

International Benchmarking of Great Britain Progress on Invasive Non Native Species

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Executive Summary

The Invasive Non-native Species Framework Strategy for Great Britain has successfully delivered a guiding framework for national, regional and local invasive non-native species mitigation, control or eradication initiatives. This has largely been as a result of the excellent work undertaken by the Non-native Species Secretariat and its subsidiary working groups. Yet, while public perceptions are comparable to other EU Member States, the goal of achieving widespread awareness and understanding of the risks and adverse impacts associated with invasive non-native species has been less evident. The GB public are regularly faced with environmental scare stories such that the issue of non-native species often is reduced to an afterthought. Increasing community participation in non-native species management and a greater emphasis on positive messages regarding the ability to prevent and eradicate problem species is needed. The absence of a single agency with clear responsibilities for addressing non-native species issues is also part of this problem since the profile of the issue is diluted through the activities of so many different government departments and agencies. Considerable investment has been made in undertaking risk assessments but the question remains whether such assessments are fit for purpose and the robustness of actions undertaken on their basis given conflicting EFSA requirements and protocols. A quantitative review of the risk assessments undertaken to date in relation to international best practice would be valuable since the original risk assessment protocol has largely evolved from framework best suited for addressing plant health risk. A one-size fits all scheme may not be the best way forward and different procedures may be better employed where prevention, eradication or containment are the likely outcomes. The absence of a clear surveillance strategy is an important omission and represents one of the weakest links in the INNS Framework Strategy for Great Britain. Integration of non-native species surveillance and monitoring in existing monitoring schemes is important but there is a role for species specific surveillance to be adopted. Sharing costs with industry for more robust surveillance and rapid response will be essential to manage non-native species incursions. There is also a pressing need to review where research investment in INNS has been made over the last decade; identify who the major funders and providers are in GB; examine the extent to which there has been research uptake among stakeholders; and point out key gaps in provision, capability and knowledge. The development of industry codes of practice will need to be managed well and ensure that compliance is reviewed regularly. These recommendations are a natural consequence of the initial successes of the strategy but after five years, the key priorities in the strategy should be revised and updated providing a clear timetable for main achievements over the next five years.

1. Introduction

The objective of this review is to provide an international context to the current state of play with Great Britain's response to invasive non-native species (INNS). The review follows the Strategy in being only concerned with the economic, environmental and social impacts of invasive non-native species of flora and fauna in the terrestrial, freshwater and marine environments with the exception of genetically modified organisms, and agents of plant, animal and human diseases.

The specific aims of the review were to:

1. Compare the progress in tackling the INNS issue in GB with progress in EU and worldwide.
2. To identify and explore any gaps in the GB framework and response.
3. To make recommendations for future priorities for the revised strategy and overall approach.

It will benchmark these criteria against the seven key priorities areas of the Strategy: Prevention; Early Detection, Surveillance, Monitoring and Rapid Response; Mitigation, Control and Eradication; Building Awareness and Understanding; Legislative Framework; Research; and Information Exchange and Integration

2. Prevention

The prevention of INNS introductions into and also within a region is widely promoted as being a far more cost-effective and environmentally desirable strategy than actions undertaken after INNS establishment (Hulme 2006). The approach to prevention is primarily one of risk assessment and requires information about the hazard (e.g. what particular INNS pose a threat) and its likelihood (e.g. probability of entry and establishment).

Several key actions of the INNS Framework Strategy for Great Britain revolved around developing a robust risk assessment process for use on species, pathways and habitats, applying the risk assessment process to identify the pathways that present the highest risks for entry of non-native species into GB and to identify the highest impact species that are most likely to enter and establish themselves in GB (for example produce high, medium and low risk list). These goals have largely been delivered upon and a revised GB NNS Risk Assessment protocol (NNRA) has been developed. This has been applied to 60 full risk assessments. The protocol is a qualitative risk assessment scheme based on the EPPO model. How does the NNRA stack up internationally?

The NNRA was included in a recent review of over 300 invasive species risk assessment schemes (Leung *et al.* 2012). This review identified several limitations of the NNRA including that there was no weighting of different components in the risk assessment, no explicit guidance on how to combine scores of individual questions to a final score, and no assessment of how abundant the species might become in specific locations (Leung *et al.* 2012). More generally, qualitative expert systems were generally found to be less replicable and robust than more quantitative risk

assessment approaches. Hulme (2012) elaborates on some of these limitations which include problems in obtaining an objective measure of the hazards posed by INNS, challenges of predicting complex hierarchical and nonlinear systems, difficulties in quantifying uncertainty and variability, as well as cognitive biases in expert judgement, all limit the utility of current risk assessment approaches. The accuracy of INNS risk assessment protocols is usually insufficient, given inherent low base-rates even when the costs and benefits of decisions are taken into account, and implies that the predictive value of INNS assessment is questionable.

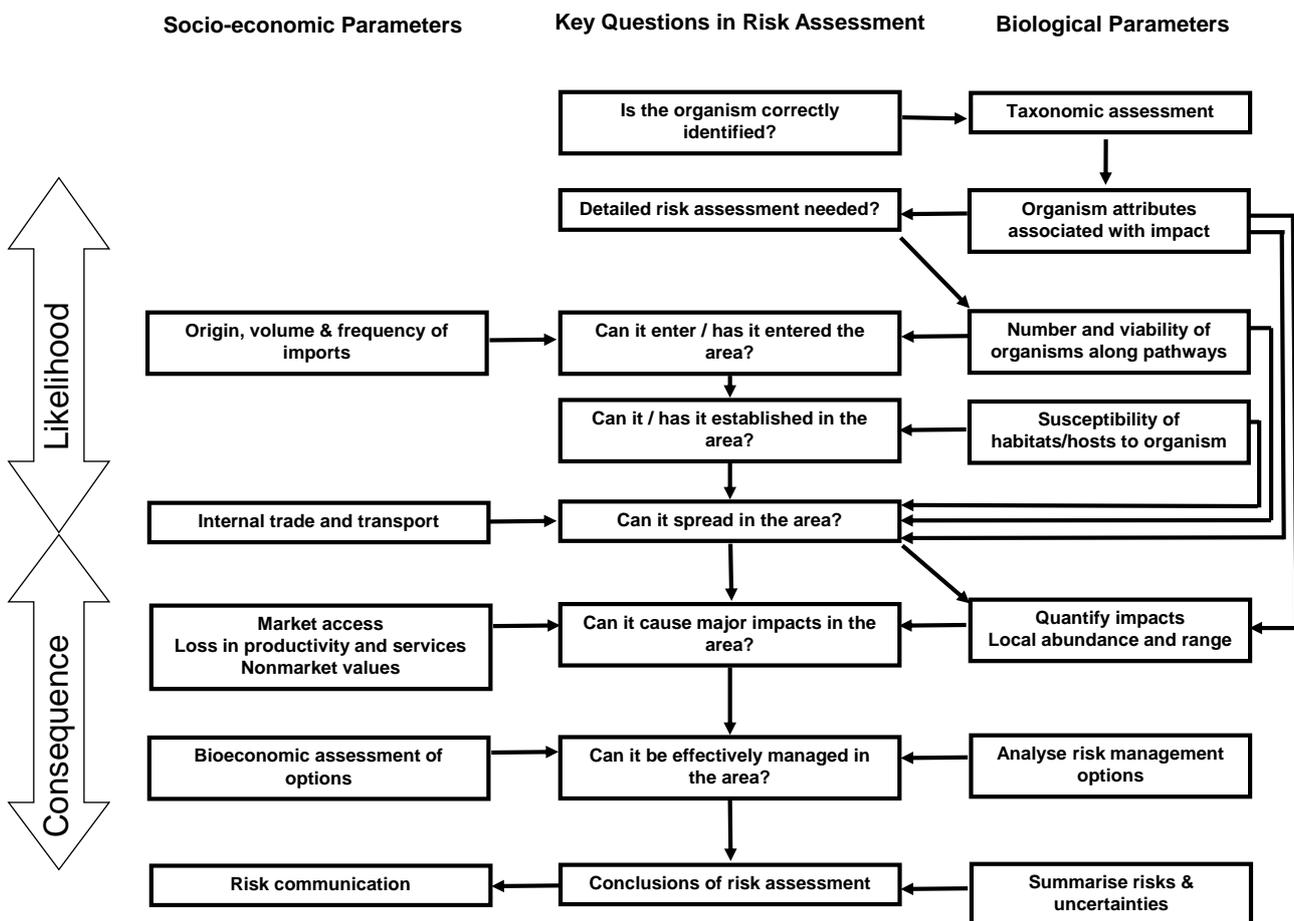


Figure 1. Overview of non-native species risk assessment scheme and the socio-economic as well as biological information required to adequately assess likelihoods and consequences of invasive species (after Hulme 2011).

Nevertheless, qualitative systems are widely used in policy context. However, in the past when EPPO risk assessments for several invasive plant species were submitted to the European Food Safety Authority (EFSA), the request to list them as official pests in Council Directive 2000/29/EC was declined (Hulme *et al.* 2009). Although EFSA acknowledged that the species were probably invasive, further quantitative information on population dynamics, environmental drivers, introduction pathways, spatial distribution, and impacts was required. One of the species was floating pennywort, *Hydrocotyle ranunculoides*, for which a NNRA exists. However, this NNRA would also probably fail the scrutiny of EFSA (EFSA 2007a) in relation to: (a) the effect of abiotic factors on the establishment, development, reproduction, survival and dispersal of the plant in both the native and introduced range; (b) the population dynamics of the plant in areas where it is present but not invasive; (c) the volume of trade in *H. ranunculoides* as an ornamental plant

entering and moving within GB, including further analysis of the means by which it can reach natural water bodies; (d) the nature and occurrence of areas within the GB where conditions are favourable to invasive behaviour of the plant and more detailed information of the factors, including eutrophication, which favour the establishment of *H. ranunculoides* (it is suggested this is undertaken using quantitative GIS analyses). Similarly, EFSA have also rejected two risk assessments addressing common ragweed *Ambrosia artemisiifolia* (EFSA 2007b, c) and a recent NNRA for this species would probably also fall short in terms of: a) more accurate assessment of the potential for establishment (including photoperiod and climatic conditions, and other abiotic factors); b) the efficacy of control measures and effects on crop yield, at least for the main crops; and c) discussion of uncertainties on all aspects of the pest risk assessment. There is therefore an increasing move towards more quantitative support for risk assessments and less dependence on expert opinion. The NNRA scheme needs to explicitly provide guidance as to how scoring can be made more quantitative and best use of appropriate sources of information needed to parameterise the scheme (Fig. 1). Such work is time intensive and the long-term viability of current situation of a single assessor undertaking risk assessments for a small fee, as opposed to a dedicated risk assessment team as in many other countries, needed to be considered.

While GB may develop its own risk assessment protocols for use within its national borders independently of developments in Europe, different criteria applied within the European Union may make challenges to GB decision more likely if EFSA proposes more stringent, quantitative criteria for decision making. This has become increasingly important with EFSA producing its own guidance on the environmental risk assessment of plant pests (EFSA 2011). This recent scheme emphasises the importance of assessing the consequences on both the structural (biodiversity) and the functional (ecosystem services) aspects of the environment, and includes methods for assessing both aspects in a pest risk assessment scheme. In addition, to ensure the consistency and transparency of the assessment, a rating system has also been developed based on a probabilistic approach with an evaluation of the degree of uncertainty. As a consequence, this leaves the GB NNRA behind, particularly in its ability to address impacts on ecosystem services and this is an important deficit especially in the light of the UK National Ecosystem Assessment (UKNEA 2011). A quantitative review of the risk assessments undertaken to date in relation to international best practice would be valuable since the original risk assessment protocol has largely evolved from framework best suited for addressing plant health risk.

The aim of prevention, and thus the key role of risk assessment, is to minimise the risk of invasive non-native species entering and becoming established in GB, and reduce the risks associated with the movement of species outside their natural range within GB. It appears that the approach to risk assessment undertaken by the UK Non-Native Risk Assessment Panel is far broader and while it includes species currently absent from GB e.g. (*Tamias sibiricus*, *Vespa velutina*) it also addresses species with restricted distributions in GB (e.g. *Ambrosia artemisiifolia*, *Rana catesbeiana*) as well as widespread taxa (e.g. *Cervus nippon*, *Rhododendron ponticum*). There

may be considerable benefits it taking a more rational and hierarchical approach to such risk assessments rather than having a one-size-fits-all approach as at present. For example, pathways risk assessment would be especially important for species yet to establish in GB and quantifying the key pathways, their volume, temporal trend and spatial distribution would be an essential part of border prevention. For species established but regionally localised in GB a greater emphasis on distribution modelling, environmental constraints and dispersal ability would be most important. Finally, widespread species are more often the target of prioritisation schemes that aim to rationalise management. Here a focus on the resources most at risk (e.g. Natura habitats) and their management would be important. The current NRRRA only briefly touches on these topics and usually in a qualitative fashion.

3. Early Detection, Surveillance, Monitoring and Rapid Response

Once established, even if impacts have not been quantified, the precautionary principle encourages action to be taken to eradicate potentially harmful IAS as soon as they are detected. In principle this should be straightforward but, in practice, for all but economic pests and vectors of disease, rapid response is often surprisingly sluggish (Hulme 2006). The limitation partly reflects the constraints identified with knowing which species to target and the problems of blacklisting, but an additional issue is the difficulty of detecting rare events.

Key actions in the INNS Framework Strategy for Great Britain include producing an 'early warning system' alert system for both flora and fauna; developing a surveillance system that maximises the use of existing information and existing capacity within relevant conservation or taxon-specific bodies; establishing protocols for surveillance and monitoring of species identified as potentially invasive; and identify appropriate means of securing adequate resources and capacity to carry out rapid responses to contingencies.

Early detection normally requires a strong link with appropriate risk assessment in order for effective protocols to be in place to discover entry of INNS sufficiently early to result in action. In many cases in GB, most species targeted for "rapid" response have been established for some time (e.g. topmouth gudgeon, water primrose, monk parakeet) and risk assessments were undertaken post- rather than pre-entry. An important exception is the contingency plan for the Asian Hornet and for early detection and rapid response a greater emphasis will be needed on such pre-entry contingency plans built on a solid risk assessment foundation. It would be expected that GB would have a much larger number of contingency plans in place for species with a high risk of entry into the region. It will therefore be essential to support recent horizon scanning activities (Natural England 2009; Thomas 2010; Roy *et al.* 2013) through formal risk assessments in order to develop additional contingency plans.

The primary progress with surveillance and monitoring has been the development of the Non-Native Species Information Portal (NNSISP) that establishes a central repository for holding data on non-native species distribution and provides a means for capturing information on non-native

species. This is an excellent information base for existing and established INNS and the underlying data recording for key taxonomic groups is among the best in the world, it also represents a platform for data recording and the NNISP providers have developed an impressive range of applications to do so through citizen science. As a repository for information the NNSISP works well but it is not a means for surveillance and monitoring. In most cases this needs to link through established programmes of species monitoring, whether interception data at the border or systematic monitoring of species taxa. As yet there is no clear surveillance and monitoring strategy of INNS in GB, examples of such strategies exist elsewhere in the world (MAF 2009) and a priority should be to develop a surveillance and monitoring framework that appraises the value of existing surveillance and monitoring programmes, much as has been attempted for monitoring GMO impacts (Hugo *et al.* 2006). Furthermore, consideration should be given to the development of specific surveillance and monitoring activities for target taxa, vulnerable habitats or high risk pathways. Considerable effort has already been devoted to assessing general biodiversity surveillance in the UK (JNCC 2009) and future work addressing INNS would benefit from this background. Finally, more detailed consideration should be given to resourcing surveillance and the responsibilities of government and industry in financing surveillance and even rapid response programmes for particular pests.

4. Mitigation, Control and Eradication

Key actions in the INNS Framework Strategy for Great Britain include establishing a set of guiding principles for assessing and identifying what action or range of actions is feasible in terms of containment, control or eradication; identify priority invasive species and priority impacted habitats for mitigation and control; draft management plans for the priority; develop and resource action programmes. It is clear that GB is supporting a wide range of mitigation, control and eradication campaigns. The LIFE programme (launched in 1992 and ended in 2006) financed 187 INNS-related projects with a budget exceeding 44 million EUR. A recent country analysis highlighted that Italy, Spain and France alone had more projects than all the remaining countries (about 52% of total). Also the level of funding was uneven among countries. Spain, UK, Denmark, Italy and Belgium alone had more than 75% of the total budget spent for IAS (Scalera 2009). However, comparative performance is hard to judge since expenditure alone is not a good guide to the effectiveness of any strategy.

Unfortunately GB is host to many non-native species and for most taxa more than most of its European neighbours (Pyšek *et al.* 2010). Management prioritisation is essential yet the process for GB is unclear and the process by which ISAPs are identified should be transparent. For example, New Zealand has the National Interest Pest Programme that aims to set joint priorities, among the government biosecurity partners and regional councils, for the management of animal and plant pest species in New Zealand at that time. Each pest is assessed against a series of standardised criteria, including an organism consequence assessment and the availability of management tools. Through using this approach, a small number of top priority pests have been

targeted for eradication. Clear criteria and processes have led to a broad consensus among stakeholders, and resources are now focused on achieving concrete results in defined timeframes. Has such a formal process been adopted in GB? If we examine the 49 most invasive species listed in National Biodiversity Indicators (Table 1), ISAPs are obviously not a random sample of these taxa but strongly biased towards aquatic species. What is the rationale behind this decision? Furthermore, even accounting for existing eradication programmes for the ruddy duck and recent biocontrol release targeting Japanese knotweed there are relatively few programmes aimed at eradicating these 49 species. Undoubtedly management is undertaken against many of the species listed in Table 1 but are these strategically managed and are resources being targeted effectively (e.g. Wadsworth et al. 2000)?

Table 1. The 49 most invasive non-native species in GB as used in the national biodiversity indicators (Defra 2013). Species in bold are covered by existing or proposed Invasive Species Action Plans while those underlined have existing risk assessments.

(a) Marine plants (1/3)

1. *Sargassum muticum* (Jap Weed, Wire Weed)
2. *Undaria pinnatifida* (Japanese Kelp, Wakame)
3. *Codium fragile ssp. tomentosoides* (Sea Fingers)

(b) Marine animals (5/16)

4. *Tricellaria inopinata* (a bryozoan)
5. *Watersipora subtorquata* (a bryozoan)
6. *Corophium sextonae* (an amphipod)
7. *Gammarus tigrinus* (an amphipod)
8. *Elminius modestus* (an acorn barnacle)
9. *Solidobalanus fallax* (a barnacle)
10. *Eriocheir sinensis* (Chinese Mitten Crab)
11. *Rhithropanopeus harrisi* (Dwarf Crab)
12. *Crassostrea gigas* (Pacific Oyster)
13. *Crepidula fornicata* (Slipper Limpet)
14. *Rapana venosa* (Rapa Whelk)
15. *Anguillicola crassus* (Swim-bladder Nematode)
16. *Botrylloides violaceus* (a tunicate)
17. *Corella eumyota* (a tunicate)
18. ***Didemnum vexillum*** (a tunicate)
19. *Styela clava* (Leathery Sea Squirt)

(c) Freshwater plants (4/4)

20. ***Crassula helmsii*** (New Zealand Pigmyweed)
21. ***Hydrocotyle ranunculoides*** (Floating Pennywort)
22. *Ludwigia grandiflora* (Uruguayan purslane)
23. ***Myriophyllum aquaticum*** (Parrot's-feather)

(d) Freshwater animals (4/8)

24. ***Pacifastacus leniusculus*** (Signal Crayfish)
25. ***Procambarus clarkii*** (Red Swamp Crayfish)
26. *Corbicula fluminea* (Asian Clam)
27. *Dreissena polymorpha* (Zebra Mussel)
28. ***Pseudorasbora parva*** (Topmouth Gudgeon)
29. *Sander lucioperca* (Pikeperch, Zander)
30. *Lithobates catesbeianus* (American Bullfrog)
31. *Trachemys scripta* (Common Slider Turtle)

(e) Terrestrial plants (2/8)

32. *Carpobrotus edulis* (Hottentot Fig)
33. *Disphyma crassifolium* (Purple Dewplant)
34. *Fallopia japonica* (Japanese Knotweed)
35. *Heracleum mantegazzianum* (Giant hogweed)
36. *Impatiens glandulifera* (Himalayan Balsam)
37. *Quercus ilex* (Evergreen Oak)
38. *Rhododendron ponticum* (Rhododendron)
39. *Rosa rugosa* (Japanese Rose)

(f) Terrestrial animals (4/10)

40. *Arthurdendyus triangulata* (NZ Flatworm)
41. *Harmonia axyridis* (Harlequin Ladybird)
42. *Branta canadensis* (Canada Goose)
43. *Oxyura jamaicensis* (Ruddy Duck)
44. *Cervus nippon* (Sika Deer)
45. *Muntiacus reevesi* (Reeves' Muntjac)
46. *Mustela vison* (American Mink)
47. *Myocastor coypus* (Coypu)
48. *Rattus norvegicus* (Brown Rat)
49. *Sciurus carolinensis* (Grey Squirrel)

Eradication, control and mitigation are not mutually exclusive approaches and it is possible to envisage a co-ordinated programme of INNS control within a region, containment at the edge of its range and eradication of outlying populations (Hulme 2006). Alternatively, containment may act as a holding response during which decisions are made regarding the costs and benefits of eradication, control or no management. The INNS Framework Strategy for Great Britain should explore the targets for eradication versus containment, control (in priority sites) and mitigation. At present the ISAPs are largely focused on eradication but this is unlikely to be possible for the 49

high profile invasive species and against each a strategy should be developed (Defra 2013). However, it is also tempting to see eradication, containment and control as three successive steps down the slippery slope towards management failure: if an INNS cannot be eradicated, it should at least be contained, if not contained at least controlled, and if not controlled then managers must learn to adapt to or mitigate any harmful impacts. To avoid this scenario, future management strategies require a wider perspective that not only includes species management but also incorporates the implications of ecosystem processes, external environmental drivers, the landscape and the impact of existing management activities on INNS.

5. Building Awareness and Understanding

Two recent surveys of European attitudes to biodiversity pinpoint a consistent pattern over the last six years that citizens across the regions think that pollution of air and water, man-made disasters, intensive farming, deforestation and over-fishing, climate change and conversion of natural areas to other uses threaten biodiversity to a greater extent than introduced plants and animals (European Commission 2007; 2013). Citizens of the United Kingdom are also consistent in this view. However, when attitudes towards introduced plants and animals are compared across Europe it appears that while in 2007 UK citizens were among those that ranked these threats most highly (after Denmark, Germany and Luxembourg) by 2013 perceptions were much closer to the European average. These findings are broadly consistent with those assessed in the *Wildlife Management and Invasive Non-Native Species* report.

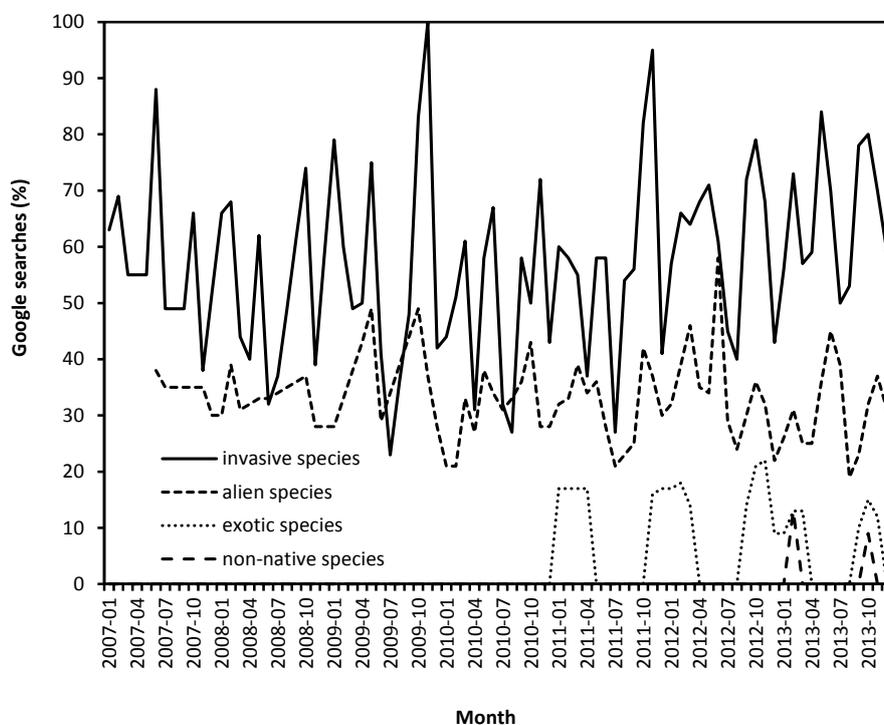


Figure 2. Relative volume of Google searches in the UK for various biosecurity terms between 2007 and 2013.

There is therefore substantial scope to increase awareness and public understanding of INNS issue in GB. The key priorities in the INNS Framework Strategy for Great Britain are to: set up and

maintain a Secretariat website on invasive non-native species issues which links to agencies, NGOs and others working on invasive non-native species; undertake action to assess public attitudes and collect baseline information on public awareness; identify and priorities for action to increase the awareness of key audience groups, produce, disseminate and implement Codes of Practice for the key pathways. Many of these priorities have been achieved successfully but have they had impact?

There appears to be no major change in the trend for internet interest (as determined by Google Trends) for topics addressing biological invasions (Fig. 2). Notable however, is the fact that non-native species is not a major search term and this runs contrary to the GB Communication strategy that emphasises this term over any other. The use of “non-native” is a particularly characteristic of GB policy whereas most international organisations (IUCN, European Commission, Convention on Biological Diversity), databases (ISSG, DAISIE, NOBANIS) and English speaking countries adopt the term “alien”. Even in the UK, while respondents to surveys may prefer the term non-native to alien, the British public appears to search for the latter term far more frequently than the former (Fig. 2). Alignment with international legislation may require a re-think of the use of non-native in GB policy. The GB public are regularly faced with environmental scare stories such that the issue of non-native species often is reduced to an afterthought. Increasing community participation in non-native species management and a greater emphasis on positive messages regarding the ability to prevent and eradicate problem species is needed. Finally, a major difference in awareness-raising in GB compared to Australia and New Zealand is at the border. Compared to these countries the profile of the risk from non-native species at the border, the level of screening and public information at ports and airports and the information provided on intercontinental flights entering GB is minimal. Passengers travelling to GB are often a captive audience for important messages regarding prevention but this opportunity is not fully exploited at present but there is substantial scope for eye-catching and informative communication regarding non-native species.

	AT	BE	BG	CY	CZ	DE	DK	EE	ES	FI	FR	GR	HU	IE	IT	LT	LU	LV	MT	NL	PL	PT	RO	SE	SI	SK	UK
General provisions																											
Risk assessment framework																											
Permitting system																											
Inspection system																											
A. Prevent intentional introduction in the EU																											
Specific IAS banned from Import																											
Specific IAS banned from Sale																											
Specific IAS banned from transport and/or holding																											
B. Prevent unintentional introduction in the EU and unintentional release in the environment																											
Pathway management																											
C. Prevent intentional release into the environment																											
General ban from release in environment																											
Specific IAS banned from release in environment																											
D. Early warning and Rapid Response																											
Information system																											
Surveillance and monitoring																											
Early warning and Rapid Response system																											
E. Management of established IAS																											
Eradication programmes																											
Management programmes																											
Restoration																											
Strategy																											

Figure 3. Overview of non-native species provision in EU-27 highlighting where legal provision exists (black); legal provision is in preparation (dark grey); informal provision (mid-grey); scattered initiatives(light-grey); and no provision (blank). From EC(2013).

6. Legislative Framework;

Part of the INNS Framework Strategy for Great Britain aims to strengthen the legislative framework particularly through: developing a package of legislative proposals designed to provide a more coherent and comprehensive framework for tackling invasive non-native species; making the most effective use of existing powers; and contributing to the development of any EU level initiatives to improve legislation. The legislative framework for tackling INNS in GB is among the most robust in the EU (Fig. 3).

Perhaps the weakest areas are those that are related to Early Warning and Rapid Response. In particular, legislative arrangements regarding responsibilities for surveillance, especially by industry and response particularly access to private property need to be strengthened. For example, in both New Zealand and Australia, Government-Industry Agreements facilitate industry groups having a direct say in managing non-native species risks with partners sharing decision making, costs and responsibility in preparing for and responding to incursions. It is also unclear how well covered different pathways are by legislation and the effectiveness of Voluntary Codes of Practice in different sectors. It would be important to assess compliance with Voluntary Codes of Practice.

7. Research

Science underpins virtually all aspects of biological invasions, from research into pre-border management, to methods of detecting pests and diseases at the border, to advising on acceptable and effective means of eradicating or managing pests and diseases which reach GB and involves a complex network of biosecurity science providers, funders and users. The INNS Framework Strategy for Great Britain aims to ensure: risk assessments, prevention, detection, surveillance, monitoring and management are underpinned with the highest quality science available; funding for the research priorities is secured; collaborative research projects are encouraged; and GB research on invasive non-native species is cutting edge.

While there have been several syntheses to identify the key research areas to assist in the management of biological invasions (e.g. Byers *et al.* 2002; Chornesky *et al.* 2005), the UK has also developed its own specific priorities for biodiversity threats (UKBRAG 2005). It remains unclear as to the impact of this prioritisation process for GB in terms of guiding research funders or providers. Given this prioritisation process is now almost 10 years old, consideration should be given to developing a new research strategy. A suitable model could be the New Zealand Biosecurity Science Strategy (MAF 2007). This strategy was drawn up following wide consultation with research funders, providers, government, industry and the general public. Such a strategy would review where research investment in INNS has been made over the last decade; identify who the major funders and providers are in GB; examine the extent to which there has been research uptake among stakeholders; and point out key gaps in provision, capability and knowledge. In addition, through consultation it would set out a series of short (1-2 years), medium (3-5 years) and long-term (6-10 year) priorities that would influence science funding policy in Defra,

NERC, Natural England etc. There should be clear criteria for ensuring research delivered is cutting edge and published in peer-reviewed literature. Several contract reports delivered through the GB Framework have not been published suggesting a lack of detailed international peer review.

8. Information Exchange and Integration

It is essential that the Invasive Non-native Species Framework for GB represents a coherent strategic approach that avoids duplication or conflict across Government Departments, and is streamlined to international approaches. The GB Coordination Mechanism consists of the Non-Native Species Programme Board, the Non-Native, Species Secretariat (NNSS), the Risk Analysis Panel, the Stakeholder Forum and a number of Working Groups. With the exception of the NNSS, all other components of the Coordinating Mechanism meet no more than four times a year, while the Stakeholder Forum is an annual one-day event. As a consequence coordination rests of the shoulders of only a few individuals, insufficient to manage the complexity of non-native threats in GB. At present in GB the logical information flow between horizon scanning, risk assessment and invasive species action plans is unclear. Furthermore, within the current GB Coordinating mechanism there are still grey areas between the activities of the NNSS and Plant, Animal and Human Health, particularly where non-native vertebrates and invertebrates are host or vectors of pathogens.

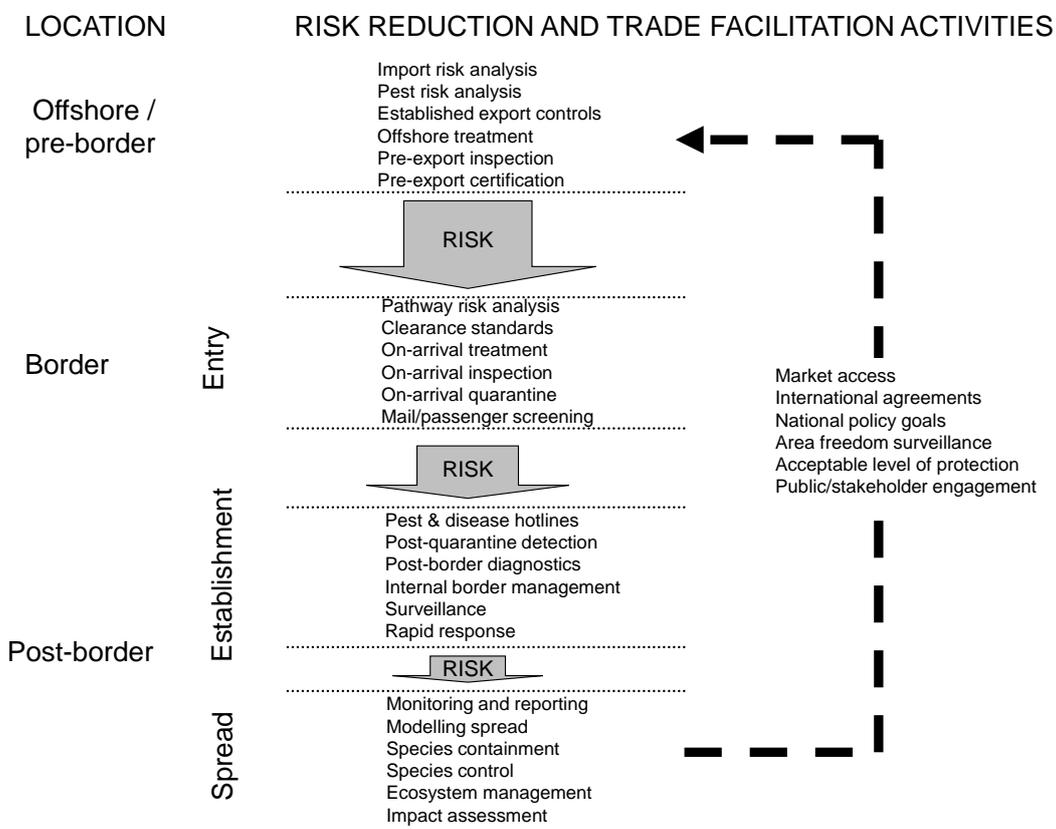


Figure 4. An integrated biosecurity system ensuring risks are managed in a coordinated fashion along the continuum from offshore to post-border (after Hulme 2014).

To address invasive non-native species successfully a whole of system perspective encompassing offshore, border and post-border risk assessment, prioritisation and management is required (Fig. 4). Coordination in GB is still far from this ideal and thought should be given to a dedicated agency with these responsibilities. In New Zealand a single lead agency takes responsibility for end-to-end biosecurity, taking a whole-of-government and whole-of-New Zealand perspective with responsibilities for pre-border and border activities, incursions and eradications, and the grey zone leading through to pest management (Biosecurity Council 2003). The absence of a single agency with clear responsibilities for addressing non-native species issues in GB is also part of this problem since the profile of the issue is diluted through the activities of so many different government departments and agencies.

9. Conclusions

Undoubtedly the Invasive Non-native Species Framework Strategy for GB has had a considerable impact on the way activities on non-native species are coordinated and there has been good progress on almost all the key priority areas. While an important first step, the question arises as to whether this activity is sufficient to stem the rising tide of invasive species likely to establish in GB over the next decade. The unfortunate answer is probably not, rather action is largely directed at established non-native species in GB. Improvements can be made in each of the key priority areas particularly in terms of ensuring risk assessment evolves to match international developments, development of a surveillance strategy supported by appropriate legislation and consideration of a single agency not only to coordinate activities but also to drive implementation.

10. References

Biosecurity Council (2003) *Protect New Zealand The Biosecurity Strategy for New Zealand*.

Biosecurity Council, Wellington.

Chornesky EA, Bartuska AM, Aplet GH, Britton KO, Cummings-Carlson J, Davis FW, Eskow J, Gordon DR, Gottschalk KW, Haack RA, Hansen AJ, Mack RN, Rahel FJ, Shannon MA, Wainger, LA & Wigley TB (2005) Science priorities for reducing the threat of invasive species to sustainable forestry. *BioScience*, **55**, 335-348.

Defra (2013) *UK Biodiversity Indicators in Your Pocket 2013*. Department for Environment, Food and Rural Affairs, London.

Byers JE, Reichard S, Randall JM, Parker IM, Smith CS, Lonsdale WM, Atkinson IAE, Seastedt TR, Williamson M, Chornesky E & Hayes D (2002) Directing research to reduce the impacts of nonindigenous species. *Conservation Biology*, **16**, 630-640

EC (2013) *Impact Assessment: Commission staff working document accompanying the proposal for a Council and European Parliament Regulation on the prevention and management of the introduction and spread of invasive alien species*. SWD(2013) 321 final, European Commission, Brussels.

European Commission (2007) Attitudes of Europeans Towards the Issue of Biodiversity Flash Eurobarometer 219. European Commission, Brussels.

European Commission (2013) Attitudes towards biodiversity Flash Eurobarometer 379, European Commission, Brussels.

EFSA (2007a) Opinion of the Scientific Panel on Plant Health on the pest risk analysis made by EPPO on *Hydrocotyle ranunculoides* L. f. (floating pennywort). *EFSA Journal*, **468**, 1-13

EFSA (2007b) Opinion of the Scientific Panel on Plant Health on a request from the Commission on the pest risk assessment made by Lithuania on *Ambrosia* spp. *EFSA Journal*, **527**, 1-33.

EFSA (2007c) Opinion of the Scientific Panel on Plant Health on a request from the Commission on the pest risk assessment made by Poland on *Ambrosia* spp. *EFSA Journal*, **528**, 1-32.

EFSA (2011) Guidance on the environmental risk assessment of plant pests. *EFSA Journal*, **2460**, 1-121.

Hugo S, Boatman N, Pietravalle S, Murray A, Blackburn J &, Wardman O (2006) *Availability and use of general surveillance information for potential changes resulting from GM crop cultivation*. Defra final report CB02042, Defra London.

Hulme PE (2006) Beyond control: wider implications for the management of biological invasions *Journal of Applied Ecology*, **43**, 835-847

Hulme PE (2011) Biosecurity: the changing face of invasion biology. *Fifty Years of Invasion Ecology - The Legacy of Charles Elton* (ed. DM Richardson), pp. 301-314. Blackwells, Oxford.

Hulme PE (2012) Weed risk assessment: a way forward or a waste of time? *Journal of Applied Ecology*, **49**, 10-19.

Hulme PE (2014) An introduction to plant biosecurity: past, present and future. *The Handbook of Plant Biosecurity* (ed. G. Gordh and S. McKirdy), pp. 1-25. Springer, Dordrecht.

Hulme PE, Pyšek P, Nentwig W & Vilà M (2009) Will threat of biological invasions unite the European Union? *Science*, **324**, 40-41

JNCC (2009) *The UK Terrestrial Biodiversity Surveillance Strategy*. JNCC, Peterborough.

Leung B, Roura-Pascual N, Bacher S, Heikkilä J, Brotons L, Burgman MA, Dehnen-Schmutz K, Essl F, Hulme PE, Richardson DM, Sol D, Vilà M (2012) TEASIng apart alien species risk assessment: a framework for best practices. *Ecology Letters*, **15**, 1475–1493.

MAF (2007) *A Biosecurity Science Strategy for New Zealand*. Ministry of Agriculture and Forestry, Wellington, NZ

MAF (2009) *Biosecurity Surveillance Strategy 2020*. Ministry of Agriculture and Forestry, Wellington, NZ

- Natural England (2009) *Horizon Scanning for New Invasive Non-native Animal Species in England*. Natural England, Sheffield.
- Pyšek P, Jarošík V, Hulme PE, Kühn I, Wild J, Arianoutsou M, Bacher S, Chiron F, Didžiulis V, Essl F, Genovesi P, Gherardi F, Hejda M, Kark S, Lambdon PW, Desprez-Loustau A-M, Nentwig W, Pergl J, Pobljšaj K, Rabitsch W, Roques A, Roy DB, Solarz W, Vilà M & Winter M (2010) Disentangling the role of environmental and human pressures on biological invasions *Proceedings of the National Academy of Sciences of the United States of America*, **107**, 12157-12162.
- Roy H, Peyton J, Aldridge D, Bantock T, Blackburn T, Britton R, Clark P, Cook E, Dehnen-Schmutz K, Dines T, Dobson M, Edwards F, Harrower C, Harvey M, Laing I, Minchin D, Newman J, Noble D, Parrott D, Pocock M, Preston C, Roy S, Salisbury A, Schonrogge K, Sewell J, Shaw R, Stebbing P, Stewart A, Walker K (2013) Horizon-scanning for invasive alien species with the potential to threaten biodiversity in Great Britain. Unpublished manuscript
- Scalera R (2009) How much is Europe spending on invasive alien species? *Biological Invasions*, **12**, 173-177.
- Thomas S (2010) *Horizon-scanning for invasive non-native plants in Great Britain*. Natural England Commissioned Reports, Number 053
- UKBRAG (2005) *Strategy for non-native species research*. UK Biodiversity Research Advisory Group, Peterborough.
- UKNEA (2011) *The UK National Ecosystem Assessment: Synthesis of the Key Findings*. UNEP-WCMC, Cambridge.
- Wadsworth RA, Collingham YC, Willis SG, Huntley B & Hulme PE (2000) Simulating the spread and management of alien riparian weeds: are they out of control? *Journal of Applied Ecology*, **37**, 28-38