# UK Biodiversity Indicators 2023

This document supports B6. Pressure from invasive species

# **Technical background document**

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# B6. Pressure from invasive species – technical document

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#### Overview

There are currently 195 invasive non-native species in Great Britain that are included within the indicator for the 2023 publication. The current indicator is the result of incremental updating of an indicator initially produced in 2014. In 2014, the first indicator was created using a two-stage process beginning with extent estimation using a statistical process fitted to occurrence data available through the NBN Gateway which were then validated and modified, where required, by taxonomic experts. The rationale for using a statistical process to produce extent estimates was to attempt to control for the patchy nature of the occurrence data. The expert validation in 2014 determined that the extent estimates produced algorithmically typically underestimated the true extent due to much of the occurrence data not being easily available, particularly for earlier decades, and therefore most of the estimates required revision by the taxonomic experts.

In 2015, the species list and the classification of extent (derived for the 2014 indicator) were reviewed and updated by taxonomic experts. The existing species list and the classification of extents were reviewed again in 2017, 2018, 2019, 2020, 2021, 2022 and 2023 to update the indicator. Given the paucity of available occurrence data these subsequent updates of the indicator omitted the statistical estimation and the review undertaken was based on expert assessment alone.

## **Species list**

In 2014, the species included within the indicator was substantially expanded from the 49 species used in the <u>previous indicator</u>, previously updated in 2012, to 179. A preliminary list was produced from the GB Non-native Species Information Portal (GB-NNSIP) by selecting all species in the database that were designated as having negative or strongly negative ecological effect. The information on impacts within the GB-NNSIP is not based on quantitative assessment but was a rapid assessment relying on expert opinion. Therefore, it was deemed necessary to review the initial list, again using expert opinion. In 2015, only one species was added (a clam, *Rangia cuneata*) and none were removed from the list.

In 2017, three new species, an aquatic plant (*Myriophyllum heterophyllum*) and two species of crab (*Hemigrapsus sanguineus* and *Hemigrapsus takanoi*), were added to the list, increasing the list of species included to 183. The scientific names of two species on the list were also updated in 2017 to reflect the current accepted taxonomy with *Ensis directus* being updated to *Ensis leei* and *Heterosiphonia japonica* being updated to *Dasysiphonia japonica*.

In 2018, a further seven species were added to the list increasing the number of species included in the list to 190. The seven species added were four freshwater fish (*Ameiurus melas, Leuciscus idus, Salvelinus fontinalis, Oncorhynchus gorbuscha*), one species of ant (*Linepithema humile*), and two species of terrapin (*Emys orbicularis, Trachemys scripta*). In addition, the scientific name for one species on the list was updated to reflect changes in taxonomy, specifically the marine algae *Neosiphonia harveyi* was renamed as *Melanothamnus harveyi*.

In 2019, three additional marine species were added to the list, two algae (*Caulacanthus okamurae* and *Gracilaria vermiculophylla*) and one species of mussel (*Arcuatula senhousia*).

The scientific name of one species on the list, *Crassostrea gigas*, was also updated to *Magallana gigas* following changes in taxonomy.

In 2020, following consultation with taxonomic experts and review of available information, the species list remained the same and no additional species were added. There was one change made to the scientific name of a species on the list, *Gracilaria vermiculophylla* was updated to *Agarophyton vermiculophyllum* to reflect changes in taxonomy.

In 2021, one further freshwater species was added to the list: Cipangopaludina chinensis.

In 2022, Cephalothrix simula, a marine species was added to the species list.

Following assessment of the species list in 2023, a further four species were added; 3 from the freshwater environment: *Chelicorophium robustum*, *Dendrocoelum romanodanubiale* and *Proasellus coxalis* and one marine species, *Bispira polyomma*.

#### Update and review in 2015, 2017, 2018, 2019. 2020, 2021, 2022 and 2023

As mentioned previously (2015, 2017, 2018 and 2019) the modelling process, originally conducted in 2014, was not repeated but rather the species lists and extent of occurrence classifications were reviewed by taxonomic experts. The taxonomic experts use the latest information to determine whether the existing classification of extent were still applicable or if they needed updating.

In 2015, the terrestrial and freshwater plant species were subject to extensive review using additional data holdings available through the Botanical Society of Britain & Ireland (BSBI). The indicator extent classifications were reviewed by BSBI experts and the extent scores adjusted if the botanical experts felt it was justified. This resulted in changes to the classification of 48 plant species across all decades, 27 of which had amendments in the last decade. These amendments were mainly decreases in extent but with one species (*Egeria densa*) assigned an increase in extent over one decade. Three plant species were considered to have decreased in extent by two categories within the classification. Consequently, the overall net change to the indicator in 2015 was a decrease in extent classifications.

In the 2017 review, the alterations were primarily limited to the marine species, with a few species going up an extent category in the most recent decade. For example, *Urosalpinx cinera*, had the extent category for the last three decades (1990s, 2000s and 2010s) increased from level 1 to level 2 while the remaining decades (1960s, 1970s, 1980s) were kept at level 1. For this species there is a sparsity of records, particularly pre-1990 and also in the last couple of years, making determining the historical or current extent difficult. Experts at the Marine Biological Association considered that the range reported post-1994 suggested multiple populations were established more than 10km from the suspected source therefore warranting an upgrade in extent. The lack of data pre-1990 makes it difficult to determine what the extent was during this period therefore it was kept at the lowest category. It was noted however that the species was adversely affected by tri-butyl tin pollution (used on small vessels and banned in the UK in 1987), might account for a period of genuine rarity before the 1990s however it is also possible that it was simply under-recorded/reported in this period.

During the 2018 review, seven additional species were added to the list. A few of these species; two terrapin species (*Trachemys scripta* and *Emys orbicularis*) and three species of freshwater fish (*Ameiurus melas, Leuciscus idus, Salvelinus fontinalis*); have been present in the UK for several decades but were previously excluded from the list as they are not considered to be established, e.g. not reproducing in the wild and therefore not self-sustaining. This year it was agreed through consultation with taxonomic experts and the

Non-native Species Secretariat that as species such as these fall within extent level 1 (Not or scarcely established), are often long-term residents, and are believed to be having a negative impact on native biodiversity that they should be included in the list. The addition of these species will have had no effect on the main indicator figure (B6i) which only shows numbers of species in extent levels 3 and 4, but will have increased the numbers of species in extent level 1 across all decades in the underlying data and also in the supplemental figure (B6ii). Another species of freshwater fish (*Oncorhynchus gorbuscha*) was also added to the list. This species had occasionally been recorded in the UK historically (e.g. a few records in 1970s) has recently been recorded a number of times in different locations in Scotland including the capture of spent/post-spawning females suggesting possible reproduction in the wild. The final addition to the list was the ant *Linepithema humile* for which a colony was found in Fulham.

The review of the existing species on the list in 2018 resulted in the extent levels for the current decade being increased for a small number of freshwater and terrestrial species based on the evaluation of new data. In a limited number of cases the classifications for one or more decades were modified based on a re-evaluation of the existing data rather than the addition of any additional data. Some of these reassessments led to an increase (e.g. *Rattus rattus, Oxyura jamaicensis, Spiraea salicifolia x douglasii = S. x pseudosalicifolia*) in one or more of the decadal time periods, while other (e.g. *Amelanchier lamarckii, Spiraea douglasii, Spiraea salicifolia*) led to a reduction in the extent level. These changes will have had an effect upon the indicator for these two environments, particularly for the current decade.

The 2019 review saw three new marine species, two species of algae and a mussel species, added to the species list. The two algae species, *Caulacanthus okamurae* and *Gracilaria vermiculophylla*, were first recorded in the UK just over a decade ago (2004 and 2009 respectively), but are now considered well established in a few localised areas (Kent, Sussex and Devon in case of *C. okamurae*, Poole & Christchurch Harbours in the case of *G. vermiculophylla*). In contrast the mussel species, *Arcuatula senhousia*, is a relatively new species to the UK being first reported in the UK in 2017/2018, were it was reported from a handful of sites in the north of the Solent. Since the initial report on this presence of this species in the UK unpublished records of this species in the same area were uncovered from 2011 and 2013 and the species in now regarded as being established in the UK.

The 2019 assessments of species already on the list only highlighted two species, *Anguillicoloides crassus* and *Rattus rattus*, where it was determined that the extent assignments presented in last year's indicator should be adjusted to reflect current knowledge. The extent of *Rattus rattus* (Black rat) in the most recent decade (2010-present) was decreased from category 2 to category 1 based on assessment of this species as possibly extinct in the recent status review of British Mammals (Mathews *et al.* 2018<sup>1</sup>). The extent of *Anguillicoloides crassus* (Swim bladder nematode) was also increased in both the previous and current decades, increasing from level 2 to 3 in 2000–2009 and from level 3 to 4 in 2010–2018, based on new data becoming available supporting a wider extent than previously thought.

The 2020 review did not result in the addition of any new species to the list which remains at 193 species. The review of the existing list highlighted an increase in extent categories for two marine species, two freshwater vertebrates and nine plant species (one freshwater and 8 terrestrial). The increases are seen almost exclusively in the 2010-2019 decade with a retrospective increase in only one of the plant species and one vertebrate species.

<sup>&</sup>lt;sup>1</sup> Mathews, F., Kubasiewicz, L.M., Gurnell, J., Harrower, C.A., McDonald, R.A. & Shore, R.F. (2018) *A Review of the Population and Conservation Status of British Mammals*. A report by the Mammal Society under contract to Natural England, Natural Resources Wales and Scottish Natural Heritage. Natural England, Peterborough.

The marine species with increased extent categories are *Caulacanthus okamurae* and *Arcuatula senhousia*, both of these species were added during the 2019 review. *Caulacanthus okamurae* is considered to have increased from an extent level of 2 to 3, reflecting its presence in the surveys carried out in 2019 where it was noted as 'often abundant and dominating turf'. The extent category of *Arcuatula senhousia* for the 2010-2019 time period has been increased from level 1 to 2 due to its spread of more than 10km from the site of introduction.

*Icthyosaura alpestris* was elevated from extent level 1 to 2 for the most recent decade due to both new releases and further spread. *Trachemys scripta* has retrospectively been increased from level 1 to 2 for three decades (1990-1999, 2000-2009 and 2010-2019) to reflect the numerous known release locations over the last three decades.

The eight plant species for which the 2010-2019 extent category was increased during this review are: *Datura stramonium* (level 1 to 3), *Disphyma crassifolium* (level 1 to 2), *Egeria densa* (level 1 to 2), *Gunnera manicata* (level 1 to 2), *Gunnera tinctoria* (level 2 to 3), *Pinus nigra* (level 2 to 3), *Prunus lusitanica* (level 2 to 3), *Rosa rugosa* (level 3 to 4). The extent category for *Cornus sericea* was increased from 1 to 3 for the 1990-1999, 2000-2009 and 2010-2019 time periods. The increases in the plant extent categories are attributed to a genuine increase in extent during this time period in some instances, possibly due to more planting (therefore not naturalisation), combined with an increase in the recording of non-native plants.

No changes to the extent categories for terrestrial invertebrates, freshwater invertebrates or fish species were made for any of the time periods in the 2020 review.

Review of the species lists and associated extent category scores in 2021 resulted in the addition of the Chinese mystery snail (*Cipangopaludina chinensis*), this species has been scored at extent level one for the 2020-2029 decade with all previous decades registering zero.

A small number of changes were made to category scores of existing species on the indicator as follows:

The extent category of one freshwater plant, *Hydrocotyle ranunculoides*, has been increased from 2 to 3 for the 2010-2019 time period and entered at level 3 for the decade beginning 2020, noting that its presence has increased dramatically in recent years. One further increase has been recorded for *Graphocephala fennahi* which has been elevated from extent level 2 (2010-2019) to extent level 3 (2020-2029) due to a wide coverage of scattered records.

A decrease from level 1 (2010-2019) to level 0 (2020-2029) for *Ameiurus melas* following the eradication of the only known population in the mid-2010s has also been made.

The 2022 review saw one marine species: *Cephalothrix simula* (Pacific death worm) added to the indicator species list being scored at extent level 2 for both 2020-2029 and 2010-2019. Two other species from the marine environment saw increases in extent categories; *Watersipora subatra* moving from 2 to 3 for the current decade and *Rhithropanopeus harrisii* from 0 to 1 for 2010-2019, however this species remains at 0 for 2020-2029. In the freshwater environment *Dreissena bugensis* (Quagga mussel) was increased from extent level 2 to 3 for the current decade. The final change resulted in *Hydrocotyle ranunculoides* seeing a reduction in extent categories from 3 to 2 for both 2020-2029 and 2010-2019.

Review of the species lists and the respective extent category scores in 2023 resulted in the addition of four species, three of these were freshwater species, an amphipod – *Chelicorophium robustum*, a flatworm – *Dendrocoelum romanodanubiale* and an isopod – *Proasellus coxalis*. These three additions were all scored at extent level 1 for the current

decade only. The fourth addition was a marine species: *Bispira polyomma* (Purple fan-worm) which has been added at extent category 2 for 2020-2029.

A number of species saw reductions in the extent categories assigned for the current decade: *Pseudorasbora parva* (from 2 to 1) and *Hydroides elegans* (from 3 to 2). The extent category for *Datura stramonium* was also reduced from 3 to 2 for both the 2020-2029 and 2010-2019 time periods. *Myriophyllum heterophyllum* (Broadleaf watermilfoil) has moved from an extent category 1 to 0 (absent) for 2020-2029.

Several species were also assessed to have increased extent scores: Oncorhynchus gorbuscha (from 1 to 2 for 2020-2029); two terrestrial invertebrates moving from an extent category 3 to 4 for 2020-2029: *Graphocephala fennahi* and *Pulvinaria regalis*; one further invertebrate, *Thaumetopoea processionea* has been increased from a score of 1 to 2 for the current decade.

Environment	Common Name	Scientific name
Freshwater	Black bullhead	Ameiurus melas
Freshwater	Turkish crayfish	Astacus leptodactylus
Freshwater	water fern	Azolla filiculoides
Freshwater	Goldfish	Carassius auratus
Freshwater	an amphipod	Chelicorophium robustum
Freshwater	Chinese mystery snail	Cipangopaludina chinensis
Freshwater	a mollusc	Corbicula fluminea
Freshwater	Northern river crangonyctid	Crangonyx pseudogracilis
Freshwater	New Zealand pigmyweed	Crassula helmsii
Freshwater	a flatworm	Dendrocoelum romanodanubiale
Freshwater	demon shrimp	Dikerogammarus haemobaphes
Freshwater	killer shrimp	Dikerogammarus villosus
Freshwater	quagga mussel	Dreissena bugensis
Freshwater	zebra mussel	Dreissena polymorpha
Freshwater	large-flowered waterweed	Egeria densa
Freshwater	Canadian waterweed	Elodea canadensis
Freshwater	Nuttall's waterweed	Elodea nuttallii
Freshwater	European pond terrapin	Emys orbicularis
Freshwater	bloody-red mysid	Hemimysis anomala
Freshwater	floating pennywort	Hydrocotyle ranunculoides
Freshwater	a polychaete	Hypania invalida
Freshwater	Italian alpine newt	Icthyosaura alpestris
Freshwater	curly waterweed	Lagarosiphon major
Freshwater	least duckweed	Lemna minuta
Freshwater	pumpkinseed	Lepomis gibbosus
Freshwater	sunbleak	Leucaspius delineatus
Freshwater	Orfe	Leuciscus idus
Freshwater	American bullfrog	Lithobates catesbeianus
Freshwater	Uruguayan hampshire- purslane	Ludwigia grandiflora
Freshwater	parrot's feather	Myriophyllum aquaticum

#### Invasive non-native species included in the 2023 Indicator

Environment	Common Name	Scientific name
Freshwater	Broadleaf watermilfoil	Myriophyllum heterophyllum
Freshwater	Pink salmon	Oncorhynchus gorbuscha
Freshwater	rainbow trout	Oncorhynchus mykiss
Freshwater	spinycheek crayfish	Orconectes limosus
Freshwater	virile crayfish	Orconectes virilis
Freshwater	signal crayfish	Pacifastacus leniusculus
Freshwater	marsh frog	Pelophylax ridibundus
Freshwater	Jenkins' spire snail	Potamopyrgus antipodarum
Freshwater	an isopod	Proasellus coxalis
Freshwater	white river crayfish	Procambarus acutus
Freshwater	red swamp crayfish	Procambarus clarkii
Freshwater	topmouth gudgeon	Pseudorasbora parva
Freshwater	a mollusc	Rangia cuneata
Freshwater	duck-potato	Sagittaria latifolia
Freshwater	Brook charr	Salvelinus fontinalis
Freshwater	zander	Sander lucioperca
Freshwater	wels catfish	Siluris glanis
Freshwater	Red-eared terrapin	Trachemys scripta
Freshwater	Italian crested newt	Triturus carniflex
Freshwater	African clawed frog	Xenopus laevis
Marine	swim-bladder nematode	Anguillicoloides crassus
Marine	Asian Mussel	Arcuatula senhousia
Marine	harpoon weed (algae)	Asparagopsis armata
Marine	compass sea squirt	Asterocarpa humilis
Marine	an acorn barnacle	Austrominius modestus
Marine	Purple fan-worm	Bispira polyomma
Marine	algae	Bonnemaisonia hamifera
Marine		Botrylloides diegensis
Marine		Botrylloides Violaceus
Marine	aigae	
Marine	Dapanese skeleton shirinp	
Marino	green see fingers	Codium fragile subsp fragile
Marine	a coelenterate	Cordvlophora caspia
Marine	a tunicate	Corella eurovota
Marine	Pacific ovster	Crassostrea gigas
Marine	slipper limpet	Crepidula fornicata
Marine	algae	Dasysiphonia japonica
Marine	a tunicate	Didemnum vexillum
Marine	a crustacean	Dyspanopeus sayi
Marine	a mollusc	Ensis leei
Marine	Chinese mitten crab	Eriocheir sinensis
Marine	an annelid	Ficopomatus enigmaticus
Marine	an amphipod	Gammarus tigrinus

Environment	Common Name	Scientific name
Marine	algae	Agarophyton vermiculophyllum
Marine	algae	Grateloupia turuturu
Marine	Asian shore crab	Hemigrapsus sanguineus
Marine	brush-clawed shore crab	Hemigrapsus takanoi
Marine	an annelid	Hydroides elegans
Marine	an annelid	Hydroides ezoensis
Marine	an amphipod	Monocorophium sextonae
Marine	a mollusc	Mytilopsis leucophaeata
Marine	algae	Melanothamnus harveyi
Marine	dwarf crab	Rhithropanopeus harrisii
Marine	wire weed	Sargassum muticum
Marine	a bryozoan	Schizoporella japonica
Marine	leathery sea squirt	Styela clava
Marine	a bryozoan	Tricellaria inopinata
Marine	Japanese kelp, wakame	Undaria pinnatifida
Marine	American sting winkle	Urosalpinx cinerea
Marine	a bryozoan	Watersipora subatra
Terrestrial	pirri-pirri-bur	Acaena novae-zelandiae
Terrestrial	bear's-breech	Acanthus mollis
Terrestrial	tree-of-heaven	Ailanthus altissima
Terrestrial	mandarin duck	Aix galericulata
Terrestrial	garden lady's-mantle	Alchemilla mollis
Terrestrial	red-legged partridge	Alectoris rufa
Terrestrial	few-flowered garlic	Allium paradoxum
Terrestrial	rosy garlic	Allium roseum
Terrestrial	Egyptian goose	Alopochen aegyptiacus
Terrestrial	juneberry	Amelanchier lamarckii
Terrestrial	great brome	Anisantha diandra
Terrestrial	berberis sawfly	Arge berberidis
Terrestrial	New Zealand flatworm	Arthurdendyus triangulatus
Terrestrial	late michaelmas-daisy	Aster laevis x novi-belgii = A. x versicolor
Terrestrial	narrow-leaved michaelmas-	Aster lanceolatus
Terrestrial	common michaelmas-daisy	Aster novi-belaii x lanceolatus = A, x salianus
Terrestrial	a flatworm	Australoplana sanguinea
Terrestrial	Canada goose	Branta canadensis
Terrestrial	eagle owl	Bubo bubo
Terrestrial	Buddleia	Buddleia davidii
Terrestrial	heath star moss	Campylopus introflexus
Terrestrial	feral goat	Capra hircus
Terrestrial	hottentot-fig	Carpobrotus edulis
Terrestrial	sika	Cervus nippon
Terrestrial	bladder-senna	Colutea arborescens
Terrestrial	red-osier dogwood	Cornus sericea
Terrestrial	wall cotoneaster	Cotoneaster horizontalis

Environment	Common Name	Scientific name
Terrestrial	entire-leaved cotoneaster	Cotoneaster integrifolius
Terrestrial	Himalayan cotoneaster	Cotoneaster simonsii
Terrestrial	montbretia	Crocosmia aurea x pottsii (C. x crocosmiiflora)
Terrestrial	fallow deer	Dama dama
Terrestrial	thorn-apple	Datura stramonium
Terrestrial	purple dewplant	Disphyma crassifolium
Terrestrial	russian-vine	Fallopia baldschuanica
Terrestrial	black-bindweed	Fallopia convolvulus
Terrestrial	Japanese knotweed	Fallopia japonica
Terrestrial	plant hybrid	Fallopia japonica x sachalinensis = F. x bohemica
Terrestrial	giant knotweed	Fallopia sachalinensis
Terrestrial	feral cat	Felis catus
Terrestrial	shallon	Gaultheria shallon
Terrestrial	edible dormouse	Glis glis
Terrestrial	rhododendron leafhopper	Graphocephala fennahi
Terrestrial	Brazilian giant-rhubarb	Gunnera manicata
Terrestrial	giant-rhubarb	Gunnera tinctoria
Terrestrial	harlequin ladybird	Harmonia axyridis
Terrestrial	giant hogweed	Heracleum mantegazzianum
Terrestrial	bluebell	Hyacinthoides non-scripta x hispanica = H. x massartiana
Terrestrial	water deer	Hydropotes inermis
Terrestrial	dump fly	Hydrotaea aenescens
Terrestrial	Himalayan balsam	Impatiens glandulifera
Terrestrial	a flatworm	Kontikia ventrolineata
Terrestrial	Western green lizard	Lacerta bilineata
Terrestrial	yellow archangel	Lamiastrum galeobdolon subsp. argentatum
Terrestrial	an ant	Lasius neglectus
Terrestrial	Argentine ant	Linepithema humile
Terrestrial	American skunk-cabbage	Lysichiton americanus
Terrestrial	potato aphid	Macrosiphum euphorbiae
Terrestrial	blotched monkey flower	Mimulus luteus
Terrestrial	wireplant	Muehlenbeckia complexa
Terrestrial	Reeve's muntjac	Muntiacus reevesi
Terrestrial	house mouse	Mus domesticus
Terrestrial	ferret	Mustela furo
Terrestrial	American mink	Mustela vison
Terrestrial	monk parakeet	Myiopsitta monachus
Terrestrial	European rabbit	Oryctolagus cuniculus
Terrestrial	Bermuda-buttercup	Oxalis pes-caprae
Terrestrial	ruddy duck	Oxyura jamaicensis
Terrestrial	Virginia-creeper	Parthenocissus quinquefolia
Terrestrial	green alkanet	Pentaglottis sempervirens
Terrestrial	lesser knotweed	Persicaria campanulata
Terrestrial	Himalayan knotweed	Persicaria wallichii

Environment	Common Name	Scientific name
Terrestrial	white butterbur	Petasites albus
Terrestrial	winter heliotrope	Petasites fragrans
Terrestrial	pheasant	Phasianus colchicus
Terrestrial	Austrian pin	Pinus nigra
Terrestrial	maritime pine	Pinus pinaster
Terrestrial	common wall lizard	Podarcis muralis
Terrestrial	spartina planthopper	Prokelisia marginata
Terrestrial	cherry laurel	Prunus laurocerasus
Terrestrial	Portugal laurel	Prunus lusitanica
Terrestrial	rum cherry	Prunus serotina
Terrestrial	biliary parasite	Pseudamphistomum truncatum
Terrestrial	arrow bamboo	Pseudosasa japonica
Terrestrial	rose-ringed parakeet	Psittacula krameri
Terrestrial	horse chestnut scale	Pulvinaria regalis
Terrestrial	Turkey oak	Quercus cerris
Terrestrial	evergreen oak	Quercus ilex
Terrestrial	brown rat	Rattus norvegicus
Terrestrial	black rat	Rattus rattus
Terrestrial	rhododendron	Rhododendron ponticum
Terrestrial	false-acacia	Robinia pseudoacacia
Terrestrial	Dutch rose	Rosa 'Hollandica'
Terrestrial	Japanese rose	Rosa rugosa
Terrestrial	Purple pitcherplant	Sarracenia purpurea
Terrestrial	broad-leaved bamboo	Sasa palmata
Terrestrial	hairy bamboo	Sasaella ramosa
Terrestrial	Eastern grey squirrel	Sciurus carolinensis
Terrestrial	alexanders	Smyrnium olusatrum
Terrestrial	Canadian goldenrod	Solidago canadensis
Terrestrial	Spiraea	Spiraea
Terrestrial	Billard's bridewort	Spiraea alba x douglasii = S. x billardii
Terrestrial	steeple-bush	Spiraea douglasii
Terrestrial	bridewort	Spiraea salicifolia
Terrestrial	confused bridewort	Spiraea salicifolia x douglasii = S. x pseudosalicifolia
Terrestrial	snowberry	Symphoricarpos albus
Terrestrial	oak processionary	Thaumetopoea processionea
Terrestrial	lesser periwinkle	Vinca minor
Terrestrial	aesculapian snake	Zamensis longissimus

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# Analytical estimation of Area of Extent (AoE) used in 2014

# Data used

The occurrence data used in the statistical analyses conducted in 2014 were obtained from the National Biodiversity Network (NBN) Gateway, downloaded in October 2014. The analysis used all data that were publicly available from the NBN Gateway having a minimum resolution of 10km. The extracted occurrence data were divided into 10-year time slices to enable the areas of extent to be calculated independently for each decade. To be included in a dataset the start date and end date of a record needed to fall within the respective time period, therefore records which span one or more time periods were excluded.

# Analytical method

The process used to calculate the area of extent is based upon the approach recently used to develop the England Vascular Plant Red List (Stroh *et al.*, 2014). Three different methods were used to determine extent of occurrence; (1) determining the number of distinct 10km squares the species has been recorded within and then calculating the total area of these 10km squares; (2) the Minimum Convex Polygon (MCP); and (3) the alpha hull.

The first of these methods involves determining for each decade the number of distinct OSGB 10km squares that contained occurrence data for each species and then the total area was obtained by summing the area of these 10km squares.

The second method involved calculating the MCP for the occurrence data for each decade. The MCP is defined as the smallest polygon in which no internal angle exceeds 180 degrees and which contains all the sites of occurrence. The MCP is often criticised due to the tendency for non-suitable areas to be included within the shape, especially when fitted to areas in which there are large areas of unsuitable habitat surrounded by suitable habitat. To reduce the extent to which this problem affected the areas estimated, a secondary polygon was created by intersecting the MCP polygon with the land mass of Great Britain (or a 50km wide coastal region in the case of marine species) and the area (in km<sup>2</sup> and also as a percentage of the total land/marine buffer area of Great Britain) of this polygon was then calculated.

The third method fitted an alpha hull to the occurrence data for each decade. Alpha hulls are a generalisation of the convex polygon and have been suggested to be more suitable to species distributions than Minimum Convex Polygon, especially for irregularly shaped species ranges (Burgman & Fox, 2003). Alpha hulls are created by a Delaunay triangulation of the data points (joining all points so that no lines intersect between points) and then selectively removing lines from this triangulation based on the value of a parameter  $\alpha$ . The smaller the value of  $\alpha$ , the finer the resolution of the hull produced. As  $\alpha$  increases the alpha hull will approach the MCP. There is no ideal value of  $\alpha$ , rather the choice depends upon the quality of the data and the aims of the study. For the indicator analyses an  $\alpha$  value of 80,000

was used. In order to minimise the inclusion of unsuitable habitat the alpha hull was also intersected with the land mass of Great Britain (or 50km wide coastal region for marine species) to produce a new hull for which the area (in km<sup>2</sup> and also as a percentage of total land/marine buffer area of Great Britain) was calculated.

## **Expert validation & modification**

A series of maps and area estimates was produced for each invasive non-native species from these analyses. An example of the maps produced, in this case *Elodea canadensis*, is given in Figure 1 below.



**Figure 1.** Example area of extent maps for *Elodea canadensis* using data from the 1970-1979 time period. The first map shows the 10km occurrence data, the second map shows the Minimum Convex Polygon (outlined by a red line) and its intersection with the land (green filled region) and third map shows the alpha hull (outlined by a red line) and its intersection with the land (green filled region). The labels above each map give the total area of distinct 10km squares, the area of the MCP/GB land intersection and the area of the alpha hull/GB land intersection respectively.

The species maps and area estimates were circulated to the relevant taxonomic or environmental experts along with a spreadsheet containing initial classifications, within the 4 extent categories used in B6ii, of the decadal distributions for each species. The initial classification was achieved using the area estimates from the alpha hull / GB intersection polygon because this resulted in the most conservative estimates which provided a guide for the experts. Experts were asked to review the maps and area estimates, alongside any additional data sources available to them where relevant, to determine whether the classification in the spreadsheet represented an accurate picture of the species distribution for each decade. Where the experts deemed a category value to be a poor representation they were asked to modify the category to the value they considered to accurately reflect the extent. It is these expert modified classifications of extent that were used in final figures present in the indicator.

## References

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