



## **Guidelines for the Selection of Biological SSSIs**

### **Part 2: Detailed Guidelines for Habitats and Species Groups**

#### **Chapter 18 Reptiles and Amphibians**

Authors:

Bernhard, T., Driver, D., Dyer, S., Edgar, P., Ellis, M.,  
Foster, J., Howe, L, McKinnell, J. and Raynor, R.

To view other Part 2 chapters and Part 1 of the SSSI Selection Guidelines visit:  
<https://jncc.gov.uk/our-work/guidelines-for-selection-of-sssis/>

Cite as: Bernhard, T., Driver, D., Dyer, S., Edgar, P., Ellis, M., Foster, J., Howe, E., McKinnell, J., and Raynor, R. 2022.  
*Guidelines for the Selection of Biological SSSIs. Part 2: Detailed Guidelines for Habitats and Species Groups. Chapter 18  
Reptiles and Amphibians.* Joint Nature Conservation Committee, Peterborough.

© Joint Nature Conservation Committee 2022

### Cover note

This chapter updates and replaces the previous Reptiles and Amphibians SSSI Selection Guidelines chapter (Nature Conservancy Council 1989). It provides detailed guidance for use in selecting reptile and amphibian sites throughout Great Britain to recommend for notification as SSSIs. It should be used in conjunction with Part 1 of the SSSI Selection Guidelines, as published in 2013 (Bainbridge *et al.* 2013), which details the overarching rationale, operational approach and criteria for selection of SSSIs.

The main changes from the previous version of the chapter are:

- text on distribution and conservation status has been updated reflecting our greater understanding of the species, with some consequent changes to selection guidance;
- the selection guidance included for the northern clade pool frog (*Pelophylax lessonae*) as a single species interest feature is included (it was considered non-native in 1989 and therefore not included in the original guidelines);
- the adder (*Vipera berus*) and common toad (*Bufo bufo*) have been included as single species interest features within the main body of the text, noting the evidence for recent declines;
- text now provides more detailed guidance on the determination of appropriate boundaries to ensure that the site size and habitat coverage will allow the population to persist;
- outline guidance on consideration of detectability issues in surveys included; and
- outline consideration of issues concerning climate change.

This chapter has been subjected to appropriate levels of evidence quality assurance. It is compliant with the JNCC Evidence Quality Assurance Policy 2014 and has been subjected to external peer review by Dr Tony Gent.

The authors thank John Wilkinson, Nick Moulton and Yvette Martin (Amphibian and Reptile Conservation Trust) for comments on various drafts of these guidelines and Tony Gent (Amphibian and Reptile Conservation) for the peer review of the final manuscript. The authors would like to pay tribute to the late Liz Howe, who initiated this document and provided inspiration to see it completed.

## 1 Introduction

The current species composition of the reptile and amphibian fauna of Great Britain is largely a result of natural colonisation before the islands were cut off by rising sea levels, selective extinction due to climatic change and/or human influence, and deliberate or accidental introductions by humans.

Most reptiles and amphibians are not bound to a specific habitat type, instead structure of the habitat is typically important, whether it provides suitable breeding sites and/or adequate cover and foraging opportunities. However, several species, e.g. natterjack toad (*Epidalea calamita*) and sand lizard (*Lacerta agilis*) exhibit very specific habitat requirements. In the case of natterjack toads, these requirements within terrestrial habitats, such as sand dune, heath and saltmarsh including component features such as ephemeral pools required for breeding purposes. The relationship that a species has with its habitats is often complex and in some cases is still not completely understood.

The purpose of biological SSSIs is to safeguard the diversity and geographic range of habitats and species throughout Great Britain, within which viable populations of all our threatened native species will be represented; as well as the full range of natural, near-natural and semi-natural ecosystems in which they occur. To do this effectively, the principle behind the designation must be to maintain or enhance populations and should include all the component parts of the habitat within an SSSI required by the species. The SSSI series should therefore include our most important natural heritage sites together with a representative selection of habitats used by the species. Reptiles and amphibians are often present on SSSIs that have been selected for other features and are often not mentioned in site designation or management planning documentation. In such cases, overlooking the needs of these species during management planning can result in adverse impacts on local populations, with a cumulative adverse impact at national level. In these situations, ideally populations should be assessed against the relevant criteria in these guidelines to determine whether they qualify as an interest feature. Long-term habitat management for notified features aims to ensure their ecological requirements are managed favourably and sustainably. Further discussion of the role, scope and purpose of SSSIs in the conservation of species and habitats across the UK is given in Guidelines for the Selection of Biological SSSIs (JNCC 2013), especially paragraphs 2.8 to 2.12. SSSIs are selected within similar sized geographical areas known as Areas of Search (AoS) to ensure consistency of coverage; for further information, see Section 4.14 and Figures 1.1 to 1.3 in: Guidelines for the Selection of Biological SSSIs, (JNCC 2013).

At national, country and county spatial scales, most reptiles and amphibian populations are primarily dependent on 'wider countryside' conservation policies and legislative protection. However, site designation and management represent the principal measure in Great Britain to safeguard and maintain the 'best' examples within each Area of Search (AoS).

## 2 Background

This section gives a brief overview of the reptile and amphibian species that are to be considered for SSSI selection. The UK supports 13 species of native amphibian and reptile. Selection as an SSSI feature may be either as an individual qualifying species or as part of an assemblage (Tables 3 and 4 below). The overall network of these sites should therefore include our most important natural heritage sites together with a representative selection of habitats.

Species should be considered for selection based on the following criteria:

- Species listed on Annex II of the Habitats Directive (1992), thus requiring the designation of Special Areas of Conservation (SACs) (in Great Britain through the Conservation of Habitats and Species Regulations 2017 (as amended) in England and Wales (including the adjacent territorial sea) and to a limited extent in Scotland (reserved matters); and the Conservation (Natural Habitats &c.) Regulations 1994 (as amended) in Scotland – hereafter referred to as the ‘Habitats Regulations’), due to their conservation significance. Protection of SACs is delivered primarily through the SSSI series and these sites are listed as Emerald Sites under the Bern Convention.
- Species listed as features of Ramsar Sites due to their conservation significance. Protection of Ramsar SACs is delivered primarily through the SSSI regulatory process.
- Species listed in Appendix II and III of the Bern Convention where SSSI designation could significantly assist with the conservation of the species concerned, especially where there are substantial national or regional population declines.
- Species listed as being at risk of extinction in Great Britain under International Union for Conservation of Nature (IUCN) criteria. And
- Outstanding assemblages of rare and/or widespread species in the AoS.

Section 3 reviews the listing of reptile and amphibian species under international and national conventions, directives and legislation.

The IUCN Red List is a globally recognised standard method for assessing the extinction risk of species at specified spatial scales. IUCN Red List assessments have been undertaken for the seven species of native amphibians at both Great Britain and country scales (Foster *et al.* 2021) are summarised in Table 1. IUCN red listing represents one of five possible reasons for informing site selection.

The great crested newt (*Triturus cristatus*) has been assessed as Least Concern in all the countries of Great Britain, the pool frog (*Pelophylax lessonae*) is Critically Endangered in Great Britain and England, and the natterjack toad is Endangered at Great Britain and country level. The other three species (common frog (*Rana temporaria*), palmate newt (*Lissotriton helveticus*) and smooth newt (*Lissotriton vulgaris*) are generally widespread and often relatively numerous, so the representation of outstanding assemblages should be the guiding principle. declines in the common toad (*Bufo bufo*) have resulted in it being classified as Near Threatened in Great Britain, England, and Scotland although its status remains as Least Concern in Wales.

**Table 1.** IUCN listing for Amphibians at Great Britain and Country Spatial Scales in 2021.

<b>Species</b>	<b>Great Britain</b>	<b>England</b>	<b>Scotland</b>	<b>Wales</b>
<i>Rana temporaria</i> Common Frog	Least Concern	Least concern	Least Concern	Least Concern
<i>Pelophylax lessonae</i> Pool Frog	Critically Endangered	Critically Endangered	Not applicable	Not applicable
<i>Bufo bufo</i> Common Toad	Near Threatened	Near Threatened	Near Threatened	Least Concern
<i>Epidalea calamita</i> Natterjack Toad	Endangered	Endangered	Endangered	Endangered
<i>Lissotriton vulgaris</i> Smooth Newt	Least Concern	Least Concern	Least Concern	Least Concern
<i>Lissotriton helveticus</i> Palmate Newt	Least Concern	Least Concern	Least Concern	Least Concern
<i>Triturus cristatus</i> Great Crested Newt	Least Concern	Least Concern	Least Concern	Least Concern

IUCN Red List assessments have been undertaken for the six species of native reptile at both Great Britain and country scales (Foster *et al.* 2021) and are summarised in Table 2.

The smooth snake (*Coronella austriaca*) and sand lizard are regarded as Endangered at Great Britain spatial scale and site selection should therefore take account of both species. Adder (*Vipera berus*) is assessed as, Near Threatened at Great Britain level and in Scotland and Wales and Vulnerable in England, whilst the other three species slow worm (*Anguis fragilis*), common lizard (*Zootoca vivipara*), and grass snake (*Natrix helvetica*) are Least Concern.

**Table 2.** IUCN listing for Reptiles in Great Britain and Country Spatial Scales in 2021.

<b>Species</b>	<b>Great Britain</b>	<b>England</b>	<b>Scotland</b>	<b>Wales</b>
<i>Anguis fragilis</i> Slow worm	Least Concern	Least Concern	Least Concern	Least Concern
<i>Zootoca vivipara</i> Common Lizard	Least Concern	Least Concern	Least Concern	Least Concern
<i>Lacerta agilis</i> Sand Lizard	Endangered	Endangered	Not applicable	Vulnerable
<i>Natrix Helvetica</i> Grass Snake	Least Concern	Least Concern	Not applicable*	Least Concern
<i>Coronella austriaca</i> Smooth Snake	Endangered	Endangered	Not applicable	Not applicable
<i>Vipera berus</i> Adder	Near Threatened	Vulnerable	Near Threatened	Near Threatened

\*' Recent records indicate the presence of the species in Dumfries and Galloway and other parts of Scotland. There is uncertainty over the presence of grass snake in Scotland as a native species. The balance of evidence currently suggests it is not native, but this requires further research and survey.

As informed by the selection criteria listed in above, four species of amphibian and three species of reptile can be notified as single species SSSI. The remaining species should usually only be notified as part of an assemblage feature. A summary of these on a geographical basis is shown in Tables 3 and 4.

**Table 3.** British Amphibians: SSSI Interest feature selection.

<b>Species</b>	<b>Distribution</b>	<b>SSSI Selection</b>
<i>Rana temporaria</i> Common Frog	All countries	Amphibian assemblage only
<i>Pelophylax lessonae</i> Pool Frog	England only	Can be notified as a single species qualifying SSSI feature
<i>Bufo bufo</i> Common Toad	All countries	Can be notified as a single species qualifying SSSI feature and/or as part of an amphibian assemblage
<i>Epidalea calamita</i> Natterjack Toad	All countries	Can be notified as a single species qualifying SSSI feature and/or as part of an amphibian assemblage
<i>Lissotriton vulgaris</i> Smooth Newt	All countries	Amphibian assemblage only
<i>Lissotriton helveticus</i> Palmate Newt	All countries	Amphibian assemblage only
<i>Triturus cristatus</i> Great Crested Newt	All countries	Can be notified as a single species qualifying SSSI feature and/or as part of an amphibian assemblage

**Table 4.** British Reptiles: SSSI Interest feature selection.

<b>Species</b>	<b>Distribution</b>	<b>SSSI Selection</b>
<i>Anguis fragilis</i> Slow Worm	All countries	Reptile Assemblage only
<i>Zootoca vivipara</i> Common Lizard	All countries	Reptile Assemblage only
<i>Lacerta agilis</i> Sand Lizard	England & Wales	Can be notified as a single species qualifying SSSI feature and/or as part of a reptile assemblage
<i>Natrix Helvetica</i> Grass Snake	All countries	Reptile Assemblage Only
<i>Coronella austriaca</i> Smooth Snake	England only	Can be notified as a single species qualifying SSSI feature and/or as part of a reptile assemblage
<i>Vipera berus</i> Adder	All countries	Can be notified as a single species qualifying SSSI feature and/or as part of a reptile assemblage

### 3 National and International Commitments

In comparison with continental Europe, Britain's reptile and amphibian fauna is relatively impoverished, partly due to its northern location and through its early postglacial isolation from the continent. The distribution of the rarer species is limited, with the largest number of species occurring in the south.

International protection for the UK's wildlife comes from two sources; legacy European Union directives, transposed into UK legislation, and international conventions, which are voluntary but binding on signatories, though derogations can be applied. The main conventions and legislative instruments that protect the UK's amphibians and reptiles are considered in the paragraphs below.

#### 3.1 The Convention on Wetlands of International Importance especially as Waterfowl Habitat, 1975 (Ramsar Convention)

The Ramsar Convention covers all aspects of wetland conservation and its 'wise use' and its requirements have again been satisfied by the designation of SSSI which can include amphibian features, for example the Dee Estuary Ramsar Site and the Upper Solway Firth Flats and Marshes Ramsar Site include natterjack toad as a listed feature.

#### 3.2 Convention on the Conservation of European Wildlife and Natural Habitats, 1979 (Bern Convention)

The [Bern Convention](#) '*...aims to ensure conservation of wild flora and fauna species and their habitats. Special attention is given to endangered and vulnerable species, including endangered and vulnerable migratory species*'. Signatories are obliged to protect listed species and sites. All species of reptile and amphibian are listed under the provisions of Appendices II and III of this Convention. Sites of international importance such as SACs are listed as Emerald sites under this convention. Under the terms of Appendix II of the Bern Convention, the United Kingdom, as a contracting party, is required to take the necessary legislative and administrative measures to ensure the conservation of important habitats of the sand lizard, smooth snake, great crested newt and natterjack toad. This was satisfied partly through the Wildlife and Countryside Act 1981 (as amended) [WCA] designation of SSSIs for these species as well as through the selection of SACs under the Habitats Regulations as Emerald sites.

### **3.3 Convention on Biological Diversity, 1992**

This provided a legal framework for biodiversity conservation. The UK established Biodiversity Action Plans to help conserve its most threatened species, working towards the aim of halting the loss of these species by 2010. The [UK Post-2010 Biodiversity Framework](#), published in July 2012, along with country-level biodiversity and environment strategies, now succeed the UK Biodiversity Action Plan (see the [UK's Clearing House Mechanism \(CHM\) website](#) for details of the latest UK and country-level plans and strategies.

### **3.4 The Habitats Regulations: the Conservation of Habitats and Species Regulations 2017 (as amended), and the Conservation (Natural Habitats, &c.) Regulations (1994) (as amended)**

The 'Habitats Regulations' provide a strict system of protection for species on Annex IV of the Habitats Directive (92/43/EEC) (known as European Protected Species); and require the designation of Special Areas of Conservation (SAC) for species listed under Annex II of the Habitats Directive; as well as specifying restrictions for species listed on Annex V of the Directive, such as prevention of the way some species may be killed, captured or sold; and the prevention of incidental capture or killing of listed species. Great crested newt is listed on both Annex II and Annex IV of the Habitats Directive, whilst sand lizard, pool frog, natterjack toad and smooth snake are listed on Annex IV. Common frog is listed on Annex V.

SACs for great crested newt have been identified across Great Britain and are all also notified as SSSIs. The SAC series, combined with Special Protection Areas (SPA) for birds, provides the UK contribution to an international network of sites listed under the Bern Convention known as the Emerald Network.

Favourable Conservation Status (FCS) forms the underpinning basis of the Habitats Regulations which requires consideration of the population, range, suitable habitat and future prospects for the species concerned at various spatial scales. This concept originates from the [Bonn Convention](#), where consideration is also given to historic conservation status. SSSIs should therefore play a crucial role in contributing to the maintenance or restoration of habitats and species to their favourable conservation status across the natural range within Great Britain. Designation of sites as SSSIs should therefore be one of the principal mechanisms for maintaining or restoring the current conservation status of populations (at a variety of spatial scales) to favorably defined levels. This overarching objective will reflect the ecological requirements of the species across its geographical and ecological range.

### **3.5 Wildlife and Countryside Act (1981) (WCA)**

The Wildlife and Countryside Act (1981) (as amended) is the primary piece of nature conservation legislation in Great Britain. This legislation transposes the Bern Convention into British Law. The provisions of this Act include the designation and protection of SSSIs and the safeguard and protection for listed species.

Schedule 5 of the WCA lists animals (apart from birds) which receive protection from various deleterious activities including injury and killing, taking, and damage or destruction to places of shelter. This schedule is subject to review every five years by JNCC and the statutory country nature conservation bodies.

The sand lizard, smooth snake, natterjack toad, great crested newt and pool frog are subject to legal protection under the provisions of Section 9(4)(b) and 9(4)(c) of the Wildlife and Countryside Act 1981 (as amended) and Regulation 43 and Schedule 2 of the Conservation of Habitats and Species Regulations 2017 (as amended) in England and Wales and

Regulation 39 of the Conservation (Natural Habitats &c.) Regulations 1994 (as amended). For the remaining species, under Section 9 of the Wildlife and Countryside Act 1981 (as amended) amphibians are subject to trade restrictions and for reptiles this also includes intentional injury or killing.

### **3.6 Other relevant national legislation and devolved legislation**

Other relevant national legislation and devolved legislation include: Countryside and Rights of Way (CROW) Act 2000, Nature Conservation (Scotland) Act 2004, the Natural Environment and Rural Communities Act 2006 (NERC Act) and The Environment (Wales) Act 2016, all of which offer varying levels of protection for all the native reptiles and amphibians. Further protection afforded to European species and all designated sites is provided under the provisions of Environmental Damage (Prevention and Remediation) Regulations legislation.

A summary of reptile and amphibian policy and species legislation in Great Britain is listed in Table 5.

**Table 5.** Summary of Species Legislation (lists under review and correct at time of publication).

<b>Species</b>	<b>Regulation 42 &amp; 43 and Schedule 2 of the Habitats Regulations (2017) (GB extent: England and Wales)</b>	<b>Regulation 39 and Schedule 2 of the Habitats Regulations (1994) (GB extent: Scotland)</b>	<b>Section 9 and Schedule 5 and Countryside Act 1981 (as amended) (GB extent: Great Britain)</b>	<b>Section 41 of the Natural Environment and Rural Communities Act 2004 (GB extent: England)</b>	<b>Section 2 of Nature Conservation (Scotland) Act 2004) (GB extent: Scotland)</b>	<b>Section 7 of the Environment (Wales) Act 2016: (GB extent: Wales)</b>
<i>Rana temporaria</i> Common Frog	–	–	✓ (sale only)	–	–	–
<i>Pelophylax lessonae</i> Pool Frog	✓	✓	✓	✓	–	–
<i>Bufo bufo</i> Common Toad	–	–	–	✓	–	✓
<i>Epidalea calamita</i> Natterjack Toad	✓	✓	✓	✓	✓	✓
<i>Lissotriton vulgaris</i> Smooth Newt	–	–	✓ (sale only)	–	–	–
<i>Lissotriton helveticus</i> Palmate Newt	–	–	✓ (sale only)	–	–	–
<i>Triturus cristatus</i> Great Crested Newt	✓	✓	✓	✓	✓	✓
<i>Anguis fragilis</i> Slowworm	–	–	✓	✓	–	✓

<b>Species</b>	<b>Regulation 42 &amp; 43 and Schedule 2 of the Habitats Regulations (2017) (GB extent: England and Wales)</b>	<b>Regulation 39 and Schedule 2 of the Habitats Regulations (1994) (GB extent: Scotland)</b>	<b>Section 9 and Schedule 5 and Wildlife and Countryside Act 1981 (as amended) (GB extent: Great Britain)</b>	<b>Section 41 of the Natural Environment and Rural Communities Act 2004 (GB extent: England)</b>	<b>Section 2 of Nature Conservation (Scotland) Act 2004 (GB extent: Scotland)</b>	<b>Section 7 of the Environment (Wales) Act 2016: (GB extent: Wales)</b>
<i>Zootoca vivipara</i> Common Lizard	✓	✓	✓	✓	–	✓
<i>Lacerta agilis</i> Sand Lizard	✓	✓	✓	✓	–	✓
<i>Natrix Helvetica</i> Grass Snake	–	–	✓	✓	–	✓
<i>Coronella austriaca</i> Smooth Snake	✓	✓	✓	✓	–	–
<i>Vipera berus</i> Adder	–	–	✓	✓	–	✓

## 4 Factors Informing the Rationale of Site Selection

### 4.1 Authorised Translocations or Releases

Sites with populations derived from authorised translocations or (introductions such as those occurring via a national reintroduction programme endorsed by the relevant country agency) should be evaluated once the population is has become established. There will be a presumption of only selecting sites supporting viable, authorized reintroductions undertaken in compliance with [IUCN translocation criteria](#), maintaining genetic provenance, relevant country guidance, and/or forming part of the implementation of any applicable species conservation strategies.

### 4.2 Natural Range and Site Selection

Selection of sites shall be located within the considered natural range of the species. Populations introduced deliberately or accidentally by man to locations which where they have never occurred naturally or where they would not have spread naturally are outside their natural range and consequently not suitable for the purposes of site selection.

### 4.3 Climate change

Modelling of climate change suggests that there may be significant changes to the distribution of reptiles and amphibians in Great Britain (Dunford & Berry 2012), though the effects of low dispersal and habitat fragmentation on the occupation of expanded climate space have yet to be properly examined. Assisted colonisation – translocating animals outside their natural range to address unavoidable range loss – is one possible response to climate-driven range changes. This action will normally only be considered when natural range is or significantly reduced, or where populations face extinction within an AoS, and only where conservation strategies specifically identify this action. This potentially could lead to changes or modifications in future SSSI notification strategies as a key delivery mechanism for long-term conservation action.

SSSI selection and boundary delineation therefore need to consider the likely consequences of climate change. Lawton Review (Lawton *et al.* 2010) recommendation 10 states “*When determining the boundaries of designated sites, responsible authorities should take better account of the need to support underpinning ecological processes and of anticipated environmental change.*”

It will become increasing important to develop a network of sites on a landscape scale. This overall network should include existing and new SSSIs together with other non-designated stepping-stone and linear habitats that will be required for migration dispersal and genetic exchange purposes. This overall approach aims to afford greater connectivity through the landscape and therefore achieve greater resilience for the species, such as enabling them to cope with extremes of weather.

Ensuring the availability of larger sites enables a greater diversity of habitats and topography, thus providing a more extensive range of micro-climates and conditions on site which should facilitate species to cope with extremes of weather. Having larger sites helps to ameliorate the effects of climate change. Predicted outcomes of climate change include rising sea-levels that undoubtedly will lead to losses of sand dune habitat for sand lizard and natterjack toad.

Increasing the size of SSSIs will also help to buffer these sites from negative outside influences, such as housing developments and intensive agriculture.

## 4.4 Detectability Issues in Surveys

Detectability is an important consideration in surveys assessing the suitability of candidate or amended SSSIs. Species may remain undetected for a range of reasons, including survey conditions, seasonal activity, and observer experience. This has important implications for the design and interpretation of surveys. Two frequent issues are that a species may be falsely concluded to be absent, or the abundance of the species can be substantially underestimated. Survey design can be altered to account for imperfect and variable detection rates, though this may result in an onerous protocol.

It is best to consult current good practice and research evidence (e.g. Sewell *et al.* 2013) to assess the best approach when surveying candidate SSSIs. As a general guide to overcoming these constraints, surveys may be designed with increased levels of effort and multiple survey methods and targeted towards periods when evidence suggests detectability is likely to be high.

The use and applications of modelling techniques can be used to inform field survey and subsequent analysis of results.

## 5 Site Selection Requirements

### 5.1 Amphibians

Seven native species of terrestrial amphibian occur in Britain. Criteria listed in Section 2 will inform the rationale and underpinning justifications for species and site selection.

There should be (a) representation of the sites supporting the two rarest species pool frog and natterjack toad, comprising most of their occupied range; (b) representation of outstanding sites and geographical/habitat representation for great crested newt and common toad and (c) representation of outstanding assemblages for the widespread species across their range. Overarching site notification strategies should aim to maintain the overall range of the species including any possible changes arising as a consequence of factors such as climate change.

At a site where several pools are utilised by amphibians, numbers of individuals or spawn counts of each species should be summed to derive a total (peak count) for the site, and whenever practical from surveys undertaken during one specific visit (to reduce the potential for double counting). The site boundary should include suitable terrestrial habitat (semi-natural or anthropogenic) where this occurs contiguous to or near the site, even though amphibians may not have been recorded in all parts of the site. Terrestrial habitat is just as essential for amphibian populations as their breeding sites. Man-made structures (e.g. tumuli, embankments and stone walls) should also be included to provide refuge, foraging areas and hibernation sites. Amphibian SSSIs should exclude recently created garden ponds, swimming pools, etc., and assessments should exclude any populations of species known to have been unofficially introduced. Natterjack toads require open terrestrial habitat, but the other species prefer structurally diverse mixtures of open, scrub, woodland, wetland and grassland habitats.

#### 5.1.1 Pool Frog (*Pelophylax lessonae*)

The northern clade pool frog is recognised as a native species and became the subject of a reintroduction programme in 2005 in Norfolk. The species is the rarest amphibian in Great Britain, and site protection should be a significant delivery mechanism for its conservation within its considered natural range in East Anglia (Buckley & Foster 2005).

All sites with populations within the considered natural range, derived from an authorised reintroduction, or from natural colonisation from reintroductions, should be selected once the population has become established. Established means that there should be evidence of sustained period of breeding at the site over a period of not less than five years.

### **5.1.2 Common Toad (*Bufo bufo*)**

Populations of this widespread species are declining across its range, perhaps due to increasing fragmentation of breeding pools, habitat loss, unsympathetic management of breeding ponds, and road traffic mortality. In any AoS, the best breeding site and its associated terrestrial habitat containing common toad ponds should be selected, based on population size, habitat functionality and considered population viability. In AoS where the common toad has undergone a substantiated decline in populations or sites during the last 20 years the best 5 populations should be selected.

### **5.1.3 Natterjack Toad (*Epidalea calamita*)**

All important and established populations of natterjack toad throughout the range should be selected. This will generally mean sites with populations greater than the median size for a British population (i.e. more than 15 spawn strings per year should have been present during at least two of the last five years). Established means that there should be evidence of a viable population having been at the site over a period of five years or more but not necessarily breeding every year.

In AoS where the distribution and populations are well known, sites should be chosen to reflect the variety of habitat and sub-habitat types utilised within the geographical range. Boundaries should be drawn to include the full range of functional requirements (hibernation, breeding and foraging) and provide connectivity between them.

At the edge of their natural range, the size of local populations may be limited (e.g. North Wales, Lincolnshire and Hampshire). Consequently, although these populations may naturally be smaller than the median given above, they should still be considered for selection within the AoS.

Coastal realignment and managed retreat may mean the boundaries require defined flexibility to ensure longer-term availability of required habitats.

### **5.1.4 Great crested newt (*Triturus cristatus*)**

Advances in recording methodologies and better understanding of great crested newt ecology mean that the previous simple approach to SSSI selection, does not give the best representation of great crested newt habitats and populations across Great Britain, and has often biased site selection towards large populations in post-industrial sites such as flooded quarries. Generally, the meta-population approach should be taken for site selection, where pond clusters in the landscape and suitable terrestrial habitat (such as grassland, woodland and scrub etc.) are included within the designated area to provide connectivity, extensive habitat for breeding, foraging, refuges and hibernation sites, enabling the species to be sustainable in the long-term.

All sites where a peak count by visual night-time surveys (torchlight or aquatic trapping) during the breeding season exceeds 100 adults/sub-adults either in one water body or in a cluster of water bodies within a defined spatial area, or encountered in terrestrial habitat, are eligible for selection. To help evidence population stability and/or to overcome problems associated with variability between counts (due to changes in vegetation cover, rainfall, etc.),

collection of data evidencing of more than 100 adults/sub-adults for three years or more is recommended for sites which are candidates for selection. As informed by extant surveys, if no site satisfies this criterion, the best site for the species in the AoS qualifies for selection.

Site selection should ensure that the wide range of habitat/ site types used by great crested newts within the AoS are included, such as agricultural field ponds, woodland ponds, dune ponds, dew ponds, marl pits, post-industrial, quarries and other aggregate sites.

### 5.1.5 Amphibian Assemblages

As well as providing a mechanism for conserving the rarer species, SSSIs are designed to safeguard the full range of biodiversity. The selection of sites containing the more widespread amphibian species should therefore provide a network of localities for these declining species. Outstanding assemblages of the geographically widespread species (i.e. great crested newt, smooth newt, palmate newt, common toad, and common frog) should be selected. The natterjack toad should be included for sites which do not qualify separately under Section 5.1.3.

A scoring system for assessment is given in **Table 6**; a **minimum value of 10** based on the presence of at least four species, is regarded as the qualifying score for site selection. When a survey of the AoS has been completed, the site with the highest score qualifies for selection if no site reaches a value of 10.

Any site with an assemblage score of five or more, which is adjacent to an existing SSSI, should be considered for inclusion within the boundary of the SSSI.

If an AoS supports a large number of sites which qualify on grounds of great crested newt (or assemblage scores), priority should be given to those sites which qualify both for crested newts and for their amphibian assemblage and which encompass the ecological and geographical range of sites within the AoS.

**Table 6.** A Scoring System for the Selection of Sites with Assemblages of Amphibians.

Species	Method	Low population Score 1	Good population Score 2	Large population Score 3
<i>Rana temporaria</i> Common Frog	Spawn clumps	< 50	50–500	> 500
<i>Bufo</i> Common Toad	Visual night survey	< 100	100–500	> 500
<i>Lissotriton vulgaris</i> Smooth Newt	Visual night survey	< 10	10–100	> 100
<i>Lissotriton helveticus</i> Palmate Newt	Visual night survey	< 10	10–100	> 100
<i>Triturus cristatus</i> Great Crested Newt	Visual night survey	< 10	10–100	> 100
<i>Epidalea calamita</i> Natterjack Toad	Spawn Strings	< 10	10–14	> 15

## 5.2 Reptiles

Six native species of terrestrial reptile occur in Britain. Criteria listed in Section 2 will inform the rationale and underpinning justifications for species and site selection. There should be (a) representation of the sites supporting either one or both of the two rarest species (smooth snake, sand lizard, comprising most of their occupied range; (b) representation of

outstanding sites for adder across its range; and (c) representation of assemblages for the widespread species across their range. Overarching site notification strategies should aim to maintain the overall range of the species including any possible changes arising as a consequence of factors such as climate change.

Reptiles are difficult to survey quantitatively, so other characteristics of sites should also be examined. Sites for the two rarest species will generally be on sand dunes or lowland heath. On other sites where there is contiguous, open, semi-natural habitat likely to be of value to reptiles, this should be included, even though reptiles may not have been recorded in all parts of the site. Reptiles can be found in a wide range of habitats providing that there are sufficient microhabitats that provide basking, feeding and hibernation opportunities. Suitable man-made structures (e.g. tumuli, embankments, and stone walls) should also be included to provide refuge, basking and hibernation sites.

There should be a presumption for selection of reptile sites on the following grounds:

### **5.2.1 Sand Lizard (*Lacerta agilis*)**

All established breeding populations of sand lizard should be selected. These populations do not include those that are very small, isolated and not form a component of metapopulation and/or only transitory in nature and not established. Established means that there should be evidence of a breeding population having been at the site over a period of five years. In AoS where the distribution and populations are well known, sites should be chosen to reflect specific habitat and sub-habitat types functionally required by the species for shelter, hibernation, breeding, egg laying and foraging, geographical range; and include within their boundaries, habitats required for migration, dispersal and genetic exchange between local populations. Sites with smaller populations should be selected at the edge of the species geographical range.

### **5.2.2 Smooth Snake (*Coronella austriaca*)**

All established populations of smooth snake should be selected. These do not include those populations that are very small, isolated and not form a component of metapopulation and/or only transitory in nature and not established. Established means that there should be evidence of a breeding at the site over a period of five years or more. In AoS where the distribution and populations are well known, sites should be chosen to reflect the variety of habitat and sub-habitat types utilised, the geographical range, and include within their boundaries the full range of functional requirements (hibernation, breeding and foraging) and provide connectivity between them. Site boundaries should be chosen to include sufficient habitat for this wide-ranging species. Sites with smaller populations should be selected at the edge of the species geographical range.

### **5.2.3 Adder (*Vipera berus*)**

In any AoS, the best locality supporting established populations of adder should be selected, based on factors such as population size, habitat suitability and evidence of breeding. It is important to safeguard the functionality of meta-populations to avoid fragmentation and leading to decline and isolation. In AoS where the adder has undergone a suspected or substantiated population decline during the last 20 years, the best five populations should be selected. Owing to the predicted impacts of climate change on the species, at least one upland site where geographically applicable should be selected.

Boundaries of sites should include a mosaic of habitats that are necessary for hibernation, breeding, foraging and spring basking (see Section 6).

## 5.2.4 Reptile Assemblages

As well as providing protection for the rarer and more threatened species, SSSIs are designed to safeguard the full range of biodiversity. The selection of sites containing the more widespread reptiles should therefore provide a network of localities for these declining species. Outstanding assemblages of the geographically widespread species (i.e. grass snake, common lizard, slow worm, and adder) should be selected from existing data and ongoing surveys within an AoS, to evidence the continued presence of larger viable populations of each component species. The definition of an outstanding reptile assemblage should normally include at least three of the widespread species. Sites supporting populations of one or two species, should count positively in the evaluation of sites chosen largely on other grounds, especially where populations are large, located in areas where the species concerned is rare or at the geographical limits of its range. The sand lizard and/or smooth snake should be included for sites which do not qualify separately under Sections 5.2.1 and 5.2.2.

The selection of sites containing the more widespread reptile species should provide a network of localities for these declining species. It will also ensure that the full range of representative sites are selected within the AoS if individual species sites do not provide sufficient coverage of habitat types or geographical spread. The occurrence of assemblages should also be included as a feature in the evaluation of sites chosen largely on other grounds (habitats or other taxa), especially for example in areas where the species concerned are rare or at the geographical limits of their range.

## 6 Site Boundaries (for all species)

### 6.1 General Principles

As highlighted in Jefferson *et al.* (2019) there are a number of standards which should be taken into account when determining site boundaries. It is important that all the notified features on site have all the habitats they require within the boundary and should include “...all land necessary to ensure the protection and sustainability of those features.” It is also essential to give thought to “...the inclusion of whole management units, entire ecological units and land required for supporting processes, such as hydrology.”

For herpetofauna, there are specific factors to take into consideration when determining site boundaries including:

- the value of the site within the broader purpose of the site series
- distribution of the target species and broad habitats on the site
- functions of key habitats (breeding, foraging, overwintering, etc.)
- connectivity between these key habitats, including the need to consider major dispersal routes in particular
- the need to encourage the inclusion of habitat mosaics (where appropriate)
- connectivity within the site
- connectivity with the wider countryside and relationships to other sites

Unlike semi-natural habitats, where the extent of the qualifying feature is obvious, the extent of species habitat can be quite hard to delineate, and some species will utilise modified habitat for foraging and dispersing away from their obvious core habitats. In addition, animals might disperse quite far from breeding or hibernation sites, for example great crested newts can travel at least 1.6 km from breeding ponds, whilst grass snake, common

toad, natterjack toad and adder can disperse over even greater distances (Sinsch *et al.* 2012; Sinsch 2017; Semlitsch *et al.* 2003).

Some species maintain meta-populations, utilising discrete patches within a broader landscape area. These can be combined to make compound sites. Sites must include any known or likely hibernation sites, basking areas (e.g. south-facing slopes) connectivity between these and important feeding areas (e.g. ponds for grass snakes) and breeding areas (e.g. ponds for amphibians). Habitat mosaics are very important for most species of reptile and amphibian, and linear features such as hedges and woodland rides are especially important for reptiles. Consideration must also be given to the inclusion of major routes for migration that abut the main site. SSSI boundaries are most usefully aligned with recognisable boundaries on the ground, such as field edges. Compound or archipelago sites, in which a single SSSI comprises more than one discontinuous parcel of land, may be appropriate when notifying sites for species with long dispersal distances.

## 6.2 Amphibians

For amphibians it is especially important to include the most important terrestrial and aquatic habitats utilised by the population. The significance of terrestrial habitat for amphibians should not be under-estimated; they spend the majority of their life on land, migrating to ponds and other waterbodies to breed in the spring. For aquatic habitat, both temporary and permanent ponds may be important. However, understanding the species distribution and habitat usage of an area can take several years of survey effort, particularly as some species will use a range of features according to the conditions on site. Determining the extent of terrestrial habitat to be included within the site boundary is inherently problematic, as amphibians are generally more difficult to detect when on land. However, considering all the ecological needs of the species and having a good understanding of the quality and extent of the habitats in the area, (and what these offer the species), is a good starting point. If there are some key habitats such as scrub (in the case of widespread amphibians including great crested newt set in sub-optimal habitat close to the breeding ponds, consideration must be given to their inclusion, particularly if habitats such as scrub are either absent or limited in the wider area.

To help with the decision on boundary setting, it may help to mark on a map all the ponds where the species has been seen (breeding & non-breeding), and to include all other ponds within a defined area. This will include a certain amount of terrestrial habitat, but it is likely that a greater amount of terrestrial habitat will need to be included to ensure all ecological functions (such as hibernation, daytime refuge and migration) are accommodated within the site boundary. Key habitats such as scrub, deciduous woodland and grasslands (particularly rough grasslands), hedgerows, tumuli and stone walls etc. should be considered for inclusion, though note that the relative value of these habitats will vary by species.

It is important not to restrict the ponds/water bodies to the known breeding ponds, as often there is insufficient evidence to identify all of the ponds used for this purpose. For some species, their use of breeding ponds could change over time and according to the conditions on site each year. Generally, the use of ponds by a species should not be considered as a static resource, as a non-breeding pond one year might be exploited the next. In addition, aquatic habitats should not be solely restricted to permanent ponds, water bodies (such as temporary/ ephemeral ponds, ditches and smaller features such as puddles and wheel ruts) that may not be used for breeding might be important for foraging and these habitats should be included within the site boundary (where appropriate).

The inclusion of woodland and other habitats that act as corridors for dispersal will allow for both population expansion and natural dynamics, for all amphibians except natterjack toads.

Habitat fragmentation can be as detrimental to amphibian populations as the loss of ponds or terrestrial habitat, so the ability to influence habitat management is essential if populations are to be restored to or maintained at a favourable conservation status and sites to be restored or maintained in a favourable condition.

SSSIs notified for amphibian interest features should not be selected where (a) the population is centred around recently created waterbodies with a primary ornamental or recreational function, such as garden ponds and swimming pools, or (b) the population is known or strongly suspected to arise from an unauthorised introduction.

The above text will help to steer boundary setting of sites selected for amphibians, but please also see the species-specific guidance outlined below.

### **6.2.1 Common Toad (*Bufo bufo*)**

The boundary for SSSIs notified for common toad and amphibian assemblages where common toads are one of the species present, must include both the main breeding site(s) and surrounding terrestrial habitat used for foraging, shelter and hibernation. Distances between these essential features may be up to 2 km. The migration route between breeding and hibernation areas is often intersected by roads or other built land. In such cases it may be appropriate to designate a compound or archipelago site that includes separate sub-sites for key habitats, including migration routes, which are essential to the survival of local populations.

### **6.2.2 Natterjack Toad (*Epidalea calamita*)**

In contrast to the other amphibian species, natterjack toads require extensive areas of open ground and short vegetation, with substrate suitable for burrowing. The species requires ephemeral ponds that are typically shallow with little or no vegetation for breeding, although they may also exploit the shallow edges of larger ponds and lakes, where they are able to cope with the presence of some types of fish. All waterbodies that are known or likely to be used for breeding, including those that are sub-optimal and only used under certain conditions, must be included within the SSSI boundary. The boundary must include a significant extent of terrestrial habitat, given that this species spends the vast majority of the lifecycle on land and disperses comparatively large distances. Lowland heathland, coastal sand dune and upper saltmarsh constitute suitable terrestrial habitat for most sites. Occasionally, other terrestrial habitats are important, (there are colonies on grassland and disused industrial sites) within the site boundary, including sandy south-facing slopes, banks, and dry-stone walls.

Natterjack toads may disperse up to 4 km (Sinsch *et al.* 2012) from breeding ponds although the extremes of dispersal are undertaken rarely and by few individuals. SSSI boundaries should, as a minimum, encompass a buffer of 600 m of suitable habitat in all directions around main breeding pools, as according to Sinsch *et al.* (2012) a terrestrial buffer of this size will protect at least 50% of the population. Depending on the spatial distribution of breeding sites, this may require a compound/archipelago approach to boundary selection. The boundary should include key habitats known or likely to be of high value for foraging, hibernation, connectivity, and dispersal beyond 600 m and up to 2 km from main breeding pools.

### 6.2.3 Great Crested Newt (*Triturus cristatus*)

Great crested newts can be predominantly found in most semi-natural lowland habitats and will also take advantage of derelict previously developed areas that can provide prey and cover.

The majority of adult newts remain within about 250 m of their natal pond for most of their lifecycle if habitat conditions are suitable, with longer range dispersal undertaken less frequently (Kupfer *et al.* 1998; Haubrock *et al.* 2017; and see overview in Jehle *et al.* 2011). Generally, areas closer to the breeding pond are of relatively higher value to newts, with certain habitat types and features being more favoured. Great crested newts have been found to disperse across habitats which offer little cover or foraging opportunity, such as hardstanding and arable land, in order to reach more distant and higher value habitats. As this species can disperse over 1.6 km between ponds, SSSI boundaries should allow for long distance movements that contribute to maintaining population viability and gene flow and recognise the range of terrestrial habitats used by the species.

Land parcels comprising suitable habitat lying completely or predominantly within 250 m of all waterbodies that are known, or likely to be used for breeding, including those that are sub-optimal and only used under certain conditions, must be included within the SSSI boundary. Practical considerations such as taking site boundaries to well-defined land management boundaries may well result in modifications, leading to exclusion of habitat within 250 m in some cases. Habitats known to be extremely unsuitable for newts, or those areas isolated by barriers to dispersal, may be excluded. Areas beyond 250 m should be included within the boundary based on (a) their importance to the population being protected by the SSSI and (b) their importance for maintaining connectivity with adjacent populations of great crested newts. Defined patches of high value terrestrial habitat, such as blocks of broadleaf woodland and scrub, should be included up to 1 km from the nearest breeding pond. Particular attention should be paid to situations in which high value terrestrial habitat is lacking within 250 m of the breeding ponds, in which case suitable land between 250 m and 1km should be actively sought for inclusion within the SSSI boundary.

It is also important to consider the population dynamics of great crested newts when setting SSSI boundaries. Great crested newts typically exist in meta-populations (Griffiths 2004) so SSSIs must contain sufficient aquatic and terrestrial habitat, with good connectivity, to enable natural population dynamics to function. The practical implications of this will vary by site, but there should be multiple ponds to ensure long term population resilience within the SSSI boundary. Sites with fewer ponds may be selected if population size criteria are satisfied.

## 6.3 Reptiles

Site boundaries for SSSIs notified for reptiles should encompass a variety of different habitats to provide sufficient structural diversity and complexity. In addition to the different characteristics of each habitat included on site, the transitions between different habitats (ecotones) are often favoured by reptiles; these include areas between wet and dry habitats, grassland and scrub habitats, sunlit woodland margins and the boundaries amongst grassland areas of varying heights. Mosaic conditions, where there is varied vegetation structure (primarily in terms of density, height and age of vegetation), open areas as well as ecotones, are ideal for reptiles and should be considered for inclusion in the site, even if it means including some intervening areas of sub-optimal habitat. Mosaic habitats create a variety of different conditions allowing reptiles to perform key behaviours including thermoregulation, resting, foraging and courtship. Consequently, the overarching

management objectives will therefore aim to ensure sufficient habitat of the right type and structure will be available allowing for changes over time.

SSSI boundaries should include a range of hydrological conditions where feasible, as reptiles commonly use damper areas in summer. SSSI boundaries should also incorporate varied topography where possible, as this will increase the diversity of habitats available for the species, as well as helping reptiles to cope with extreme conditions, such as extended periods of hot, dry weather.

All of our native reptiles hibernate over winter and therefore known and likely hibernation areas must be included within the SSSI boundary. The boundary should include sufficient land around hibernation areas to incorporate key areas used for dispersal and early spring basking. Reptiles may habitually use the same hibernation features in successive years and may hibernate communally. Hibernation sites are typically located underground, but also include structures within suitable features above ground. Hibernation locations include animal burrows, rotted tree stumps, root holes, banks, mounds, boundary features and in some cases large, dense grass tussocks (such as those formed by *Molinia caerulea*).

The above text will help to steer boundary setting of sites selected for reptiles, but please also see the species-specific guidance outlined below.

### **6.3.1 Sand Lizard (*Lacerta agilis*)**

The sand lizard requires either mature or degenerate dry heathland or structurally varied coastal sand dune habitat, though at some sites other habitats are also used to a lesser extent (see review in Blanke & Fearnley 2015). Individual sand lizards may disperse up to around 600 m, but the species typically disperses over much shorter distances, often less than 100 m. Sand lizards breed by laying eggs in burrows which are excavated in bare ground, normally open sand generated by humans or animals, or due to surface geology. The species overwinters below ground, typically in crevices or mammal burrows. Night-time refuges are sought in sheltered locations within vegetated areas or underground. SSSIs notified for sand lizard should include suitable breeding areas, together with areas likely or known to be used for foraging, shelter and hibernation. Beyond this, the boundary should include defined parcels of high-quality habitat lying completely or predominantly within 200 m of the nearest breeding area. Where there is evidence of regular use by sand lizards, habitat within 600 m of the nearest breeding area must also be included.

### **6.3.2 Smooth Snake (*Coronella austriaca*)**

The smooth snake occurs primarily in mature and degenerate dry heathland, also uses adjacent secondary habitats including humid and wet heath, bogs and grassland. These habitats provide conditions suitable for dispersal, foraging, courtship, breeding and hibernation. Smooth snakes feed almost exclusively on reptiles and small mammals, and a large area of high-quality habitat is required to ensure an adequate prey base. Individual smooth snakes may typically disperse up to around 300 m, though daily movements are typically over shorter distances (Gent & Spellerberg 1993), and maximum home range size is around 4 ha (Reading 2012). However, it is likely that individual range sizes may increase over time and elsewhere (e.g. Goddard 1981) larger maximum range sizes have been suggested. Generally though individuals maintain fairly defined ranges which even can result in genetic differences within large sites (Pernetta *et al.* 2011); therefore the site boundaries should encompass the extent of the core habitats used by the species. SSSIs notified for smooth snake must include core heathland and associated secondary habitats. The core area should typically accord with particular topographic features, aspect and especially favourable vegetation structure, including south-facing banks, mounds, tumuli, etc., with a

high coverage of heathland vegetation. Beyond this, the boundary should include defined parcels of high-quality habitat lying completely or predominantly within 300 m of the core area, although ongoing research may suggest that larger areas are required in the longer term to maintain or restore local populations to their favourable conservation status.

### **6.3.3 Adder (*Vipera berus*)**

Adders can travel up to 2 km between areas used for hibernation and breeding, and those used for summer foraging. Hibernation typically occurs in higher and drier areas, with courtship and mating happening nearby, while summer foraging areas tend to be more humid and low-lying.

Adders are known to hibernate communally at some sites, especially upland or northern sites or where underground voids are limiting. Adders commonly hibernate in holes or crevices in the ground associated with tree root systems, such as those found in slopes, banks, mounds, mammal burrows and the edges of scrub and woodland. Typically, these areas are open, south-facing and are associated with birch, heather, bracken, gorse or bramble.

SSSI boundaries for sites notified for adder must include known or likely hibernation areas, along with those areas used for emergence and courtship in spring and foraging in summer. Edge features, such as rides, scrub edges and railway embankments, can be especially important for dispersal. This guidance focuses on adder habitat preferences at certain well-studied sites and as usage will not be consistent across the species range observations of adders at the candidate site should be used to guide SSSI boundary decisions.

## **6.4 Boundaries of existing SSSIs**

The boundaries of some existing SSSIs designated for amphibians and reptiles need to be reviewed, as some sites are too small and do not include sufficient habitat features (such as terrestrial habitat), for the interest features to be able breed, forage and hibernate within the site boundary.

Consideration will need to be given to amending the site boundary to ensure all functional and functionally linked habitats within a landscape that are required by a species, or an assemblage of species are present with the notified boundary of the site. Management of habitats required by these features can therefore be tailored to the specific requirements of these interest features. Boundaries should take into consideration long-term prospects of notified populations by assessing potential landscape changes arising as a consequence of factors such as climate change.

Any site supporting one more of qualifying reptile or amphibian features adjacent to an existing SSSI should be considered for inclusion within a revised boundary of the SSSI.

## 7 Relevant Literature

- Amphibian and Reptile Groups of the United Kingdom. 2010. ARG UK Advice Note 5: *Great Crested Newt Habitat Suitability Index*.
- Baker, J., Suckling, J. & Carey, R. 2004. Status of the adder *Vipera berus* and slow-worm *Anguis fragilis* in England. English Nature Research Reports No. 546.
- Beebee, T. J.C., & Ratcliffe, S. 2018. Inferring status changes of three widespread British reptiles from NBN Atlas records. *Herpetological Bulletin*, **143**, 18–22.
- Beebee, T. J.C., Wilkinson, J.W. & Buckley, J. 2009. Amphibian declines are not uniquely high amongst the vertebrates: trend determination and the British perspective. *Diversity*, **1**(1), 67–88.
- Beebee, T.J.C. & Buckley, J. 2015. *Natterjack toad site register for the UK 1970-2009 inclusive*. ARC, Bournemouth.
- Beebee, T.J.C. & Denton, J. 1996. *The natterjack toad conservation handbook*. English Nature, Peterborough.
- Beebee, T.J.C., Buckley, J., Evans, I., Foster, J.P., Gent, A.H., Gleed-Owen, C.P., Kelly, G., Rowe, G., Snell, C., Wycherley, J.T. & Zeisset, I. 2005. Neglected native or undesirable alien? Resolution of a conservation dilemma concerning the pool frog *Rana lessonae*. *Biodiversity and Conservation*, **14**, 1607–1626.
- Beebee, T.J.C. & Griffiths, R.A. 2000. *Amphibians and reptiles: A natural history of the British herpetofauna*. The New Naturalist series. London: Harper Collins.
- Blanke, I. & Fearnley, H. 2015. *The sand lizard: between light and shadow*. Laurenti-Verlag.
- Bourmpoudakis, D., Foster, J., Gent, T., Griffiths, R.A., Russell, L., Starnes, T., Tzanopoulos, J. & Wilkinson, J. 2015. Developing models to estimate the occurrence in the English countryside of great crested newts, a protected species under the Habitats Directive. Report to Defra, WC1108. Defra, London.
- Buckley, J. & Foster, J. 2005. Reintroduction strategy for the pool frog *Rana lessonae* in England. English Nature Research Report 642. English Nature, Peterborough.
- Buckley, J. & Beebee, T.J. 2004. Monitoring the conservation status of an endangered amphibian: the natterjack toad *Bufo calamita* in Britain. *Animal Conservation*, **7**(3), 221–228.
- Buckley, J., Beebee, T.J.C. & Schmidt, B.R. 2014. Monitoring amphibian declines: population trends of an endangered species over 20 years in Britain. *Animal Conservation*, **17**(1), 27–34.
- Carrier, J.A. & Beebee, T.J. 2003. Recent, substantial, and unexplained declines of the common toad *Bufo* in lowland England. *Biological Conservation*, **111**(3), 395–399.
- Cooke, A.S. & Scorgie, H.R.A. 1983. The status of the commoner amphibians and reptiles in Britain. Focus on Nature Conservation No. 3, Nature Conservancy Council, Peterborough, 49 pp.

- Dunford, R.W. & Berry, P.M. 2012. Climate change modelling of English Amphibians and Reptiles: Report to Amphibian and Reptile Conservation Trust (ARC-Trust). Environmental Change Institute, University of Oxford Centre for the Environment, Oxford.
- Edgar, P. 2015. Natural England Notification Strategy: SSSI notification review for amphibians and reptiles. Unpublished report, Natural England, York.
- Edgar, P., Foster, J. & Baker, J. 2010. *Reptile Habitat Management Handbook*. Amphibian and Reptile Conservation, Bournemouth.
- Foster, J., Driver, D., Ward, R. & Wilkinson, J. 2021. IUCN Red List assessment of amphibians and reptiles at Great Britain and country scale. Report to Natural England. ARC report. ARC, Bournemouth.
- French, G.C.A., Wilkinson, J.W., Fletcher, D.H. & Arnell, A.P. 2014b. Quantifying the Status of Great Crested Newts in Wales. Report No. 31. 24 pp. Cyfoeth Naturiol Cymru / Natural Resources Wales, Bangor.
- Gent, A. & Bray, R. (eds). 1994. *Conservation and Management of Great Crested Newts*. English Nature Science Series 20. English Nature, Peterborough.
- Gent, A. & Gibson S. (eds). 1998. *Herpetofauna Workers' Manual*. Joint Nature Conservation Committee, Peterborough.
- Gent, A.H., & Spellerberg, I.F. 1993. Movement rates of the smooth snake *Coronella austriaca* (Colubridae): a radio-telemetric study. *Herpetological Journal*, **3**(4), 140–146.
- Gleed-Owen, C. & Langham, S. 2012. The Adder Status Project: A conservation condition assessment of the adder (*Vipera berus*) in England, with recommendations for future monitoring and conservation policy. Report to Amphibian and Reptile Conservation. ARC, Bournemouth, UK, 70 pp.
- Goddard, P. 1981. Ecology of the Smooth Snake *Coronella austriaca* Laurenti in Britain. Unpublished PhD thesis, Southampton University.
- Griffiths, R.A. 2004. *Great crested newts (Triturus cristatus) in Europe; Effects of metapopulation structure and juvenile dispersal on population persistence*. In: H.R. Ackakaya, M. Burgman, O. Kindvall, C.C. Wood, P. Sjogren-Gulve, J.S. Hatfield & M.A. McCarthy (eds). *Species Conservation and Management Case Studies*. Oxford University Press, New York, pp 281–291.
- Haubrock, P.J. & Altrichter, J. 2017. Northern crested newt (*Triturus cristatus*) migration in a nature reserve: multiple incidents of breeding season displacements exceeding 1 km. *Herpetology Bulletin*, **138**, 31–33.
- Hilton-Brown, D. & Oldham, R.S. 1991. The status of the widespread amphibians and reptiles in Britain, 1990, and changes during the 1980's. Nature Conservancy Council.
- Howe, L., Day, P., Ellis, M. & Foster, J. 2003. Great Crested Newt SSSI Boundary Guidance. Unpublished internal note, Countryside Council for Wales, Bangor.
- Jefferson, R.G., Smith, S.L.N. & MacKintosh, E.J. 2019. *Guidelines for the Selection of Biological SSSIs. Part 2: Detailed Guidelines for Habitats and Species Groups. Chapter 3 Lowland Grasslands*. Joint Nature Conservation Committee, Peterborough.

- Jehle, R., Thiesmeier, B. & Foster, J. 2011. *The Crested Newt, A dwindling pond-dweller*. Laurenti – Verlag, Bielefeld, Germany.
- Kupfer, A. 1998. Wanderstrecken einzelner Kammolche (*Triturus cristatus*) in einem Agrarlebensraum. *Zeitschrift für Feldherpetologie*, **5**(1/2), 238–241.
- Langton, T., Beckett, C. & Foster, J. 2001. *Great Crested Newt Conservation Handbook*. Froglife, Halesworth.
- Lawton, J.H., Brotherton, P.N.M., Brown, V.K., Elphick, C., Fitter, A.H., Forshaw, J., Haddow, R.W., Hilborne, S., Leafe, R.N., Mace, G.M., Southgate, M.P., Sutherland, W.J., Tew, T.E., Varley, J. & Wynne, G.R. 2010. *Making Space for Nature: a review of England's wildlife sites and ecological network*. Report to Defra.
- McInerny, C. & Minting, P. 2016. *Amphibians and reptiles of Scotland*. Glasgow Natural History Society, Glasgow.
- Moulton, N. & Corbett, K. 1999. *The Sand Lizard Conservation Handbook*. English Nature, Peterborough.
- Nature Conservancy Council. 1983. *The ecology and conservation of amphibian and reptile species endangered in Britain*. Shrewsbury, Nature Conservancy Council.
- Nicholson, M. & Oldham, R.S. 1986. Status of the warty newt *Triturus cristatus*. CSD Report No. 703. Nature Conservancy Council, Peterborough.
- Oldham, R.S., Keeble, J., Swan, M.J.S. & Jeffcote, M. 2000. Evaluating the suitability of habitat for the great crested newt (*Triturus cristatus*). *Herpetological Journal*, **10**, 143–155.
- Petrovan, S.O. & Schmidt, B.R. 2016. Volunteer conservation action data reveals large-scale and long-term negative population trends of a widespread amphibian, the common toad (*Bufo bufo*). *PLoS One*, **11**(10), e0161943.
- Reading, C.J. 2012. Ranging behaviour and home range size of smooth snakes inhabiting lowland heath in southern England. *Herpetological Journal*, **22**, 241–247
- Reading, C.J., Buckland, S.T. McGowan, G.M., Gorzula, S., Jayasinghe, G., Staines, B.W., Elston, D.A. & Ahamadi, S. 1994. Status of the adder *Vipera berus* in Scotland. Scottish Natural Heritage.
- Semlitsch, R.D. & Bodie, J.R. 2003. Biological criteria for buffer zones around wetlands and riparian habitats for amphibians and reptiles. *Conservation Biology*, **17**(5), 1219–1228.
- Sinsch, U. 2017. Wie weit wandern Amphibien? Verhaltensbiologische und genetische Schätzung der Konnektivität zwischen Lokalpopulationen. *Zeitschrift für Feldherpetologie*, **24**(1), 1–18.
- Sinsch, U., Oromi, N., Miaud, C., Denton, J. & Sanuy, D. 2012. Connectivity of local amphibian populations: modelling the migratory capacity of radio-tracked natterjack toads. *Animal Conservation*, **15**(4), 388–396.
- Sewell, D., Griffiths, R.A., Beebee, T.J.C., Foster, J. & Wilkinson, J.W. 2013. *Survey Protocols for the British Herpetofauna: Version 1*. Amphibian and Reptile Conservation, Durrell Institute of Conservation and Ecology, University of Kent and University of

Sussex, 22 pp. (Available at: <https://www.arc-trust.org/Handlers/Download.ashx?IDMF=7c736bcd-9dde-4473-8115-12cf9a5d7462>).

Swan, M.J. & Oldham, R.S. 1993. Herptile sites Volume 1: National Amphibian Survey, Final report. English Nature Research Reports No. 38, Peterborough.

Swan, M.J.S. & Oldham, R.S. 1989. Amphibian Communities Final Report. Unpublished report, Nature Conservancy Council, Peterborough.

Swan, M.J.S. & Oldham, R.S. 1993. Herptile Sites Volume 2: National Common Reptile Survey, Final Report. English Nature Research Reports No. 39, Peterborough, 232 pp.

van Vliet, W., Gent, T. & Edgar, P. 2018. Establishing Favourable Reference Values – example for Great Crested Newt (*Triturus cristatus*) in England. Paper on EC Article 17 Reference Portal (Available from: [http://cdr.eionet.europa.eu/help/habitats\\_art17](http://cdr.eionet.europa.eu/help/habitats_art17)).

Wilkinson, J.W., Arnell, A., Driver, D. & Driver, B 2014. Elaborating the distribution of the great crested newt in Scotland (2010-2011). SNH Commissioned Report No. 793, Scottish Natural Heritage, Inverness.

Wilkinson, J.W. & Arnell, A.P. 2013. NARRS Report 2007-2012. Establishing the baseline. Amphibian & Reptile Conservation Research Report 13/01, ARC, Bournemouth.

Wilkinson, J.W., Wright, D., Arnell, A. & Driver, B. 2011. Assessing population status of the great crested newt in Great Britain. Natural England Commissioned Reports, Number 080.

## 8 Useful online resources

SSSI condition reports at UK level: <https://jncc.gov.uk/our-work/common-standards-monitoring/#common-standards-monitoring-report-2006>.

Habitats Directive reports on conservation status (Article 17 reports): <https://jncc.gov.uk/our-work/article-17-habitats-directive-report-2019/>.

Amphibian and Reptile Conservation Trust website, for information on species status: [www.arc-trust.org](http://www.arc-trust.org).