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Horizon-scanning for invasive alien species with the potential to threaten biodiversity and ecosystems, human health and economies in Britain

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Invasive non-native species (INNS) are defined as species, introduced through human action outside of their native range, that have the ability to spread causing damage to the environment, the economy, our health or the way we live (Roy, Bacon et al. 2012). Over the last century there has been a dramatic increase in the movement of non-native species around the world (Seebens, Blackburn et al. 2017, Seebens, Blackburn et al. 2018), as a consequence of increasing international trade and travel (Hulme, Roy et al. 2009, Seebens, Essl et al. 2015).

Here, we present the outcomes of a consensus approach which repeated the process undertaken for Britain in 2013 (Roy, Peyton et al. 2014) to derive ranked lists of INNS likely to arrive and establish over the next ten years. Previously only biodiversity and ecosystem impacts were considered but here the approach was extended to human health and economic impacts (Roy, Peyton et al. 2019).

Methods

We used an adapted version of the consensus method (Sutherland, Fleishman et al. 2011) for a horizon scanning approach previously used to derive a ranked list of potential Invasive Non-Native Species with high impact on biodiversity and ecosystems in Britain (Roy, Peyton et al. 2014) and Europe (Roy, Bacher et al. 2019) (Figure 1). We extended the approach to consider human health and economic impacts. Furthermore, we also considered which of the INNS prioritised within the three separate impact (biodiversity and ecosystems, human health and economic) lists should be considered the highest priority. As such we derived four ranked lists comprising potential Invasive Non-Native Species with high impact on:

1. biodiversity and ecosystems
2. human health
3. economies

and a fourth list constituting the INNS considered to be the highest priority from the three other lists.

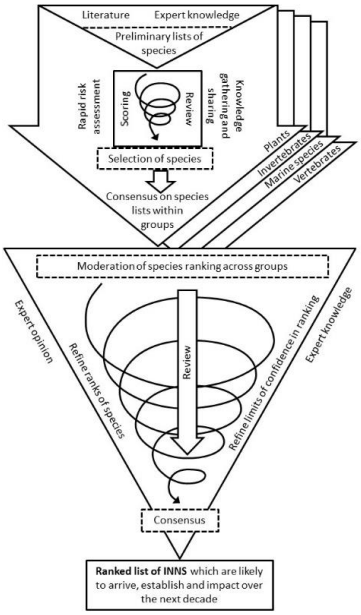

Figure 1. Horizon scanning process, based on consensus method, to derive a ranked list of INNS which are likely to arrive, establish and have an impact in Britain over the next decade.

Geographic scope: Britain. The geographic scope of the search for potential INNS was global but with the following restrictions:

(i) Are absent or not considered established in GB
(ii) Have documented histories of invasion and causing undesirable impacts in other regions worldwide with similar climatic conditions
(iii) Traded within GB or are present in areas that have strong trade or travel connections with GB and where there is a recognised potential pathway for arrival.
(iv) Are present in captivity including gardens, zoological parks, aquaculture facilities and glasshouses but not present in the wider environment.

Temporal scope: Invasive non-native species likely to arrive and establish in the next 10 years. This temporal limit informs the relevance of, for instance, long-term climate change projections.

The process involved a sequence of steps which were outlined to the participants through e-mail correspondence (Roy, Peyton et al. 2019).

Thematic groups: Species were considered within four broad thematic groups -

- Plants (lead: Oli Pescott, UK Centre for Ecology & Hydrology; Katharina Dehnen-Schmutz, University of Coventry)
- Terrestrial invertebrates (lead: Alan Stewart, University of Sussex)
- Freshwater invertebrates (lead: David Aldridge, University of Cambridge)
- Vertebrates (lead: David Noble, BTO)
- Marine species (lead: Jack Sewell, MBA; Elizabeth Cottier-Cook, Scottish Association for Marine Science (SAMS) Associate Institute)

Lists of experts are provided in Annex 1. Consultation between experts was completed both through e-mail discussions in advance of the workshops and through the workshop breakout groups.

Scoring of species: Experts were advised that the scoring approach was not absolute but to provide an initial ranking of all potential INNS. This context was important to ensure that experts were empowered to use expert judgement alongside available evidence sources (Roy, Peyton et al. 2020). Experts were asked to score each species within their thematic group for their separate likelihoods of: i) arrival, ii) establishment, iii) magnitude of the potential negative impact on biodiversity or ecosystems, human health or economies. A 5-point scale from 1=very low to 5=very high (Blackburn, Essl et al. 2014, Bacher, Blackburn et al. 2017) was adopted. The scores from each expert within each thematic group were then compiled and discussions within the thematic groups (at the workshop) led to an overall agreed impact and confidence score for each species. While acknowledging that the scores were only for guidance, an overall risk score for each species was calculated as the product of the individual scores for arrival, establishment and impact on biodiversity. With a 3-criterion, 5-point scoring system, this produces a maximum score of 125.

The workshop was held at the UK Centre for Ecology & Hydrology, Wallingford 5-6 December 2019. The aims of the workshops were outlined and then an overview of the INNS selected by each thematic group was presented to inform the other participants of the range of species and their life-histories within each group, enabling subsequent review and moderation of the scores within the breakout sessions for each thematic group. During the breakout session, participants reviewed the species lists (adding or removing species, justifying and moderating scores and to consider levels of confidence attached to scores). The lists of INNS from across the thematic groups were collated into single lists for each of the impact categories (biodiversity and ecosystems, human health or economic). In plenary, experts were invited to justify their scores in comparison to those of other groups. All participants were then invited to review, consider and refine the rankings of all species through plenary discussion. Again scores were adjusted accordingly. The end result was three ranked lists of INNS with the potential to arrive establish and pose a threat through biodiversity and ecosystem, human health or economic impacts.

For all the INNS included within the priority lists we documented the pathways (Harrower, Scalera et al. 2018) by which they are most likely to arrive; this information is currently under review.

Combined horizon scanning list

Following the workshop a fourth list was developed which considered which of the INNS would be considered as having the highest risk when considering all three impact categories – so called combined impact list. The list was derived through two on-line surveys.

Initial selection of INNS for combined list

An initial on-line survey was developed that included all INNS (n=57) within the lists derived for each separate impact category. The on-line survey was circulated to all the experts (Annex 1) who had previously contributed to the horizon scanning to rank INNS within each of the three impact categories. The experts were invited to indicate whether a species should be ranked as 1-10, 11-20, 21-30, 31-40 when considering the magnitude of biodiversity and ecosystem, human health and economic impact simultaneously. Experts were advised that a species within the top 10 could be one that is predicted to have moderate impacts across all three categories but it could also be a species that would have catastrophic impacts in just one category.

The survey was completed by 12 experts (with representation from all the thematic groups) but not all experts assigned each species to a rank, so there was a variable number of responses per species. Therefore, only species with more than 8 responses were included in the next on-line survey.

Deriving the final combined horizon scanning list

The species list for the second on-line survey was derived by using a scoring system (assigning 5 points for species in 1-10 band to 1 point for species in 41+ band). The average scores were then calculated noting that there were a variable number of responses for each INNS. Experts were invited to note through an on-line survey:

1. agreements or disagreements in relation to whether the INNS should be included within the combined list
2. Rank position of the INNS within the list
3. any arguments for species not listed that should be included from the other lists

There was also an option for the experts to add comments. 19 responses were received (although there were only comments from 18 of the experts).

The resulting combined impact list comprised 30 INNS ranked in two bands: 1-15 and 16-30.

Results

Biodiversity and Ecosystem impacts

A total of 243 species was compiled into a long list for consideration during the workshop. The group reached a consensus on the ranking of the top 100 species in bands: 1-10, 11-20, 21-30, 31-40, 41-50, 51-100.

Table 1: Invasive Non-Native Species with high likelihood of arrival, establishment and **biodiversity** impacts within Britain[1]

Rank	Species name	Common name	Workshop group	Environment
1-10	*Corbicula fluminalis*	Asian clam	Freshwater invertebrate	F
1-10	*Gyrodactylus salaris*	salmon fluke	Freshwater invertebrate	F
1-10	*Hemigrapsus sanguineus*	Asian shore crab	Marine	M
1-10	*Myriophyllum heterophyllum*	American water-milfoil	Plant	T
1-10	*Neogobius melanostomus*	round goby	Vertebrate	F
1-10	*Procyon lotor*	raccoon	Vertebrate	T
1-10	*Agrilus plannipennis*	Emerald ash borer	Terrestrial invertebrate	T
1-10	*Akebia quinata*	Chocolate vine	Plant	T
1-10	*Baccharis halimifolia*	Tree groundsel	Plant	T
1-10	*Procambarus fallax*	marbled crayfish	Freshwater invertebrate	F
11-20	*Anoplophora glabripennis*	Asian longhorn beetle	Terrestrial invertebrate	T
11-20	*Homarus americanus*	American lobster	Marine	M
11-20	*Lithobates catesbeianus*	American bullfrog	Vertebrate	T
11-20	*Sinanodonta woodiana*	Chinese giant mussel	Freshwater invertebrate	F

11-20	*Acer rufinerve*	Snakebark maple	Plant	T
11-20	*Anoplophora chinensis*	Citrus longhorn beetle	Terrestrial invertebrate	T
11-20	*Bellamya chinensis*	Chinese mystery snail	Freshwater invertebrate	F
11-20	*Dikerogammarus bispinosus*	An amphipod	Freshwater invertebrate	F
11-20	*Mnemiopsis leidyi*	American comb jelly	Marine	M
11-20	*Mulinia lateralis*	the dwarf surf clam	Marine	M
21-30	*Nyctereutes procyonoides*	raccoon dog	Vertebrate	T
21-30	*Oncorhynchus gorbuscha*	Pink salmon	Vertebrate	F
21-30	*Pontogammarus robustoides*	An amphipod	Freshwater invertebrate	F
21-30	*Threskiornis aethiopicus*	African sacred ibis	Vertebrate	F
21-30	*Celtodoryx ciocalyptoides*	cauliflower sponge	Marine	M
21-30	*Jaera istri*	An isopod	Freshwater invertebrate	F
21-30	*Phyllostachys nigra*	Black bamboo	Plant	T
21-30	*Vespa velutina*	Asian hornet	Terrestrial invertebrate	T
21-30	*Amelanchier spicata*	Thicket shadbush	Plant	T
21-30	*Proterorhinus semilunaris*	tubenose goby	Vertebrate	F

31-40	*Echinogammarus ischnus*	bald urchin shrimp	Freshwater invertebrate	M
31-40	*Echinogammarus trichiatus*	curly haired urchin shrimp	Freshwater invertebrate	F
31-40	*Ocinebrellus inornatus*	Japanese sting winkle	Marine	M
31-40	*Rapana venosa*	veined rapa whelk	Marine	M
31-40	*Amorpha fruticosa*	False indigo bush	Plant	T
31-40	*Elaeagnus angustifolia*	Russian olive	Plant	T
31-40	*Lonicera maackii*	Amur honeysuckle	Plant	T
31-40	*Sicyos angulatus*	Star-cucumber	Plant	T
31-40	*Xenopus laevis*	African Clawed Toad	Vertebrate	T
31-40	*Miscanthus sinensis*	Chinese silvergrass	Plant	T
41-50	*Limnomysis benedeni*	A mysid	Freshwater invertebrate	F
41-50	*Obesogammarus obesus*	An amphipod	Freshwater invertebrate	F
41-50	*Asterias amurensis*	Northern Pacific seastar	Marine	M
41-50	*Fraxinus pennsylvannica*	green ash	Plant	T
41-50	*Mytilicola orientalis*	A parasitic copepod (red worm disease)	Marine	M

41-50	*Psittacula eupatria*	Alexandrine Parakeet	Vertebrate	T
41-50	*Rugulopteryx okamurae*	Asian fan weed	Marine	M
41-50	*Tamarix ramosissima*	salt cedar	Plant	T
41-50	*Tamias sibiricus*	Siberian chipmunk	Vertebrate	T
41-50	*Rhododendron sinogrande*	Great Chinese rhododendron	Plant	T
51-100	*Chelicorophium robustum*	An amphipod	Freshwater invertebrate	F
51-100	*Ciona savignyi*	Sea squirt	Marine	M
51-100	*Corvus splendens*	Indian house crow	Vertebrate	T
51-100	*Odocoileus virginianus*	White tailed deer	Vertebrate	T
51-100	*Acridotheres cristatellus*	Crested Myna	Vertebrate	T
51-100	*Acridotheres tristis*	common myna	Vertebrate	T
51-100	*Aromia bungii*	Red-necked Longhorn beetle	Terrestrial invertebrate	T
51-100	*Bubo bubo*	Eagle Owl	Vertebrate	T
51-100	*Bufotes viridis*	Green toad	Vertebrate	T
51-100	*Carassius gibelio*	Prussian carp	Vertebrate	F
51-100	*Corythucha arcuata*	Oak Lace bug	Terrestrial invertebrate	T

51-100	*Dyspanopeus sayi*	small mud Crab	Marine	M, Brackish
51-100	*Echinogammarus warpachowskyi*	An amphipod	Freshwater invertebrate	F
51-100	*Elaphe schrenkii*	Amur rat snake	Vertebrate	T
51-100	*Emys orbicularis*	European Pond Terrapin	Vertebrate	T
51-100	*Geukensia demissa*	ribbed horsemussel	Marine	M
51-100	*Micropterus salmoides*	Largemouth bass	Vertebrate	F
51-100	*Nassella neesiana (Stipa neesiana)*	Chilean needle grass	Plant	T
51-100	*Natrix natrix*	Eastern/Common grass snake	Vertebrate	T
51-100	*Obesogammarus crassus*	An amphipod	Freshwater invertebrate	F
51-100	*Ommatotriton ophryticus*	Northern banded newt	Vertebrate	F
51-100	*Pantherophis guttatus*	Corn snake	Vertebrate	T
51-100	*Paramysis lacustris*	Ponto-Caspian mysid	Freshwater invertebrate	F
51-100	*Podarcis sicula*	Italian wall lizard	Vertebrate	T
51-100	*Potamocorbula amurensis*	Amur river clam	Marine	FW/M
51-100	*Rhithropanopeus harrisii*	Harris mud crab	Marine	M

51-100	*Styela plicata*	Pleated tunicate	Marine	M
51-100	*Tamias striatus*	Eastern chipmunk	Vertebrate	T
51-100	*Thamnophis sirtalis*	Common Garter Snake	Vertebrate	T
51-100	*Thaumetopoea pityocampa*	Pine processionary moth	Terrestrial invertebrate	T
51-100	*Umbra pygmaea*	eastern mudminnow	Vertebrate	F
51-100	*Xenostrobus securis*	pigmy mussel	Marine	M
51-100	*Aedes albopictus*	Asian tiger mosquito	Terrestrial invertebrate	T/F
51-100	*Axis axis*	Axis Deer	Vertebrate	T
51-100	*Babka gymnotrachelus*	Racer goby	Vertebrate	F
51-100	*Cephalothrix simula*	nemertean worm (no common name)	Marine	M
51-100	*Cercopagis pengoi*	a water flea	Freshwater invertebrate	F
51-100	*Chelicorophium sowinskyi*	An amphipod	Freshwater invertebrate	F
51-100	*Cherax destructor*	Common yabby	Freshwater invertebrate	F
51-100	*Elaeagnus pungens*	Thorny olive	Plant	T
51-100	*Heracleum persicum*	Persian hogweed	Plant	T
51-100	*Megabalanus coccopoma*	titan acorn barnacle/ large pink	Marine	M

		barnacle		
51-100	*Megabalanus tintinnabulum*	sea tulip	Marine	M
51-100	*Miscanthus sacchariflorus*	Amur silvergrass	Plant	T
51-100	*Moschus moschiferus*	Siberian musk deer	Vertebrate	T
51-100	*Neogobius fluviatilis*	monkey goby	Vertebrate	F
51-100	*Orconectes rusticus*	Rusty crayfish	Freshwater invertebrate	F
51-100	*Setaria parviflora*	Marsh bristlegrass	Plant	T
51-100	*Theora lubrica*	Asian Semele	Marine	M
51-100	*Bispira polyomma*	a tube worm	Marine	M

[1]Pathway information is under review. Additionally terrestrial invertebrate experts are reviewing lists of Arachnids (including spiders and mites) for potential inclusion.

Human health impacts

A total of 33 species was compiled into a long list for consideration during the workshop. The group reached a consensus on the ranking of the top 20 species predicted to have the potential for human health impacts in bands of 1-5 and 6-20 (Table 2).

Table 2: Invasive Non-Native Species with high likelihood of arrival, establishment and **human health** impacts within Britain[2]

Rank	Species name	Common name	Workshop group	Environment
1-5	*Aedes albopictus*	Asian tiger mosquito	Terrestrial invertebrate	T/F
1-5	*Aedes japonicus*	Asian Bush Mosquito	Terrestrial invertebrate	T
1-5	*Ambrosia trifida*	Giant ragweed	Plant	T
1-5	*Artemisia annua*	Sweet wormwood	Plant	T
1-5	*Baccharis halimifolia*	Tree groundsel	Plant	T
6-10	*Nyctereutes procyonoides*	raccoon dog	Vertebrate	T
6-10	*Bellamya chinensis*	Chinese mystery snail	Freshwater invertebrate	F
6-10	*Procyon lotor*	raccoon	Vertebrate	T
6-10	*Vespa mandarinia*	Asian giant hornet	Terrestrial invertebrate	T
6-10	*Vespa velutina*	Asian hornet	Terrestrial invertebrate	T
11-20	*Pterois volitans*	red lionfish	Marine	M
11-20	*Tamias sibiricus*	Siberian chipmunk	Vertebrate	T
11-20	*Tamias striatus*	Eastern chipmunk	Vertebrate	T
11-20	*Thaumetopoea pityocampa*	Pine processionary moth	Terrestrial invertebrate	T
11-20	*Triadica sebifera*	candle-berry Tree	Plant	T
11-20	*Chelydra serpentina*	snapping turtle	Vertebrate	T
11-20	*Cephalothrix simula*	nemertean worm	Marine	M

11-20	*Heracleum persicum*	Persian hogweed	Plant	T
11-20	*Lissachatina fulica (formerly Achatina fulica)*	Giant African snail	Terrestrial invertebrate	T
11-20	*Wasmannia auropunctata*	Little Fire ant	Terrestrial invertebrate	T

[2]Pathway information is under review. Additionally terrestrial invertebrate experts are reviewing lists of Arachnids (including spiders and mites).

Economic impacts

A total of 49 species was compiled into a long list for consideration during the workshop. The group reached a consensus on the ranking of the top 20 species predicted to have the potential for economic impacts in bands of 1-5 and 6-21 (Table 3).

Table 3: Invasive Non-Native Species with high likelihood of arrival, establishment and **economic** impacts within Britain

Rank	Species name	Common name	Workshop group	Environment
1-5	*Gyrodactylus salaris*	salmon fluke	Freshwater invertebrate	F
1-5	*Ips typographus*	Eight tooth spruce bark beetle	Terrestrial invertebrate	T
1-5	*Halyomorpha halys*	Brown marmorated stink bug	Terrestrial invertebrate	T
1-5	*Setaria faberi*	Japanese bristlegrass	Plant	T
1-5	*Homarus americanus*	American lobster	Marine	M
6-21	*Aethina tumida*	Small Hive Beetle	Terrestrial invertebrate	T
6-21	*Anoplophora glabripennis*	Asian longhorn beetle	Terrestrial invertebrate	T
6-21	*Nassella neesiana (Stipa neesiana)*	Chilean needle grass	Plant	T
6-21	*Ambrosia trifida*	Giant ragweed	Plant	T
6-21	*Anoplophora chinensis*	Citrus longhorn beetle	Terrestrial invertebrate	T
6-21	*Procyon lotor*	raccoon	Vertebrate	T
6-21	*Sicyos angulatus*	Star-cucumber	Plant	T
6-21	*Thaumetopoea pityocampa*	Pine processionary moth	Terrestrial invertebrate	T
6-21	*Aedes albopictus*	Asian tiger mosquito	Terrestrial invertebrate	T/F
6-21	*Aedes japonicus*	Asian Bush Mosquito	Terrestrial invertebrate	T
6-21	*Setaria parviflora*	Marsh bristlegrass	Plant	T

6-21	*Vespa velutina*	Asian hornet	Terrestrial invertebrate	T
6-21	*Mnemiopsis leidyi*	American comb jelly	Marine	M
6-21	*Ocinebrellus inornatus*	Japanese sting winkle	Marine	M
6-21	*Rapana venosa*	veined rapa whelk	Marine	M
6-21	*Myriophyllum heterophyllum*	American water-milfoil	Plant	T

[3]Pathway information is under review. Additionally terrestrial invertebrate experts are reviewing lists of Arachnids (including spiders and mites). *Myriophyllum heterophyllum* was added after the workshop following confirmation of recent eradication.

Combined list

Rank	Species	Common name
1-15	*Vespa velutina*	Asian hornet
1-15	*Anoplophora glabripennis*	Asian longhorn beetle
1-15	*Aedes japonicus*	Asian bush mosquito
1-15	*Mnemiopsis leidyi*	Comb jelly
1-15	*Gyrodactylus salaris*	Salmon fluke
1-15	*Bellamya chinensis*	Chinese mystery snail
1-15	*Myriophyllum heterophyllum*	Twoleaf water milfoil
1-15	*Baccharis halimifolia*	Sea mrytle
1-15	*Agrilus plannipennis*	Emerald ash borer
1-15	*Celtodoryx ciocalyptoides*	Sponge
1-15	*Aedes albopictus*	Tiger mosquito
1-15	*Hemigrapsus sanguineus*	Asian shore crab
1-15	*Corbicula fluminalis*	Clam
1-15	*Procyon lotor*	Raccoon
1-15	*Nyctereutes procyonoides*	Raccoon dog
16-30	*Procambarus fallax*	Marbled crayfish
16-30	*Halyomorpha halys*	Brown marmorated stink bug
16-30	*Sicyos angulatus*	Oneseed bur cucumber
16-30	*Mulinia lateralis*	Dwarf surf clam
16-30	*Ips typographus*	European spruce bark beetle
16-30	*Homarus americanus*	American lobster
16-30	*Anoplophora chinensis*	Citrus long-horned beetle
16-30	*Psittacula eupatria*	Alexandrine parakeet
16-30	*Ocinebrellus inornatus*	Japanese oyster drill
16-30	*Asterias amurensis*	Northern Pacific seastar
16-30	*Ambrosia trifida*	Giant ragweed
16-30	*Thaumetopoea pityocampa*	Pine processionary moth
16-30	*Cephalothrix simula*	Nemertean worm (no common name)
16-30	*Neogobius melanostomus*	Round goby
16-30	*Tamias sibiricu*	Siberian chipmunk

Discussion

The INNS considered to be the greatest risk across all impact categories was dominated by invertebrates. The Asian hornet, *Vespa velutina*, was identified in the previous horizon scanning list for GB in 2013 (Roy, Peyton et al. 2014). It was subsequently recorded in 2016 but rapidly eradicated. Indeed there have been records of this INNS every year since 2016 but in all cases the nest has been located and destroyed. Asian hornets consume honeybees and wild pollinators and as such are considered a risk to biodiversity and ecosystems but also economies with losses in honey production but also pollination services. Human health can be impacted because *V. velutina* can sting people. As

competent disease vectors it is not surprising that the species of mosquito listed were considered to present a risk to human health but also reduction in tourism in regions where the mosquitoes occur constituting an economic impact.

Two plants were ranked within the top 15 on the combined horizon scanning list: *Baccharis halimifolia* and *Myriophyllum heterophyllum*. The aquatic plant *M. heterophyllum* has been recorded in Britain but is currently considered absent following successful eradication. It can have major biodiversity and ecosystem impacts by outcompeting other plants and altering the community composition and functioning within invaded water bodies. Additionally it can adversely affect recreational and commercial use of water bodies. *Baccharis halimifolia* can become a dense thicket and is particularly problematic in saltmarshes where it can rapidly dominate. However, it will also grow in other habitats and is toxic to livestock. The seeds and pollen of *B. halimifolia* are allergenic.

Five marine INNS were listed in the top 15 on the combined list. *Bellamya chinensis* has the potential to outcompete other molluscs but may also transmit organisms that are pathogenic to humans. *Mnemiopsis leidyi* is an ecosystem engineer affecting physical conditions of recipient ecosystems including decrease in water transparency, and change in nutrients availability. This jellyfish can lead to cascading effects by decreasing zooplankton effecting other trophic levels.

A number of vertebrates were included in the list. Most notably the two mammals *Procyon lotor* and *Nyctereutes procyonoides*. Both these animals can impact biodiversity and ecosystem but also human health as reservoirs for disease. *Psittacula eupatria*, a parakeet, was also included in the combined list. This invasive bird is known to compete for nest sites in tree holes with other birds but there is also evidence of economic damage because *P. eupatria* can be an agricultural pest. There are also concerns that this parakeet could potentially be infected with influenza A viruses and transmit these to humans.

Many of the INNS listed as posing an economic impact were considered to be a risk to plant health. *Anoplophora glabripennis* and *Agrilus plannipennis* are examples of insects that can cause damage to plants both in managed and wild contexts. *Anoplophora glabripennis* attacks a range of hardwood trees, such as *Salix* spp, but can also cause economic loss to fruit trees. *Agrilus plannipennis* consumes ash trees which are already being threatened by ash dieback, *Hymenoscyphus fraxineus*. The effects of *A. plannipennis* to the community composition of woodland is likely to cause cascading biodiversity impacts.

The species lists derived through this horizon scanning approach can be used in multiple ways. Comprehensive risk assessments could be undertaken to robustly assess the evidence of impacts. However, meanwhile the INNS identified as high risk could be included within a communication plan to inform awareness.

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Annex 1: Expert list for horizon scanning

Name	Role/area of expertise	Country	Institute
Tim Adriaens	Vertebrates	Belgium	Research Institute for Nature and Forest
David Aldridge	Freshwater Invertebrates	UK	University of Cambridge
Bjorn Beckmann	Terrestrial Invertebrates	UK	UK Centre for Ecology & Hydrology
Olaf Booy	Observer	UK	GB Non-Native Species Secretariat
Robert Britton	Vertebrates (and Freshwater Invertebrates)	UK	Bournemouth University
Juliet Brodie	Marine	UK	Natural History Museum
Peter Brown	Terrestrial Invertebrates	UK	University of East Anglia
Imogen Cavadino	Terrestrial Invertebrates	UK	Royal Horticultural Society
Paul Clark	Marine	UK	The Natural History Museum
Katharina Dehnen-Schmutz	Plants	UK	Coventry University
Alison Dunn	Freshwater Invertebrates	UK	University of Leeds
Jim Foster	Vertebrates	UK	Amphibian and Reptile Conservation Trust
Colin Harrower	Data manager	UK	UK Centre for Ecology & Hydrology
Martin Harvey	Terrestrial Invertebrates	UK	UK Centre for Ecology & Hydrology
Michelle Jackson	Freshwater Invertebrates	UK	University of Oxford
Jeanne Vallet	Plants	France	Muséum national d'histoire naturelle
Tomos Jones	Plants	UK	University of Reading
Christine Maggs	Marine	UK	JNCC
Gabrielle Martin	Plants	France	Muséum national d'histoire naturelle
Fiona Matthews	Vertebrates	UK	University of Sussex
Aileen Mill	Vertebrates	UK	Newcastle University
Niall Moore	Observer	UK	GB Non-Native Species Secretariat
Debbie Murphy	Vertebrates (and Freshwater Invertebrates)	UK	Centre for Environment Fisheries and Aquaculture Science
David Noble	Vertebrates	UK	British Trust for Ornithology
Ellie Paganini	Freshwater Invertebrates	UK	University of Leeds
Robin Payne	Plants	UK	Botanical Society of Britain and Ireland
Oli Pescott	Plants	UK	UK Centre for Ecology & Hydrology
Jodey Peyton	Plants	UK	UK Centre for Ecology & Hydrology
Wolfgang Rabitsch	Terrestrial Invertebrates	Austria	Environment Agency Austria

Trevor Renals	Freshwater Invertebrates	UK	Environment Agency
Steph Rorke	Data manager	UK	UK Centre for Ecology & Hydrology
Helen Roy	Terrestrial Invertebrates	UK	UK Centre for Ecology & Hydrology
Karsten Schonrogge	Terrestrial Invertebrates	UK	UK Centre for Ecology & Hydrology
Jack Sewell	Marine	UK	Marine Biological Association
Dick Shaw	Terrestrial Invertebrates	UK	CABI-UK
Graham Smith	Vertebrates	UK	APHA
Paul Stebbing	Marine	UK	APEM
Alan Stewart	Terrestrial Invertebrates	UK	University of Sussex
Peter Stroh	Plants	UK	Botanical Society of Britain and Ireland
Angela Taylor	Observer	UK	Defra
Hannah Tidbury	Marine	UK	Centre for Environment Fisheries and Aquaculture Science
Elena Tricarico	Freshwater Invertebrates	Italy	University of Florence
Kevin Walker	Plants	UK	Botanical Society of Britain and Ireland
Louisa Wood	Marine	UK	Centre for Environment Fisheries and Aquaculture Science
Chris Wood	Marine	UK	Marine Biological Association