monitoring of the effectiveness of the media used, to enable positive feedback mechanisms to operate for future media planning. This may be generalised, or may be specific; for example, monitoring of the reporting rates of 'least wanted' non-native species in the light of particular publicity activities.

8.3: Membership of the BRAG Non-Native Species Sub-group

Ian Bainbridge	Scottish Executive
Liz Cook	Scottish Association for Marine Science
Tracy Edwards	JNCC
Richard Ferris	BRAG Secretariat, JNCC
Mary Gibby	Royal Botanic Garden Edinburgh
Phil Hulme	CEH Banchory
David Macdonald	WildCRU, University of Oxford
Niall Moore	Central Science Laboratory
Sean Murphy	CABI Bioscience
Brigid Primrose	Scottish Natural Heritage
Michael Usher	University of Stirling
Jeff Waage	Imperial College
Ruth Waters	English Nature
Chris Bear	Defra