Measuring the pulse
of European biodiversity

European Red List of Amphibians

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European Commission
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SSC Species Survival Commission
ASG IUCN SSC Amphibian Specialist Group

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All data produce through this project are available via the IUCN Red List Data Repository:
www.iucnredlist.org/resources/data-repository

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Salamandrina perspicillata (Endangered) © Antonio Romano

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Executive summary

Aim

The European Red List is a review of the conservation status of selected European taxa, including all vertebrate species (mammals, amphibians, reptiles, birds and fishes), terrestrial and aquatic molluscs, dragonflies, butterflies, bees, grasshoppers, crickets and bush-crickets, trees, medicinal plants, bryophytes (mosses, liverworts and hornworts), hoverflies, and pteridophytes (ferns and lycopods), and selected saproxylic beetles, endemic shrubs, moths (in prep.) and further selected vascular plants (including crop wild relatives and 'policy' taxa that appear on international policy instruments such as the EU Habitats Directive) according to IUCN regional Red List guidelines. It identifies those species that are threatened with extinction at the regional level – in order that appropriate conservation action can be taken to improve their status. This European Red List publication summarises the results for European amphibians.

Scope

All amphibian species native to Europe or naturalised in Europe before 1500 CE are included. The geographical scope of the assessments is continent-wide, extending from Iceland in the west to the Urals in the east, and from Franz Josef Land in the north to the Canary Islands in the south. The Caucasus region, including the Russian Northern Caucasus, is excluded. Red List assessments were made at two regional levels: for geographical Europe and for the current 27 Member States of the European Union.

Status assessment

The status of all species was assessed using the IUCN Red List Categories and Criteria (IUCN 2012a), which are the world's most widely accepted system for measuring extinction risk. All assessments followed the Guidelines for the application of the IUCN Red List criteria at regional and national levels (IUCN 2012b). Regional assessments were developed and updated through correspondence with relevant experts in a series of workshops and interviews from 2015 to 2023. More than 130 herpetologists actively participated in the assessment and review process for European reptiles and amphibians. Assessments and distribution maps are available on the IUCN Red List website (www.iucnredlist.org) and Data Repository (www.iucnredlist.org/resources/data-repository).

Results

Overall, nearly one-third of amphibians are considered threatened in Europe, with a similar proportion threatened at the EU level. A further 8% of European amphibians are considered Near Threatened. More than three-quarters of European amphibians (76%) have declining populations; a further 15% of species have stable population trends, whilst only 2% are increasing. The overwhelming majority of threatened and Near Threatened amphibian species are endemic to both Europe and the EU, highlighting the responsibility that European countries have to protect the entire global populations of these species. Almost all (96%) of species considered threatened (Critically Endangered, Endangered, or Vulnerable) at the European level are endemic to Europe and are found nowhere else in the world. Amphibian species richness is greatest in the south of the continent (Italy, Spain and throughout the south/eastern Balkans e.g. Bulgaria and Greece), but also in France (which is the second most species-rich European country richest in amphibians), as well as on islands. Invasive species and diseases are the most significant identified threat to amphibians in Europe. Other major threats include pollution and urban and commercial development.

Conclusions

- Threatened amphibians in Europe require urgent action to improve their status. Priorities identified in this study include addressing threats such as invasive species, pathogens, and pollution, which have been intensifying since the last regional assessment, as well as habitat destruction and degradation, particularly of aquatic habitats such as small water bodies, despite overall efforts to educate the public and decision-makers on amphibian conservation.

- Species can be, and some already have been, saved from extinction. Species like the Mallorcan Midwife Toad *Alytes muletensis* would almost certainly now be extinct were it not for intensive ongoing conservation efforts. However, we need more such success stories realised to ensure that amphibian conservation in Europe is progressing. Threats such as invasive alien species, disease, and climate change have been intensifying, as does, in some parts of the continent, the unconscionable destruction of natural habitats.

- Sustained species-, site- and landscape-level conservation efforts are spreading among European countries, although with variable success. Although the green agenda is becoming imperative, there is a risk that it is being implemented only in some parts of the continent. To ensure that European species are secure in the long term, conservation action must be implemented in all policy sectors as a priority.

1. Background

1.1 The European context

Europe is one of the seven continents on Earth, and both physically and geologically it is the westernmost peninsula of Eurasia. Europe is bound to the north by the Arctic Ocean, to the west by the Atlantic Ocean, to the south by the Mediterranean Sea, and to the southeast by the Black Sea and the Caucasian Mountains. In the east, Europe is separated from Asia by the Ural Mountains and by the Caspian Sea (see Figure 1 below). Europe is the world's second-smallest continent in terms of area, covering approximately 10,530,000 km^2.

The European Union, comprising 27 Member States (EU27), is Europe's largest political and economic entity. It is the world's largest economy with an estimated Gross Domestic Product (GDP) in 2022 of 18.8 trillion euros (EUROSTAT, 2022). Per-capita GDP in many EU states is among the highest in the world, and rates of resource consumption and waste production are correspondingly high – the EU's "ecological footprint" has been estimated to exceed the region's biological capacity (the total area of cropland, pasture, forest, and fishing grounds available to produce food, fibre and timber, and absorb waste) by 2.6 times (WWF, 2007).

The EU's Member States stretch from the Arctic Circle in the north to the Mediterranean in the south, and from the Atlantic coast and several Atlantic islands in the west to the Danube Delta and Cyprus in the east – an area containing a great diversity of landscapes and habitats, and a wealth of flora and fauna. Mediterranean Europe is particularly rich in plant and animal species and has been recognised as a global "biodiversity hotspot" (Mittermeier et al., 2004; Cuttelod et al., 2008).

Europe has arguably the most highly anthropogenically fragmented landscape of all continents, and only a tiny fraction of its land and freshwater surface can be considered as wilderness. For centuries most of Europe's land has been used by humans to produce food, timber and fuel and provide living space. About 80% of Europe's land surface has been shaped by human activities: covered with buildings, roads, industrial infrastructure or used for agriculture. The way the land is used constitutes one of the main drivers of environmental degradation and climate change (European Environment Agency, 2024). Consequently, European species are to a large extent dependent upon semi-natural habitats created and maintained by human activity, particularly traditional, non-intensive forms of land management. These habitats are under pressure from agricultural intensification, urban sprawl, infrastructure development, land abandonment, acidification, eutrophication and desertification. Many species are directly affected by overexploitation, persecution and impacts of alien invasive species, and climate change is set to become an even more increasingly serious threat in the future. Europe is a huge, diverse region and the relative importance of different threats varies widely across its biogeographic regions and countries. Although considerable efforts have been made to protect and conserve European habitats and species, biodiversity decline and the associated loss of vital ecosystem services (such as water purification, crop pollination, and carbon sequestration) continue to be a major concern in the region.

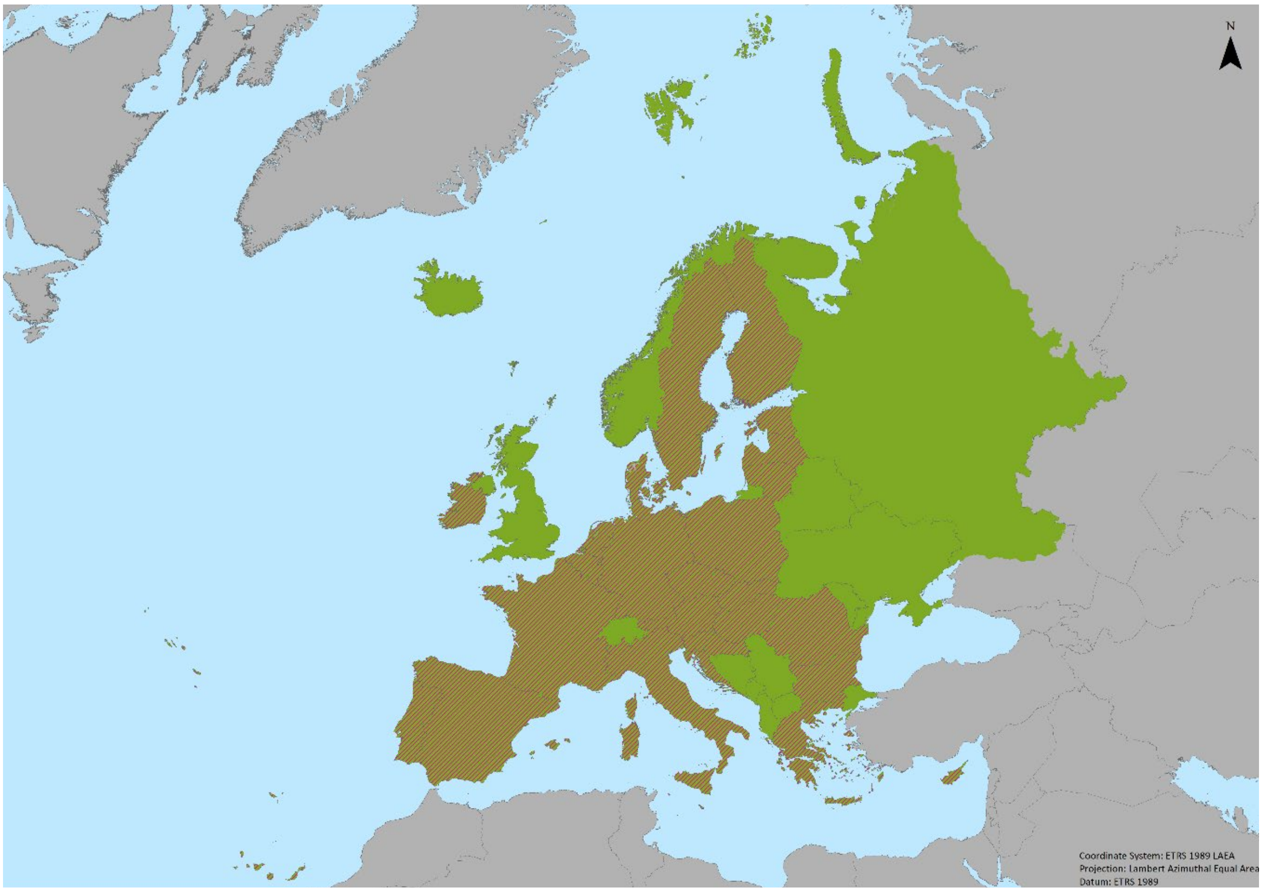

Figure 1. *The European Red List terrestrial assessment boundaries. Regional terrestrial assessments were made for two areas: for geographical Europe (green), and for the EU27 Member States (hatched area).*

Riparian forest along the Sava River in the southern part of Pannonian Plain. These places are often key habitats for European amphibians. © Jelka Crnobrnja-Isailović

1.2 The European policy context

Besides its intrinsic and environmental value, biodiversity is integral to sustainable development as it provides resources and services that are critical for human well-being. Despite this, biodiversity loss is today one of the world's most critical crises. The causes of this phenomenon are often very complex, and solutions require the involvement of various stakeholders acting at different scales. Over the decades, a diverse set of policy tools and frameworks have developed throughout the European region to address biodiversity loss, along with its causes and consequences. These include the Convention on the Conservation of European Wildlife and Natural Habitats (the Bern Convention).

The Bern Convention, which came into force in 1982, is a binding international legal instrument focused on nature conservation across 49 states and the EU and extending to some African states. The Convention aims to ensure the conservation of wild flora and fauna species and their habitats, including migratory species, with a focus on endangered and vulnerable species, specified in four appendices, of which two are relevant to amphibians; Appendix II (strictly protected fauna species) and Appendix III (protected fauna species).

The Bern Convention established (Recommendation No. 16 (1989) of the Standing Committee to the Bern Convention) the Emerald Network of national-level protected areas (Emerald Network of Areas of Special Conservation Interest) as one of the main tools for Convention parties to comply with their obligations under the Bern Convention and their implementation of the appendices.

In the European Union, species-focused conservation is implemented primarily through the Birds Directive (entered into force in 1979, amended in 2009) and followed by the 1992 Habitats Directive (HD), which provided for the establishment of a representative system of legally protected areas throughout the EU. These HD protected areas are termed Sites of Community Importance (SCI) and aim to support the conservation of the 233 habitat types listed in Annex I of the Directive and the >900 species (and infrataxa) listed in Annex II of the Habitats Directive. Collectively, the protected areas designated under the Birds and Habitat directives are termed the Natura 2000 network.

The Habitats Directive and subsequently the Natura 2000 network were established to fulfil the EU's obligations to the Bern Convention, and Natura 2000 sites are therefore considered as the EU Member States' contribution to the Pan-European Emerald Network of the Bern Convention. The two networks are fully compatible and use the same methodology and information tools. Whereas Natura 2000 applies to the EU Member States, the Emerald Network applies to much of the rest of Europe.

In May 2011, the European Union (EU) adopted a strategy entitled 'Our life insurance, our natural capital: an EU biodiversity strategy to 2020', designed to halt biodiversity loss in the region. It set out six targets and 20 actions to halt the loss of biodiversity and ecosystem services in the EU Member States by 2020. Despite its achievements, the Strategy failed to reach several of its objectives (EC, 2022). This has led the EU to embark on "a path to recovery by 2030" through a new EU Biodiversity Strategy for 2030, featuring specific actions and commitments to protect nature and reverse the degradation of ecosystems by 2030. As a core part of the European Green Deal, the Biodiversity Strategy will also support a green recovery following the COVID-19 pandemic.

However, without reliable and timely information on the status and trends of biodiversity, it is not possible to build an actionable knowledge and evidence base for curbing the extinction crisis. Effective action hinges upon both rapid and consistent monitoring of the status of species and measuring the impacts of human activities. One of the available tools to assess the status and trends of species is The IUCN Red List of Threatened Species™, a highly authoritative and objective methodology for classifying species by their extinction risk. Red List assessment also holds the potential to inform the development of European biodiversity indicators, through the Streamlining European Biodiversity Indicators

(SEBI) process, and to help improve the general understanding among policymakers, interested parties, and the public of the need for European conservation action on biodiversity and ecosystem services. This is the context for the development and publication of this updated *European Red List of Amphibians*.

Table 1. *Overview of amphibian species mentioned in the Bern Convention Annex II, the EU Habitats Directive Annexes (II or IV), and the species that are endemic to Europe. Brackets indicate that a species is considered to inherit the listed status of its parent taxon. For example,* Alytes almogavarii *is considered to be listed given the listed status of its parent taxon,* Alytes obstetricans, *under both the Habitats Directive and the Bern Convention.*

Species	Bern Convention	Habitat Directive	CITES	EU wildlife trade regulations	Endemic to Europe (*)/ Endemic to EU (**)
Alytes almogavarii	(II)	(IV)			**
Alytes cisternasii	II	IV			**
Alytes dickhilleni	(II)	(IV)			**
Alytes muletensis	II	II, IV			**
Alytes obstetricans	II	IV			*
Bombina bombina	II	II, IV			
Bombina variegata	II	II, IV			*
Bufotes balearicus	II	IV			**
Bufotes cypriensis	(II)	(IV)			**
Bufotes viridis	II	IV			
Calotriton arnoldi	(II)	(IV)			**
Calotriton asper	II	IV			*
Chioglossa lusitanica	II	II, IV			**
Discoglossus galganoi	II	II, IV			**
Discoglossus montalentii	II	II, IV			**
Discoglossus pictus	II	IV			
Discoglossus sardus	II	II, IV			**
Epidalea calamita	II	IV			*
Euproctus montanus	II	IV			**
Euproctus platycephalus	II	IV			**
Hyla arborea	II	IV			*
Hyla intermedia		IV			*
Hyla meridionalis	II	IV			
Hyla molleri	(II)	(IV)			**
Hyla sarda	II	IV			**
Ichthyosaura alpestris					*
Lissotriton boscai					**
Lissotriton graecus					*
Lissotriton helveticus					*
Lissotriton italicus	II	IV			**
Lissotriton maltzani					**
Lissotriton montandoni	II	II, IV			*

Lissotriton vulgaris					*
Lyciasalamandra helverseni	(II)	(II, IV)			**
Lyciasalamandra luschani	II	II, IV			
Pelobates balcanicus	(II)	(IV)			*
Pelobates cultripes	II	IV			**
Pelobates fuscus	II	II, IV			*
Pelobates syriacus	II	IV			
Pelodytes atlanticus					**
Pelodytes ibericus					**
Pelodytes punctatus					**
Pelophylax cerigensis					**
Pelophylax cretensis					**
Pelophylax cypriensis					**
Pelophylax epeiroticus					*
Pelophylax kurtmuelleri					*
Pelophylax lessonae		IV			*
Pelophylax perezi					**
Pelophylax shqipericus				D	*
Proteus anguinus	II	II, IV			*
Rana arvalis	II	IV			
Rana dalmatina	II	IV			
Rana graeca		IV			*
Rana iberica	II	IV			**
Rana italica	II	IV			*
Rana latastei	II	II, IV			*
Rana parvipalmata					**
Rana pyrenaica					**
Salamandra algira			II	C	
Salamandra atra	II	II, IV			*
Salamandra corsica					**
Salamandra lanzai	II	IV			**
Salamandra salamandra					*
Salamandrina perspicillata	II	II, IV			**
Salamandrina terdigitata	II	II, IV			**
Speleomantes ambrosii		II, IV			**
Speleomantes flavus	II	II, IV			**
Speleomantes genei	II	II, IV			**
Speleomantes imperialis	II	II, IV			**
Speleomantes italicus	II	IV			**
Speleomantes sarrabusensis		(II, IV)			**
Speleomantes strinatii		II, IV			**

Speleomantes supramontis	II	II, IV	**
Triturus carnifex	II	II, IV	*
Triturus cristatus	II	II, IV	
Triturus dobrogicus	II	II	*
Triturus karelinii	II	II, IV	
Triturus macedonicus	II	II, IV	*
Triturus marmoratus		IV	**
Triturus pygmaeus		(IV)	**

1.3 European amphibians: diversity and endemism

Amphibians form a class of vertebrates that includes frogs, toads, salamanders, newts, and caecilians. All amphibians are ectotherms, meaning that their body temperature regulation is highly dependent on external temperature sources and the behavioural exploration of the different thermal niches available in a particular habitat (de Andrade, 2016), and most lay eggs in water. Through their life cycle, most amphibian species undergo metamorphosis, changing from a usually aquatic larval stage into terrestrial juveniles and adults. A significant minority of amphibians develop directly from eggs - then usually laid on land - without undergoing a larval stage and a few viviparous species reproduce without laying eggs at all, sometimes without an aquatic phase. Amphibians are known for their connection with water as almost all species are dependent on moist conditions, and many rely on freshwater habitats for breeding. Some species are restricted to freshwater habitats for their whole life cycle, both as larvae and adults. It is no coincidence that the greatest diversity in amphibians is found in ecosystems rich in water and humidity such as tropical forests, whereas species richness is generally lower in temperate and arid regions. It should be noted that amphibians are excellent indicators of environmental quality, as they are very sensitive to perturbations in ecosystems (Temple and Cox, 2009). These animals are absent from marine environments, but some can tolerate brackish waters.

In Europe, amphibians can be divided into two distinctive orders: Anura (frogs and toads) and Caudata (newts and salamanders). It is important to note that since the first *European Red List of Amphibians* (Temple and Cox, 2009), scientific names and taxonomy have undergone a number of changes. Temple and Cox (2009) assessed 85 species (58 Anura species and 27 Caudata species), excluding a further five species as Not Applicable. According to the *Amphibian Species of the World* species list, which is followed by the IUCN SSC Amphibian Specialist Group (ASG), on 1st January 2023, the frogs and toads of Europe amounted to 55 species (not including two allochthonous species – one of the family Pipidae and another one of the family Ranidae), while newts and salamanders included 42 species. Seventy (71%) of these 97 species are endemic to Europe, where the largest families are the Salamandridae (newts and relatives) with 32 species, and the Ranidae (true frogs) with 20 species. Within the Anura, nine of the world's twelve species of the Alytidae family (i.e. painted frogs and midwife toads) are found in Europe, where eight of these species are endemic to the region. Three of the world's four species of Pelodytidae (i.e. parsley frogs) are found in Europe, all three being European endemics. All six members of the Pelobatidae (i.e. Eurasian spadefoots) occur in the region, with three of these being endemic to Europe. The monotypic genus *Epidalea* (until recently included within the genus *Bufo*) is also endemic to Europe. As to Caudata, 32 species of the family Salamandridae are present in

Europe, amounting to over 22% of the world's species. Importantly, five European genera of Salamandridae (*Calotriton*; *Chioglossa*; *Euproctus*; *Ichthyosaura*; *Salamandrina*) are endemic to the region. Europe also hosts eight endemic cave salamanders belonging to the lungless salamanders Plethodontidae family. Along with the Korean *Karsenia koreana* (Min et al., 2005), these are the only Old-World members of a family that has around 496 species in the Americas. Finally, the single Old-World member of the Proteidae, *Proteus anguinus,* is endemic to Europe while the other eight members of the family occur in eastern North America.

Table 2. *Diversity and endemism in amphibian orders and families in Europe and in the EU27 region. Species of marginal occurrence in Europe and/or the EU are included, with the number of marginal occurrence Not Applicable (NA) species shown in [brackets]. This table includes species that are native or naturalised prior 1500 CE and species of marginal occurrence in Europe and/or the EU. Not Applicable non-native species introduced after this date are not included.*

Order	Family	Number of species	Endemic Europe	Endemic EU27
Anura	Alytidae	9	8 (89%)	7 (78%)
	Bombinatoridae	2	1 (50%)	0 (0%)
	Bufonidae	8 [1]	3 (38%)	2 (25%)
	Hylidae	7	4 (57%)	2 (29%)
	Pelobatidae	6 [1]	3 (50%)	1 (17%)
	Pelodytidae	3	3 (100%)	1 (33%)
	Ranidae	20 [1]	14 (70%)	7 (35%)
	SUBTOTAL	55 [3]	36 (65%)	20 (36%)
Caudata	Hynobiidae	1	0 (0%)	0 (0%)
	Plethodontidae	8	8 (100%)	8 (100%)
	Proteidae	1	1 (100%)	0 (0%)
	Salamandridae	32 [1]	25 (78%)	14 (44%)
	SUBTOTAL	42 [1]	34 (81%)	22 (52%)
TOTAL		**97 [4]**	**70 (72%)**	**42 (43%)**

In summary, the number of amphibian species in Europe has increased from the last regional Red List assessment (Temple and Cox, 2009) from 88 to 97 species. This increase in species numbers has been the result of the upgrading to species-level of the taxonomic status of certain clades within already existing species, placing them as separate species based on the results of the application of molecular genetic techniques in phylogeographic studies. The proportion of endemic species has not changed (72%). Additionally, the number of amphibian species within the EU since the last regional assessment has increased, from 84 to 93 species, excluding Not Applicable species such as *Pelophylax shqipericus*, which occurs in the EU as a result of introduction. However, 43% of European species are now considered to be endemic to the EU, in contrast to the 54.8% recorded in 2009.

According to the *Atlas of Amphibians and Reptiles in Europe* (Gasc et al., 1997), at the end of the 20th century, 65 amphibian species occurred in the region - 30 tailed amphibians (Caudata) and 35 tailless amphibians (Anurans), including the introduced American Bullfrog *Rana catesbeiana* (now *Aquarana catesbeianus*). Sillero et al. (2014) updated the list of European amphibians with an additional seven species – 31 Caudata species and 41 Anuran species, including two allochthonous ones (*Aquarana catesbeianus* and *Xenopus laevis*) and provided an updated distribution atlas.

It is important to mention that five Anura and three Caudata "species" on that list were, in fact, species complexes. The most recent taxonomic revision, made by the Taxonomic Committee of Societas Europaea Herpetologica (Speybroeck et al., 2020), confirmed the species status of 95 amphibian taxa occurring on European territory: 41 Caudata and 54 Anura including the allochthonous *Xenopus laevis* and *Aquarana catesbeianus*. The new amphibian species recognised by Speybroeck et al. (2020) were earlier defined as genetically differentiated population groups or questionable independent taxonomic units (former infrataxa) mostly occurring within widespread species. The rapid increase in the application of molecular genetic techniques in European amphibian taxonomy started in the last decade of the 20th century and, since then, has revealed many "hidden" taxa (see Wallis and Arntzen, 1989; Recuero et al., 2012; Wielstra et al., 2014; Dufresnes et al., 2019a,b).

*The Western Spadefoot (*Pelobates cultripes*) digs its burrows in sandy and soft soil and relies largely on temporary ponds for breeding. © Julia Wittmann*

1.4 Assessment of extinction risk

The conservation status of plants, animals and fungi is one of the most widely used indicators for assessing the condition of ecosystems and their biodiversity. At the global scale, the primary source of information on the extinction risk of plants and animals is The IUCN Red List of Threatened Species™ (www.iucnredlist.org), which contributes to the understanding of the conservation status of assessed species. The IUCN Red List Categories and Criteria (IUCN, 2012a) are designed to determine the relative risk of extinction of a taxon, with the main purpose of cataloguing and highlighting those taxa that are facing an elevated risk of extinction. Red List assessments are policy-relevant and can be used to inform conservation planning and priority-setting processes, but they are not intended to be policy-prescriptive and are not in themselves a system for setting biodiversity conservation priorities.

The IUCN Red List Categories are based on a set of quantitative criteria linked to population trends, size and structure, threats, and the geographic ranges of species. There are nine categories, with species classified as Vulnerable (VU), Endangered (EN) or Critically Endangered (CR) which are considered 'threatened'. When conducting regional assessments of taxa that are not endemic to the region being assessed, the IUCN Red List Regional Guidelines (IUCN, 2012b) must be applied, and two additional categories are used: Regionally Extinct (RE), and Not Applicable (NA) (see Figure 2). As the extinction risk of a species can be assessed at global, regional, or national levels, a species may be classified under different Red List Categories depending on the scale of assessment, considering the population of that species at each geographical level. Logically, a species that is endemic to the EU27 region would have a single assessment, as it is not present anywhere else in the world.

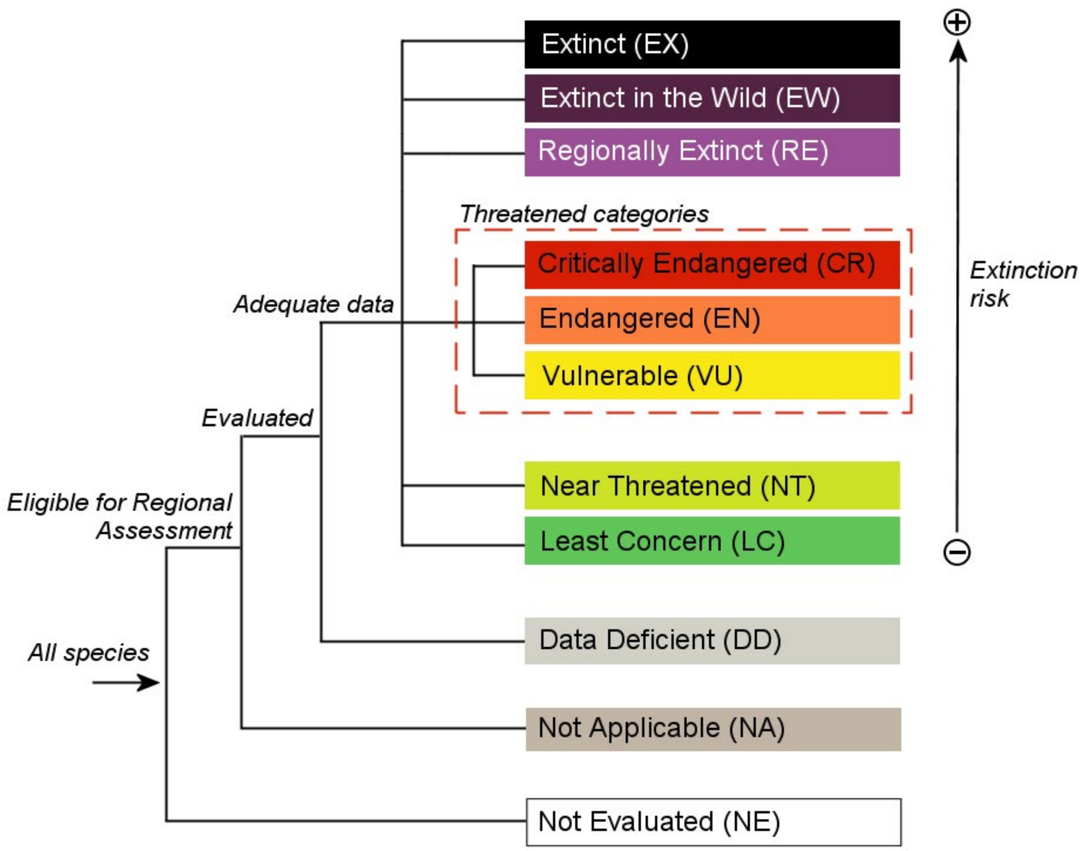

Figure 2. *The IUCN Red List Categories at the regional scale (IUCN, 2012b).*

1.5 Objectives of the assessment

This updated *European Red List of Amphibians* had five main objectives:

- To update the *European Red List of Amphibians*, considering the latest information on the latest trends and threats that amphibians experienced.
- To identify geographical areas and habitats in need of urgent protection to prevent extinctions and to ensure that European amphibians reach and maintain a favourable conservation status.
- To identify the major threats to European amphibians and to propose potential mitigating measures and conservation actions to address them.
- To use the knowledge mobilised to contribute to regional amphibian conservation planning.
- To strengthen the network of amphibian experts in Europe, so that the knowledge can be kept current, and expertise can be recruited to address the highest conservation priorities.

The assessment produced three main outputs:

- An updated report on the status of all European amphibians (this report).
- A website (www.iucnredlist.org) where the individual assessments and distribution maps are published.
- A data portal (www.iucnredlist.org/resources/datarepository) showcasing these data in the form of downloadable assessment data, distribution maps, and the species list for all European amphibians included in this study.

This European Red List is a completely revised second edition. It is a comprehensive, region-wide assessment of amphibians, built on the previous work done for the first *European Red List of Amphibians* (Temple and Cox, 2009), and incorporates many new data contributed from personal and institutional databases from across the European region. The substantial amount of fieldwork, data and accumulated knowledge means that this assessment is based on a robust trend analysis by many experts. The individual species assessments will continue to be updated periodically by the ASG as new information becomes available.

*The Olm (*Proteus anguinus*) lives in subterranean aquatic systems up to 1,500 m deep. Increasing groundwater pollution is a threat to this species. © swveenstra*

2. Assessment methodology

2.1 Geographic scope

The geographic scope of this European Red List spans the entirety of the European continent. It extends from Iceland, Svalbard and Franz Josef Land (Земля́ Фра́нца-Ио́сифа) in the north to the Canary Islands in the south, and from the Azores in the west to Ukraine and the Ural Mountains in the east, including the European part of Türkiye ('Türkiye-in-Europe'), and most of the European parts of the Russian Federation. Cyprus, the European Macaronesian islands (the Canaries, Madeiran and Azores archipelagos) and the Spanish North African Territories (Ceuta, Melilla, and the Plazas de Soberanía) are included in the assessment region, whereas the North Caucasus parts of European Russia (e.g. Krasnodar Krai, Republic of Dagestan, Stavropol Krai and other administrative units within the Russian Northern Caucasus) fall beyond the European scope of this European Red List. The extent of the geographic scope of this European Red List is portrayed in Figure 1.

Red List assessments were made at two regional levels: 1) for geographical Europe (limits described above); and 2) for the area of the 27 Member States of the European Union. In comparison with the previous European Red List of Amphibians (Temple and Cox, 2009) the EU assessment region now includes Croatia but no longer includes the United Kingdom.

2.2 Taxonomic scope

The Amphibian Specialist Group (ASG) of IUCN's Species Survival Commission (SSC) leads the global assessment of all amphibians and uses the *Amphibian Species of The World* online database as its taxonomic authority. This *European Red List of Amphibians* was updated according to the taxonomic changes referred to in the *Amphibian Species of The World* online database up to January 2023 (Frost, 2023). At that time, this database had listed 42 Caudata species and 55 anuran species native or naturalised in Europe before 1500 CE defined for the purpose of updating the regional Red List. Based on this, the Red List assessment analyses the threat status of 70 European endemic amphibian species and an additional 27 amphibian species whose distribution range partly overlaps with the Pan Europe assessment area covered in this report. Anurans or tailless amphibians – frogs and toads – in Europe are represented by eight families: Alytidae (nine species), Bombinatoridae (two species), Bufonidae (eight species), Hylidae (seven species), Pelobatidae (six species), Pelodytidae (three species) and Ranidae (20 species). Caudata or tailed amphibians - salamanders and newts - in Europe belong to four families: Hynobiidae (one species), Plethodontidae (eight species), Proteidae (one species) and Salamandridae (32 species).

It should be noted that since the end of 2022/ start of 2023, taxonomic changes have been implemented in Frost's list for some of the species listed in this report: the synonymisation of *Bufotes balearicus* with *B. viridis* (Speybroeck et al., 2020); the synonimisation of *Pelophylax bedriagae*, *P. cerigensis, P. cypriensis, P. kurtmuelleri* with *P. ridibundus* (Dufresnes et al., 2024), and the splitting of *Triturus pygmaeus* with *T. pygmaeus* and *T. rudolfi* (Arntzen, 2024). These changes are updated on the Red List website but could not be applied in this report due to the timeline of the publication.

This *European Red List of Amphibians* has assessed the status of all amphibian species native to Europe or naturalised there before 1500 CE, amounting to a total of 93 taxa. An additional six species - introduced to Europe by humans after 1500 CE or vagrant species (i.e. taxa found only occasionally in Europe) - have been considered Not Applicable (NA). The original species list published in 2009 harboured fewer amphibian species (85) but with a slightly higher proportion of endemic species (75.3%) than the present one (see Table 2). Taxonomic changes from 2009 (Temple and Cox, 2009) onward included both those at the genus and species level: the number of anuran genera native and naturalised before 1500 CE increased from 12 to 13, due to renaming *Bufo mauritanicus* to *Sclerophrys mauritanica*. The number of anuran species increased (from 54 to 57) due to downlisting of seven species (*Discoglossus jeanneae*, *Bombina pachypus, Pseudepidalea sicula* (later *Bufotes siculus*), *P. variabilis* (later *B. variabilis*), *Pelophylax bergeri, Pelophylax grafi* and *P. hispanicus*), exclusion of one species (*Pelophylax esculentus*) and inclusion of one NA species (*Pelobates varaldii*) and ten new species - *Alytes almogavarii* (Dufresnes and Martínez-Solano, 2020), *Bufo spinosus* (Recuero et al., 2012), *Bufotes cypriensis* (Dufresnes et al., 2019a), *Hyla molleri*, *Hyla orientalis* (Stöck et al., 2008), *Pelobates balcanicus* (Dufresnes et al., 2019b), *P. vespertinus* (Suryadnaya, 2014), *Pelodytes atlanticus* (Díaz-Rodríguez et al., 2017), *Pelophylax cypriensis* (Plötner et al., 2012) and *Rana parvipalmata* (Dufresnes et al., 2020a). Distinct subpopulations and subspecies of amphibians within Europe were not individually assessed as part of this project, although some species-level assessments do refer to information for component taxa. Within Caudata, the number of species increased from 35 in 2009 (Temple and Cox, 2009) to 42 in 2023, due to inclusion of *Salamandrella keyserlingii* and *Salamandra algira* in the regional list and taxonomical changes - three new species of the genus *Lissotriton* - *L. graecus* (Pabijan et al., 2017), *L. maltzani* (Sequeira et al., 2020) and *L. schmidtleri* (Pabijan et al., 2017) and two new species of the genus *Triturus* - *T. ivanbureschi* (Wielstra et al., 2013) and *T. macedonicus* (Arntzen et al., 2007). Since the 2009 report, some new species have been described but not yet accepted by taxonomic authorities (e.g. *Hyla perrini*, which is currently retained within *H. intermedia*).

This European Red List assesses species belonging to the Caudata (tailed amphibians or salamanders and newts) and Anura (tailless amphibians or frogs and toads) orders (see Table 3). The following families of tailed amphibians have been considered in this work: Hynobiidae (one genus and one species), Plethodontidae (one genus and eight species), Proteidae (one genus and one species) and Salamandridae (ten genera and 32 species). As for tailless amphibians, the Alytidae (two genera and nine species), Bombinatoridae (one genus and two species), Bufonidae (four genera and eight species), Hylidae (one genus and seven species), Pelobatidae (one genus and six species), Pelodytidae (one genus and three species) and Ranidae (three genera and 20 species) families have been assessed.

Table 3. *The list of amphibian orders/families assessed for this European Red List update. Not Applicable (NA) species are included, except for the two allochthonous recent introductions (*Xenopus laevis *and* Aquarana catesbeianus*).*

Caudata (42) (tailed amphibians)	Hynobiidae (1)
	Plethodontidae (8)
	Proteidae (1)
	Salamandridae (32)
Anura (55) (tailless amphibians)	Alytidae (9)
	Bombinatoridae (2)
	Bufonidae (8)
	Hylidae (7)
	Pelobatidae (6)
	Pelodytidae (3)
	Ranidae (20)

*The Pyrenean Frog (*Rana pyrenaica*) is a European endemic frog found only in Spain and France. © Benny Trapp*

2.3 Assessment protocol

Assessments were undertaken following the *IUCN Red List Categories and Criteria Version 3.1* (IUCN, 2012a), the *Guidelines for the application of the IUCN Red List Criteria at regional and national levels* (IUCN, 2012b), and the *Guidelines for Using the IUCN Red List Categories and Criteria* (IUCN Standards and Petitions Committee, 2024), and the correct interpretation of the terms and application of criteria were ensured through training workshops.

The IUCN Species Information Service (SIS) online database was used to store relevant information for each species, based mostly on published data but also unpublished data and expert knowledge. This online database includes:

- Taxonomic classification and notes.
- Geographic range (descriptive, Area of Occupancy, Extent of Occurrence).
- List of countries of occurrence.
- Population information and overall population trend.
- Habitat preferences and primary ecological requirements.
- Major threats.
- Conservation measures (in place and needed).
- Red List assessment.
- Key literature references.

For each species, a Red List Category is based on the selection of a set of standardised criteria and justified by an assessment rationale (IUCN 2012a,b). For recently introduced species and taxa with marginal or vagrant occurrence in Europe, a brief Not Applicable species factsheet was produced, without a distribution map.

The lead assessor (Jelka Crnobrnja-Isailović) compiled draft Red List assessments, with information based on the earlier European Red List regional assessments (Temple and Cox, 2009) or on more recent global Red List assessments produced by the IUCN Global Amphibian Assessment initiative (ASG, Conservation International and NatureServe). Draft assessments were updated with current information based on published and unpublished data and following consultation with experts from across the European region. Throughout the project, the lead assessor and regional experts have worked together – with the support of IUCN staff – to discuss the selection of species, taxonomic issues, distribution maps, and all other technical matters. This collaborative process developed assessments and distribution maps for each species that represent the current state of knowledge for each species.

Where the reassessment resulted in a species moving into a different Red List Category from that assigned in the first *European Red List of Amphibians*, the assessment indicates whether this change occurred for genuine or non-genuine reasons:

<u>Non-genuine reasons</u>

- New information has become available since the last assessment (e.g., new or more recent data are available on population sizes, threatening processes, rates of decline or recovery, etc.).
- There has been a taxonomic revision resulting in the species no longer being the same concept as it was before (e.g., it is now split into several species each with smaller ranges, population sizes, etc.; or it has been merged with other species so the range, population size, etc. are now larger than they were previously).
- An error has been discovered in the previous assessment (e.g., the wrong information was used; the IUCN Red List Categories and Criteria were applied incorrectly; etc.).
- The previous assessment used an older version of the IUCN Red List Categories and Criteria, and the reassessment uses the current criteria which have slightly different thresholds.

<u>Genuine reasons</u>

- The main threats are no longer present, or conservation measures (e.g., reintroduction, habitat protection or restoration, legal protection, harvest management, etc.) have

successfully improved the status of the species enough to downlist it to a lower category of threat.
- The main threats have continued unabated, have increased, or new threats have developed causing the status of the species to deteriorate enough to move it into a higher category of threat.

The overall process aimed at creating final scientifically robust species assessments based on expert consensus and supported by relevant and trustworthy literature and data. The results of this exercise and related analysis of the data are found in this report.

Consistency in the application of the IUCN Categories and Criteria was checked by the IUCN European Regional Office staff and the IUCN Red List Unit. The resulting finalised set of IUCN Red List assessments is a product of scientific consensus concerning species status supported by relevant literature and data sources.

2.4 Species mapping

Amphibian species maps were created using distribution data available from existing published global and European regional Red List assessments, published literature, plausibility-checked internet sources, and several global and regional citizen science projects. The data available varied immensely in terms of quality; for some regions, distributional data were available as point locality data (latitude/longitude) or in grid cell format and were therefore spatially precise. Where point or grid data were available, these were projected in a Geographical Information System (GIS; ESRI ArcMap). Polygons were then drawn manually, clustering occurrence data where appropriate.

The spatial analyses presented in this publication (see section 3) were analysed using a geodesic discrete global grid system, defined on an icosahedron, and projected to the sphere using the inverse Icosahedral Snyder Equal Area (ISEA) Projection (S39). This corresponds to a hexagonal grid composed of individual units (cells) that retain their shape and area (864 km^2) throughout the globe. These are more suitable for a range of ecological applications than the most commonly used rectangular grids (S40).

For the spatial analyses, species distributions with the following presence, origin and seasonality codes were included: presence = extant, possibly extinct; origin = native, reintroduced, assisted colonisation; and all seasonality codes (resident, breeding season, non-breeding, passage, seasonal occurrence uncertain) and converted to the hexagonal grid (see section 3.4). The occurrence information can be found here. Polygons coded as 'possibly extant', 'extinct', 'presence uncertain', 'introduced', 'vagrant' and/or 'origin uncertain' were not considered in the analyses. Coastal cells were clipped to the coastline. Thus, patterns of species richness considered 93 species (Figure 9) and were mapped by counting the number of species in each cell (or cell section, for species with a coastal distribution). Patterns of endemic species richness (70 species) were mapped by counting the number of species in each cell (or cell section for coastal species) that were flagged as being endemic to geographic Europe as defined in this project (Figure 11). Patterns of threatened species richness (Categories CR, EN, VU at the European regional level, 36 species) (Figure 10) were mapped by counting the number of threatened species in each cell or cell section.

3. Assessment results

3.1 The threatened status of European amphibians

For this European Red List, the extinction risk of amphibians has been assessed at two regional levels: geographical Europe and the current EU 27 Member States.

Six species (*Sclerophrys mauritanica*, *Pelobates varaldii*, *Xenopus laevis*, *Aquarana catesbeianus*, *Pelophylax saharicus* and *Salamandra algira*) were considered as Not Applicable and omitted from the following analyses because they were either introduced to the European region after 1500 CE or they are of marginal (<1% of their global distribution) occurrence in the Pan European region. No species were assessed as Extinct, Extinct in the Wild or Regionally Extinct in the Wild.

Considering the 93 native and naturalised species that occur in the European region, 28 species (30.1%) are threatened (assessed as Vulnerable, Endangered, or Critically Endangered) at the regional level: four species are Critically Endangered, 12 are Endangered, and 12 are Vulnerable (Figures 3 and 4, Table 4). Eight species were assessed as Near Threatened and 57 as Least Concern. Significantly, no species were considered Data Deficient.

A similar pattern was recorded in the EU 27 where 33.0% of the 88 amphibian species (NA excluded) are threatened: four are CR, 14 are EN and eleven are VU (Figure 5, Table 4). Overall, approximately one-third of amphibians are threatened by extinction in the European Union, the same as for Europe (see Figures 4 and 6). A further six species are Near Threatened. Species classified as threatened (Critically Endangered, Endangered and Vulnerable) at the European and EU 27 levels are listed in Table 4.

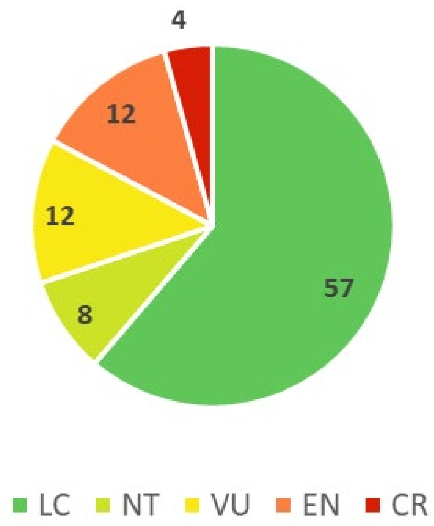

Figure 3. *Red List status of amphibians in Europe excluding NA.*

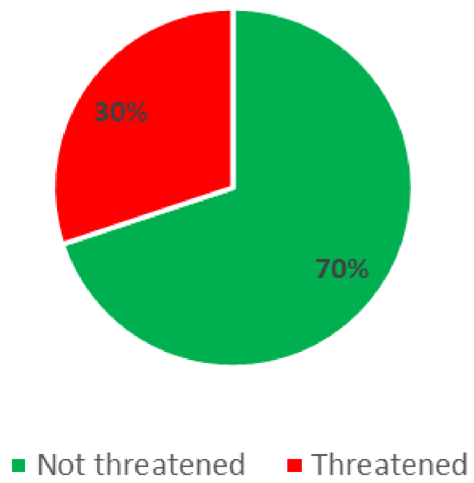

Figure 4. *Threatened and non-threatened amphibians in Europe excluding NA.*

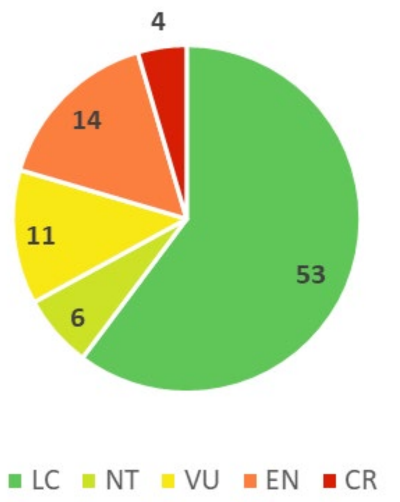

Figure 5. *Red List status of amphibians in the EU 27 member states excluding NA.*

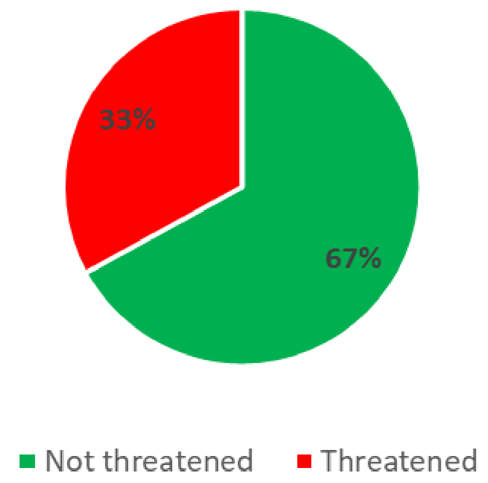

Figure 6. *Threatened and non-threatened amphibians in the EU 27 member states excluding NA.*

Table 4. *Threatened amphibian species at the European and EU 27 levels.*

				Red List Status	
Order	**Family**	**Scientific Name**	**Common English Name**	**Europe**	**EU27**
CAUDATA	PLETHODONTIDAE	*Speleomantes ambrosii*	Ambrosi's Cave Salamander	CR	CR
CAUDATA	PLETHODONTIDAE	*Speleomantes sarrabusensis*	Sette Fratelli Cave Salamander	CR	CR
CAUDATA	SALAMANDRIDAE	*Calotriton arnoldi*	Montseny Brook Newt	CR	CR
CAUDATA	SALAMANDRIDAE	*Salamandra lanzai*	Lanza's Alpine Salamander	CR	CR
ANURA	ALYTIDAE	*Alytes dickhilleni*	Betic Midwife Toad	EN	EN
ANURA	ALYTIDAE	*Alytes muletensis*	Mallorcan Midwife Toad	EN	EN
ANURA	PELOBATIDAE	*Pelobates syriacus*	Syrian Spadefoot	NT	EN
ANURA	RANIDAE	*Pelophylax cerigensis*	Karpathos Frog	EN	EN
ANURA	RANIDAE	*Pelophylax cretensis*	Cretan Frog	EN	EN
ANURA	RANIDAE	*Rana pyrenaica*	Pyrenean Frog	EN	EN
CAUDATA	PLETHODONTIDAE	*Speleomantes flavus*	Mount Albo's Cave Salamander	EN	EN
CAUDATA	PLETHODONTIDAE	*Speleomantes italicus*	Italian Cave Salamander	EN	EN
CAUDATA	PLETHODONTIDAE	*Speleomantes strinatii*	French Cave Salamander	EN	EN
CAUDATA	PLETHODONTIDAE	*Speleomantes supramontis*	Supramonte Cave Salamander	EN	EN
CAUDATA	SALAMANDRIDAE	*Euproctus platycephalus*	Sardinian Brook Salamander	EN	EN
CAUDATA	SALAMANDRIDAE	*Lyciasalamandra luschani*	Luschan's Salamander	EN	EN
CAUDATA	SALAMANDRIDAE	*Salamandrina perspicillata*	Northern Spectacled Salamander	EN	EN

CAUDATA	SALAMANDRIDAE	*Triturus macedonicus*	Macedonian Crested Newt	VU	EN
ANURA	PELOBATIDAE	*Pelobates cultripes*	Western Spadefoot	VU	VU
ANURA	RANIDAE	*Pelophylax cypriensis*	Cyprus Water Frog	VU	VU
ANURA	RANIDAE	*Pelophylax epeiroticus*	Epirus Water Frog	NT	VU
ANURA	RANIDAE	*Pelophylax shqipericus*	Albanian Water Frog	VU	NA
ANURA	RANIDAE	*Rana iberica*	Iberian Frog	VU	VU
ANURA	RANIDAE	*Rana latastei*	Italian Stream Frog	VU	VU
CAUDATA	PLETHODONTIDAE	*Speleomantes genei*	Gene's Cave Salamander	VU	VU
CAUDATA	PROTEIDAE	*Proteus anguinus*	Olm	VU	VU
CAUDATA	SALAMANDRIDAE	*Lyciasalamandra helverseni*	Karpathos Salamander	VU	VU
CAUDATA	SALAMANDRIDAE	*Salamandra salamandra*	Common Fire Salamander	VU	VU
CAUDATA	SALAMANDRIDAE	*Triturus carnifex*	Italian Crested Newt	VU	VU
CAUDATA	SALAMANDRIDAE	*Triturus marmoratus*	Marbled Newt	VU	VU

*The Endangered (EN) Northern Spectacled Salamander (*Salamandrina perspicillata*) is endemic to peninsular Italy, where it can be found in dense undergrowth in hilly and mountainous areas. © Antonio Romano*

3.2 Status by taxonomic group

European amphibians belong to different families (see Section 1.3), among which considerable differences exist both in species numbers as well as in threatened status (Table 5). The Anuran families Alytidae (midwife toads and painted frogs), Pelobatidae (spadefoot toads), and Ranidae (true frogs) contain an average proportion of threatened species (20-35%). Two of four families of newts and salamanders (Plethodontidae and Proteidae) contain a high proportion of threatened species. Of the eight Plethodontids (lungless salamanders) occurring in Europe, 87.5% are threatened when the IUCN criterion E is applied (due to the projected threat of the spread of the fungus *Batrachochytrium salamandrivorans*) and the remaining 12.5% are classified as Near Threatened (on the contrary, if criterion E is not applied, only 50% of plethodontid salamanders are threatened, while 25% are Near Threatened and 25% are Least Concern). The family Proteidae (Mudpuppies or Waterdogs) contains six extant species worldwide, of which only one (the Olm - *Proteus anguinus* - which is likely a species complex) occurs in Europe. This species is considered Vulnerable, hence 100% of species in the family Proteidae are threatened at the European level.

Table 5. *Red List status at the European regional level of amphibians by taxonomic family (NA species excluded).*

Order	Family	Total	CR	EN	VU	NT	LC	DD	% Threatened
Anura	Alytidae	9	0	2	0	1	6	0	**22%**
	Bombinatoridae	2	0	0	0	0	2	0	0%
	Bufonidae	7	0	0	0	1	6	0	0%
	Hylidae	7	0	0	0	0	7	0	0%
	Pelobatidae	5	0	0	1	1	3	0	**20%**
	Pelodytidae	3	0	0	0	0	3	0	0%
	Ranidae	19	0	3	4	1	11	0	**37%**
Caudata	Hynobiidae	1	0	0	0	0	1	0	0%
	Plethodontidae	8	2	4	1	1	0	0	**88%**
	Proteidae	1	0	0	1	0	0	0	**100%**
	Salamandridae	31	2	3	5	3	18	0	**32%**
	Total	**93**	**4**	**12**	**12**	**8**	**57**	**0**	**30%**

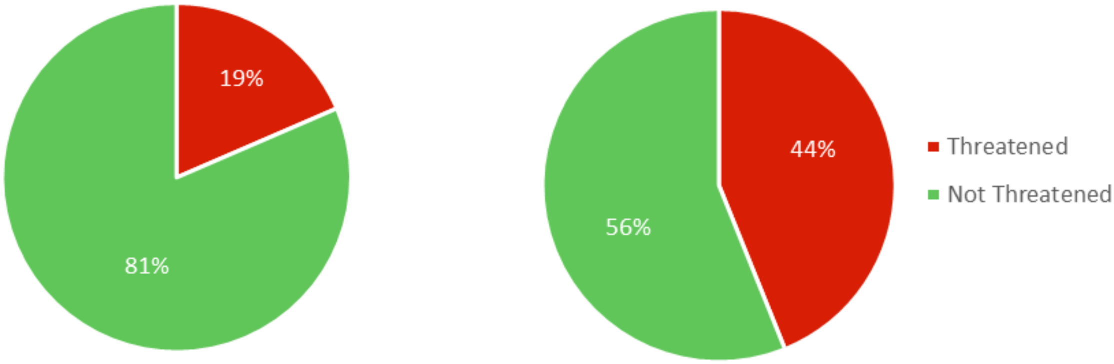

Figure 7. *The percentages of species that are considered threatened and not threatened within the Anura (left) and Caudata (right) orders.*

3.3 Spatial distribution of species

3.3.1 Species richness

Information on the species richness of European amphibians within orders and families is presented in Section 1.3 and Table 2. The geographic distribution of species richness in Europe is depicted in Figures 8 and 9. European amphibian diversity is the highest in the Italian peninsula and France, followed by the Iberian Peninsula (Spain) and throughout the south/eastern Balkans (e.g. Bulgaria and Greece) (Figure 8, see Appendix 1 for more details). Comparison with results from the 2009 *European Red List of Amphibians* report reveals slight changes in the five most diverse countries: Italy and France share the highest position, followed by Spain, whereas Germany is replaced by Bulgaria, and Greece improved its position, shifting from fifth place to the fourth. These changes are the result of recent molecular taxonomic revisions – downgrading the species status of certain taxa and raising some genetically divergent clades within already existing species as separate species (briefly mentioned in subchapter 1.3 of this report).

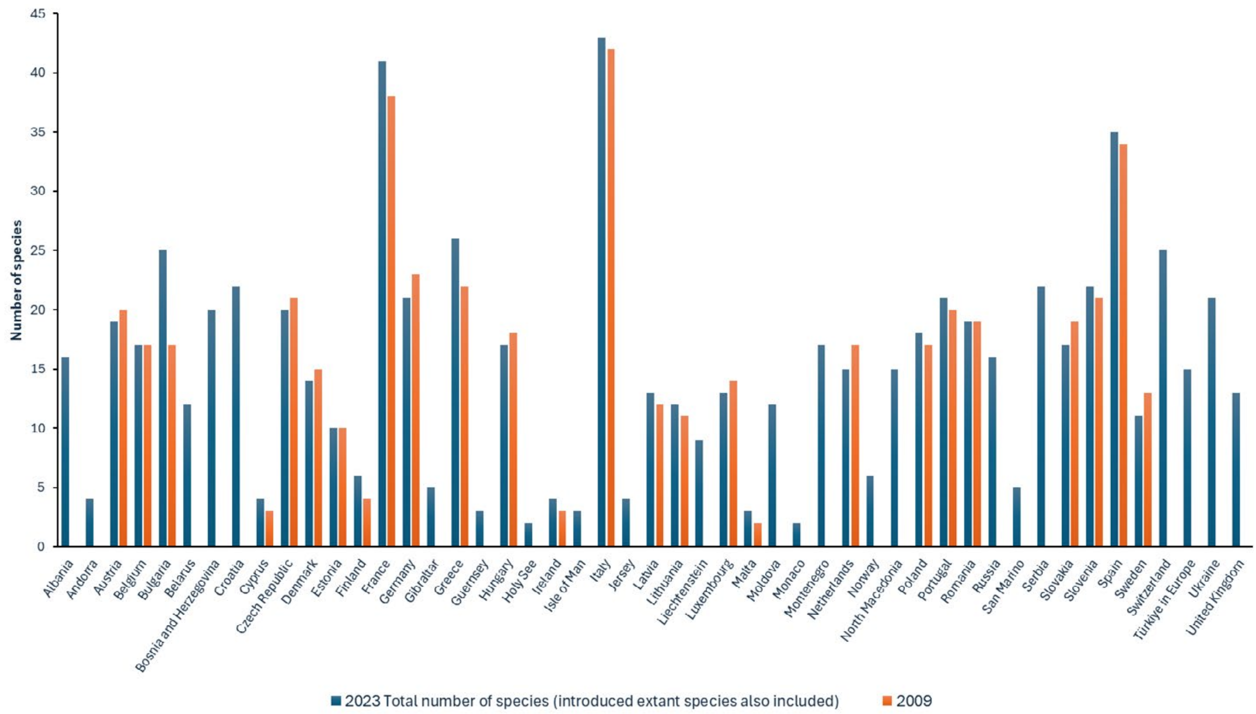

Figure 8. *The overall number of amphibian species in Europe, including naturalised introduced extant species but excluding Not Applicable species. The earlier* European Red List of Amphibians *(Table 5, Temple and Cox, 2009) presented species occurrence in EU countries only.*

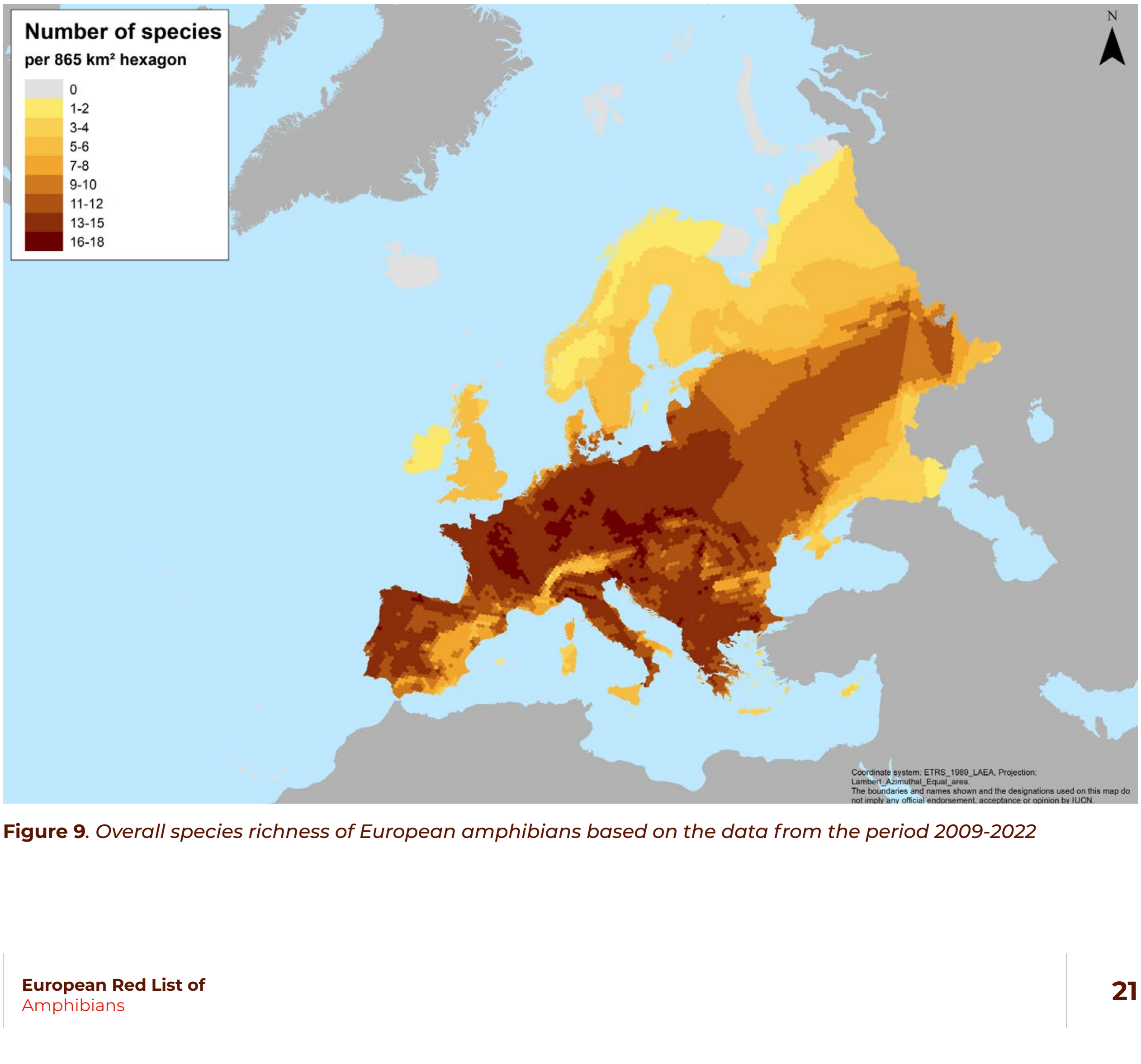

Figure 9. *Overall species richness of European amphibians based on the data from the period 2009-2022*

3.3.2 Distribution of threatened species

From Table 6 and the map showing the distribution of threatened amphibians in Europe (Figure 10) it is obvious that the greatest numbers of threatened amphibian species are recorded in the Italian (15 species) and Iberian (eight species) peninsulas, followed by France and the southern part of the Balkan Peninsula - Greece (six species each). Italy harbours the greatest number of threatened European amphibians - 15 in total, followed by Spain – eight species. Three threatened species have relatively broad distributions – *Salamandra salamandra* (29 countries), *Triturus carnifex* (13 countries) and *T. macedonicus* (seven countries).

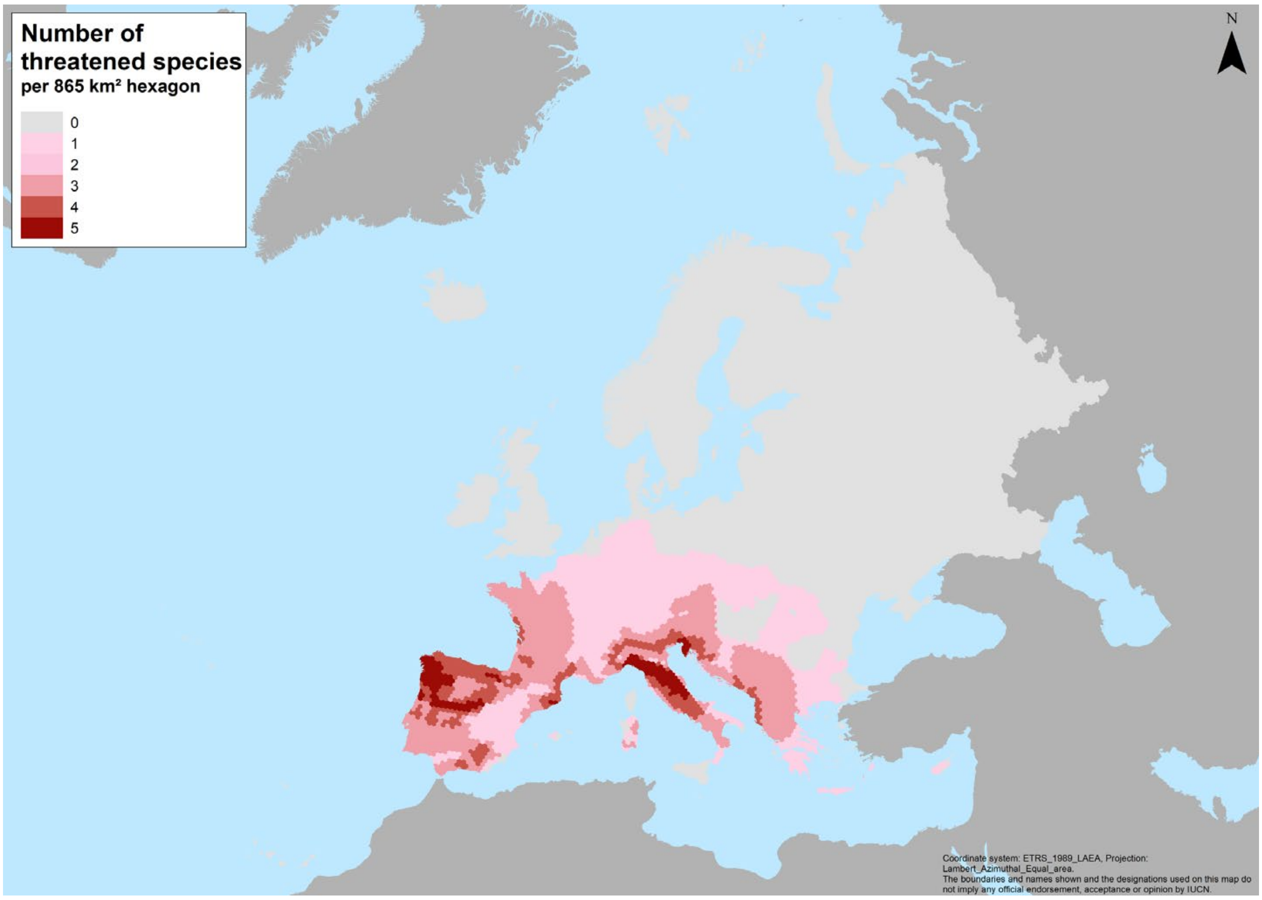

Figure 10. *Threatened (CR, EN, VU) amphibian species richness in Europe based on data over the period 2009-2022.*

Table 6. *Presence of threatened amphibian species in European countries (both native presence and introduced extant). BiH: Bosnia and Herzegovina, UK: United Kingdom.*

Order	Family	Species	Red List Category	Countries
ANURA	Alytidae	*Alytes dickhilleni*	EN	Spain
		Alytes muletensis	EN	Spain
	Pelobatidae	*Pelobates cultripes*	VU	France, Portugal, Spain
	Ranidae	*Pelophylax cerigensis*	CR	Greece
		Pelophylax cretensis	VU	Greece
		Pelophylax cypriensis	VU	Cyprus
		Pelophylax shqipericus	VU	Albania, Italy, Montenegro
		Rana iberica	VU	Portugal, Spain
		Rana latastei	VU	Croatia, Italy, Slovenia, Switzerland
		Rana pyrenaica	EN	France, Spain
CAUDATA	Plethodontidae	*Speleomantes ambrosii*	CR	Italy
		Speleomantes flavus	EN	Italy
		Speleomantes genei	VU	Italy
		Speleomantes italicus	EN	Italy
		Speleomantes sarrabusensis	CR	Italy
		Speleomantes strinatii	EN	France, Italy
		Speleomantes supramontis	EN	Italy
	Proteidae	*Proteus anguinus*	VU	BiH, Croatia, Italy, Slovenia
	Salamandridae	*Calotriton arnoldi*	CR	Spain
		Euproctus platycephalus	VU	Italy
		Lyciasalamandra helverseni	VU	Greece
		Lyciasalamandra luschani	EN	Greece
		Salamandra lanzai	CR	France, Italy
		Salamandra salamandra	VU	Albania, Andorra, Austria, Belgium, BiH, Bulgaria, Croatia, Czechia, France, Germany, Greece, Hungary, Italy, Liechtenstein, Luxembourg, Montenegro, Netherlands, North Macedonia, Poland, Portugal, Romania, San Marino, Serbia, Slovakia, Slovenia, Spain, Switzerland, Türkiye, Ukraine
		Salamandrina perspicillata	EN	Italy
		Triturus carnifex	VU	Austria, BiH, Croatia, Czechia, France, Germany, Hungary, Italy, Netherlands, Portugal, Slovenia, Switzerland, UK
		Triturus macedonicus	VU	Albania, BiH, Bulgaria, Greece, Montenegro, North Macedonia, Serbia
		Triturus marmoratus	VU	France, Portugal, Spain

3.3.3 Endemic species richness

Figure 11 shows the distribution of the 70 European endemic amphibian species. Again, amphibians show particularly high endemic species richness in the Iberian and Italian peninsulas and parts of France, followed by the Balkan peninsula. Some Mediterranean islands have range-restricted endemic amphibians (e.g. Corsica: *Discoglossus montalentii*, *Euproctus montanus*, *Salamandra corsica*; Crete: *Pelophylax cretensis*; Cyprus: *Bufotes cypriensis, Pelophylax cypriensis,* Sardinia: *Euproctus platycephalus*, *Speleomantes flavus, S. genei, S. imperialis, S. sarrabusensis, S. supramontis*), although these regions do not necessarily show up on the endemic species richness maps because typically each particular island will have only one or a few endemic species (Sardinia being an exception with six endemic amphibian species).

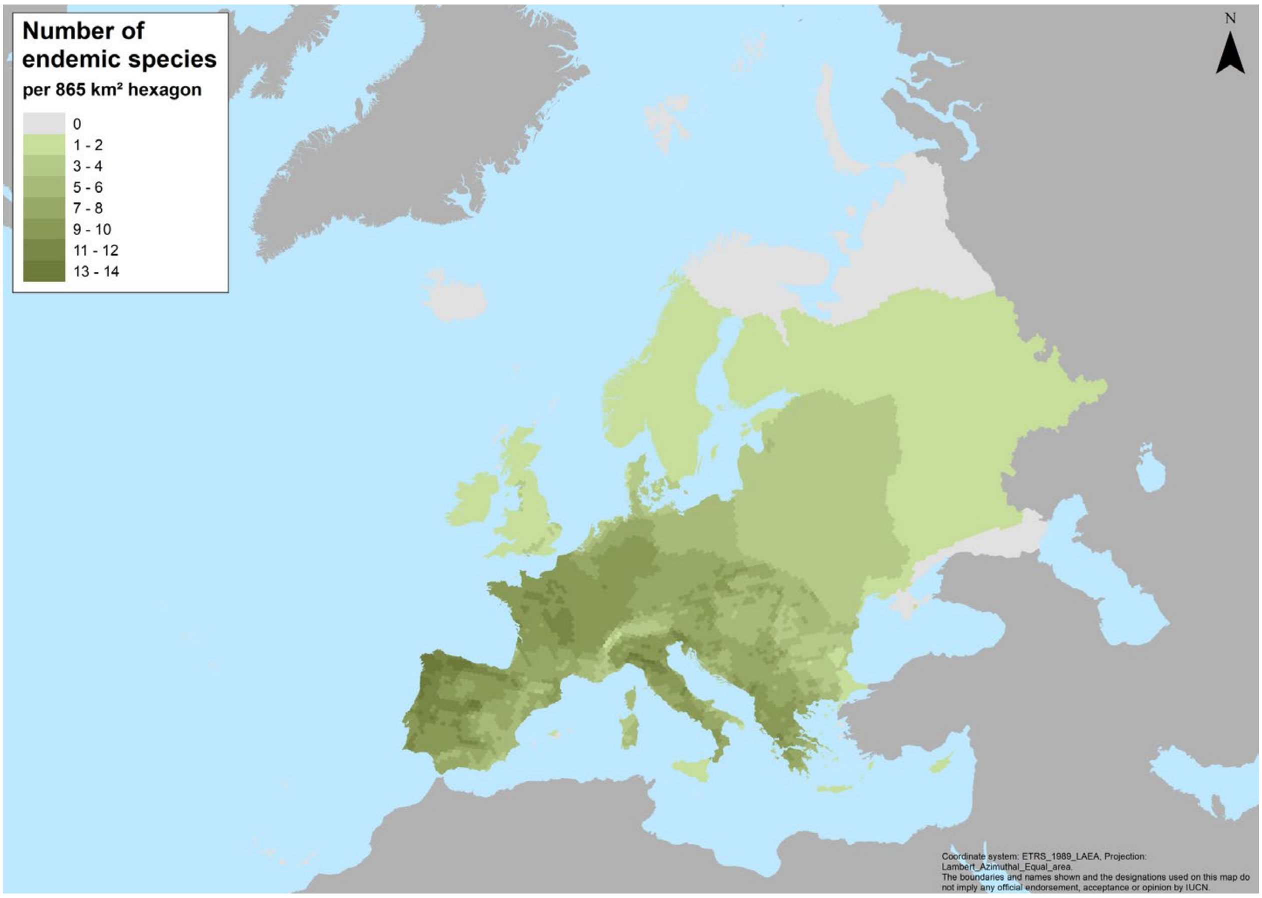

Figure 11. *European endemic amphibian species richness based on the data over the period 2009-2022.*

3.4 Major threats to amphibians in Europe

The second Global Amphibian Assessment (GAA2; and see Luedtke et al., 2023) has shown that the status of world amphibians is not improving, with 40.7% of species being threatened in comparison to 39.7% in the 2004 first Global Amphibian Assessment (GAA1; Stuart et al., 2004). European amphibians are subject to a varied set of threats, some of which are very specific to this taxonomic group, whereas others are affecting biodiversity more generally. A summary of the relative importance of the different threats is presented in Figure 12, whereas specific information can be found in each species assessment. It should be mentioned that the list of major threats in the 2009 report differs in the definition of particular threats, so it is not possible to entirely compare these two lists.

Invasive and other problematic species, diseases and genes are currently the most significant major threat to European amphibians, affecting about 76% of the studied species. These include both invasive alien species and pathogenic organisms. According to a general overview of species assessments, invasive species alone affect about 55% of European amphibian species and include predators such as some introduced reptile species and freshwater fish species, but also non-native species of amphibians which may predate on, or compete or hybridise with, native populations and/or act as vectors of diseases and parasites. Tadpoles of native species are the prey of various non-native species of turtles, including invasive *Trachemys* freshwater turtle species, crayfish – mostly *Procambarus clarkii* and *Orconectes limosus*, as well as several fish species which prey on amphibian aquatic stages; e.g. the tadpoles of *Alytes* species have a long larval phase and are especially vulnerable to predation. Apart from this, there are threats from locally introduced European amphibian species, such as competition for space and resources between the Mallorcan Midwife Toad (*Alytes muletensis)* and the locally introduced European amphibian species, Perez's Frog (*Pelophylax perezi*). Pathogens are also included here; they alone have been harming/could harm in the future about 44.4% of Europe's amphibian species. *Batrachochytrium dendrobatidis* and *B. salamandrivorans* are the main pathogens threatening Anura and Caudata, respectively, but *Iridovirus sp.*, *Ranavirus sp., Aeromonas hydrophila* ("Red-leg disease"), etc. have also been detected in European aquatic habitats. There are also taxonomic differences in susceptibility to infection (e.g. Alytidae and Bombinatoridae are more prone to infection than other European anurans; Balaž et al., 2013).

Pollution from agriculture and forestry is the second most significant threat, affecting about 71% of the studied species, while pollution from wastewater and from industrial and military effluents affects about 40% and 25% of European amphibian species, respectively. It should be noted that there is also the threat of pollution from other sources which affects some 10% of species. Pollution has large effects on abnormality frequency in offspring and medium effects on the survival and body mass of local amphibian species through the accumulation of pollutants from different external sources in the body tissues. Pollution also influences activity levels, habitat use, courtship, and swimming performance (see Egea-Serrano et al., 2015). In the 2009 *European Red List of Amphibians* assessment, pollution was combined with climate change; therefore, the changes in intensity of these two threat factors over the last 13 years cannot be compared.

Residential and commercial development is on the third place on the list of major threats to European amphibians, affecting 66% of species, followed by negative effects of agriculture and aquaculture due to production of non-timber crops, while negative effects of livestock farming and ranching are on the seventh place, affecting about 45% of European amphibian species.

Natural system modifications, climate change and severe weather are in the fifth and sixth place, affecting, roughly, half of European amphibian species.

Overexploitation, or, broadly speaking, exploitation for human consumption, research and/or pet industry, named here as "use of biological resources", is in the eighth place, impacting about 40% of species, which is almost doubled with respect to the 2009 report, where it was presented as "harvesting".

The coded major threats with the least impact (each affecting up to 23% of analysed species) include transportation and service corridors, energy production and mining, human intrusion and disturbance, and some minor agriculture and aquaculture and pollution impacts.

If some of these coded major threats were categorised instead as habitat loss, then habitat loss would become the most significant general threat to European amphibians, affecting 95% of the studied species (information obtained from threat overviews in species assessments). A total of 21 of the 28 threatened species (75.0% of the total) is deemed threatened by some variant of habitat loss but the number grows up to 27 (96.4%) if we consider also a localised habitat loss. Habitat loss and degradation can occur in various ways which are here presented as separate coded major threats. For example, residential and commercial development (including the expansion of industrial development) in the area decreases or destroys both small water bodies necessary for the reproduction of local amphibian species and important terrestrial habitats; natural system modifications for other purposes, such as the construction of dams that slow down water current or completely redirect water flow into several kilometres long tubes, which is a common practise when establishing run-of-river small hydropower plants in southern and eastern Europe (Crnobrnja-Isailović et al., 2021, 2022) negatively affect habitats important for reproduction of certain species (e.g. *Rana graeca*, *Salamandra salamandra*); in some countries, conversion of wetlands into agricultural fields destroys suitable habitats for lowland amphibian species (e.g. negative impact on local populations of the Fire-bellied Toad, *Bombina bombina,* in the Pannonian Plain); logging, mineral extraction, and many others also could lead to habitat loss. Following such an approach in the categorisation of threats would shift pollution and invasive alien species to the positions of second and third major threat, respectively, followed then by climate change, which alone influences the extinction risk of 41% of analysed species. Amphibians with narrow microclimatic preferences are expected to suffer from climate-caused alteration of their distribution and activity (e.g. endemic salamander genus *Speleomantes*, including Sardinian Gene's Cave Salamander, *S. genei,* Mount Albo's Cave Salamander, *S. flavus,* and others), but the impact of climate change on microclimates is still insufficiently known, especially in the mountains where small-scale spatial heterogeneity in microclimates could be enormous.

Overcollection is not featured among the top major threats, despite the general development of the pet trade industry, and over-collection for the pet/collector trade can be significant (Auliya et al., 2016; Altherr and Lameter, 2020). The same applies to road mortality, a well-known threat to some common European amphibian species (Petrovan and Schmidt, 2016), but not so much to the threatened ones. Persecution due to the negative perception of the public toward amphibian species was mentioned in just one case (European Common Toad, *Bufo bufo*).

Information has not been collected during the assessment process on the relative importance of one threat compared to another for a particular species. Development of such information in the future is a priority for the assessment and will enable a more complete analysis of significant threats to species, as it was done in some other parts of the world (Grant et al., 2016).

Invasive alien species and native amphibians in Europe: patterns, mechanisms and impacts

Mathieu Denoël and Francesco Ficetola

Invasive alien species (IAS), also sometimes termed invasive non-native species (INNS), have been widely introduced into European freshwaters and constitute one of the main threats to European amphibians, most of which rely on water bodies for breeding (Falaschi et al., 2019, 2020). These introductions continue at a growing pace, even in protected habitats and inside national parks. The involved IAS differ across European regions, but in most of Europe, there is an increase in the number of IAS originating from all the continents, leading to complex impacts on amphibians and their habitats. Alien teleost fish, crayfish and frogs have been voluntarily introduced in many places for a variety of reasons, including food purposes (salmonids, frogs, crayfish), ornamental use (goldfish), or biocontrol (Mosquitofish; *Gambusia* spp.) but also due to teaching or research activities (clawed and water frogs) (Measey et al., 2012; Denoël et al., 2019; Bounas et al., 2020; Dufresnes et al., 2024). Many alien species established and dispersed spontaneously at both the regional (e.g. fish in rivers and crayfish or clawed frogs) and continental level (e.g. water frogs). Nevertheless, secondary anthropogenic translocations are accelerating several ongoing invasions (e.g. frogs, crayfish and fish from stagnant waters).

The mechanisms by which the different IAS affect amphibians are complex and differ among the involved species and native amphibians. Predation is probably the most widespread mechanism of impacts of IAS on European amphibians. Some alien species such as large predatory fishes (e.g. trout species and other salmonids), mammals (e.g. Raccoons, American Mink), crayfish as well as large frogs (water frogs and bullfrogs) exert predation on all life stages of most amphibians (DAISIE, 2009; Ficetola et al., 2012; Miró et al., 2018; Pille et al., 2023). Smaller fish species such as goldfish eat amphibian eggs and larvae, while others such as mosquitofish forage on amphibian larvae (Lejeune et al., 2023). IAS can also compete with native species, decreasing the available resources such as prey species or the availability of aquatic vegetation (Tiberti et al., 2014; Lejeune et al., 2024). When IAS are closely related to native amphibians, they can also hybridise with them, potentially replacing native genotypes with non-native ones (Quilodrán et al., 2019). The issue of hybridisation is particularly problematic for hybridogenetic water frogs, following the introduction in multiple European countries of *Pelophylax ridibundus* as a food source (Dufresnes et al., 2024). Some IAS can also spread pathogens to native amphibians (Garner et al., 2006). For instance, American bullfrogs, clawed frogs and introduced salamanders have been proposed as possible vectors for the spread of chytridiomycosis in Europe. In addition to these direct effects, IAS can have multiple indirect detrimental effects, by interplaying with other environmental stressors. Indirect impacts include 1) modifications of habitats, 2) behavioural alterations such as pond avoidance (direct escape or earlier metamorphosis), 3) disruption of breeding activities, and 4) demographic sinks occurring when IAS coexist with adults but prey on their progeny (Winandy et al., 2017; Cano-Rocabayera et al., 2019; Lejeune et al., 2023).

Diversity assessments have detected detrimental effects of all IAS on amphibian species in all the areas of Europe. Although some amphibian species show tolerance to invaders (for instance, toads and water frogs are generally resistant to predatory fish), most pond-breeding amphibians disappear or show reduced abundance in habitats colonised by IAS. The few long-term data sets converge all to show the decline of native populations with even complete local extirpations of populations and of some endemic subspecies. Newts spend long periods in wetlands and thus suffer particularly strong impacts by IAS. Paedomorphic newts (i.e. permanently gilled forms that attain sexual maturity without metamorphosis) are perhaps the amphibians most severely impacted by alien predators and are becoming critically endangered in many parts of Europe due to these introductions (Denoël et al., 2019).

In light of these widespread and catastrophic effects of IAS on amphibian diversity, it is essential to better regulate the trade of IAS and forbid introductions in amphibian habitats, to inform on the risks caused by IAS. There is a huge need to assess and prevent new upcoming invasions (Pupins et al., 2023) and therefore new monitoring schemes should be implemented. Management procedures (e.g. eradication) are often challenging and expensive (Schabetsberger et al., 2023), but can be successful for some taxa, particularly fish in isolated wetlands (Denoël and Winady 2015; Ventura et al., 2017). Such actions can allow the recovery of freshwater biodiversity and therefore should be generalised in key environments for amphibian diversity.

Both the mosquitofish (left) and the crayfish (right) are alien predators that feed on native amphibians. © Mathieu Denoël and Francesco Ficetola

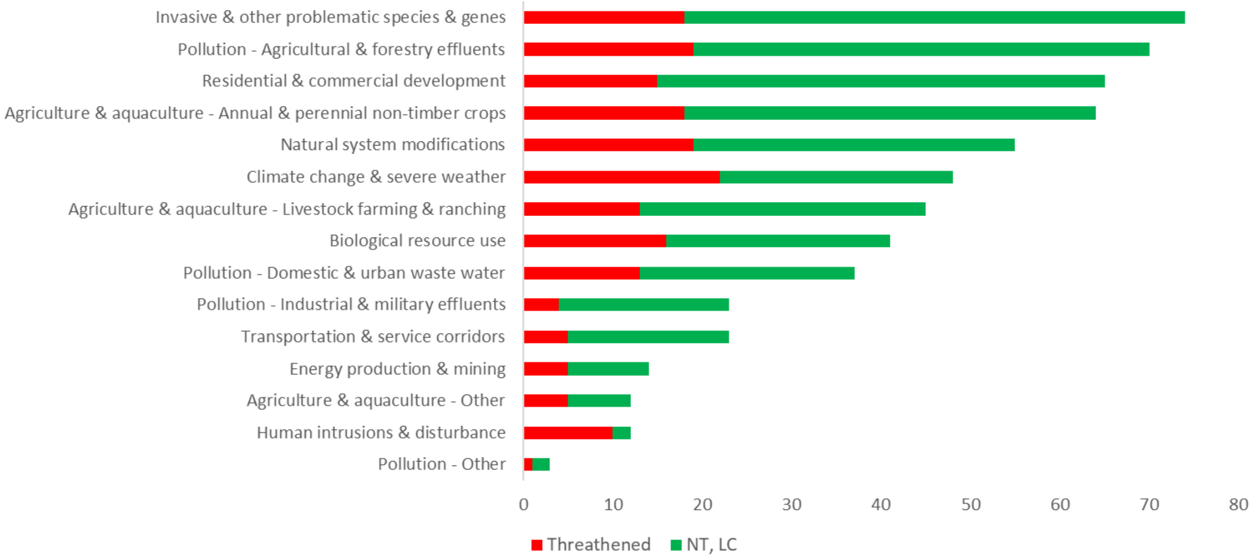

Figure 12. *Major threats to amphibians in Europe. The number of affected species is presented on the x-axis.*

3.5 Population trends

Documenting population trends is crucial to assessing species status, hence a special effort was made to determine whether each taxon's population is declining, stable, or increasing (Figure 13). Some of the data on population trends are from studies of common European species (Petrovan and Schmidt, 2016). More than half of European amphibians show signs of population decline (76% of the total species number and 85.5% of the endemic species). A further 15% (10% of endemic species) are stable. Only 2% (1.5% of endemic taxa) are increasing. The two species with increasing population trends are the native *Alytes muletensis* (but trends in populations highly infected with chytrid fungus were conflicting – Doddington et al., 2013) and *Pelophylax ridibundus,* accompanied by two non-native species – *Xenopus laevis* and *Aquarana catesbeianus*. *Alytes muletensis* is a threatened species that has increased in number because of intensive conservation efforts, while *P. ridibundus* is a European native in some parts of the continent, while is highly invasive in some areas following human-mediated introductions in non-native parts of its range where it constitutes the main threat to native taxa of the same genus (Dufresnes et al., 2024). It is therefore increasing mainly within its non-native areas. At least in Switzerland, recent genetic studies showed that *P. ridibundus* is not the only invading species (Dubey et al., 2014).

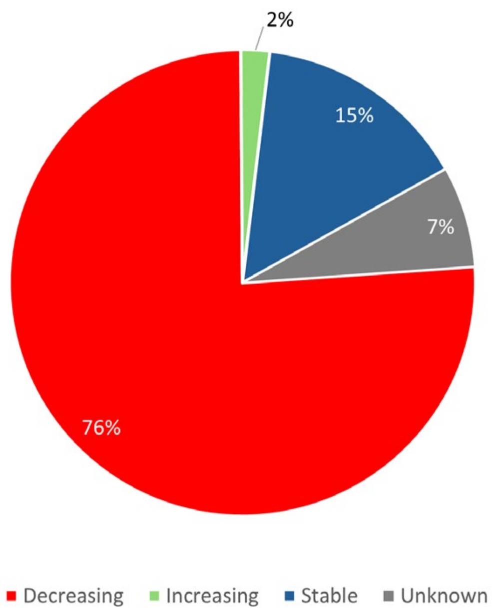

Figure 13. *Population trends of European amphibians (NA excluded).*

3.6 Gaps in knowledge

Although carefully compiled using available data and expert opinion, information is missing or inadequate for some aspects of IUCN Red List species assessments. For instance, distributional and occurrence data are known for all analysed species, but the area of occupancy (AOO) metric is missing for 7.1% of species, either because they are so widespread that the species is unlikely to qualify for a threatened category, or because the available locality records were considered to not represent the distribution of the species, and hence underestimate the AOO of a species. Distributional data curated by the Global Biodiversity Information Facility (GBIF) have greatly increased in terms of taxonomic and geographical coverage for the European region in recent years and can be invaluable in estimating the key Red List metrics of EOO (extent of occurrence) and AOO, as well as informing the production of the species distribution map. However, data quality and accuracy can be an issue, data do not always keep pace with taxonomic revisions, and data are still lacking for some species groups and for some countries.

The population trend of some species is not known, including that for three endemic species, *Pelophylax cerigensis, Pelophylax lessonae*, and *Rana italica*. However, detailed demographic trend and population size data required for demographic population viability analysis (see Morris and Doak, 2002) are also mainly lacking for European amphibians. This is perhaps a consequence of significant logistical, financial and temporal efforts required to conduct long-term population studies, resources that are not easy to obtain under current regulations of both national and international funding agencies. Research projects mostly last from one to three years, sometimes up to five years, which means that additional effort must be devoted to creating new projects on some novel topics, just to enable the continuation of data collection necessary for estimating population trends. Furthermore, scientific studies too often focus on rare species, and we know far too little about the dynamics of populations of supposedly common species. For instance, long-term analyses on species not considered threatened globally showed strong regional declines over the last decades (Petrovan and Schmidt, 2016; Denoël et al., 2019). Of course, conducting monitoring does not necessarily require research projects, and the potential for an EU-wide and EU-supported amphibian monitoring scheme should be investigated. Research efforts are usually focused on a small number of populations of certain species, while monitoring would have to collect population data in an entire country. Monitoring of protected areas is usually funded by national or regional governments and that could be a solid source of logistic support to continuous collection of population data. However, as this funding is on an annual basis, national priorities could be subjected to change and would not necessarily include detailed standardised biodiversity monitoring, which could lead to gaps in time series databases and, consequently, to less accurate analyses of population trends. An additional issue is that monitoring in nature reserves does not give a representative view of the trends of a species. There are different possible ways to overcome these obstacles and to ensure continuity of data collection and one would be making regular species monitoring an integral part of high-education ecology courses.

A strong argument in favour of enabling a solid basis for long-term population monitoring is the case of the first attempts to assess European Caudata species by using Criterion E (population viability modelling, PVA) to predict extinction risk under the pressure of a particular pathogen, the chytridiomycete fungus *Batrachochytrium salamandrivorans* (*Bsal*) that causes chytridiomycosis. As negative impacts are modelled but not yet observed, expert opinion is that grounded data on actual trends should be collected for an assessment to confirm that species populations are following the trajectories predicted by the PVA model.

*The Italian Cave Salamander (*Speleomantes italicus*) is endemic to the central Apennines in Italy. The species is threatened by localised habitat loss (e.g. due to quarrying) and might also be subject to collection for the pet trade. © Antonio Romano*

A further gap in knowledge on European amphibian species is related to taxonomic uncertainties for some taxa, those currently representing separate genetic clades or evolutionarily significant units within the same species where there are some indications for separate species status. Usually, if a group of populations does not have a separate species status, it is not in the focus of funding agencies, decision-makers and other stakeholders, which could lead to the loss of a portion of the species' genetic diversity. A focus on local genetic lineages should be encouraged and highlighted as important for species conservation.

4. Conservation measures

4.1 Comparison with previous assessment

The proportion of threatened amphibian species at the European level increased by 8% since the last assessment, changing from 22% to 30%. The new assessments registered a change from 2.4% to 4.3% in the number of Critically Endangered species, from 6.1% to 12.6% of Endangered ones and 13.4% to 12.9% of Vulnerable species. Although the overall number of species increased between the two reports, the reasons for the increase in the proportion of threatened amphibians in Europe are mainly related to genuine changes in conservation status (see 2.3 Assessment protocol, above) – the known threats have increased or novel threats, such as diseases, have arisen or intensified. The new species added in this report make up 15.2% of the overall number of 99 species (native plus Not Applicable), but only two of them have threatened status and one is Near Threatened. This suggests that the overall increase in the number of threatened European amphibian species found in this report is rather due to the intensification and diversification of threats, and the absence of effective conservation action to mitigate them.

The proportion of threatened Anuran species within the Bombinatoridae family declined from 33% in 2009 to none in this report, but this is due to the degradation of the species status of one of three *Bombina* species listed in that report (a non-genuine change). The proportion of threatened species increased in the Pelobatidae and Ranidae families from 0% to 20% (a genuine change) and from 29% to 37% (genuine and non-genuine change), respectively. Among the Caudata, the proportion of threatened salamander species increased from 50% in 2009 to 88% in 2022 in the Plethodontidae family (genuine changes) and from 20% in 2009 to 32% in 2022 in the Salamandridae family (mostly genuine changes).

In 2009, all (three) Caudata families featured threatened species. In 2022, four out of seven Anuran families (57%) and one out of four Caudata families (25%) contained no threatened species at all (it is worth mentioning that the Hynobiidae family was not listed in the 2009 report). In addition, the number of Near Threatened amphibians in Europe declined since the last assessment from 17% to 8%. Five of those species from the 2009 report worsened in status by being assessed as threatened in this report, three of them due to results of extinction risk modelling if *B. salamandrivorans* (*Bsal*) continues spreading. Other two species changed status as a result of rapid population decline in the recent past driven, mainly, by habitat loss, fragmentation or degradation. Just three NT species from the 2009 report improved in status to Least Concern, but not necessarily due to genuine change. For example, the Danube Crested Newt *Triturus dobrogicus* underwent a non-genuine change from NT to LC mainly because the rate of decline is not fast enough to qualify for the Near Threatened category under criterion A. It shows that the down-listing of a species' Red List status does not necessarily infer a significant improvement in its conservation status – it could be that a population decline is still underway, but at a rate not fast enough to qualify a species as threatened (or Near Threatened). Pyrenean Brook Salamander *Calotriton asper* is a similar example, while only for Iberian Midwife Toad *Alytes cisternasii* this recent change from NT to LC could be partially genuine, based on the potential distribution of predicted suitability by Maxent model which suggested that climate change would contribute to population range increase (Rodriguez-Rodriguez *et al.*, 2020).

Major threats impacting species and populations have not changed since the last European

Red List assessment of amphibians – these are habitat loss/degradation, followed by pollution and invasive alien species (although in the 2009 assessment, pathogens were included as invasive alien species which, in this assessment, are considered as a separate threat). The overall impact of habitat loss/degradation and invasive alien species seems to have increased in the last decade, affecting, respectively, almost 6% and 7% more species than fifteen years ago. On the other hand, the effects of pollution on amphibians seem to have decreased and it is now listed as a significant threat for nearly 16% fewer species than in 2009. One might assume that this is the result of applying stricter regulations on pollutants, at least within the EU27 area, or an increased awareness amongst the public due to the increase of conservation grants related to citizen science and ecological education to the public, but it also could be simply due to variation between assessors in the coding of threats. However, amphibian experts still emphasise the negative impact of plant protection products (pesticides, herbicides, insecticides, etc.) on habitats - see the following textbox on the impact of habitat loss and degradation on amphibians. The fact that regulation of chemicals used in agriculture regarding their impact on amphibians (and reptiles) is at a very early stage has led to recent initiatives such as the COST action PERIAMAR (Pesticide Risk Assessment for Amphibians and Reptiles), conducted from 2019 to 2024 and funded by the Horizon Europe Framework Programme of the European Union. PERIAMAR has created a multidisciplinary network of scientists from academia, government, business and non-governmental organisations (NGOs), addressing the challenge of ensuring a straightforward and useful procedure to avoid unacceptable risks of pesticide use on amphibians and reptiles.

Compared with the 2009 report, demographic trends portray a moderately more optimistic picture with -10% of studied species deemed to have decreasing population trends and 6% more species characterised by stable populations. Moreover, the number of species characterised by increasing populations grew from one to four. However, it is worth noting that two of these four species are introduced invasive species: the African Clawed Frog (*Xenopus laevis*) and the American Bullfrog (*Aquarana catesbeianus*). A third species, the Marsh Frog (*Pelophylax ridibundus*) is recently considered an alien species in part of its distribution area due to many introductions (Dufresnes et al., 2024) and its overall positive population trend could be just a reflection of successful invasions. Finally, the percentage of species with unknown population trends increased from 3% to 7% since 2009.

The impact of habitat loss and degradation on amphibians

Benedikt R. Schmidt

There are many reasons why amphibians are threatened. The most significant reason is the loss and degradation of habitat. All other drivers of amphibian declines can only operate if there is some habitat in which amphibians can live. Conversely, this can also mean that a habitat patch which would be suitable is not occupied because a threatening factor makes it unsuitable for amphibians.

European landscapes are not pristine landscapes (Poschlod and Braun-Reichert, 2017). They have been modified by humans for millennia. For amphibians, the conversion of natural landscapes to anthropogenic, mostly agricultural, landscapes was not always negative. Man-created landscapes used for low-intensity agriculture were very suitable for amphibians (Hartel et al., 2020). Those landscapes were often mosaics of agricultural and seminatural habitats (e.g. hedges), often enriched with man-made water bodies such as fishponds and watering troughs for livestock (Curado et al., 2011; Hartel et al., 2020; Romano et al., 2023). Even completely novel habitats, such as gravel pits, were (and are) often used by amphibians (in the case of gravel pits this may be the case because they functionally resemble alluvial zones in floodplains; Heusser, 1968). These high nature-value landscapes have been changing in the past decades because of agricultural intensification.

Agricultural fields are made larger and seminatural habitats are lost; not even payments to farmers for ecological set-aside can slow down this loss which shows a west-to-east gradient in Europe (Donald et al., 2001). Agricultural intensification not only leads to the loss of seminatural habitats but is also associated with the greater use of plant protection agrochemical products and fertilisers (Rigal et al., 2023) which can be toxic to amphibians (Brühl et al., 2013).

Because most European amphibians depend on ponds, wetlands and other bodies of water for reproduction, the large-scale destruction and drainage of wetlands and the loss of ponds through abandonment and filling have strongly negatively affected amphibian communities. In 1850, wetlands covered 8% of the area of the Swiss canton of Zurich (Gimmi et al., 2011). By 2020, the proportion of wetland area was reduced to less than 1%. Agricultural intensification was the reason why 57% of the ponds were lost in the French department of Pas-de-Calais between 1975 and 2006 (Curado et al., 2011). In addition, the excessive use of water for agriculture can have strong negative effects on amphibian communities. A prime example of this is the Doñana wetland in southern Spain (Diaz-Paniagua et al., 2024).

Habitat loss and degradation can have many effects on individuals, populations and metapopulations. Evidently, habitat loss leads to the local extirpation of populations. The loss of populations can affect metapopulations because connectivity is reduced (i.e., the distance between populations increases). Because many amphibians depend on immigration, populations which have low connectivity (i.e., more isolated) have higher extinction risk because they are more susceptible to environmental, demographic and genetic stochasticity.

Where suitable habitat persists, habitat quality can be degraded through many processes. For example, roads fragment landscapes and intense traffic leads to amphibian mortality during seasonal migrations and among-population dispersal. Amphibians can be exposed to plant protection products in both aquatic and terrestrial habitats. The illegal release and the intentional stocking of amphibian breeding sites with fish is also a form of habitat degradation. Because habitat quality determines demography and population dynamics, habitat degradation reduces individual performance, survival, recruitment and dispersal. These reductions, in turn, can lead to reduced population size. Smaller populations are more susceptible to environmental, demographic and genetic stochasticity, which increases their extinction risk. Consequently, populations can go extinct in habitat patches which are still suitable. This exacerbates the thinning of populations within metapopulations and may cause regional extinction of species.

This pond has accumulated nutrients from agricultural runoff and fertilisers resulting in a eutrophic habitat for amphibians. The loss of these areas due to local degradation can have a significant impact on multiple amphibian species with cascading effects on the broader environment. © Beratungsstelle IANB

Some amphibians find adequate habitats near humans. This drinking trough – originally built for livestock – is an example that amphibians (in this case, Yellow-bellied Toads and Alpine Newts) can sustain in man-made landscapes and habitats. © Jelka Crnobrnja-Isailović

4.2 Conservation management of amphibians in the EU

The Financial Instrument for the Environment (LIFE) is amongst the main EU financial instruments supporting environmental and nature conservation projects throughout the Union and occasionally neighbouring countries. Since 1992, LIFE has co-financed over 5,000 projects. LIFE supports the implementation of the Birds and Habitats directives and the establishment of the Natura 2000 network of protected areas. Projects involve a variety of actions, including habitat restoration, site purchases, communication and awareness-raising, protected area infrastructure and conservation planning. Based on a search of the LIFE project database that lists all past and current LIFE projects, up to 2009, 50 LIFE projects linked their actions to amphibian conservation and five targeted specific amphibian species.

These updated *European Red List of Amphibians* assessments revealed somewhat positively surprising facts: since the previous assessments (Temple and Cox, 2009), the number of amphibian species targeted by LIFE projects, directly or indirectly, increased from five to eleven. The number of LIFE projects per species varied from one (*Triturus carnifex*) to 71 (*Bombina bombina*). In total, 235 LIFE projects included either amphibian species or their habitats, which is an enormous increase compared to about 50 or fewer LIFE projects dedicated to amphibian species and their habitats up to the year 2009, whereas this number was above 550 in 2022 as shown in Table 7.

Table 7. *The number of LIFE projects targeted either towards specific amphibian species or broader taxonomic groups, those summarised in 2009 in the first regional Red List report (Temple and Cox, 2009) and those realised or occurring after 2009. The review in 2009 is based on a search for amphibian species on the LIFE database (https://webgate.ec.europa.eu/life/publicWebsite/search) which identified 50 projects. Some projects target more than one species. Species-based projects were not included in the count for taxonomic group projects. Most of the 50 projects were focused on the habitat or site level rather than on particular species. The review in 2022 relies on amphibian species experts' reports on LIFE projects dedicated to European amphibian species.*

Species	2009	2022
Bombina bombina	1	71
Bombina variegata	—	Several
Bufo bufo	—	34
Alytes muletensis	1	—
Hyla arborea	—	21
Pelobates fuscus	—	4
Pelobates fuscus insubricus	1	—
Rana arvalis	—	10
Rana dalmatina	—	8
Rana temporaria	—	6
Calotriton arnoldi	—	1
Triturus carnifex	—	24
Triturus cristatus	1	56
Salamandra atra aurorae	1	—
Taxonomic Group		
Amphibians	4	>100
Fire-bellied toads	1	>70
Habitat		
Habitats and sites for amphibian species	40	>100
TOTAL	**50**	**> 550**

4.3 Red List status versus priority for conservation action

Assessment of extinction risk and setting conservation priorities are two related but separate processes, but the former can be used to inform the latter. The assessment of extinction risk, such as the assignment of the IUCN Red List Categories, generally precedes the setting of conservation priorities. The purpose of the Red List categorisation is to produce a relative estimate of the likelihood of extinction of a taxon or subpopulation. Setting conservation priorities, on the other hand, which normally includes the assessment of extinction risk, also considers local conservation status and other factors such as ecological, phylogenetic, historical, or cultural preferences for some taxa over others (see in Dufresnes and Perrin, 2015), as well as the probability of success of conservation actions, availability of funds or personnel, cost-effectiveness, and legal frameworks for conservation of threatened taxa. In the context of regional risk assessments, additional information is invaluable for setting conservation priorities at the national and regional levels. For example, it is important to consider not only conditions within the region but also the status of the taxon from a global perspective and the proportion of the global population that occurs within the region. Decisions on how these three variables, as well as other factors, are used for establishing conservation priorities are a matter for the regional authorities to determine.

In 2022, nine European endemic salamander species were for the first time assessed against criteria E (six species) and/or A3 (four species) by the IUCN SSC ASG (Table 8), which applied a modelling approach to predict species extinction risk arising from infection by the novel disease caused by the fungus *Batrachochytrium salamandrivorans*. For example, juveniles of the Northern Spectacled Salamander (*Salamandrina perspicillata*) exhibited 100% mortality when exposed to *Bsal*, and extinction risk modelling indicated that the probability of extinction for the species would be >20% in the following five generation lengths (25–50 years; see IUCN SSC Amphibian Specialist Group, 2022). Applying this approach, these nine European steno-endemic salamander species were assessed as highly threatened by the ASG as part of their global amphibian assessment project, in contrast, for example, to their status in the Italian national Red List (see Rondinini et al., 2022). The IUCN Red List status of these species assessed under Criterion E has been subject to discussion between the IUCN SSC Standards and Petitions Committee and national amphibian experts, focusing on the modelling methodology used. Before the model-based assessments undertaken by the ASG, Criterion E was rarely used for species assessments, and no amphibian species were assessed under Criterion E in the first global amphibian assessment (2004-2008), as "....quantitative analysis of extinction risk requires considerably more data over longer time periods than is usually available for threatened amphibians" (Stuart et al., 2008). However, Criterion E was utilised by the ASG as a precautionary and novel approach to deal with the emerging threat of *Bsal* in Europe. The main concern is that it had been seen how devastating the impact of *Bd* has been and continues to be in the Neotropics and other parts of the world; perhaps the Red Listing process could in the future provide an early warning system for species susceptible to *Bsal* by ensuring and intensifying collaboration and communication between experts and practitioners to ensure rapid action.

The Red List assessments based on Criterion E for the European steno-endemic salamander species are used in this reassessment report. It should be emphasised that the presentation of the elevated threatened status of the species according to the IUCN criteria does not discredit the opinion of national experts or national conservation priorities. Global or regional extinction risk is not the same as a conservation priority at a local scale and national processes can quite correctly prioritise a species that is locally threatened.

Since the publication of the GAA2 results and the completion of this updated *European Red List*, there have been subsequent discussions between the Amphibian Red List Authority (which is the Red Listing branch of the ASG), a member of the IUCN SSC Standards and Petitions Committee, and national amphibian experts. Following this, improvements were made to the *Bsal* model that was used to produce the results for GAA2. The revised methods (see Akçakaya et al., 2023) better account for factors such as elevation and marine dispersal barriers, environmental suitability of *Bsal*, and plausible human-mediated dispersal pathways. There is now a need to reassess the European salamander species by applying the revised model which will be carried out on a global basis as soon as possible during the third GAA (2024-2028) with all relevant experts. Preliminary findings have found that two of the species, *Salamandra salamandra* and *Triturus carnifex*, will be downlisted to a non-threatened category which will be more consistent with the Italian national listings. A small number of the other species may also be downlisted to categories of lower extinction risk, however, they will still remain in the threatened categories and may still differ from the current national Italian Red List.

Table 8. *Red List status of European amphibian species assessed under criterion A3 (future population decline) or criterion E (quantitative analysis of the probability of extinction in the wild) in 2022 based on population declines resulting from* Bsal *mortality and other threats, and the national Red List status of the species that occur in Italy (Rondinini et al., 2022).*

Species	Range	IUCN Red List	Italian national Red List
IUCN Criterion A3:			
Calotriton arnoldi	Spanish endemic	CR A3ce; E	—
Salamandra salamandra	Widespread European endemic	VU A3ce	LC
Triturus carnifex	European endemic	VU A3ce	NT A3ce
Triturus marmoratus	European endemic	VU A3ce	—
IUCN Criterion E:			
Calotriton arnoldi	Spanish endemic	CR A3ce; E	—
Speleomantes ambrosii	Italian endemic	CR E	NT B1b(iii)
Speleomantes italicus	Italian endemic	EN E	LC
Speleomantes strinatii	Narrow-range endemic (France, Italy)	EN E	LC
Salamandra lanzai	Narrow-range endemic (France, Italy)	CR E	VU D2
Salamandrina perspicillata	Italian endemic	EN E	LC

Eggs of Pelobates fuscus *in Northern Italy. The life history of this species is not well documented due to its nocturnal behavior, weak underwater calls, and cryptic coloration. © antoniog*

5. Recommendations

5.1 Recommended actions

Analysis of European amphibian species assessments has shown that the most needed conservation action for European amphibians is the collection of more knowledge on detailed species distributions, population sizes and population trends, as well as on health status (mentioned for 52 of 99 species assessed or 52%). Scientific studies on all kinds of threats are required for 37% of species assessed, followed by those focused on life history and ecology (19% of species), and then taxonomy (18% of species assessed). Research priorities for amphibian conservation at a global level include the effects of climate change, community-level (rather than single species-level) drivers of declines, methodological improvements for research and monitoring, genomics, effects of land-use change, but also improved inclusion of under-represented members of the amphibian conservation community (Grant et al., 2023). It was already mentioned in the previous chapters that enabling continuous support for long-term population studies is the most challenging, especially if the species is of low threatened status or Least Concern because for funding agencies it is usually not attractive enough to be funded. However, research, monitoring and conservation action should not be separated.

The most recommended actions (43.2%) proposed by amphibian species experts in the Red List assessments are related to the control or eradication of various threats including pesticides, fires, tourism, overcollection, trade, pollution, introduced (alien) species, irresponsible waste disposal and diseases in general. A coordinated Europe-wide action plan for protection against *B. salamandrivorans* (*Bsal*) pathogen, prepared by Bern Convention, is crucial to protect salamander and newt species, particularly in controlling the trade of amphibians (see below "An emerging pathogen in Europe: the case of *Batrachochytrium salamandrivorans* (*Bsal*)"); however, as *Bsal* is already in Europe, further conservation actions and continuous education on precautionary measures are needed to stop further spreading of the pathogen/ raising awareness about the devastating effect of the pathogen on amphibian diversity. For comparison, *B. dendrobatidis* (*Bd*), an Anuran pathogen, is rarely recorded as a threat in the newest European amphibian species Red List assessment, but conservation action against *Bd* can be important locally, as in the case of *Alytes* species in Spain.

The second highest group of recommended actions tackles both terrestrial and aquatic habitats of amphibian species (39.0%), focusing on protection, but also including restoration and monitoring. Creation of new ponds and habitat management is particularly recommended and there are already examples of how specific conservation actions could contribute to collecting more knowledge (see Moor et al., 2022, 2024), as well as restoration of traditional grazing, protection of caves and old mines (key habitats for endemic cave salamanders), improvement of connectivity of suitable amphibian habitats and protection of temporary (vernal) ponds.

It also should be mentioned that, besides conservation actions focused on particular species, there is a lot of intraspecific variation that should be protected. For instance, paedomorphic newts (i.e. those retaining gills at the adult stage) are highly declining in several European countries due to fish intriductions (Denoël et al. 2019, 2023).

An emerging pathogen in Europe: the case of *Batrachochytrium salamandrivorans* (*Bsal*)

Jelka Crnobrnja-Isailović

Batrachochytrium salamandrivorans (*Bsal*) is an emerging fungal pathogen affecting amphibians and is closely related to *B. dendrobatidis* (*Bd*), which has had a devastating impact on amphibian populations around the world. These pathogens cause the infectious disease chytridiomycosis, which may lead to a fatal skin disease, and both are believed to have originated in Asia. *Bsal* has only been reported to cause disease in salamanders and newts, although the pathogen has been detected in some frog species (Martel et al., 2013). *Bsal* has been introduced to Europe, most likely through the pet trade in salamanders (Martel et al., 2014, Nguyen et al., 2017), and *Bsal* has been detected in the wild in the Netherlands, Belgium, Germany (e.g. Thein et al., 2020) and Spain (Martel et al., 2020). *Bsal* is highly contagious and is transmitted by i) direct contact with pathogen-shedding hosts, or ii) indirectly by contact with contaminated water or substrate (Thomas et al., 2019) and is highly pathogenic to most urodelan taxa in Europe (Martel et al., 2014). It has caused serious declines in populations of native host species in the areas where it is present, as was the case with *Salamandra salamandra* where, within seven years after the supposed introduction of the fungus, a population in the Netherlands declined by 99.9% (Spitzen-van der Sluijs et al., 2013). Because of its virulence and the fact that it appears to have a wide host range, it is feared that it could devastate European newt and salamander populations (IUCN SSC Amphibian Specialist Group, 2023; Areces-Berazain, 2024).

Since the global trade of salamanders and newts is suspected to be the principal route for the international spread of *Bsal*, bans and/or restrictions on amphibian trade, alongside controls at import pathways, are likely to be the most effective precautionary measures for preventing the spread of the disease. However, this measure is likely to reduce introduction events of *Bsal* and may prevent the outbreak of disease at intact sites, but does not provide long-term, sustainable solutions for infected systems. This will require research on the following knowledge gaps:

1. Confirmation of introduction pathways.
2. Understanding pathways of the dispersal of *Bsal* between populations.
3. Understanding *Bsal* reservoirs.
4. Understanding host susceptibility to *Bsal* infection.
5. Field tests of solutions that can be used to stop within-population pathogen spread, emergency actions in the case of local disease outbreaks, and mitigation measures in places where *Bsal* is present and persists.

A set of possible solutions for preventing the further spread of *Bsal* was recently subjected to modelling, but the results were not promising (Canessa et al., 2018). It suggests the need to clearly define the real, rather than theoretical, decision context for *Bsal* management and to embed scientific analysis of emerging diseases in a realistic decision context.

*Fire Salamander (*Salamandra salamandra*) covered with fungal ulcerations (*Bsal*), which are visible as black spots. Taken from Gray et al. (2015). © Frank Pasmans) / via Wikimedia Commons - CC0 1.0*

5.2 Application of project outputs

According to amphibian species (re)assessments for the period 2009-2022, reported outputs of various implemented conservation projects included two large groups: those related directly to habitats and those more focused on species. Conservation actions focused on habitats included pond creation, terrestrial and aquatic habitat restoration, restoration of pond networks, creation of wetland habitats, and supporting protected areas, which made 8.6%, 8.6%, 3.4%, 1.7% and 1.7% (24.0% in total) of all listed actions, respectively. This is a worrying fact, as conservationists should invest more time and effort into habitat conservation. It seems that conservation actions related to species were more abundant, with mitigation measures to reduce roadkill, as well as reintroductions and translocations, captive and supportive breeding and head-starting, subpopulations monitoring, as well as the establishment of amphibian rehabilitation centres, making 25.9%, 12.0%, 10.3% 5.2% and 1.7% (55.1% in total) of all mentioned actions taken, respectively. Only 1.7% of all implemented conservation actions were dedicated to some efforts implemented against *Bsal,* even though the most commonly recommended conservation actions were exactly those related to the mitigation of various threats and pathogens and therefore also *Bsal* included.

This amphibian data set provides a valuable resource for conservationists, policymakers, and environmental planners throughout the region. By making this data widely and freely available, we aim to stimulate and support research, monitoring and conservation action at local, regional, and international levels. The outputs from this project can be applied at the regional scale to prioritise sites and species to include in regional research and monitoring programmes and for the identification of internationally important sites for biodiversity. Apart from contributing to the update of the IUCN global Red List (www.iucnredlist.org), the large amount of data collected during the assessment process can be used for further analyses to provide deeper insights into the conservation needs of European species and the impacts on their populations of land-use policies and natural resource use.

5.3 Future work

The number of scientists and conservationists interested in various aspects of European amphibians' biology and ecology is increasing, and conservation biology topics are becoming increasingly attractive. It is well illustrated by The Conservation Evidence initiative (www.conservationevidence.com) which is a free, authoritative information resource designed to support decisions about how to maintain and restore global biodiversity.

European amphibians are comparatively well studied when compared to the results presented in a global review paper by Womack et al., (2022) where many amphibian species worldwide are understudied, including basic information such as natural history data. These authors also emphasised that an integration of amphibian databases is necessary for future conservation actions, including adaptive management strategies. In scientific publications on European amphibians, an integration can already be recognised by cooperation in producing phylogeographic studies, but it could be even better if life history and ecology research become unified on a regional (continent) level. Some progress is already reflected in studies such as Cayuela et al. (2022) on endemic European species *Bombina variegata*.

The process of compiling amphibian data for the European Red List also provides evidence of knowledge gaps which still occur. Although the quality of data available on the distribution and status of the species is higher than in the previous report, there are still some significant geographic, geopolitical, and taxonomic biases. Monitoring of amphibian species of European interest is a statutory responsibility under EU legislation, so regular reports on species status have been performed since 2001, and the number of European countries which apply systematic and regular amphibian monitoring is increasing (although the number of monitored areas per species is too low). Some initial discrepancies have occurred, as national amphibian population monitoring schemes have been initiated in some European countries as far back as in the last century, while in other countries, even basic data on species distribution and population status are limited. There is hope that this report will further encourage and facilitate national and regional monitoring to provide new data and to improve the quality of that already given.

A challenge for the future is to improve both the monitoring and quality of data, so that the information and analyses presented here and on the European Red List website can also be updated and enhanced, and conservation actions can be given as solid a scientific basis as possible. If the amphibian assessments are periodically updated, they will enable the changing status of these species to be tracked through time via the production of a Red List Index (Butchart et al., 2004, 2005, 2006, 2007). By regularly updating the data presented here we will be able to continue to track the changing fate of European amphibians.

Last but not least, the structural heterogeneity of Europe as a continent should not be an additional burden to the already challenging future of European amphibians. Therefore, future species and habitat action plans must be done by joint efforts of all its countries, as it is proposed in the Strategic Plan for the Bern Convention for the period to 2030 (Standing Committee of Convention on The Conservation of European Wildlife and Natural Habitats, 2023). The impoverishment of local biodiversity and the degradation or loss of some essential amphibian habitats in some parts of Europe should not be considered a purely national issue because many local losses could make a cumulative negative impact at the regional level.

Appropriate monitoring is crucial for effective conservation action and decision-making. This picture shows how minnow traps are used to count amphibians and assess the well-being of local populations. © Jelka Crnobrnja-Isailović

Successful amphibian conservation by focusing on manageable threats

Benedikt R. Schmidt

A large number of scientific publications document the loss of amphibian biodiversity at local, regional and global levels. An even larger number of scientific publications explains how a myriad of drivers, and interactions between them, cause the loss of amphibian biodiversity and the knock-on effects of the loss of amphibians on the ecosystems that they live(d) in.

That is a lot of bad news and leaves little room for hope. Is it nevertheless possible to “bend the curve”? It won’t be easy, but yes, we can. More than a decade ago, Rannap et al. (2009) showed that pond creation and restoration led to large increases in amphibian occupancy and abundance. It takes a lot of effort, but pond creation and restoration is not a complicated conservation action. More recently, Moor et al., (2022) reported a similar success story from Switzerland. In the Swiss canton of Aargau, the construction of more than 400 ponds over a 20-year period led to a strong increase in the number of populations of both common and threatened species. In the US, frog populations recovered in the Yosemite National Park after the removal of nonnative fish (Knapp et al., 2016). The take-home message from these three examples is that amphibian conservation if done well, can be successful. In many cases, we know how successful amphibian conservation action can be done (Grant et al., 2019). There is no lack of knowledge, but there is often a lack of political will, manpower and money. On the positive side, there are many conservationists and NGOs who are actively involved in practical local amphibian conservation.

Some readers may argue that there are threats that can never be eliminated. For example, despite decades of research, we still cannot mitigate the effects of Bd, the amphibian chytrid fungus, on amphibian populations, but there are some encouraging examples, for example, Thumsova et al. (2024) and Waddle et al. (2024). Such an argument is valid but there is reason for optimism. The conservation successes described above were possible despite ongoing exposure to multiple stressors. For example, Bd is still present in the Yosemite National Park. Nevertheless, the removal of non-native fish led to a recovery of the frog populations. Thus, while Bd mitigation would probably be beneficial, it was not necessary for the recovery of the frog populations. The study area of Moor et al., (2022) in Switzerland is highly urbanized, has a high road density, and intensive agriculture and forestry. Reducing the effects of all these stressors would be beneficial to populations but was not necessary for amphibian populations to recover. Recovery was possible by targeting the stressors that could be acted upon.

Pesticides are another stressor whose effects are difficult to mitigate because food producers argue that pesticides are necessary. It may be possible that amphibian populations can thrive in agricultural landscapes where pesticides are used. This is a somewhat hidden message in a scientific opinion published by the European Food Safety Authority (EFSA PPR Panel 2018). A model was used to predict the effects of pesticide use by farmers on the occurrence and abundance of the Great Crested Newt (*Triturus cristatus*) in spatially realistic landscapes. Unsurprisingly, pesticide use reduced both occurrence and abundance. Surprisingly, however, the net effect of pesticides varied among landscapes. It was almost zero in some landscapes, probably because these landscapes had more seminatural habitats such as hedges or a higher pond density.

What is the take-home message from the three examples? In all cases, amphibian populations faced threats that were hard to mitigate, but persistence or recovery was possible. This suggests that amphibian conservation may be successful if it focuses on manageable threats and solutions, particularly if conservation action boosts reproductive success. It may not be necessary to remove all stressors which have a negative impact on amphibian populations.

References

Akçakaya, H.R., Neam, K., Hobin, L., Lötters, S., Martel, A., and Pasmans, F. (2023). Assessing the extinction risks of amphibians impacted by infectious diseases. *Biological Conservation* 284: 110205. https://doi.org/10.1016/j.biocon.2023.110205

Altherr, S. and Lameter, K. (2020). The Rush for the Rare: Reptiles and Amphibians in the European Pet Trade. *Animals* 10(11): 2085. https://doi.org/10.3390/ani10112085

de Andrade, D.V. (2016). Temperature effects on the metabolism of amphibians and reptiles: Caveats and recommendations. In: D.V. de Andrade, C.R. Bevier, and J.E. de Carvalho (Eds.). *Amphibian and Reptile Adaptations to the Environment: Interplay Between Physiology and Behavior. Pp.*129-154. CRC Press. https://doi.org/10.1201/b20420

Areces-Berazain, F. (2024). *Batrachochytrium salamandrivorans* (Bsal). *CABI Compendium* 120547: 519. https://doi.org/10.1079/cabicompendium.120547

Arntzen, J.W. (2024). Morphological and genetic diversification of pygmy and marbled newts, with the description of a new species from the wider Lisbon Peninsula (*Triturus,* Salamandridae). *Contributions to Zoology* 93(2): 178-200. https://doi:10.1163/18759866-bja10057

Arntzen, J.W., Espregueira Themudo, G., and Wielstra, B. (2007). The phylogeny of crested newts (*Triturus cristatus* superspecies): nuclear and mitochondrial genetic characters suggest a hard polytomy, in line with the palaeogeography of the centre of origin. *Contributions to Zoology* 76: 261–278. https://doi.org/10.1163/18759866-07604005

Auliya, M., Altherr, S., Ariano-Sanchez, D., Baard, E,H., Brown, C., Brown, R.M., Cantu, J.-C., Gentile, C., Gildenhuys, P., Henningheim, E., Hintzmann, J., Kanari, K., Krvavac, M., Lettink, M., Lippert, J., Luiselli, L., Nilson, G., Nguyen T.Q., Nijman, V., Parham James, F., Pasachnik, S.A., Pedrono, M., Rauhaus, A., Rueda, C.D., Sanchez, M.-E., Schepp, U., van Schingen, M., Schneeweiss, N., Segniagbeto, G.H., Somaweera, R., Sy, E.Y., Türkozan, O., Vinke, S., Vinke, T., Vyas, R., Williamson, S., and Ziegler T. (2016). Trade in live reptiles, its impact on wild populations, and the role of the European market. *Biological Conservation* 204, Part A: 103-119. https://doi.org/10.1016/j.biocon.2016.05.017

Balaž, V., Vörös, J., Civiš, P., Vojar, J., Hettyey, A., Sós, E., Dankovics, R., Jehle, R., Christiansen, D.G., Clare, F., Fisher, M.C., Garner, T.W.J., and Bielby, J. (2013). Assessing Risk and Guidance on Monitoring of *Batrachochytrium dendrobatidis* in Europe through Identification of Taxonomic Selectivity of Infection. *Conservation Biology* 28(1), 213-223. https://doi.org/10.1111/cobi.12128

BirdLife International. (2021). *European Red List of Birds*. Luxembourg: Publications Office of the European Union. https://data.europa.eu/doi/10.2779/959320

Bounas, A., Keroglidou, M., Toli, E.-A., Chousidis, I., Tsaparis, D., Leonardos, I., and Sotiropoulos, K. (2020). Constrained by aliens, shifting landscape, or poor water quality? Factors affecting the persistence of amphibians in an urban pond network. *Aquatic Conservation-Marine and Freshwater Ecosystems* 30: 1037-1049. https://doi.org/10.1002/aqc.3309

Brühl, C.A., Schmidt, T., Pieper, S., and Alscher, A. (2013). Terrestrial pesticide exposure of amphibians: An underestimated cause of global decline? *Scientific Reports* 3: 1135. https://doi.org/10.1038/srep01135

Butchart, S.H.M, Stattersfield, A.J., Bennun, L.A., Shutes, S.M., Akçakaya, H.R., Baillie, J.E.M., Stuart, S.N., Hilton-Taylor, C., and Mace, G.M. (2004). Measuring global trends in the status of biodiversity: Red List Indices for birds. *PLOS Biology* 2: e383. https://doi.org/10.1371/journal.pbio.0020383

Butchart, S.H.M., Stattersfield, A.J., Baillie, J.E.M., Bennun, L.A., Stuart, S.N., Akçakaya, H.R., Hilton-Taylor, C., and Mace, G.M. (2005). Using Red List Indices to measure progress towards the 2010 target and beyond. *Philosophical Transactions of the Royal Society of London* B 360: 255-268. https://doi.org/10.1098/rstb.2004.1583

Butchart, S.H.M., Akçakaya, H.R., Kennedy, E. and Hilton-Taylor, C. (2006). Biodiversity indicators based on trends in conservation status: strengths of the IUCN Red List Index. *Conservation Biology* 20: 579-581. https://doi.org/10.1111/j.1523-1739.2006.00410.x

Butchart, S.H.M., Akçakaya, H.R., Chanson, J., Baillie, J.E.M., Collen, B., Quader, S., Turner, W.R., Amin, R., Stuart, S.R., and Hilton-Taylor, C. (2007). Improvements to the Red List Index. *PLOS ONE* 2(1): e140. https://doi.org/10.1371/journal.pone.0000140

Canessa, S., Bozzuto, C., Grant, E.H.C., Cruickshank, S.S., Fisher, M.C., Koella, J.C., Lötters, S., Martel, A., Pasmans, F., Scheele, B.C., Spitzen-van der Sluijs, A., Steinfartz, S., and Schmidt, B.R. (2018). Decision-making for mitigating wildlife diseases: From theory to practice for an emerging fungal pathogen of amphibians. *Journal of Applied Ecology* 55(4): 1987-1996. https://doi.org/10.1111/1365-2664.13089

Cano-Rocabayera, O., de Sostoa, A., Coll, L., and Maceda-Veiga, A. (2019). Managing small, highly prolific invasive aquatic species: Exploring an ecosystem approach for the eastern mosquitofish (*Gambusia holbrooki*). *Science of the Total Environment* 673: 594-604. https://doi.org/10.1016/j.scitotenv.2019.02.460

Cayuela, H., Monod-Broca, B., Lemaître, J.-F., et al. (2022). Compensatory recruitment allows amphibian population persistence in anthropogenic habitats. PNAS 119 (38): e2206805119. https://doi.org/10.1073/pnas.2206805119

Crnobrnja-Isailović, J., Jovanović, B., Ilić, M., Ćorović, J., Čubrić, T., Stojadinović, D., and Ćosić, N. (2021). Small Hydropower Plants' Proliferation Would Negatively Affect Local Herpetofauna. Mini Review. *Frontiers in Ecology and Evolution* 9: 610325. https://doi.org/10.3389/fevo.2021.610325

Crnobrnja-Isailović, J., Adrović, A., Bego, A., Čađenović, N., Hadžiahmetović-Jurida, E., Jablonski, D., Sterijovski, B., and Jovanović-Glavaš, O. (2022). The Importance of Small Water Bodies' Conservation for Maintaining Local Amphibian Diversity in the Western Balkans. In: V. Pešić, D. Milošević and M. Miliša (Eds.). *Small Water Bodies of the Western Balkans*. Springer Water. Springer, Cham. https://doi.org/10.1007/978-3-030-86478-1_17

Curado, N., Hartel, T., and Arntzen, J.W. (2011). Amphibian pond loss as a function of landscape change – A case study over three decades in an agricultural area of northern France. *Biological Conservation* 144: 1610-1618. https://doi.org/10.1016/j.biocon.2011.02.011

Cuttelod, A., Garcia, N., Abdul Malak, D., Temple, H., and Katariya, V. (2008). The Mediterranean: a biodiversity hotspot under threat. In: J.-C. Vié, C. Hilton-Taylor and S.N. Stuart (eds). *The 2008 Review of the IUCN Red List of Threatened Species*. Gland, Switzerland: IUCN. https://iucn.org/sites/default/files/import/downloads/the_mediterranean_a_biodiversity_hotspot_under_threat.pdf

DAISIE (Delivering Alien Invasive Species Inventories for Europe). (2009). *Handbook of Alien Species in Europe*. Invading Nature - Springer Series in Invasion Ecology, 3. Springer: Dordrecht. ISBN 978-1-4020-8279-5.

Denoël, M. and Winandy, L. (2015). The importance of phenotype diversity in conservation: Resilience of palmate newt morphotypes after fish removal in Larzac ponds (France). *Biological Conservation* 192: 402-408. http://dx.doi.org/10.1016/j.biocon.2015.10.018

Denoël, M., Ficetola, G.F., Sillero, N., Džukić, G., Kalezić, M.L., Vukov, T., Muhovic, I., Ikovic, V., and Lejeune, B. (2019). Traditionally managed landscapes do not prevent amphibian decline and the extinction of paedomorphosis. *Ecological Monographs* 89: e01347. https://doi.org/10.1002/ecm.1347

Denoël, M., B. R. Schmidt, R. Fonters, G. Hansbauer, A. Johanet, J. Kühnis, K. Poboljsaj, S. Schweiger & N. Sillero, (2023). Quantifying rarity of intraspecific diversity at multiple spatial scales by combining fine-grain citizen-based data across national boundaries. Biological Conservation 280: 109937. https://doi.org/10.1016/j.biocon.2023.109937

Díaz-Rodríguez, J., Gehara, M. C., Márquez, R., Vences, M., Gonçalves, H., Sequeira, F., Martínez-Solano, Í., and Tejedo. M. (2017). Integration of molecular, bioacoustical and morphological data reveals two new cryptic species of *Pelodytes* (Anura, Pelodytidae) from the Iberian Peninsula. *Zootaxa* 4243: 1-41. https://doi.org/10.11646/zootaxa.4243.1.1

Diaz-Paniagua, C., Florencio, M., de Felipe, M., Ramirez-Soto, M., Roman, I., and Arribas, R. (2024). Groundwater decline has negatively affected the well-preserved amphibian community of Doñana National Park (SW Spain). *Amphibia-Reptilia* 45(1): 1-13. https://doi.org/10.1163/15685381-bja10179

Doddington, B.J., Bosch, J., Oliver, J.A., Grassly, N.C., Garcia, G., Schmidt, B.R., Garner, T.W., and Fisher, M.C. (2013). Context-dependent amphibian host population response to an invading pathogen. *Ecology* 94(8): 1795-804. https://doi.org/10.1890/12-1270.1

Donald, P.F., Green, R.E., and Heath, M.F. (2001). Agricultural intensification and the collapse of Europe's farmland bird populations. *Proceedings of the Royal Society of London B* 268(1432): 25-29. https://doi.org/10.1098/rspb.2000.1325

Dubey, S., Leuenberger, J., and Perrin, N. (2014). Multiple origins of invasive and 'native'water frogs (*Pelophylax* spp.) in Switzerland. *Biological Journal of the Linnean Society* 112(3): 442-449. https://doi.org/10.1111/bij.12283

Dufresnes, C. and Perrin, N. (2015). Effect of biogeographic history on population vulnerability in European amphibians. *Conservation Biology* 29(4): 1235-1241. http://www.jstor.org/stable/24483198

Dufresnes, C., Mazepa, G., Jablonski, D., Oliveira, R.C., Wenseleers, T., Shabanov, D.A., Auer, M., Ernst, R., Koch, C., Ramírez-Chaves, H.E., Mulder, K.P., Simonov, E., Tiutenko, A., Kryvokhyzha, D., Wennekes, P.L., Zinenko, O.I., Korshunov, O.V., Al-Johany, A.M., Peregonstev, E.A., Masroor, R., Betto-Colliard, C., Denoël, M., Borkin, L.J., Skorinov, D.V., Pasynkova, R.A., Mazanaeva, L.F., Rosanov, J.M., Dubey, S., and Litvinchuk, S. (2019a). Fifteen shades of green: the evolution of *Bufotes* toads revisited. *Molecular Phylogenetics and Evolution* 141: 106615. https://doi: 10.1016/j.ympev.2019.106615

Dufresnes, C., Strachinis, I., Suriadna, N., Mykytynets, G., Cogălniceanu, D., Szekely, P., Vukov, T., Arntzen, J.W., Wielstra, B., Lymberakis, P., Geffen, E., Gafny, S., Kumlutaş, Y., Ilgaz, C., Candan, K., Mizsei, E., Szabolcs, M., Kolenda, K., Smirnov, N., Geniez, P., Lukanov, S., Crochet, P.A., Dubey, S., Perrin, N., Litvinchuk, S. and Denoël, M. (2019b). Phylogeography of a cryptic speciation continuum in Eurasian spadefoot toads (*Pelobates*). *Molecular Ecology* 28(13): 3257-3270. https://doi.org/10.1111/mec.15133

Dufresnes, C., Nicieza, A.G., Litvinchuk, S.N., Rodrigues, N., Jeffries, D.L., Vences, M., Perrin, N., and Martínez-Solano, I. (2020a). Are glacial refugia hotspots of speciation and cyto-nuclear discordances? Answers from the genomic phylogeography of Spanish common frogs. *Molecular Ecology* 29(5): 986-1000. https://doi.org/10.1111/mec.15368

Dufresnes, C. and Martínez-Solano, I. (2020b). Hybrid zone genomics supports candidate species in Iberian *Alytes obstetricans. Amphibia-Reptilia* 41: 105-112. https://doi.org/10.1163/15685381-20191312

Dufresnes, C., Monod-Broca, B., Bellati, A., Canestrelli, D., Ambu, J., Wielstra, B., Dubey, S., Crochet, P.-A., Denoël, M., and Jablonski, D. (2024). Piecing the barcoding puzzle of Palearctic water frogs (*Pelophylax*) sheds light on amphibian biogeography and global invasions. *Global Change Biology* 30: e17180. https://doi.org/10.1111/gcb.17180

Dufresnes, C., Denoël, M., di Santo, L., and Dubey, S. (2017). Multiple uprising invasions of *Pelophylax* water frogs, potentially inducing a new hybridogenetic complex. *Scientific Reports* 7: 6506. https://doi.org/10.1038/s41598-017-06655-5

EFSA PPR Panel (EFSA Panel on Plant Protection Products and their Residues), Ockleford, C., Adriaanse, P., Berny, P., Brock, T., Duquesne, S., Grilli, S., Hernandez-Jerez, A.F., Bennekou, S.H., Klein, M., Kuhl, T., Laskowski, R., Machera, K., Pelkonen, O., Pieper, S., Stemmer, M., Sundh, I., Teodorovic, I., Tiktak, A., Topping, C.J., Wolterink, G., Aldrich, A., Berg, C., Ortiz-Santaliestra, M., Weir, S., Streissl, F, and Egea-Serrano, A., Relyea, R.A., Tejedo, M., and Torralva, M. (2012). Understanding of the impact of chemicals on amphibians: a meta-analytic review. *Ecology and Evolution* 2(7):1382-97. https://doi.org/10.1002/ece3.249

European Environment Agency (EEA). *European Climate Risk Assessment: EEA Report No 1/2024*. Copenhagen: European Environment Agency, 2024. Available at: https://www.eea.europa.eu/publications/european-climate-risk-assessment.

Falaschi, M., Manenti, R., Thuiller, W., and Ficetola, G.F. (2019). Continental-scale determinants of population trends in European amphibians and reptiles. *Global Change Biology* 25: 3504-3515. https://doi.org/10.1111/gcb.14739

Falaschi, M., Melotto, A., Manenti, R., and Ficetola, F. (2020). Invasive species and amphibian conservation. *Herpetologica* 76: 216-227. https://doi.org/10.1655/0018-0831-76.2.216

Ficetola, G.F., Siesa, M.E., De Bernardi, F., and Padoa-Schioppa, E. (2012). Complex impact of an invasive crayfish on freshwater food webs. *Biodiversity and Conservation* 21: 2641-2651. https://doi.org/10.1007/s10531-012-0323-1

Frost, D.R. (2023). *Amphibian Species of the World: An Online Reference*. Version 6.2. Electronic Database. American Museum of Natural History, New York, USA. https://amphibiansoftheworld.amnh.org/index.php

Galli, A., Antonelli, M., Wambersie, L., Bach-Faig, A., Bartolini, F., Caro, D., Iha, K., Lin, D., Mancini, M.S., Sonnin, R., Vanham, D., and Wackernagel, M. (2023). EU-27 ecological footprint was primarily driven by food consumption and exceeded regional biocapacity from 2004 to 2014. *Nature Food* 4: 810–822. https://doi.org/10.1038/s43016-023-00843-5

Garner, T.W.J., Perkins, M.W., Govindarajulu, P., Seglie, D., Walker, S., Cunningham, A.A. and Fisher, M.C. (2006). The emerging amphibian pathogen *Batrachochytrium dendrobatidis* globally infects introduced populations of the North American bullfrog, *Rana catesbeiana*. *Biology Letters* 2: 455-459. https://doi.org/10.1098/rsbl.2006.0494

Gasc, J.-P., Cabela, A., Crnobrnja-Isailović, J., Dolmen, D., Grossenbacher, K., Haffner, P., Lescure, J., Martens, H., Martinez-Rica, J.P., Maurin, H., Oliveira, M.L., Sofianidou, T.S., Veith, M., and Zuiderwijk, A. (Eds.). (1997). *Atlas of Amphibians and Reptiles in Europe*. Societas Europaea Herpetologica and Muséum national d'Histoire naturelle (IEGB/SPN), Paris.

Gimmi, U., Lachat, T., and Bürgi, M. (2011). Reconstructing the collapse of wetland networks in the Swiss lowlands 1850–2000. *Landscape Ecology* 26: 1071-1083. https://doi.org/10.1007/s10980-011-9633-z

Grant, E.H.C, Miller, D.A.W., Schmidt, B.R., Adams, M.J., Amburgay, S.M., Chambert, T., Cruickshank, S.S., Fisher, R.N., Green, D.M., Hosack, B.R., Johnson, P.T.J., Joseph, M.B., Rittenhouse, T.A.G., Ryan, M.E., Waddle, J.H., Walls, S.C., Bailey, L.L., Fellers, G.M., Gorman, T.A., Ray, A.M., Pilliod, D.S., Price, S.J., Saenz, D., Sadinski, W., and Muths, E. (2016). Quantitative evidence for the effects of multiple drivers on continental-scale amphibian declines. *Scientific Reports* 6: 25625. https://doi.org/10.1038/srep25625

Grant, E.H.C., Muths, E., Schmidt, B.R., and Petrovan, S.O. (2019). Amphibian conservation in the Anthropocene. *Biological Conservation* 236: 543-547. https://doi.org/10.1016/j.biocon.2019.03.003

Grant, E.H.C., Amburgey, S.M., Gratwicke, B., *et al*. (2023). Priority Research Needs to Inform Amphibian Conservation in the Anthropocene. *Conservation Science and Practice* 2023: e12988. https://doi.org/10.1111/csp2.12988

Gray, M.J., Lewis, J.P., Nanjappa, P., *et al*. (2015). *Batrachochytrium salamandrivorans*: The North American Response and a Call for Action. *PLOS Pathogens* 11(12): e1005251. https://doi.org/10.1371/journal.ppat.1005251

Hartel, T., Scheele, B.C., Rozylowicz, L., Horcea-Milcu, A., and Cogălniceanu, D. (2020). The social context for conservation: Amphibians in human shaped landscapes with high nature values. *Journal for Nature Conservation* 53: 125762. https://doi.org/10.1016/j.jnc.2019.125762

Heusser, H. (1968). Wie Amphibien schützen? *Flugblatt Naturforschende Gesellschaft Schaffhausen* 3: 1-14.

IUCN. (2012a). *IUCN Red List Categories and Criteria: Version 3.1. Second edition*. Gland, Switzerland and Cambridge, UK: IUCN. https://www.iucnredlist.org/resources/categories-and-criteria

IUCN. (2012b). *Guidelines for application of IUCN Red List criteria at regional and national levels. Version 4.0*. Gland, Switzerland: IUCN Species Survival Commission. https://www.iucnredlist.org/resources/regionalguidelines

IUCN SSC Amphibian Specialist Group. (2022). *Salamandrina perspicillata*. *The IUCN Red List of Threatened Species* 2022(1): e.T136135A89706481. https://dx.doi.org/10.2305/IUCN.UK.2022-1.RLTS.T136135A89706481.en

IUCN SSC Amphibian Specialist Group. (2023). *Salamandra salamandra*. *The IUCN Red List of Threatened Species* 2023(1): e.T59467A219148292. https://dx.doi.org/10.2305/IUCN.UK.2023-1.RLTS.T59467A219148292.en

IUCN Standards and Petitions Committee. (2024). *Guidelines for Using the IUCN Red List Categories and Criteria*. Version 16. Prepared by the Standards and Petitions Committee. Downloadable from https://www.iucnredlist.org/documents/RedListGuidelines.pdf

IUCN. (2024). *Mapping Standards and Data Quality for the IUCN Red List Spatial Data*. Version 1.20 (January 2024). IUCN SSC Red List Technical Working Group: Cambridge and Gland. https://www.iucnredlist.org/resources/mappingstandards

Knapp, R.A., Fellers, G.M., Kleeman, P.M., Miller, D.A.W., Vredenburg, V.T., Rosenblum, E.B., and Briggs, C.J. (2016). Large-scale recovery of an endangered amphibian despite ongoing exposure to multiple stressors. *Proceedings of the National Academy of Sciences of the USA* 113: 11889-11894. https://doi.org/10.1073/pnas.1600983113

Lejeune, B., Clément, V., Nothomb, T., Lepoint, G., and Denoël, M. (2023). Trophic interactions between native newts and introduced mosquitofish suggest invaded ponds may act as demographic sinks. *Biological Invasions* 25: 2993-3007. https://doi.org/10.1007/s10530-023-03089-1

Lejeune, B., Lepoint, G., and Denoël, M. (2024). Food web collapse and regime shift following goldfish introduction in permanent ponds. *Global Change Biology* 30(7): e17435. https://doi.org/10.1111/gcb.17435

Luedtke, J.A., Chanson, J., Neam, K., *et al*. (2023). Ongoing declines for the world's amphibians in the face of emerging threats. *Nature* 622: 308-314. https://doi.org/10.1038/s41586-023-06578-4

Martel, A., Spitzen-van der Sluijs, A., Blooi, M., Bert, W., Ducatelle, R., Fisher, M.C., Woeltjes, A., Bosman, W., Chiers, K., Bossyjt, F., and Pasmans, F. (2013). *Batrachochytrium salamandrivorans* sp. nov. causes lethal chytridiomycosis in amphibians. *PNAS* 110: 15325-15329. https://doi.org/10.1073/pnas.1307356110

Martel, A., Blooi, M., Adriaensen, C., Van Rooij, P., Beukema, W., Fisher, M.C., Farrer, R. A., Schmidt, B. R., Tobler, U., Goka, K., Lips, K. R., Muletz, C., Zamudio, K. R., Bosch, J., Lötters, S., Wombwell, E., Garner, T. W. J., Cunningham, A. A., Spitzen-Van Der Sluijs, A., Salvidio, S., Ducatelle, R., Nishikawa, K., Nguyen, T. T., Kolby, J. E., Van Bocxlaer, I., Bossuyt, F., and Pasmans, F. (2014). Recent introduction of a chytrid fungus endangers Western Palearctic salamanders. *Science* 346: 630-631. https://doi.org/10.1126/science.1258268

Martel, A., Vila-Escale, M., Fernández-Giberteau, D., Martinez-Silvestre, A., Canessa, S., Van Praet, S., Pannon, P., Chiers, K., Ferran, A., Kelly, M., Picart, M., Piulats, D., Li, Z., Pagone, V., Pérez-Sorribes, L., Molina, C., Tarragó-Guarro, A., Velarde-Nieto, R., Carbonell, F., Obon, E., Martínez-Martínez, D., Guinart, D., Casanovas, R., Carranza, S., and Pasmans, F. (2020). Integral chain management of wildlife diseases**.** *Conservation Letters* 13: e12707. https://doi.org/10.1111/conl.12707

Measey, G.J., Rödder, D., Green, S.L., Kobayashi, R., Lillo, F., Lobos, G., Rebelo, R., and Thirion, J.M. (2012). Ongoing invasions of the African clawed frog, *Xenopus laevis*: A global review. *Biological Invasions* 14: 2255-2270. https://doi.org/10.1007/s10530-012-0227-8

Min, M.S., Yang, S.Y., Bonett, R.M., Vieites, D.R., Brandon, R.A., and Wake, D.B. (2005). Discovery of the first Asian plethodontid salamander. *Nature* 435: 87-90. https://doi.org/10.1038/nature03474

Miró, A., Sabás, I., and Ventura, M. (2018). Large negative effect of non-native trout and minnows on Pyrenean Lake amphibians. *Biological Conservation* 218: 144-153. https://doi.org/10.1016/j.biocon.2017.12.030

Mittermeier, R.A., Robles Gil, P., Hoffmann, M., Pilgrim, J., Brooks, T., Mittermeier, C.G., Lamoreux, J., and Fonseca, G.A.B. (2004). *Hotspots Revisited: Earth's Biologically Richest and Most Endangered Terrestrial Ecoregions*. Mexico City: CEMEX, Conservation International and Agrupacion Sierra Madre.

Moor, H., Bergamini, A., Vorburger, C., Holderegger, R., Bühler, C., Egger, S., and Schmidt, B.R. (2022). Bending the curve: Simple but massive conservation action leads to landscape-scale recovery of amphibians. *Proceedings of the National Academy of Sciences of the USA* 119: e2123070119. https://doi.org/10.1073/pnas.2123070119

Moor, H., Bergamini, A., Vorburger, C., Holderegger, R., Bühler, C., Bircher, N., and Schmidt, B.R. (2024). Building pondscapes for amphibian metapopulations. *Conservation Biology*: e14165. https://doi.org/10.1111/cobi.14281

Morris, W.F. and Doak, D.F. (2002). *Quantitative Conservation Biology: Theory and Practice of Population Viability Analysis*. Sinauer Associates Inc., Sunderland MA USA. ISBN 0-87893-546-0.

Nguyen, T.T., Nguyen, T.V., Ziegler, T., Pasmans, F., and Martel, A. (2017). Trade in wild anurans vectors the urodelan pathogen *Batrachochytrium salamandrivorans* into Europe. *Amphibia-Reptilia 38*(4): 554-556. https://doi.org/10.1163/15685381-00003125

Pabijan, M., Zielinski, P., Dudek, K., Stuglik, M., and Babik, W. (2017). Isolation and gene flow in a speciation continuum in newts. *Molecular Phylogenetics and Evolution* 116: 1-12. https://doi.org/10.1016/j.ympev.2017.08.003

Petrovan, S.O. and 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. https://doi.org/10.1371/journal.pone.0161943

Pille, F., Pinto, L., and Denoël, M. (2023). Functional and temporal facets of predation by marsh frogs across the aquatic-terrestrial ecotone of ponds and implications in the context of biological invasions. *Freshwater Biology* 68: 2184-2196. https://doi.org/10.1111/fwb.14186

Plötner, J., Baier, F., Akın, C., Mazepa, G.O., Schreiber, R., Beerli, P., Litvinchuk, S.N., Bilgin, C.C., Borkin, L.J., and Uzzell, T. (2012). Genetic data reveal that water frogs of Cyprus (genus *Pelophylax*) are an endemic species of Messinian origin. *Zoosystematics and Evolution. Mitteilungen aus dem Museum für Naturkunde in Berlin* 88: 261-283. https://doi.org/10.1002/zoos.201200021

Poschlod, P. and Braun-Reichert, R. (2017). Small natural features with large ecological roles in ancient agricultural landscapes of Central Europe - history, value, status, and conservation. *Biological Conservation* 211: 60-68. https://doi.org/10.1016/j.biocon.2016.12.016

Pupins, M., Nekrasova, O., Marushchak, O., Tytar, V., Theissinger, K., Čeirāns, A., Skute, A., and Georges, J.-Y. (2023). Potential threat of an invasive fish species for two native newts inhabiting wetlands of Europe vulnerable to climate change. *Diversity* 15(2): 201. https://doi.org/10.3390/d15020201

Quilodrán, C.S., Currat, M., and Montoya-Burgos, J.I. (2018). Effect of hybridization with genome exclusion on extinction risk. *Conservation Biology* 32: 1139-1149. https://doi.org/10.1111/cobi.13120

Rannap, R., Lohmus, A., and Briggs, L. (2009). Restoring ponds for amphibians: a success story. *Hydrobiologia* 634: 87-95. https://doi.org/10.1007/s10750-009-9884-8

Recuero, E., Canestrelli, D., Vörös, J., Szabo, K., Poyarkov, N.A., Arntzen, J.W., Crnobrnja-Isailović, J., Kidov, A.A, Cogălniceanu, D., Caputo, F.P., Nascetti, G., and Martínez-Solano, I. (2012). Multilocus species tree analyses resolve the radiation of the widespread *Bufo bufo* species group (Anura, Bufonidae). *Molecular Phylogenetics and Evolution* 62(1): 71-86. https://doi.org/10.1016/j.ympev.2011.09.008

Rigal, S., Dakos, V., Alonso, H., and Devictor, V. (2023). Farmland practices are driving bird population decline across Europe. *Proceedings of the National Academy of Sciences of the USA* 120: e2216573120. https://doi.org/10.1073/pnas.2216573120

Rodriguez-Rodriguez, E.J., Beltrán, J.F., Tejedo, M., Nicieza, A.G., Llusia, D., Márquez, R., and Aragón, P. (2020). Niche models at inter and intraspecific levels reveal hierarchical niche differentiation in midwife toads. *Scientific Reports* 10: 10942. https://doi.org/10.1038/s41598-020-67992-6

Romano, A., Bernabò, I., Rosa, G., Salvidio, S., and Costa, A. (2023). Artificial paradises: Man-made sites for the conservation of amphibians in a changing climate. *Biological Conservation* 286: 110309. https://doi.org/10.1016/j.biocon.2023.110309

Rondinini, C., Battistoni, A., and Teofili, C. (compilatori). (2022). *Lista Rossa IUCN dei vertebrati italiani 2022 Comitato.* Italiano IUCN e Ministero dell'Ambiente e della Sicurezza Energetica, Roma. https://www.iucn.it/pdf/Lista-Rossa-vertebratiitaliani-2022.pdf

Schabetsberger, R., Jersabek, C.D., Maringer, A., Kreiner, D., Kaltenbrunner, M., Blažková, P., Pokorný, P., Denoël, M., Emmerstorfer, H., Lipovnik, C., and Wölger, H. (2023). Pulling the plug - Draining an alpine lake failed to eradicate alien minnows and impacted lower trophic levels. *Water* 15: 1332. https://doi.org/10.3390/w15071332

Sequeira, F., Bessa-Silva, A., Tarroso, P., Sousa-Neves, T., Vallinoto, M., Gonçalves, H., and Martínez-Solano, I. (2020). Discordant patterns of introgression across a narrow hybrid zone between two cryptic lineages of an Iberian endemic newt. *Journal of Evolutionary Biology* 33(2): 202-216. https://doi.org/10.1111/jeb.13562

Sillero, N., Campos, J., Bonardi, A., Corti, C, Creemers, R., Crochet, P.-A., Crnobrnja-Isailović, J., Denoël, M., Ficetola, G.F., Gonçalves, J., Kuzmin, S., Lymberakis, P., de Pous, P., Rodríguez, A., Sindaco, R., Speybroeck, J., Toxopeus, B., Vieites, D.R., and Vences, M. (2014). Updated distribution and biogeography of amphibians and reptiles of Europe. *Amphibia-Reptilia* 35(1): 1-31. https://doi.org/10.1163/15685381-00002935

Speybroeck, J., Beukema, W., Dufresnes, C., Fritz, U., Jablonski, D., Lymberakis, P., Martínez-Solano, I., Razzetti, E., Vamberger, M., Vences, M., Vörös, J., and Crochet, P.-A. (2020). Species list of the European herpetofauna – 2020 update by the Taxonomic Committee of the Societas Europaea Herpetologica. *Amphibia-Reptilia* 41(2): 139-189. https://doi.org/10.1163/15685381-bja10010

Spitzen-van der Sluijs, A., Spikmans, F., Bosman, W., De Zeeuw, M., Van der Meij, T., Goverse, E., Kik, M., Pasmans, F., and Martel, A. (2013). Rapid enigmatic decline drives the fire salamander (*Salamandra salamandra*) to the edge of extinction in the Netherlands. *Amphibia-Reptilia* 34: 233-239. https://doi.org/10.1163/15685381-00002891

Standing Committee of Convention on the Conservation of European Wildlife and Natural Habitats. (2023). Strategic Plan for the Bern Convention for the period to 2030. Convention Secretariat, Council of Europe: Strasbourg. https://rm.coe.int/tpvs18e-2023-strategic-plan-final/1680ada084

Stöck, M., Dubey, S., Klütsch, C., Litvinchuk, S.N., Scheidt, U., and Perrin, N. (2008). Mitochondrial and nuclear phylogeny of circum-Mediterranean tree frogs from the *Hyla arborea* group. *Molecular Phylogenetics and Evolution* 49: 1019-1024. https://doi.org/10.1016/j.ympev.2008.08.029

Stuart, S.N., Chanson, J.S., Cox, N.A., Young, B.E., Rodgriguez, A.S.L., Fischman, D.L., and Waller, R.W. (2004). Status and trends of amphibian declines and extinctions worldwide. *Science* 306: 1783-1786. https://doi.org/10.1126/science.1103538

Stuart, S.N., Hoffman, M., Chanson, J.S., Cox, N.A., Berridge, R.J. Ramani, P., and Young, B.E. (Eds.). (2008). *Threatened amphibians of the world*. Lynx Editions, IUCN and Conservation International, Barcelona, Spain.

Suryadnaya, N.N. (2014). Comparative analysis of karyotypes of two cryptic species of pelobatid frogs (Amphibia, Anura) of Ukraine. *Vestnik Zoologii* 48: 511–520. https://doi.org/10.2478/vzoo-2014-0061

Temple, H.J. and Cox, N.A. (2009). *European Red List of Amphibians*. Luxembourg: Office for Official Publications of the European Communities. https://data.europa.eu/doi/10.2779/73661

Thein, J., Reck, U., Dittrich, C., Martel, A., Vanessa Schulz, V., and Hansbauer, G. (2020). Correspondence: Preliminary report on the occurrence of *Batrachochytrium salamandrivorans* in the Steigerwald, Bavaria, Germany. *Salamandra* 56(3): 227-229.

Thomas, V., Wang, Y., Van Rooij, P., Verbrugghe, E., Baláž, V., Bosch, J., Cunningham, A.A., Fisher, M.C., Garner, T.W.J., Gilbert, M.J., Grasselli, E., Kinet, T., Laudelout, A., Lötters, S., Loyau, A., Miaud, C., Salvidio, S., Schmeller, D.S., Schmidt, B.R., Spitzen-van der Sluijs, A., Steinfartz, S., Veith, M., Vences, M., Wagner, N., Canessa, S., Martel, A., and Pasmans, F. Mitigating *Batrachochytrium salamandrivorans* in Europe. *Amphibia-Reptilia* 40(3): 1-26. https://doi.org/10.1163/15685381-20191157

Thumsova, B., González-Miras, E., Rubio, Á., Granados, I., Bates, K.A., and Bosch, J. (2024). Chemical disinfection as a simple and reliable method to control the amphibian chytrid fungus at breeding points of endangered amphibians. *Scientific Reports* 14: 5151. https://doi.org/10.1038/s41598-024-55946-1

Tiberti, R., von Hardenberg, A., and Bogliani, G. (2014). Ecological impact of introduced fish in high altitude lakes: a case of study from the European Alps. *Hydrobiologia* 724: 1-19. https://doi.org/10.1007/s10750-013-1696-1

Ventura, M., Tiberti, R.T. Buchaca, T., D. Buñay, D., Sabás I., and Miró, A. (2017). Why should we preserve fishless high mountain lakes? In: J. Catalan, M. Ninot and M.M. Aniz (eds). *High Mountain Conservation in a Changing World*. Springer International Publishing: Cham. https://doi.org/10.1007/978-3-319-55982-7_8

Waddle, A.W., Clulow, S., Aquilina, A., Sauer, E.L., Kaiser, S.W., Miller, C., Flegg, J.A., Campbell, P.T., Gallagher, H., Dimovski, I., Lambreghts, Y., Berger, L., Skerratt, L.F., and Shine, R. (2024). Hotspot shelters stimulate frog resistance to chytridiomycosis. *Nature* 631: 344–349. https://doi.org/10.1038/s41586-024-07582-y

Wallis, G.P. and Arntzen, J.W. (1989). Mitochondrial DNA variation in the crested newt superspecies: limited cytoplasmic gene flow among species. *Evolution* 43(1): 88-104. https://doi.org/10.1111/j.1558-5646.1989.tb04209.x

Wielstra, B., Litvinchuk, S.N., Naumov, B., Tzankov, N., and Arntzen, J.W. (2013). A revised taxonomy of crested newts in the *Triturus karelinii* group (Amphibia: Caudata: Salamandridae), with the description of a new species. *Zootaxa* 3682(3): 441-453. https://doi.org/10.11646/zootaxa.3682.3.5

Wielstra, B.M., Sillero, N., Vörös, J., and Arntzen, J.W. (2014). The distribution of the crested and marbled newt species (Amphibia: Salamandridae: *Triturus*) – an addition to the New Atlas of Amphibians and Reptiles of Europe. *Amphibia-Reptilia* 35(3): 376-381. https://doi.org/10.1163/15685381-00002960

Winandy, L., Legrand, P., and Denoël, M. (2017). Habitat selection and reproduction of newts in networks of fish and fishless aquatic patches. *Animal Behaviour* 123: 107-115. https://doi.org/10.1016/j.anbehav.2016.10.027

Womack, M.C., Steigerwald, E., Blackburn, D.C., Cannatella, D.C., Catenazzi, A., Che, J., Koo, M.S., McGuire, J.A., Ron, S.R., Spencer, C.L., Vredenburg, V.T., and Tarvin, R.D. (2022). State of the Amphibia 2020: A Review of Five Years of Amphibian Research and Existing Resources. *Ichthyology & Herpetology* 110(4): 638-661. https://doi.org/10.1643/h2022005

Yaşar, Ç., Çiçek, K., Mulder, J., and Tok, C. V. (2021). The distribution and biogeography of amphibians and reptiles in Turkey. *North-Western Journal of Zoology* 17(2): 232-275. https://biozoojournals.ro/nwjz/content/v17n2/nwjz_e201512_Yasar.pdf

Appendix 1

A comparison of the species assessed in the first (Temple and Cox, 2009) and this updated version of the *European Red List of Amphibians*.

			2024 European Red List						2009 European Red List				
Family	**Species**	**Comment**	**Endemic to Europe**	**Endemic to EU**	**Pan Europe Category**	**Pan Europe Criteria**	**EU27 Category**	**EU27 Criteria**	**Species**	**Pan Europe Category**	**Pan Europe Criteria**	**EU27 Category**	**EU27 Criteria**
ALYTIDAE	*Alytes almogavarii*	*Alytes almogavarii* was elevated from subspecies level of *Alytes obstetricans* following Dufresnes & Martínez-Solano (2020a)	Yes	Yes	LC		LC		[not assessed]				
ALYTIDAE	*Alytes cisternasii*		Yes	Yes	LC		LC		*Alytes cisternasii*	NT	A2ce	—	
ALYTIDAE	*Alytes dickhilleni*		Yes	Yes	EN	A2ace	EN	A2ace	*Alytes dickhilleni*	VU	B2ab(iii,iv)	—	
ALYTIDAE	*Alytes muletensis*		Yes	Yes	EN	B1ab(iii,v)	EN	B1ab(iii,v)	*Alytes muletensis*	VU	D2	—	
ALYTIDAE	*Alytes obstetricans*		Yes	No	LC		LC		*Alytes obstetricans*	LC		LC	
ALYTIDAE	*Discoglossus galganoi*		Yes	Yes	LC		LC		*Discoglossus galganoi*	LC		—	
ALYTIDAE	*Discoglossus jeanneae*	Reduced to a synonym of *D. galganoi*							*Discoglossus jeanneae*	NT	A2c	—	
ALYTIDAE	*Discoglossus montalentii*		Yes	Yes	NT	B1ab(iii)	NT	B1b(iii)	*Discoglossus montalentii*	NT	B1b(iii,v)	—	
ALYTIDAE	*Discoglossus pictus*		No	—	LC		LC		*Discoglossus pictus*	LC		LC	
ALYTIDAE	*Discoglossus sardus*		Yes	Yes	LC		LC		*Discoglossus sardus*	LC		—	
BOMBINATORIDAE	*Bombina bombina*		No	—	LC		LC		*Bombina bombina*	LC		LC	
BOMBINATORIDAE	*Bombina pachypus*	Reduced to a synonym of *B. variegata*							*Bombina pachypus*	EN	A2ce	—	
BOMBINATORIDAE	*Bombina variegata*		Yes	No	LC		LC		*Bombina variegata*	LC		LC	
BUFONIDAE	*Bufo bufo*		No	—	LC		LC		*Bufo bufo*	LC		LC	

BUFONIDAE	*Bufo spinosus*	This species was elevated from its previous status as a subspecies of *Bufo bufo* by Recuero et al. (2012)	No	—	LC		LC		[not assessed]		
BUFONIDAE	*Bufotes balearicus*	Revised genus	Yes	Yes	LC		LC		*Pseudepidalea balearica*	LC	—
BUFONIDAE	*Bufotes boulengeri*	Revised genus; new taxonomic concept which includes *B. siculus*	No	—	LC		LC		*Pseudepidalea boulengeri*	LC	NA
BUFONIDAE	*Bufotes cypriensis*	Described in 2019	Yes	Yes	NT	B1ab(iii)	NT	B1ab(iii)	[not assessed]		
BUFONIDAE	*Bufotes siculus*	Now reduced to a synonym of *B. boulengeri*							*Pseudepidalea sicula*	LC	—
BUFONIDAE	*Bufotes variabilis*	Now reduced to a synonym of *B. viridis*							*Pseudepidalea variabilis*	DD	DD
BUFONIDAE	*Bufotes viridis*	Revised genus	No	—	LC		LC		*Pseudepidalea viridis*	LC	LC
BUFONIDAE	*Epidalea calamita*		Yes	No	LC		LC		*Epidalea calamita*	LC	LC
BUFONIDAE	*Sclerophrys mauritanica*	Revised genus	No	—	NA		NA		*Bufo mauritanicus*	NA	NA
HYLIDAE	*Hyla arborea*	This is a restricted concept following the elevation of *H. orientalis* and *H. molleri* from subspecies to species level.	Yes	No	LC		LC		*Hyla arborea*	LC	LC
HYLIDAE	*Hyla intermedia*	New taxonomic concept which includes *Hyla perrini* as a synonym	Yes	No	LC		LC		*Hyla intermedia*	LC	LC
HYLIDAE	*Hyla meridionalis*		No	—	LC		LC		*Hyla meridionalis*	LC	LC
HYLIDAE	*Hyla molleri*	Previously considered a subspecies of *Hyla arborea*, then elevated to species status by Stöck et al. (2008).	Yes	Yes	LC		LC		[not assessed]		
HYLIDAE	*Hyla orientalis*	This was previously considered a subspecies of *Hyla arborea* until it was elevated to species status by Stöck et al. (2008)	No	—	LC		LC		[not assessed]		
HYLIDAE	*Hyla sarda*		Yes	Yes	LC		LC		*Hyla sarda*	LC	—

HYLIDAE	*Hyla savignyi*		No	—	LC		LC		*Hyla savignyi*	LC		LC	
HYNOBIIDAE	*Salamandrella keyserlingii*	Omitted in error in 2009. Reduced concept which excludes subspecies *tridactyla* now recognised as a valid species	No	—	LC		Not Recorded		[not assessed]				
PELOBATIDAE	*Pelobates balcanicus*	Populations referring to *P. balcanicus* were assessed in 2009 as *P. syriacus*	Yes	No	LC		LC		*Pelobates syriacus*	LC		LC	
PELOBATIDAE	*Pelobates cultripes*		Yes	Yes	VU	A2ace	VU	A2ace	*Pelobates cultripes*	NT	A2e	—	
PELOBATIDAE	*Pelobates fuscus*	A new concept of the species is assessed to reflect the split of this species and *P. vespertinus*	Yes	No	LC		LC		*Pelobates fuscus*	LC		LC	
PELOBATIDAE	*Pelobates syriacus*	A restricted concept of this species following the split of the broader concept into this species (which as now defined contains the subspecies *P. syriacus syriacus* and *P. s. boettgeri*) and *P. balcanicus* (Dufresnes et al. 2019b)	No	—	NT	A2ac	EN	B2ab(i,ii,iii,iv,v)	*Pelobates syriacus*	LC		NT	A2c
PELOBATIDAE	*Pelobates varaldii*	Not a new taxon; only known from an unconfirmed record from Melilla (Spanish North Africa)	No	—	NA		NA		[not assessed]				
PELOBATIDAE	*Pelobates vespertinus*	Not assessed in 2009, the taxon was removed from the synonymy of *Pelobates fuscus*	No	—	LC		Not Recorded		[not assessed]				
PELODYTIDAE	*Pelodytes atlanticus*	This is a split from the broader concept of *P. punctatus*	Yes	Yes	LC		LC		[not assessed]				
PELODYTIDAE	*Pelodytes ibericus*		Yes	Yes	LC		LC		*Pelodytes ibericus*	LC		—	
PELODYTIDAE	*Pelodytes punctatus*	This is a restricted concept of this species following the split of the broader concept into this and *Pelodytes atlanticus*	Yes	Yes	LC		LC		*Pelodytes punctatus*	LC		—	

PIPIDAE	*Xenopus laevis*	New concept since 2009; *subspecies victorianus* and *sudanensis* are now split off; the former is a good species and the latter is part of *X. poweri*	No	—	NA		NA		*Xenopus laevis*	NA		NA	
PLETHODONTIDAE	*Speleomantes ambrosii*		Yes	Yes	CR	E	CR	E	*Speleomantes ambrosii*	NT	B1b(iii)	—	
PLETHODONTIDAE	*Speleomantes flavus*		Yes	Yes	EN	B1ab(iii)	EN	B1ab(iii)	*Speleomantes flavus*	VU	D2	—	
PLETHODONTIDAE	*Speleomantes genei*	Revised genus	Yes	Yes	VU	B1ab(iii)	VU	B1ab(iii)	*Atylodes genei*	VU	B1ab(iii)	—	
PLETHODONTIDAE	*Speleomantes imperialis*		Yes	Yes	NT	B1ab(iii)	NT	B1b(iii)	*Speleomantes imperialis*	NT	B1b(iii)	—	
PLETHODONTIDAE	*Speleomantes italicus*		Yes	Yes	EN	E	EN	E	*Speleomantes italicus*	NT	B1b(iii)	—	
PLETHODONTIDAE	*Speleomantes sarrabusensis*		Yes	Yes	CR	A2a; B1ab(v)	CR	A2a; B1ab(v)	*Speleomantes sarrabusensis*	VU	D2	—	
PLETHODONTIDAE	*Speleomantes strinatii*		Yes	Yes	EN	E	EN	E	*Speleomantes strinatii*	NT	B1b(iii)	—	
PLETHODONTIDAE	*Speleomantes supramontis*		Yes	Yes	EN	B1ab(iii,v)	EN	B1ab(iii,v)	*Speleomantes supramontis*	EN	B1ab(iii,v)	—	
PROTEIDAE	*Proteus anguinus*		Yes	No	VU	B2ab(ii,iii,v)	VU	B2ab(ii,iii,v)	*Proteus anguinus*	VU	B2ab(ii,iii,v)	VU	B2ab(ii,iii,v)
RANIDAE	*Aquarana catesbeianus*	Revised genus	No	—	NA		NA		*Lithobates catesbeianus*	NA		NA	
RANIDAE	*Pelophylax bedriagae*	Subsequently placed as a synonym of *Pelophylax ridibundus* in the current version of Amphibian Species of the World, but revision made too late to include here	No	—	LC		LC		*Pelophylax bedriagae*	LC		LC	
RANIDAE	*Pelophylax bergeri*	Now accepted as a synonym of *Pelophylax lessonae*							*Pelophylax bergeri*	LC		—	
RANIDAE	*Pelophylax cerigensis*	Subsequently placed as a synonym of *Pelophylax ridibundus* in the current version of Amphibian Species of the World, but revision made too late to include here	Yes	Yes	EN	B1ab(iii)+2ab(iii)	EN	B1ab(iii)+2ab(iii)	*Pelophylax cerigensis*	CR	B1ab(iii)+2ab(iii)	—	

RANIDAE	*Pelophylax cretensis*		Yes	Yes	EN	B2ab(iii)	EN	B2ab(iii)	*Pelophylax cretensis*	EN	B1ab(iii)+2ab(iii)	—	
RANIDAE	*Pelophylax cypriensis*	New taxon described in 2012. Subsequently placed as a synonym of *Pelophylax ridibundus* in the current version of Amphibian Species of the World, but revision made too late to include here	Yes	Yes	VU	B1ab(iii)	VU	B1ab(iii)	[not assessed]				
RANIDAE	*Pelophylax epeiroticus*		Yes	No	NT	B1ab(iii)	VU	B1ab(iii)	*Pelophylax epeiroticus*	VU	B1ab(iii)	VU	B1ab(iii)
RANIDAE	*Pelophylax esculentus*	Assessed in 2009 but removed from the ASW taxonomy and hence from the IUCN Red List because it is a fixed hybridogenetic form between *P. lessonae* and *P. ridibundus*							*Pelophylax esculentus*	LC		LC	
RANIDAE	*Pelophylax grafi*	Assessed in 2009 but removed from the ASW taxonomy and hence from the IUCN Red List because it is a fixed hybridogenetic form between *P. ridibundus* and *P. perezi*							*Pelophylax grafi*	NT	A2e	—	
RANIDAE	*Pelophylax hispanicus*	Assessed in 2009 but removed from the ASW taxonomy and hence from the IUCN Red List because it is a fixed hybridogenetic form between *P. lessonae* and *P. ridibundus*							*Pelophylax hispanicus*	LC		—	
RANIDAE	*Pelophylax kurtmuelleri*	Subsequently placed as a synonym of *Pelophylax ridibundus* in the current version of Amphibian Species of the World, but revision made too late to include here	Yes	No	LC		LC		*Pelophylax kurtmuelleri*	LC		LC	

RANIDAE	*Pelophylax lessonae*	New taxonomic concept of *P. lessonae* which includes *Pelophylax bergeri, P. esculentus,* and *P. hispanicus* as synonyms	Yes	No	LC		LC		*Pelophylax lessonae*	LC		LC	
RANIDAE	*Pelophylax perezi*		Yes	Yes	LC		LC		*Pelophylax perezi*	LC		—	
RANIDAE	*Pelophylax ridibundus*		No	—	LC		LC		*Pelophylax ridibundus*	LC		LC	
RANIDAE	*Pelophylax saharicus*		No	—	NA		NA		*Pelophylax saharicus*	NA		NA	
RANIDAE	*Pelophylax shqipericus*		Yes	No	VU	B1ab(iii)	NA		*Pelophylax shqipericus*	EN	B1ab(iii)	—	
RANIDAE	*Rana arvalis*		No	—	LC		LC		*Rana arvalis*	LC		LC	
RANIDAE	*Rana dalmatina*		No	—	LC		LC		*Rana dalmatina*	LC		LC	
RANIDAE	*Rana graeca*		Yes	No	LC		LC		*Rana graeca*	LC		LC	
RANIDAE	*Rana iberica*		Yes	Yes	VU	A2ace	VU	A2ace	*Rana iberica*	NT	A2ce	—	
RANIDAE	*Rana italica*		Yes	No	LC		LC		*Rana italica*	LC		—	
RANIDAE	*Rana latastei*		Yes	No	VU	B2ab(iii,v)	VU	B2ab(iii,v)	*Rana latastei*	VU	B2ab(iii)	VU	B2ab(iii)
RANIDAE	*Rana parvipalmata*	Not assessed in 2009. This is a split from *Rana temporaria*, where it was previously considered a subspecies (Dufresnes et al., 2020)	Yes	Yes	LC		LC		[not assessed]				
RANIDAE	*Rana pyrenaica*		Yes	Yes	EN	B1ab(iii,iv,v)	EN	B1ab(iii,iv,v)	*Rana pyrenaica*	EN	B1ab(ii,iii,iv)	—	
RANIDAE	*Rana temporaria*	New narrower concept of *R. temporaria* after the recognition of *R. parvipalmata*	No	—	LC		LC		*Rana temporaria*	LC		LC	
SALAMANDRIDAE	*Calotriton arnoldi*		Yes	Yes	CR	A3ce; E	CR	CR A3ce; E	*Calotriton arnoldi*	CR	B2ab(iii,iv)	—	
SALAMANDRIDAE	*Calotriton asper*		Yes	No	LC		LC		*Calotriton asper*	NT	B1b(iii)	—	
SALAMANDRIDAE	*Chioglossa lusitanica*		Yes	Yes	NT	A2ac	NT	A2ac	*Chioglossa lusitanica*	VU	B2ab(ii,iii,iv)	—	
SALAMANDRIDAE	*Euproctus montanus*		Yes	Yes	LC		LC		*Euproctus montanus*	LC		—	
SALAMANDRIDAE	*Euproctus platycephalus*		Yes	Yes	EN	B2ab(iii,iv)	EN	B2ab(iii,iv)	*Euproctus platycephalus*	EN	B2ab(iii,iv)	—	

SALAMANDRIDAE	*Ichthyosaura alpestris*	Revised genus	Yes	No	LC		LC		*Mesotriton alpestris*	LC		LC	
SALAMANDRIDAE	*Lissotriton boscai*	This is a new, narrower concept after the recognition of *L. maltzani*	Yes	Yes	LC		LC		*Lissotriton boscai*	LC		—	
SALAMANDRIDAE	*Lissotriton graecus*	Elevated from subspecies level of *Lissotriton vulgaris*	Yes	No	LC		LC		[not assessed]				
SALAMANDRIDAE	*Lissotriton helveticus*		Yes	No	LC		LC		*Lissotriton helveticus*	LC		LC	
SALAMANDRIDAE	*Lissotriton italicus*		Yes	Yes	LC		LC		*Lissotriton italicus*	LC		—	
SALAMANDRIDAE	*Lissotriton maltzani*	This taxon was removed from the synonymy of *Lissotriton boscai*	Yes	Yes	LC		LC		[not assessed]				
SALAMANDRIDAE	*Lissotriton montandoni*		Yes	No	LC		LC		*Lissotriton montandoni*	LC		LC	
SALAMANDRIDAE	*Lissotriton schmidtleri*	This taxon was elevated from subspecies level of *Lissotriton vulgaris*, although there is ongoing discussion about its taxonomic placement	No	—	LC		LC		[not assessed]				
SALAMANDRIDAE	*Lissotriton vulgaris*	A new taxonomic concept that recognises the promotion of *L. schmidtleri* and *L. graecus* as a valid species	Yes	No	LC		LC		*Lissotriton vulgaris*	LC		LC	
SALAMANDRIDAE	*Lyciasalamandra helverseni*		Yes	Yes	VU	D2	VU	D2	*Lyciasalamandra helverseni*	VU	D2	—	
SALAMANDRIDAE	*Lyciasalamandra luschani*		No	—	EN	B1ab(iii)	EN	B1ab(iii)	*Lyciasalamandra luschani*	NA		NA	
SALAMANDRIDAE	*Pleurodeles waltl*		No	—	NT	A2ac	NT	A2ac	*Pleurodeles waltl*	NT	A2c	NT	A2c
SALAMANDRIDAE	*Salamandra algira*	Not assessed in 2009	No	—	NA		NA		[not assessed]				
SALAMANDRIDAE	*Salamandra atra*		Yes	No	LC		LC		*Salamandra atra*	LC		LC	
SALAMANDRIDAE	*Salamandra corsica*		Yes	Yes	LC		LC		*Salamandra corsica*	LC		—	
SALAMANDRIDAE	*Salamandra lanzai*		Yes	Yes	CR	E	CR	E	*Salamandra lanzai*	VU	D2	—	
SALAMANDRIDAE	*Salamandra salamandra*		Yes	No	VU	A3ce	VU	A3ce	*Salamandra salamandra*	LC		LC	

SALAMANDRIDAE	*Salamandrina perspicillata*		Yes	No	EN	E	EN	E	*Salamandrina perspicillata*	LC		—	
SALAMANDRIDAE	*Salamandrina terdigitata*		Yes	Yes	LC		LC		*Salamandrina terdigitata*	LC		—	
SALAMANDRIDAE	*Triturus carnifex*	This is the new narrower concept of *Triturus carnifex* which excludes subspecies *macedonicus* (now split off as a separate species)	Yes	Yes	VU	A3ce	VU	A3ce	*Triturus carnifex*	LC		LC	
SALAMANDRIDAE	*Triturus cristatus*		No	—	LC		LC		*Triturus cristatus*	LC		LC	
SALAMANDRIDAE	*Triturus dobrogicus*		Yes	No	LC		LC		*Triturus dobrogicus*	NT	A2ce	NT	A2ce
SALAMANDRIDAE	*Triturus ivanbureschi*	Not assessed in 2009. This species is a re-description of the previously elevated subspecies of *Triturus karelinii* which was known as *T. arntzeni*	No	—	LC		LC		[not assessed]				
SALAMANDRIDAE	*Triturus karelinii*	New taxonomic concept since 2009	No	—	LC		Not Recorded		*Triturus karelinii*	LC		LC	
SALAMANDRIDAE	*Triturus macedonicus*	New concept since 2009. A former component of *Triturus carnifex*	Yes	No	VU	B2ab(iii,v)	EN	B2ab(iii,v)	[not assessed]				
SALAMANDRIDAE	*Triturus marmoratus*		Yes	Yes	VU	A3ce	VU	A3ce	*Triturus marmoratus*	LC		—	
SALAMANDRIDAE	*Triturus pygmaeus*		Yes	Yes	NT	A2ce	NA	A2ce	*Triturus pygmaeus*	NT	A2ce	—	

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