Common Wall Lizard (*Podarcis muralis*)

- Native to central Europe, from Spain to Turkey, and Greece to France.
- Local populations established in southern England and South Wales.
- Able to establish large populations rapidly.
- Potential to cause declines in native lizards, possibly through disease, competition or predation of juveniles.

History in GB

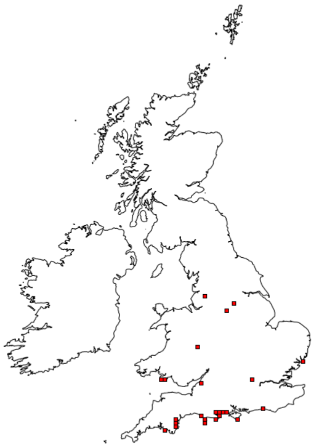
First GB introduction is thought to have been a deliberate release to the Ventnor (Isle of Wight) in the 1920s. Currently 31 viable populations recorded, most in southern England and South Wales, but sightings have been confirmed in other areas.

Native distribution

Native to central Europe, from Spain to Turkey, and Greece to France.

Source: NNSIP 2014

Distribution in GB



Source: NBN 2014

Impacts

Environmental (moderate)
- Reported declines in native lizards in England, potentially due to *P. muralis,* biggest concern is the threat to the rare sand lizard.
- May disrupt local community structure by reducing invertebrate diversity and density, and supplementing predators.

Economic (minimal)
- None known

Social (minimal)
- None known

Introduction pathway

Accidental import (unlikely) — as stowaways in imported garden or agricultural produce, or in tourists' luggage or vehicles
Deliberate import (very unlikely) —by dealers and enthusiasts

Spread pathways

Natural (very slow) — mainly by dispersal over land
Human (very rapid) — accidental or deliberate releases from captive stock, translocations from existing wild populations, or as stowaways with goods transported within GB

Summary

	Risk	Confidence
Entry	VERY LIKELY	HIGH
Establishment	VERY LIKELY	HIGH
Spread	SLOW	HIGH
Impacts	MODERATE	MEDIUM
Conclusion	MEDIUM	HIGH

RISK ASSESSMENT COVERING PAGE - ABOUT THE PROCESS

It is important that policy decisions and action within Great Britain are underpinned by evidence. At the same time it is not always possible to have complete scientific certainty before taking action. To determine the evidence base and manage uncertainty a process of risk analysis is used.

Risk analysis comprises three component parts: risk assessment (determining the severity and likelihood of a hazard occurring); risk management (the practicalities of reducing the risk); and risk communication (interpreting the results of the analysis and explaining them clearly). This tool relates to risk assessment only. The Non-native Species Secretariat manages the risk analysis process on behalf of the GB Programme Board for Non-native Species. During this process risk assessments are:

- Commissioned using a consistent template to ensure the full range of issues is addressed and maintain comparable quality of risk and confidence scoring supported by appropriate evidence.
- Drafted by an independent expert in the species and peer reviewed by a different expert.
- Approved by the NNRAP (an independent risk analysis panel) only when they are satisfied the assessment is fit-for-purpose.
- Approved by the GB Programme Board for Non-native Species.
- Placed on the GB Non-native Species Secretariat (NNSS) website for a three month period of public comment.
- Finalised by the risk assessor to the satisfaction of the NNRAP and GB Programme Board if necessary.

Common misconceptions about risk assessments

The risk assessments:

- Consider only the risks (i.e. the chance and severity of a hazard occurring) posed by a species. They do not consider the practicalities, impacts or other issues relating to the management of the species. They also only consider only the negative impacts of the species, they do not consider any positive effects. They therefore cannot on their own be used to determine what, if any, management response should be undertaken.
- Are advisory and therefore part of the suite of information on which policy decisions are based.
- Are not final and absolute. They are an assessment based on the evidence available at that time. Substantive new scientific evidence may prompt a re-evaluation of the risks and/or a change of policy.

Period for comment

Once placed on the NNSS website, risk assessments are open for stakeholders to provide comment on the scientific evidence which underpins them for three months. Relevant comments are collated by the NNSS and sent to the risk assessor for them to consider and, if necessary, amend the risk assessment. Where significant comments are received the NNRAP will determine whether the final risk assessment suitably takes into account the comments provided.

To find out more: published risk assessments and more information can be found at https://secure.fera.defra.gov.uk/nonnativespecies/index.cfm?sectionid=22

GB NON-NATIVE ORGANISM RISK ASSESSMENT SCHEME

Name of organism: Common (European) wall lizard *Podarcis muralis* (Laurenti, 1768)
Author: Jim Foster
Risk Assessment Area: Great Britain (England, Scotland, Wales and their islands)
Reason for conducting the assessment: The non-native species Programme Board has requested a risk assessment be produced for this species.

Date: Draft 1 (September 2012); NNRAP review (February 2013); Peer Review (March 2013); Draft 2 (October 2013); NNRAP review (October 2013)
Signed off by NNRAP: October 2013
Approved by Programme Board: March 2015
Placed on NNSS website: September 2015

SECTION A – Organism Information and Screening		
Stage 1. Organism Information	**RESPONSE** **[chose one entry, delete all others]**	**COMMENT**
1. Identify the organism. Is it clearly a single taxonomic entity and can it be adequately distinguished from other entities of the same rank?	*Podarcis muralis* (Laurenti, 1768). Common wall lizard or European wall lizard. Yes, it is a clear a single taxonomic entity that can be distinguished from others of the same rank.	This species shows considerable genetic and phenotypic variation across its range (Schulte, 2007) and while several subspecies have been described, the subspecific taxonomy is currently under investigation (e.g. Glandt, 2010; Schulte 2012). For the purpose of this risk assessment, such variation is not especially relevant (though note the existence of distinctly different phenotypes has probably led to increased deliberate introductions – see below).
2. If not a single taxonomic entity, can it be redefined? (if necessary use the response box to re-define the organism and carry on)	NA	
3. Does a relevant earlier risk assessment exist? (give details of any previous risk assessment)	No	
4. If there is an earlier risk assessment is it still entirely valid, or only partly valid?	NA	
5. Where is the organism native?	Europe and the very west of Asia, with a broadly central European range, from Spain to Turkey, and from Greece to France.	More details in Schulte (2007) and IUCN (2009) though note that the latter erroneously gives UK as a native range state.
6. What is the global distribution of the organism (excluding Great Britain)?	Native range as in above response, plus non-native range which comprises mainly small,	Schulte (2007) gives a detailed discussion of both native and introduced range. Kraus

	isolated populations in several other countries, notably Canada (Allan et al, 2006) and USA (Burke & Deichsel, 2008; Kraus, 2009). In addition, there are some introduced populations outside the native range but inside countries into which the native range extends (especially Germany and Netherlands; see Schulte, 2007; Schulte et al, 2012).	(2009) lists original sources for introduction reports, which are too numerous to reproduce in full here.
7. What is the distribution of the organism in Great Britain?	31 viable populations are recorded by Langham (2012), which is the most accurate and up to date reference in terms of locations. Another 9 confirmed sightings may also represent populations, though this is unverified. Based on the rate and pattern of discoveries in recent years, there are likely to be more currently unrecorded populations on or near the south coast of England (Langham, pers. comm.) The majority of populations are in southern England and South Wales (Langham, 2012; Lever, 2009; Quayle & Noble, 2000). The first GB introduction is thought to have been to the Ventnor (Isle of Wight) in the 1920s, although there are questionable claims of an introduction here in 1841 (Lever, 2009).	Maps showing the locations of populations and approximate site boundaries are available online (Langham, 2012). The list of breeding populations from that source is: Bristol (Bristol), Newton Abbot (Devon), Newton Ferrers (Devon), Abbotsbury (Dorset), Boscombe (Dorset), Branksome Dean (Dorset), Canford Cliffs (Dorset), Cheyne Weare (Dorset), Dancing Ledge (Dorset), East Cliff (Dorset), Longstone Ope (Dorset), Pearce Avenue (Dorset), Seacombe Quarry (Dorset), West Weare (Dorset), Winspit Quarry (Dorset), Holmsley (Hampshire), Shorwell (Isle of Wight), Ventnor (Isle of Wight), Folkestone (Kent), Tyler Hill (Kent), Birdbrook (London), Islington (London), Wellington (Somserset), Wembdon (Somerset), Felixstowe (Suffolk), Banstead (Surrey), Nutfield (Surrey), Bury (Sussex), Shoreham by Sea (Sussex), West Worthing (Sussex), South Gower (Swansea). Source references for discovery of the species

		at each site, often with information on known or suspected introduction pathways, are given in Langham (2012), Beebee & Griffiths (2000), Quayle & Noble (2000) and Lever (2009). These references are too numerous to list in full here.
8. Is the organism known to be invasive (i.e. to threaten organisms, habitats or ecosystems) anywhere in the world?	Yes	*P. muralis* can establish large populations rapidly. This gives the potential for substantial impacts, for which there is a varying degree of evidence. There is compelling evidence that at least some *P. muralis* introductions have caused impacts on native species. This is discussed further below. In summary, the main impacts with scientific or persuasive anecdotal support are: (1) loss of native genetic integrity through hybridisation of non-native *P. muralis* with native conspecifics (e.g. Schulte et al, 2012). (2) declines in syntopic native reptile populations (e.g. Münch, 2001, Mole, 2010), though the mechanism for causing declines is unverified (this could include predation and competition). Other conceivable impacts include: - transmission of disease to native reptiles - local reductions in invertebrate densities - subsidising native predators, causing disruption to local ecosystem dynamics - loss of “conservation potential”; planned

		reintroductions of nationally rare sand lizards *Lacerta agilis* in or close to areas where *P. muralis* has been introduced are now on hold (N. Moulton, pers. comm.) - "scientific loss" (Kraus, 2009), in the sense that understanding of the original, native population dynamics at introduction sites are being eroded by interactions imposed by invading *P. muralis*.
Stage 2. Screening Questions		
9. Has this risk assessment been requested by the GB Programme Board? (If uncertain check with the Non-native Species Secretariat)	Yes If yes, go to section B (detailed assessment) If no, got to 10	

SECTION B – Detailed assessment

PROBABILITY OF ENTRY

Important instructions:

- Entry is the introduction of an organism into GB. Not to be confused with spread, the movement of an organism within GB.
- For organisms which are already present in GB, only complete the entry section for current active pathways of entry or if relevant potential future pathways. The entry section need not be completed for organisms which have entered in the past and have no current pathways of entry.

QUESTION	**RESPONSE** **[chose one entry, delete all others]**	**CONFIDENCE** **[chose one entry, delete all others]**	**COMMENT**
1.1. How many active pathways are relevant to the potential entry of this organism? (If there are no active pathways or potential future pathways respond N/A and move to the Establishment section)	very few	very high	
1.2. List relevant pathways through which the organism could enter. Where possible give detail about the specific origins and end points of the pathways. For each pathway answer questions 1.3 to 1.10 (copy and paste additional rows at the end of this section as necessary).	(1) Accidental import (2) Import by lizard enthusiasts, after collection or purchase overseas		Two pathways are known or suspected: (1) Introductions may occur as accidental imports, such as stowaways in imported garden or agricultural produce. The lizard may then escape (or be accidentally transferred) into the wild. This species has been found in shipments of reeds, garden plants, fruit and vegetables in GB (D. Bird, pers. comm.), and similar species are imported accidentally (e.g. the Italian wall lizard *Podarcis siculus* has been found in stone imported to GB from Italy (Hodgkins et al, in prep); *P. siculus* has been introduced to Spain via olive tree consignments from Italy; Silva-Rocha et al, 2012). Lizards may also be imported accidentally in tourists’

			luggage or vehicles. (2) Importation by dealers or enthusiasts who collect lizards at wild sites in continental Europe, or purchase/exchange them at trade fairs or breeders in continental Europe. The lizards would start the pathway either in the wild or at a breeder or dealer, and end the pathway in a private collection in GB (possibly later being released into the wild). It is general knowledge among reptile enthusiasts that this used to be common practice (J. Foster, pers. obs.), with organised visits to collect lizards overseas. However, this pathway appears now to be much reduced or non-existent, perhaps due to increased legislative protection and the ready availability of *P. muralis* at wild sites in the UK. There is still potential for dealers or enthusiasts to import *P. muralis* legally so long as the correct procedures are followed (for example, importing captive bred animals with reliable provenance), but it appears this is rarely done.
Pathway name:	Accidental import		
1.3. Is entry along this pathway intentional (e.g. the organism is imported for trade) or accidental (the organism is a contaminant of imported goods)? (If intentional, only answer questions 1.4, 1.9, 1.10, 1.11)	accidental	very high	Lizards may be accidentally transferred to imported materials via a range of mechanisms (see references above).
1.4. How likely is it that large numbers of the organism will travel along this pathway from the point(s) of origin over the course of one year? Subnote: In your comment discuss how likely the	very unlikely	low	Only very low numbers are expected, but this is difficult to be sure about. The opportunity for lizards to enter the pathway in the first place is haphazard and probably low risk.

organism is to get onto the pathway in the first place.			
1.5. How likely is the organism to survive during passage along the pathway (excluding management practices that would kill the organism)? Subnote: In your comment consider whether the organism could multiply along the pathway.	moderately likely	medium	This would depend on the type of import (material with which the animal is transported, method of transport, temperature, length of transport, etc). *P. muralis* would likely perish in many transport environments through crush injuries, dehydration or extremes of temperature. However, the species could easily survive passage for several days if the conditions were favourable; there are credible reports of this species surviving long distance movements. It is highly unlikely that lizards would multiply along the pathway as there would not be sufficient time, and conditions would not be conducive.
1.6. How likely is the organism to survive existing management practices during passage along the pathway?	moderately likely	low	This would depend on the management practices, which vary widely between import types. In the case of accidental import in holiday-maker luggage, for example, management practices would do little to prevent successful entry. Some horticultural produce, however, would be subject to cleaning, which would reduce the chance of survival.
1.7. How likely is the organism to enter GB undetected?	likely	high	Most entries would not be noticed, since the species is small, cryptic and can rapidly flee when it senses danger.
1.8. How likely is the organism to arrive during the months of the year most appropriate for establishment?	moderately likely	high	Arrivals from April to October would favour establishment, and imports of various kinds occur during this period. However, lizards could potentially survive and establish following arrival at any time of year, if local conditions were favourable.
1.9. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	unlikely	medium	Only certain habitat types are suitable for establishment of viable populations, but there is a moderate chance that an imported animal could be transferred from the import pathway into such a habitat (e.g. docks, railway

			yards and lines, and garden centres).
1.10. Estimate the overall likelihood of entry into GB based on this pathway?	unlikely	medium	*P. muralis* is likely to enter GB in only low numbers via this pathway. Entry to the wild, after entering GB, is therefore also unlikely. Entry to the wild in areas where there are suitable habitats, and in sufficient numbers to form a viable population, is therefore even more unlikely. However, there is only medium confidence in this assessment.
Pathway name:	Import by lizard dealers or enthusiasts, after collection or purchase overseas		
1.3. Is entry along this pathway intentional (e.g. the organism is imported for trade) or accidental (the organism is a contaminant of imported goods)? (If intentional, only answer questions 1.4, 1.9, 1.10, 1.11)	intentional	very high	*P. muralis* has been deliberately imported by private breeders in the past, but this is considered to be very unlikely at the time of writing (2012). Due to legal or personal sensitivities, there is little firm evidence on this pathway.
1.4. How likely is it that large numbers of the organism will travel along this pathway from the point(s) of origin over the course of one year? Subnote: In your comment discuss how likely the organism is to get onto the pathway in the first place.	very unlikely	high	Deliberate imports are likely to be rare now, and if they do occur would likely involve only low numbers of animals.
1.9. How likely is the organism to be able to transfer from the pathway to a suitable habitat or host?	unlikely	medium	Most lizards imported would likely not be transferred to the wild, since most breeders and dealers would keep animals in captivity until the animals die or passed on to another collection. However, the evidence suggests that a tiny minority of breeders may release lizards into the wild (see above).
1.10. Estimate the overall likelihood of entry into GB based on this pathway?	very unlikely	high	This pathway is currently unlikely to be very active, if at all.
End of pathway assessment, repeat as necessary.			

1.11. Estimate the overall likelihood of entry into GB based on all pathways (comment on the key issues that lead to this conclusion).	unlikely	high	Key issues: *P. muralis* is probably neither deliberately nor accidentally imported in appreciable numbers. Even if some animals do pass along these two pathways, there is a very low chance of them reaching the wild in suitable numbers and in suitable habitat to enable population establishment. Note: in terms of introduction to the wild in GB, the main issue is release and escape of animals that are already present in captivity in GB, or deliberate translocation of animals that are already present in the wild in GB.

PROBABILITY OF ESTABLISHMENT

Important instructions:

- For organisms which are already well established in GB, only complete questions 1.15 and 1.21 then move onto the spread section. If uncertain, check with the Non-native Species Secretariat.

QUESTION	RESPONSE	CONFIDENCE	COMMENT
1.15. How widespread are habitats or species necessary for the survival, development and multiplication of the organism in GB?	isolated	high	Studies in the UK and at other sites in the north of the range indicate that *P. muralis* has rather specific habitat requirements. Most importantly, it needs open, well-insolated areas with abundant, closely spaced refuges. For egg-laying, it needs an undisturbed substrate where eggs can develop in a warm, moderately humid environment during the summer months. These requirements mean that most GB wall lizards are found in very particular microhabitats, invariably south-facing and often near-vertical, with multiple refuges (crevices or vegetation) and close to sandy substrate or rocks for egg-laying. Hence, most GB populations are associated with quarries, buildings, walls, or cliffs. For more details, see, e.g., Ghergel et al, 2009; Schulte, 2007; Schulte et al, 2008; Quayle & Noble, 2000. The fact that there has generally been very slow rate of spread from introduction sites indicates that critical microhabitats are lacking (T. Uller, pers. comm.) Climatic conditions in GB are unfavourable in general for *P. muralis*, a situation that appears to (a) restrict this species to suitable microhabitats and (b) strongly limit successful establishment to southern England (this is

			supported by studies on hatching success; T. Uller, unpublished data).
1.21. How likely is it that biological properties of the organism would allow it to survive eradication campaigns in GB?	unlikely	medium	The main biological properties of the species that make eradication difficult are (i) rapid population establishment and high population density, (ii) crypsis, (iii) escape behaviour, (iv) preference for habitats that render capture problematic, and (v) concealed location of egg-laying sites. Individuals can certainly be removed from the wild using standard reptile capture methods, such as noosing (Allan et al, 2006). Hence, the species would likely not survive eradication so long as sufficient method and effort were applied. This is supported by the fact that there are cases in which introduced *P. muralis* and closely related species have been successfully eradicated, or appear to be on course for eradication (e.g. Deichsel & Walker, 2010; Cabido et al, 2010; Garin-Barrio et al, 2009; N. Squirrell, pers. comm.) However, note that this statement is deliberately made without considering the possible negative impacts of any eradication methods, which would clearly need to be fully assessed.

PROBABILITY OF SPREAD

Important notes:

- Spread is defined as the expansion of the geographical distribution of a pest within an area.

QUESTION	RESPONSE	CONFIDENCE	COMMENT
2.1. How important is the expected spread of this organism in GB by natural means? (Please list and comment on the mechanisms for natural spread.)	minimal	high	Spread at the GB introduction sites has generally been slow (Lever, 2009; Quayle & Noble, 2000), and this is generally the case in other non-native *P. muralis* populations (e.g. Allan et al, 2006; Burke & Deichsel, 2008.) Note that in contrast to this general scenario, there is evidence that at some sites, where local connectivity to suitable microhabitats allows, the lizards are spreading rapidly. This has been the case, for example, at Boscombe in Dorset. The mode of natural spread is mainly by lizards dispersing over land. There is no detailed record of dispersal at most GB sites, and assessing natural dispersal is confounded by human-assisted movements, which have certainly occurred at some sites (see below). Assessing what is known of movements, maximum annual rate of natural dispersal is in the region of 50m. Note that this is mediated by the presence of suitable habitat (notably basking sites and egg-laying substrate). There is good evidence from continental Europe that colonisation and population establishment is greatest in subsidised habitat, i.e. areas where human activity creates particularly favourable microhabitats such as walls and railway embankments (e.g. Schulte et al, 2008; Gherghel et al, 2009). Certainly most large GB

			populations are associated with either (a) human-created or modified habitats, or (b) semi-natural habitats with south-facing aspect, especially high insolation combined with favoured substrates (Langham, 2012; Quayle & Noble, 2000). Rafting has been reported as a possible natural dispersal method for other introduced *Podarcis* populations (see Burke & Deichsel, 2008). In contrast to spread, the rate of local population increase can be surprisingly high. Given favourable habitat, GB *P. muralis* populations have attained substantial sizes within a few years of entry, with likely population sizes in the high hundreds or even thousands (see e.g. Langham, 2012; Gleed-Owen, 2004; Mole, 2010).
2.2. How important is the expected spread of this organism in GB by human assistance? (Please list and comment on the mechanisms for human-assisted spread.)	massive	very high	Human assisted spread is substantially more important than natural spread in GB, as is reflected in most overseas *P. muralis* introduction scenarios (e.g. Burke & Deichsel, 2008; Schulte et al, 2012). Four known or suspected pathways exist, the first two being deliberate, the last two accidental: (1) Some of the currently extant GB colonies originate from deliberate releases from captive stock, undertaken by private lizard enthusiasts (Lever, 2009; Langham, 2012). Some animals may have been released as they were viewed as “surplus stock” following good breeding success. However, the current distribution is also consistent with multiple, cross-referring anecdotal reports that there has been a sustained and methodical campaign to introduce *P.*

			muralis to previously unoccupied sites in southern England (J Foster, pers. obs.) This campaign appears to be organised by a small number of private lizard breeders. Furthermore, the releases appear to have continued until at least the late 2000s, and there are indications they may continue. Recent genetic evidence (Michaelides et al, in press) is consistent with the southern coast populations arising largely from introductions or translocations from a modest number of sources; haplotype data strongly suggest that the Dorset populations, in particular, result from a common origin. *[Note: this is undoubtedly the main pathway for entry to the wild in GB in recent years, but it does not quite fit into (B) Probability of entry above, since that section relates to entry into GB from overseas; nor does it quite sit here comfortably, since this section relates to movements of animals already in the wild.]* (2) Deliberate translocations of lizards from established populations to new, unoccupied sites. There are reliable reports of people capturing lizards at some sites (D. Bird, pers. comm.; T Uller, pers. comm.) In the recent past there have been requests to Natural England to move lizards to new sites (J. Foster, pers. obs.) Genetic evidence is also consistent with this scenario (Michaelides et al, in press). It is feasible that holiday makers could capture low numbers of lizards (given that some populations are at prime tourist locations), and then release them elsewhere. (3) Escapes from captive garden or zoo colonies are possible (Lever, 2009; Quayle & Noble, 2000). *[Again, not movement of animals already in the wild,*

			but important to note.] (4) Introductions may occur as stowaways with goods transported within GB. It is possible that animals could be moved in consignments of sand, stone, etc. In Germany and Austria, it is highly likely that *P. muralis* are transported accidentally as stowaways with rail freight, as patterns of dispersal are consistent with rail networks (Maletzky et al, 2011; Schulte, 2012). This is plausible in GB, although two confounding factors are: lineside habitats are known to promote natural dispersal due to their favourable thermal properties and refuge opportunities; railway locations may also be chosen as deliberate release sites by those who understand habitat requirements of this species.
2.3. Within GB, how difficult would it be to contain the organism?	with some difficulty	medium	The populations are still relatively contained in that rate of spread is low and is constrained by habitat quality. Putting in place measures to prevent further spread (such as habitat manipulation or installing barriers) would be feasible given sufficient resources. It would be a substantial task at some sites because of the terrain and site size. At some sites, further spread is unlikely as there appears not to be suitable habitat within dispersal range (T. Uller, pers. comm.)
2.4. Based on the answers to questions on the potential for establishment and spread in GB, define the area endangered by the organism.	Small patches of South Wales and Central and Southern England	low	There is a large area of southern GB which provides marginal climate for *P. muralis*, and a smaller area where climate is locally suitable. However, suitable habitat is also crucial, and this combination likely only exists in moderately small, often fragmented patches (coastal areas, quarries, railway land, some brownfield sites, possibly road verges and other built land having the right aspect and geology). Transport

			corridors and coastal areas could offer unfragmented and therefore high risk potential for dispersal.
2.5. What proportion (%) of the area/habitat suitable for establishment (i.e. those parts of GB were the species could establish), if any, has already been colonised by the organism?	0-10	low	It is likely that only a small proportion of land that could potentially support populations is currently occupied. However, this requires further study.
2.6. What proportion (%) of the area/habitat suitable for establishment, if any, do you expect to have been invaded by the organism five years from now (including any current presence)?	0-10	low	The total area occupied is unlikely to change rapidly in 5 years, even given the likelihood of some further deliberate introductions or translocations.
2.7. What other timeframe (in years) would be appropriate to estimate any significant further spread of the organism in Great Britain? (Please comment on why this timeframe is chosen.)	40	low	In 40 years there would be greater potential for natural spread and for further introductions, such that range would increase
2.8. In this timeframe what proportion (%) of the endangered area/habitat (including any currently occupied areas/habitats) is likely to have been invaded by this organism?	33-67	low	Note that this assumes there would be no reduction in the rate of population spread by human or natural means. In practice, the increase in proportion of endangered area would only be advanced significantly by human-assisted spread. Natural spread would account for comparatively small gains in range, possibly except along transport corridors and coastal areas.
2.9. Estimate the overall potential for future spread for this organism in Great Britain (using the comment box to indicate any key issues).	Intermediate	medium	The species is likely to spread locally though natural means, but at a slow rate in most sites. Where there are locally assisted translocations, populations will spread more rapidly. New populations may appear at distant sites, as people introduce animals from captivity or translocate wild animals. This pattern of “jump dispersal” is reported in North America with various introduced Lacertid lizards, including *P. muralis* (Burke & Deichsel, 2008). It is feasible that there are further, currently undetected populations. As the number of populations increases, so does the

			number of sources for new populations established by translocation.

PROBABILITY OF IMPACT

Important instructions:

- When assessing potential future impacts, climate change should not be taken into account. This is done in later questions at the end of the assessment.
- Where one type of impact may affect another (e.g. disease may also cause economic impact) the assessor should try to separate the effects (e.g. in this case note the economic impact of disease in the response and comments of the disease question, but do not include them in the economic section).
- Note questions 2.10-2.14 relate to economic impact and 2.15-2.21 to environmental impact. Each set of questions starts with the impact elsewhere in the world, then considers impacts in GB separating known impacts to date (i.e. past and current impacts) from potential future impacts. Key words are in bold for emphasis.

QUESTION	RESPONSE	CONFIDENCE	COMMENTS
2.10. How great is the economic loss caused by the organism within its existing geographic range **excluding GB**, including the cost of any current management?	minimal	high	No reports of economic loss are known.
2.11. How great is the economic cost of the organism **currently** in GB **excluding management** costs (include any past costs in your response)?	minimal	high	No reports of economic loss are known.
2.12. How great is the economic cost of the organism likely to be **in the future** in GB **excluding management** costs?	minimal	high	There is no reasonable likelihood of economic loss accruing from introduction of *P. muralis* in GB.
2.13. How great are the economic costs **associated with managing** this organism **currently** in GB (include any past costs in your response)?	minimal	very high	Very little management currently occurs for this species. There is a single, low intensity eradication project that has been undertaken with minimal costs. Some habitat management to attempt to reduce population densities has also occurred (D. Bird, pers. comm.), again with minimal costs.
2.14. How great are the economic costs **associated with managing** this organism likely to be **in the future** in GB?	moderate	medium	If a decision were made to control or eradicate the species in GB, there would be moderate costs compared

			with other notable non-native species eradication projects. The species is present at a limited number of sites and eradication methods are feasible, if extremely onerous at large populations. Prevention, or at least major reduction, of future deliberate releases is possible through education campaigns (and where appropriate, enforcement), combined with management to reduce the chance of accidental entry into the wild.
2.15. How important is environmental harm caused by the organism within its existing geographic range **excluding GB**?	major	medium	The harm or potential harm described to date has been major but highly localised. Confirmed, widespread impacts on the genetic integrity of native *P. muralis* have been reported in Germany (e.g. Schulte et al, 2012), and are likely elsewhere in the native range. Population declines of native reptiles due to *P. muralis* introduction have been suspected at a range of sites (e.g. Münch, 2001; Schulte et al, 2008; Schulte, 2009; Deichsel & Schulte, 2011; Kühnis & Schmocker, 2008). Assigning a definite cause to declines is very difficult in observational studies, but there is a sound rationale for suspecting that *P. muralis* may negatively affect native species through competition or interference. There has been particular concern about apparent declines in *Lacerta agilis* after *P. muralis* introduction at some sites in Germany and Switzerland (Deichsel, pers. comm.). Note, however, that co-occurrence with no negative effects on native reptile species has also been observed (e.g. Heym, 2012). The likelihood of any negative impacts on native reptiles may be context-dependent, perhaps mediated by habitat type and the subspecies of wall lizard involved. Impacts on non-reptilian biodiversity, notably

			invertebrates, are feasible but apparently have yet to be investigated.
2.16. How important is the impact of the organism on biodiversity (e.g. decline in native species, changes in native species communities, hybridisation) **currently** in GB (include any past impact in your response)?	moderate	medium	There have been several reports of declines in native lizards apparently caused by *P. muralis* introduction (D. Bird, pers. comm.; N. Moulton, pers. comm.; Mole, 2008, 2010). This reflects strong indications of *P. muralis*-mediated declines of sand lizards *Lacerta agilis* at some sites in Germany (see comments in 2.16). This would be an important conservation concern if replicated in GB, given their restricted range. At present most *L. agilis* sites are not contiguous with *P. muralis* site and so there is little immediate threat, but this could easily change with further introductions, and in some cases with further dispersal along current dispersal routes. Without reliable control data, however, it is difficult to demonstrate that apparent GB native reptile declines are caused by *P. muralis*, rather than just coincident with its introduction and caused by another factor. Indeed, at the Boscombe site, there is another introduced lizard, the western green lizard *Lacerta bilineata*, which may have impacts on native species as well as *P. muralis*. In addition, invasive plants (e.g. Hottentot fig, holm oak) have had a negative impact on native lizards here too. Notwithstanding this uncertainty, the rationale for potential impacts and the evidence for declines should both be treated seriously, and subjected to further investigation. It is not well known how the risks posed by *P. muralis* compare to those posed by *L. bilineata*. Conceivably, the risks of harm to native biodiversity from *P. muralis* are currently larger because the species is already

			present and well established at a range of sites. However, the establishment, dispersal and potential impacts of *L. bilineata* are not as well observed. There is a risk of disease transmission, notably to native reptiles. This is a potential high risk, especially given that some introduced lizards originate from captive colonies, where they could be exposed to non-native parasites. A preliminary investigation into pathogens at GB *P. muralis* sites has identified some issues of concern, but no pathogens likely to cause serious disease in native species (Sainsbury et al, 2011). Reliably detecting parasites and disease in wild reptiles is problematic, however, and so this possibility should not be ruled out. The demographic signal of decline at one Dorset sand lizard population - sudden loss of adults (D. Bird, pers. comm.) - is at least suggestive of decline mediated by disease, but requires further study. Given the high population densities achieved by *P. muralis* in GB, it is feasible that they may have local impacts on invertebrate density or diversity. The sites that this species thrives in are often valuable for invertebrates, as - being ectotherms - they share some habitat requirements. Invertebrates of sandy soils, rocky substrates and quarry sites might be most at risk. Any impact would likely be very localised. The modification of native invertebrate abundance by an introduced species has been shown in other studies (e.g. Choi & Beard, 2012). High introduced lizard densities could also serve to subsidise local predators and scavengers, such that in turn their population densities could increase locally (as is suspected to occur, for example, with grass snake

			Natrix natrix populations predating introduced marsh frogs *Pelophylax ridibundus* in south-eastern GB; Gregory & Isaac, 2004). This process can lead to unpredictable disruption of local community structure.
2.17. How important is the impact of the organism on biodiversity likely to be in the **future** in GB?	moderate	medium	The likely rate of spread on a national scale is low, so no substantial change in the extent of impacts is likely. However, the longer the species is present, the more locally severe the impacts are likely to be.
2.18. How important is alteration of ecosystem function (e.g. habitat change, nutrient cycling, trophic interactions) caused by the organism **currently** in GB (include any past impact in your response)?	minimal	low	Impact on ecosystem functions is unknown, but there is no rationale to suggest a serious impact. Some change in trophic interactions in a strict ecological (rather than ecosystem services) sense is likely to be happening; see comments on disruption to community dynamics, above.
2.19. How important is alteration of ecosystem function (e.g. habitat change, nutrient cycling, trophic interactions) caused by the organism likely to be in GB in the **future**?	minimal	low	Impact on ecosystem functions is unknown, but there is no rationale to suggest a serious impact. Some change in trophic interactions in a strict ecological (rather than ecosystem services) sense is likely to continue and exacerbate in future; see comments on disruption to community dynamics, above.
2.20. How important is decline in conservation status (e.g. sites of nature conservation value, WFD classification) caused by the organism **currently** in GB?	minor	medium	*P. muralis* introductions have caused a loss of "conservation potential," in that planned reintroductions of nationally rare sand lizards *Lacerta agilis* in or close to areas where *P. muralis* has been introduced are now on hold (N. Moulton, pers. comm.). This has been done because of the risk of negative impacts on introduced lizards. Thus, the introduced species has already impacted on recovery of a rare native species.

2.21. How important is decline in conservation status (e.g. sites of nature conservation value, WFD classification) caused by the organism likely to be in the **future** in GB?	minor	low	If current concerns about declines in native reptiles caused by *P. muralis* are realised, then future losses may be of concern. The extent of any losses would depend on the extent of spread, which currently appears limited.
2.22. How important is it that genetic traits of the organism could be carried to other species, modifying their genetic nature and making their economic, environmental or social effects more serious?	minimal	very high	Not important in GB as no native species could hybridise with *P. muralis*.
2.23. How important is social, human health or other harm (not directly included in economic and environmental categories) caused by the organism within its existing geographic range?	minimal	medium	Not known to cause social, human health or other harm.
2.24. How important is the impact of the organism as food, a host, a symbiont or a vector for other damaging organisms (e.g. diseases)?	minimal	low	Not known to be a vector for serious disease, but this has only been subject to preliminary examination (Sainsbury et al, 2011).
2.25. How important might other impacts not already covered by previous questions be resulting from introduction of the organism? (specify in the comment box)	minor	high	"Scientific loss" (Kraus, 2009), in the sense that the understanding original, native population and community dynamics at introduction sites are being eroded by interactions imposed by invading *P. muralis*.
2.26. How important are the expected impacts of the organism despite any natural control by other organisms, such as predators, parasites or pathogens that may already be present in GB?	moderate	medium	See comments in impacts above. Natural control by predators is unlikely to be limiting, except perhaps where the founder size is very small and predation happens early in introduction history.
2.27. Indicate any parts of GB where economic, environmental and social impacts are particularly likely to occur (provide as much detail as possible).	Parts of South Wales and central and	low	Patches of South Wales and central and southern England, notably coastal areas, are most likely to be impacted should introductions occur. There could be

	southern England, notably coastal areas.		many fragmented patches. The main areas where environmental impacts are most likely to be severe are: - areas of semi-natural habitat supporting important reptile and invertebrate populations, occurring on free-draining soils, with high insolation. Coastal cliffs and cliff-top habitats are most likely. - transport networks and other areas of human-modified habitat supporting important reptile and invertebrate populations, particularly where there are key habitat features suitable for this species (south-facing walls with suitable crevices, loose sandy soils, etc).Certain built structures, quarries and brownfield sites would be at risk.

RISK SUMMARIES

	RESPONSE	CONFIDENCE	COMMENT
Summarise Entry	very likely	high	Likelihood of entry into the wild in GB, arising from animals already present in GB: very likely, high confidence. This is because there is a high likelihood of at least one of the following occurring: introductions from captive stock, escapes from captive stock, translocation from wild stock, or accidental transfer with movement of goods. Likelihood of new entry to GB from overseas: moderately likely, low confidence. Reason: accidental imports are feasible but probably rare or of low numbers; intentional import is probably now rare.
Summarise Establishment	very likely	high	Animals released as part of a deliberate introduction stand a high chance of establishing a viable population. This is because those undertaking releases understand the factors that make population establishment more likely (chiefly, the number and age class of founder stock, and the habitat type at the release site). The chance of population establishment is substantially lower for other mechanisms of entry to the wild.
Summarise Spread	slow	high	Unassisted spread is relatively slow. Human-assisted spread can be very rapid, as animals may be released and subsequently thrive at sites distant from source the population. Wild sites are now well known, aiding future deliberate translocations.
Summarise Impact	moderate	medium	Impacts on biodiversity are potentially serious but local, with studies in GB and overseas indicating that native

			reptiles are negatively impacted by *P. muralis* introduction at some sites. Given the very high population densities achieved by *P. muralis*, there is likely to be disruption to local community structure. Competition, interference, disease and predation may lead to impacts on a range of native wildlife, not limited to reptiles. Economic and social impacts are probably negligible. A degree of "scientific loss" is also likely: i.e. loss of understanding of natural distribution and population dynamics, once a non-native species is introduced.
Conclusion of the risk assessment	moderate	high	Introduction of *P. muralis* clearly poses potential for risks to native biodiversity, albeit at a highly localised scale. The species can establish large populations quickly, which can persist for at least decades. There is reasonable evidence that introduction of this species may already be causing local declines in native reptiles in GB, as it almost certainly has overseas. Local impacts on non-reptilian biodiversity are also conceivable. The absence of irrefutable evidence that *P. muralis* causes adverse impacts is often advanced to argue against eradication action, or even to encourage future releases. The same applies to the argument that this species is native on the near-continent, and therefore is unlikely to be problematic. Yet this risk assessment concludes that both the rationale and the evidence for impacts (indeed, even on the continent closer to the native range) are sufficiently sound to warrant concern. Clearly, though, any decision on eradication, control or mitigation would need to take into account a range of considerations such as feasibility and non-target

			impacts. Without action, it is likely there will be further spread through deliberate releases, translocations and natural spread. This in turn may lead to more widespread negative impacts on biodiversity.

Additional questions are on the following page ...

ADDITIONAL QUESTIONS - CLIMATE CHANGE			
3.1. What aspects of climate change, if any, are most likely to affect the risk assessment for this organism?	(a) Summer temperatures, in particular the duration of warm, sunny days from June to September; (b) winter temperatures, in particular the duration and severity of periods of freezing conditions.	high	These aspects are suggested because (a) egg incubation is currently limiting, and (b) successful hibernation is currently limiting (both being heavily mediated by habitat conditions). Longer warm periods in summer and milder winters would likely increase potential for establishment and spread. This in turn would increase the risk posed by *P. muralis*, since it would be present at a wider range of sites, in broader habitat conditions and at higher population densities.
3.2. What is the likely timeframe for such changes?	50 years	low	
3.3. What aspects of the risk assessment are most likely to change as a result of climate change?	Establishment and spread potential; potential for impacts on biodiversity.	high	See answer to 3.1.
ADDITIONAL QUESTIONS – RESEARCH			
4.1. If there is any research that would significantly strengthen confidence in the risk assessment please summarise this here.	Research should be aimed at establishing the type and	very high	Research aims: (1) assess risk of effects on native reptiles through competition, predation and disease transmission; (2) assess risk of effects on native invertebrates through predation;

	scale of threat to biodiversity, and how to respond to this threat.		(3) assess risk of disruption to local ecosystem dynamics through subsidising predators or other effects; (4) assess feasibility of eradication and control; (5) assess methods to reduce deliberate and accidental releases, including communication with specialist reptile keepers and the broader herpetological community.

Please provide a reference list on the following page ...

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