Measuring the pulse
of European biodiversity

European Red List of Dragonflies & Damselflies (Odonata)

Geert De Knijf, Magnus Billqvist, Roy van Grunsven, Florent Prunier, Damjan Vinko, Aurore Trottet, Vittorio Bellotto, Joanna Clay, David Allen

European Commission
IUCN
RED LIST
SSC Species Survival Commission
IUCN Dragonfly Specialist Group

European Red List of Dragonflies & Damselflies (Odonata)

Geert De Knijf, Magnus Billqvist, Roy van Grunsven, Florent Prunier, Damjan Vinko, Aurore Trottet, Vittorio Bellotto, Joanna Clay, David Allen

This report was produced for the European Commission under the project '*Providing technical and scientific support in measuring the pulse of European biodiversity using the Red List Index*' (Contract No 07.027755/2020/840209/SER/ENV.D.2).

Project duration:	January 2021 to December 2024
Published by:	European Commission
Citation:	De Knijf, G., Billqvist, M., van Grunsven, R.H.A., Prunier, F., Vinko, D., Trottet, A., Bellotto, V., Clay, J. and Allen, D.J. (2024). *Measuring the pulse of European biodiversity. European Red List of Dragonflies & Damselflies (Odonata).* Brussels, Belgium: European Commission. 46 pp.
ISBN:	978-92-68-18365-6 (PDF)
DOI:	https://doi.or/10.2779/462053 (PDF)
Design and layout:	Imre Sebestyén jr. / Unit Graphics
Cover page picture credit:	Cazuma Pincertail *Onychogomphus cazuma* (Endangered). © Magnus Billqvist
Back page picture credit:	*Sympetrum depressiusculum* (Vulnerable) © Geert De Knijf

Available from: IUCN (International Union for Conservation of Nature)
64 Boulevard Louis Schmidt, 1040 Brussels, Belgium
brussels@iucn.org
www.iucn.org/resources/publications

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

Contents

Orthetrum nitidinerve (Endengered) © Magnus Billqvist

Acknowledgements

This report would not have been possible without the help of many people, organisations, societies and institutions. First of all, we would like to thank all the organisations who were willing to share their data for use in this project:

Flemish Dragonfly Society - LVV (Belgium), Groupe Gomphus Wallonie-Bruxelles (Belgium), Association Hyla (Croatia), Cyprus Dragonfly Study Group (Cyprus), Naturbasen (Denmark), Finnish Biodiversity Information Facility (Finland), Office pour les insectes et leur environnement - Opie, groupe Odonata (France), Gesellschaft deutschsprachiger Odonatologen (GdO) & regional groups (Germany), State Service for Protected Areas (Lithuania), Dutch Dragonfly Society – NVL (the Netherlands), Artsdatabanken (Norway), Centre for Cartography of Fauna and Flora (Slovenia), Slovene Dragonfly Society (Slovenia), Grupo Ibérico de Odonatología (Spain & Portugal), SLU Artdatabanken (Sweden), Centre suisse de la Cartographie de la Faune (Switzerland) and the British Dragonfly Society (UK).

Additional personal databases were provided by Jean-Pierre Boudot (European database), Vladimir Onishko and Oleg Kosterin (European Russia), Miloš Jović (Serbia), Bogić Gligorović (Montenegro), Dejan Kulijer (Bosnia and Herzegovina), Denis Kitel (Belarus) and Dimitar Bechev (Bulgaria).

The assessments were reviewed by Matjaž Bedjanič, Klaus-Jürgen Conze, Sonia Ferreira, Miloš Jović, Vincent Kalkman, Göran Sahlén and Frank Suhling; and contributions made by Giacomo Assandri, Jean-Pierre Boudot, Cecilia Diaz Martinez and David Sparrow.

Thanks go to the IUCN staff involved in the project for their practical help and support in the coordination of this European Red List of Dragonflies.

IUCN gratefully acknowledges the funding received by the European Commission. The European Red List of Dragonflies and Damselflies, and consequently this publication, were produced as part of the European Commission under the project '*Providing technical and scientific support in measuring the pulse of European biodiversity using the Red List Index*' (Contract No 07.027755/2020/840209/SER/ENV.D.2). In particular, we would like to thank Anne Teller and Vujadin Kovacevic (European Commission) for their support throughout the project, allowing for a smooth implementation.

A male of the Mediterranean Bluet Coenagrion caerulescens. © *Florent Prunier*

Executive Summary

Aim

This European Red List provides an updated summary of the conservation status of the European species of dragonflies and damselflies (hereafter Odonata), evaluated according to the IUCN *Red List Categories and Criteria* (2012a) and IUCN's global (IUCN Standards and Petitions Committee, 2022) and regional (IUCN, 2012b) guidelines. It is a completely revised second edition with inclusion of any new data. It is a comprehensive, region-wide assessment of dragonflies and builds on the previous work done for the first European Red List of Dragonflies (Kalkman et al., 2010) and on the Atlas of the dragonflies and damseflies in Europe (Boudot and Kalkman, 2015; Kalkman et al., 2018). It identifies species threatened with extinction at the European and EU27 Member State levels so that appropriate policy measures and conservation actions can be taken to improve their status, based on the best available evidence.

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 the Urals 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 Caucuses) fall beyond the European scope of this European Red List. Red List assessments were made at two regional levels: for geographical Europe and for the 27 Member States of the European Union (hereafter, EU27).

All 146 dragonfly species recorded for the European region were included in this assessment. The original list of species was supplemented by recently published taxonomic revisions of findings of new species (see Appendix 1). Four species that are only very occasionally observed in Europe without proof of reproduction were classed as Not Applicable for the European Red List, and this analysis focuses on the 142 assessed species.

Results

Of the 142 species assessed, a best estimate of 21.0% (29 species) of extant species for which sufficient data are available are threatened (i.e., assessed as Critically Endangered, Endangered or Vulnerable) on the European scale, with 1.4% being Critically Endangered, 6.3% Endangered and 12.7% Vulnerable.. In addition, 12.0% (17 species) were assessed as Near Threatened, with four species (2.8%) considered Data Deficient (Figure 5; Table 3). The situation for the 137 species occurring within the EU is quite similar to that of Europe as a whole (Figure 6); 21.9% (30 species) of extant species for which sufficient data are available are threatened (with none assessed as Data Deficient), of which 1.5% are Critically Endangered, 7.3% Endangered and 13.9% Vulnerable. A further 19 species (13.1%) were assessed as Near Threatened. The highest number of threatened species are found in a broad belt approximately from southern France to southern Scandinavia and the Baltic states.

Comparing the present Red List with the previous one (Kalkman et al., 2010), a significant increase in the number of threatened species is observed, at both Pan Europe and EU levels. The number of Endangered and Vulnerable species

increased by nearly 50%. Many of these new threatened species are typical of nutrient poor or small oligotrophic aquatic ecosystems. Despite a slight increase in the number of dragonfly species being found in Europe and in EU27, a lower number of species are now considered as Least Concern. Both indicate that the situation of dragonflies has dramatically declined over a period of only 10 years.

Recommendations

Conservation action

After the assessments of the European dragonflies was completed, European dragonfly experts participated in February and March 2024 in conservation action planning workshops focusing on the threatened species. The project followed the IUCN SSC Conservation Planning Specialist Group (CPSG) "Assess-to-Plan" (A2P) methodology which is designed to build consensus on the priority actions required over the next 5-10 years and to identify organisations that can take these actions. Recommended conservation actions were organised under three goals: 1) Knowledge, tools, and expert capacity; 2) Protecting, restoring, managing, and monitoring key habitats and populations; and 3) Ensuring effective policy and planning support. An increased awareness permeates all three goals.

Each conservation action includes a goal and a set of associated sub-goals. The targets include European and national government agencies and local management authorities, funding agencies, NGOs, relevant business sectors, policy makers (local, national and regional), water management agencies, developers and their ecologists, the scientific community and places of learning (universities, institutes, schools), the main land-user groups (agriculture, grasslands, forestry), Natura 2000 site managers, municipal managers of public territory and parks, nature conservation area management bodies, groups with similar conservation interests (e.g. groups aiming to conserve freshwater habitats for other invertebrate species), and local communities in areas where action is most needed. See *Moving from Assessment to Planning for Threatened European Dragonflies* (TBD, 2024) for these details.

Work on the ground

To properly protect the threatened species there must be effective policy and planning support for dragonflies at European, national, and local levels. An update to the species included in the Annexes of the EU Habitats Directive can be a first step. But the European Commission (hereinafter EC) can also take the necessary steps and action to ensure that conservation measures are taken for threatened European dragonflies. Other important factors are funding mechanisms for the protection and management of threatened species, European regulation on minimum water flow (e-flow), reduced risks from dams (stricter ecological guidelines for new dams, funding for dam removal). The European Red List must also work through at the national level. The national countries must also take their responsibility for the European threatened species that occur in their national territories. This is even more important for very localised species, often endemics that are threatened. This must include not only associated protection and planning, but also adequate implementation and enforcement of existing laws and regulations, as well as the necessary conservation actions.

To achieve adequate protection, restoration and management of priority habitats and populations of threatened dragonflies, several measures are required. Natural flow rates and clean water in European rivers and streams should be a focus of course. In priority oligotrophic wetlands, water levels should be maintained or restored, while nutrient-enrichment, such as through atmospheric nitrogen deposition, and other risks are excluded. In protected areas, threatened species should be conserved effectively with species-specific planning and urgent measures for the most pressing cases. Climate change is an overarching threat to many species, so climate-adapted management plans that include dragonflies should be established for the planning and management of wetlands and their surroundings.

As the results of the assessments conclude, the most urgent measures needed are the conservation of smaller watercourses in the Mediterranean area. Stopping, often illegal, water abstraction and mitigating the effects of prolonged drought is vital for Europe's most threatened dragonflies, which depend on streams and rivers.

Management plans for these systems need to be prioritised, developed and implemented.

The European Red List of Dragonflies & Damselflies is part of a wider initiative aimed at assessing the status of European species. The current European assessments of dragonflies, this report and the A2P (TBD, 2024) provide key resources for policy makers, conservationists, NGOs, environmental planners, and other stakeholders across the region. The results of this project can be applied at a regional scale to prioritise sites and species for inclusion in regional research and monitoring programs and to identify internationally important biodiversity sites. Red Lists are a dynamic tool that will evolve over time as species are reassessed according to new information or situations.

Research and monitoring

More research and European-wide monitoring are needed to be able to carry out adequate conservation. Improved knowledge of threatened species population trends and their drivers as well as development of dragonfly indicators and an established data sharing platform are essential. For this reason, the Dragonfly Conservation Europe (DCE), a European society was recently established. It aims to be an overarching society of dragonfly experts providing essential knowledge, tools, and expertise to support effective dragonfly conservation..

Nurturing volunteers through funded programs and well-targeted Citizen Science initiatives can also help. Capacity building through education will be important over the next 5–10 years and priority countries or regions include Greece and other countries in south-eastern Europe such as Albania, Bulgaria, Romania and North Macedonia. During the process of compiling data for this European Red List, several knowledge gaps have been identified. Across Europe, there are significant geographical, geopolitical, and taxonomic differences and other challenges regarding the quality of available data on species distribution and status.

There is a clear need to collate information from all ongoing and planned data collection initiatives and for a wider European dragonfly conservation action plan to be researched and developed. Few European countries have any kind of organised and systematic monitoring program for dragonflies, and many have only basic data on the species' distribution and population status at best.

The Spotted Darter Sympetrum depressiusculum © *Geert De Knijf*

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 km².

The European Union, comprising of 27 Member States, is Europe's largest political and economic entity. It is the world's largest economy with an estimated 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).

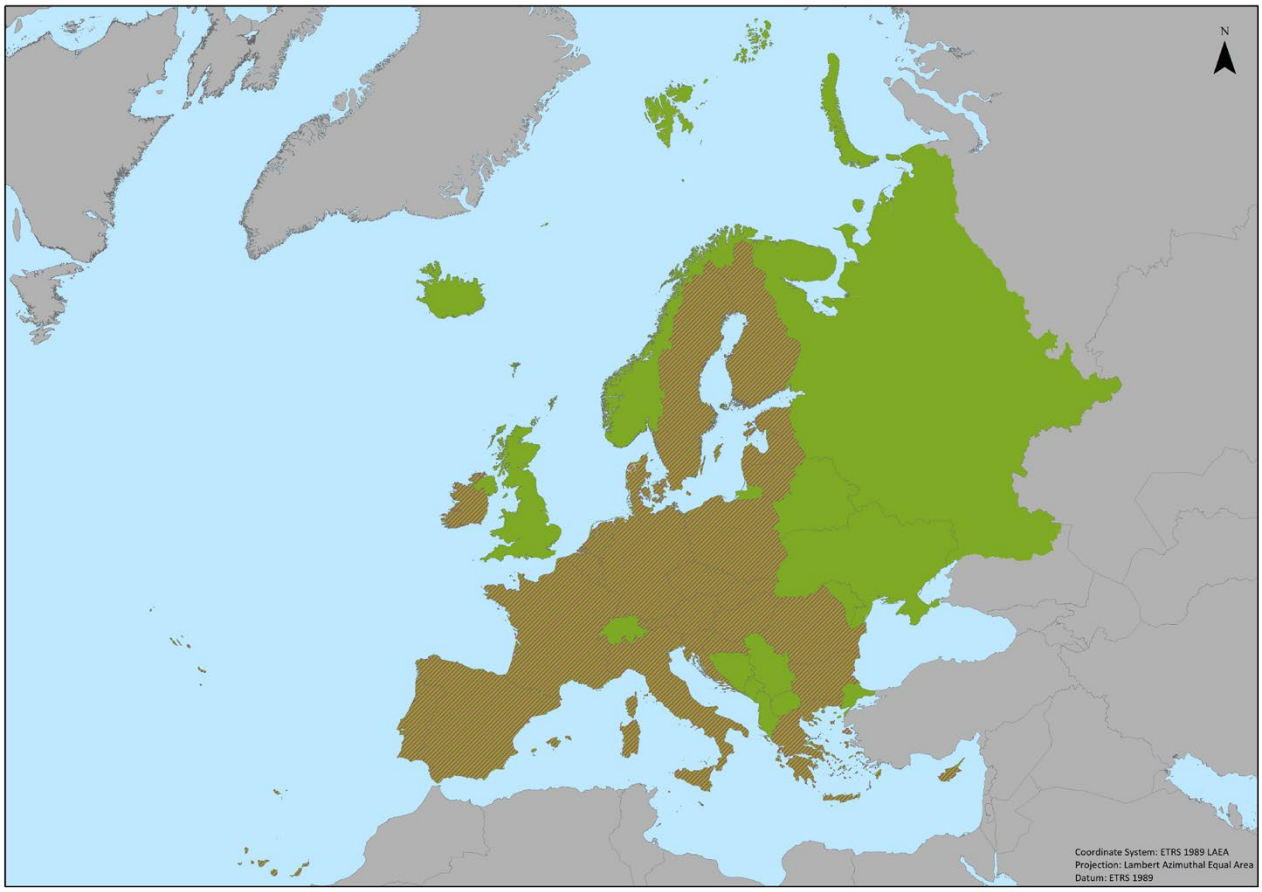

Figure 1. *The European Red List terrestrial assessment boundaries. Regional assessments were made for two areas: for geographical Europe (green), and for the EU27 Member States (hatched area).*

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-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) continues to be a major concern in the region.

1.2 The European policy context

Biodiversity provides resources and services that are essential for sustainable development, however the loss of biodiversity remains one of the most pressing crises facing the world. The factors driving this loss can be complex and the solutions often rely on the involvement of various groups ranging from international bodies to governments to civil society. Data on the status of biodiversity is essential to inform policies and develop frameworks which aim to reduce its loss.

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. Whilst there were successes from the delivery of various actions resulting in the recovery of some populations and habitats, the strategy did not succeed in delivering its headline target and the loss of biodiversity continues (EC, 2015; IPBES, 2018; EC, 2022). This has prompted the EU to set out its new Biodiversity Strategy for 2030, which aims to protect nature and reverse the degradation of ecosystems by 2030 through specific actions and commitments. As a core part of the European Green Deal, the Biodiversity Strategy will also support a green recovery following the COVID-19 pandemic, and it is the EU's contribution to the ongoing international negotiations on the post-2020 global biodiversity framework.

The Council of Europe's Convention on the Conservation of European Wildlife and Natural Habitats (1979), or the Bern Convention, was the first international treaty to protect both species and habitats and to bring countries together to decide how to act on nature conservation. This convention was adopted to protect Europe's wild plants and animals and formed the backbone of later adapted European legislation on nature conservation and protection. Several dragonflies are mentioned as strictly protected species in Annex II.

For the conservation of dragonflies, in the EU several regulations are relevant, some directly and others indirectly. The predominant regulation is the Habitats Directive. This Directive aims to conserve biodiversity by setting up a network of protected areas, the Natura 2000 network, and protect specific species and habitats in and outside these areas. There are several dragonfly species included in Annexes II and IV. For species in Annex II, countries need to designate special areas of conservation. For these species special conservation is required to ensure the continuing persistence in the countries where they occur. The designation of Natura 2000 areas in locations where species from Annex II occur and the protection of species from Annex IV will have contributed to their conservation in Europe. An overview of the species mentioned in the Bern Convention, the Annexes (II or IV) of the Habitats Directive and the species endemic to Europe, is presented in Table 1.

Table 1. *Overview of dragonflies mentioned in the Bern Convention Appendix II (Strictly protected fauna species), the EU Habitats Directive Annexes (II and/or IV), and the species that are endemic to Europe.*

Species	Bern Convention	Habitats Directive	Endemic
Calopteryx xanthostoma			●
Sympecma paedisca	●	IV	
Coenagrion castellani		II	●
Coenagrion hylas	●	II	
Coenagrion intermedium			●
Coenagrion mercuriale	●	II	
Coenagrion ornatum		II	
Ischnura genei			●
Pyrrhosoma elisabethae			●
Platycnemis acutipennis			●
Platycnemis latipes			●
Aeshna viridis	●	IV	
Boyeria cretensis			●
Cordulegaster bidentata			●
Cordulegaster helladica			●
Cordulegaster heros		II, IV	●
Cordulegaster trinacriae	●	II, IV	●
Gomphus graslinii	●	II, IV	●
Gomphus pulchellus			●
Gomphus simillimus			●
Onychogomphus cazuma			●
Ophiogomphus cecilia	●	II, IV	

Stylurus flavipes	●	IV	
Lindenia tetraphylla	●	II, IV	
Macromia splendens	●	II, IV	●
Oxygastra curtisii	●	II, IV	
Somatochlora borisi			●
Leucorrhinia albifrons	●	IV	
Leucorrhinia caudalis	●	IV	
Leucorrhinia pectoralis	●	II, IV	
Sympetrum nigrifemur			●
Total	**14**	**17**	**19**

Besides dragonfly species mentioned on the Habitats Directive Annexes, several species are protected under the Habitats Directive through the protection of their habitats. Annex I of the Habitats Directive contains 233 habitat types for which the member states must designate and protect core areas are listed. This list includes habitats that are of importance for dragonflies such as 3130 - Acidic nutrient-poor heathland ponds, 3150 - Natural eutrophic lakes with Magnopotamion or Hydrocharition type vegetation, and 7110 - Active raised bogs. Many species are protected indirectly by the protection of these habitats. Sometimes they are formally designated as a typical species and quality indicator for a habitat by a member state (e.g. De Knijf et al., 2013) but often they simply benefit from the conservation of the habitat without specific conservation goals being formulated for dragonflies.

The Water Framework Directive (WFD) has had, and still has, an impact on the conservation of dragonflies in Europe. This Directive aims to achieve a good qualitative and quantitative status of waterbodies in Europe. There are several criteria: biological quality (fish, benthic invertebrates, aquatic flora), hydromorphological quality, physical-chemical quality (temperature, oxygen and nutrient levels) and chemical (pollutants). The WFD together with the Habitats Directive has resulted in an improvement of the water quality over large areas of Europe. This has had a positive impact on several dragonfly species, in particular species from running waters, such as *Stylurus flavipes*. Besides streams and rivers, the Water Framework Directive focuses especially on larger water bodies and therefore, small water bodies, ponds, small lakes, headwaters and temporary waters are not covered in most countries, even though these harbour a large fraction of the aquatic biodiversity, especially invertebrate biodiversity such as dragonflies.

The Nature Restoration Law aims to restore nature quality in the EU and sets goals to protect larger areas of the EU's land and sea area, 20% by 2030. This law would enormously benefit biodiversity, including dragonflies, if implemented. The law states that greater efforts to restore freshwater ecosystems are required. However, care should be taken that smaller water bodies will get the attention they deserve in the implementation of this law. Besides the existing protected habitats, the explicit targets include urban, forest, agriculture and marine ecosystems but for aquatic ecosystems only river connectivity is included. The attention for water bodies that are not covered under the WFD is essential. While small in surface area they contribute disproportionately to biodiversity. As has become clear in this assessment of dragonflies in Europe, the species that are most threatened are those that occur in small waterbodies, in particular nutrient poor ponds in Central Europe and small streams in the Mediterranean.

1.3 European Odonata

With around 6,400 species described worldwide, dragonflies are one of the world's smaller insect groups, but they are without doubt the best studied group of aquatic macroinvertebrates. Their taxonomy, ecology, behaviour, physiology, and evolution are well documented (e.g. Corbet, 1999; Cordoba-Aguilar et al., 2022). Dragonflies are also the first insect group that have been globally assessed for the IUCN Red List (Clausnitzer et al., 2009).

Dragonflies belong to the insect order Odonata, which in Europe includes the two suborders true dragonflies (Anisoptera = dissimilar wings) and the damselflies (Zygoptera = uniform wings). Generally, the word "dragonflies" is used for both suborders.

All dragonflies have two pairs of wings, large eyes and long, elongated abdomens. The damselflies are very slender with eyes that are separated and can therefore give their heads a hammerhead shark-impression. Their larvae have protruding lamellae at the far end of their abdomen that act as gills. True dragonflies are more robust, and their very large eyes are usually not separated. The larvae of the Anisoptera have no external gills.

The wings are extremely thin but at the same time durable and thanks to very powerful wing muscles, the larger species can fly at speeds of around 35 kilometres per hour. They have excellent colour vision with both depth perception and high acuity and a near 360-degree field of view. The legs are long and can act as a basket, in which prey can be caught. This, together with a lightning-quick reaction, contribute to dragonflies being perhaps the world's most efficient hunters.

In Europe, the largest dragonflies are found in the genera *Aeshna* and *Anax*, where *Aeshna crenata* and *Anax immaculifrons* can reach almost nine centimetres in lenght, and in the Cordulegastridae family. However, today's dragonflies are nowhere near the giant relatives that once populated our planet. The smallest dragonfly in Europe is *Nehalennia speciosa* which has a body length of only 22–26 mm.

Adult dragonflies do not normally live longer than a few weeks or months. The exceptions are the species in the genus *Sympecma* which live for almost a whole year. They leave their larval phase in late summer, overwinter as fully developed dragonflies and can live until the following summer.

A female dragonfly can lay hundreds of eggs. Some species lay their eggs directly in water, so-called exophytic oviposition. Others protect the eggs by laying them in plants (endophytic oviposition) or pushing them into mud. The exophytic eggs are surrounded by a protective gelatinous mass. The endophytic eggs lack protection.

How and where the eggs are oviposited depends on the species. Some go underwater to lay eggs, while others release a string of eggs in flight that resembles the egg strings of toads. Some lay eggs by repeatedly thrusting their rear end into the bottom sediment of the waterbody. Many dragonflies have a scythe-like ovipositor adapted to push the eggs into plants, rotting wood, mud, moss, and other soft materials. One group of species places their eggs in plant stems next to bodies of water in temporarily dry flood zones. Some have more specific requirements and only lay eggs in wet *Sphagnum* or under the bark of branches that hang over water.

In some species, the male guards the female during egg-laying. In other species where females lay eggs themselves, they may have to endure strenuous courtship by interested males. To avoid this, she may therefore choose to lay eggs when the males are not present, such as in bad weather or during early mornings or late evenings. The eggs usually hatch within two to five weeks, but for some species not until the following spring.

When the eggs hatch, the first instar larva emerges. It is very small and somewhat tadpole-like. Already after one or a few hours, the

first of between 6 and 17 skin moults occur before the larva is fully grown. This development varies between species from just over two months to five years or more. Development is fastest in warm, shallow waters where some species can have more than one generation in a year.

The larvae's appearance, shape and prey differ so that species have different niches. The larvae use different forms of camouflage. Some are covered in a hair-like structure that collects sediment and organic matter. Others camouflage themselves by being green or brown. The diet consists of live prey such as other insect larvae, crustaceans, worms, tadpoles, and small fish. The larvae themselves can become food for larger dragonfly larvae as well as amphibians, fish, and birds.

The abundant presence of predatory fish or crayfish can have a devastating effect on a dragonfly population within a water body, and most species therefore avoid such waters. Some species such as *Leucorrhinia caudalis* and *Epitheca bimaculata*, are adapted to the presence of predatory fish in that their larvae have developed protection in the form of long spines.

Unlike butterflies and beetles, the dragonfly larva does not go through a pupal phase. Instead, it makes a final moult above the water. When it has found a suitable location, its skin splits open allowing it to squeeze out its head, midbody, legs and wings. When it has achieved sufficient stability, it is time for the final step, when the rear body is pulled out.

When the dragonfly hardens, it begins to eat and for a time it stays away from water. This is when it sexually matures, which depending on the species, temperature, and weather, ranges from a few days to several weeks. It is also during this stage that dragonflies move the furthest from aquatic environments. Certain individuals and species can, especially in warm conditions, be lifted by the wind and drift long distances at high altitude.

When they are sexually mature, they seek out wetlands to mate. There, the males hold territories which, depending on species, population size, number of males and the quality of the habitat, vary in size from a few metres to long stretches along the sites. In the territory, the males inspect other dragonflies that pass by and try to drive them away and find females to mate with. The number of individuals of the same species at a location varies between different species. Those with strong territorial behaviour usually occur in fewer numbers.

The mating of dragonflies is unique. The male transfers sperm from the posterior part of the hind body to the secondary genitalia under the anterior part of the hind body. He then grabs the female's 'neck' with his appendages. The female bends her back and meets the male's secondary genitalia, whereupon the sperm is transferred.

Because dragonflies are essentially aquatic insects and their habitats can change drastically, they must be able to find new, suitable wetlands. Their flight ability is one of the keys to this. Another is that the females can carry fertilised eggs for a long time and thereby lay them far from the place where the mating took place. Some species regularly disperse several kilometres. Still other species move significantly further. Local populations of, for example *Aeshna mixta*, can be replenished every late summer and early autumn with individuals from other parts of Europe.

Different species of dragonflies have different habitat requirements. Most species thrive in permanent and open water habitats with good water quality. Some species are hardy and cope better than others with changes in their habitat, such as lightly polluted, brackish conditions or wetlands that dry out. Generalists are found in the most diverse types of aquatic environments, while others are specialists and are found only where their specific needs are met and the habitat quality is stable.

A habitat is rarely static but changes over time through, for example, changes in water quality, water levels or shading by trees. The presence of species and the extent to which they suffer from impacts on their habitats also depends on their ability to disperse to new areas. Proximity to suitable habitats is of great importance. It is more difficult for specialised species to disperse

when the habitats they need are missing, uncommon or fragmented.

Dragonflies depend on water to be able to lay eggs and for the larvae to develop, but the surrounding areas must also meet their needs. They need sunlit, insect-rich grounds as well as places to seek shelter for the night or during bad weather. Studies show that some species fly several kilometres every day to seek out trees for the night (Minot et al., 2021).

The more different habitats a landscape contains, the more species of dragonflies can be found. A rich dragonfly fauna is therefore a good indicator of a rich diverse biological landscape.

1.4 Assessment of species 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, fungi and animals is The IUCN Red List of Threatened Species™ (www.iucnredlist.org), which contributes to understanding 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 a high 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 geographic ranges of species. There are nine categories, with species classified as Vulnerable (VU), Endangered (EN) or Critically Endangered (CR) considered 'threatened'. When conducting regional or national assessments, the IUCN Red List Regional Guidelines (IUCN, 2012b) must be applied, and two additional categories are used: Regionally Extinct (RE), and Not Applicable (NA) (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.

1.5 Objectives of the assessment

The European Red List of Dragonflies had five main objectives:

- To update the European Red List of dragonflies, taking into account new information, recent trends and threats that dragonflies experienced;
- To identify prioritised geographical areas and habitats in need of urgent protection to prevent extinctions and to ensure that European dragonflies reach and maintain a favourable conservation status;
- To identify the major threats to European dragonflies and to propose potential mitigating measures and conservation actions to address them;
- To use the knowledge mobilised to contribute to regional dragonfly conservation planning; and,
- To strengthen the network of dragonfly experts in Europe, so that the knowledge can be kept current and expertise can be recruited to address the highest conservation priorities.

This assessment produced four main outputs:

- A summary report on the status of all European dragonfly species (this report).
- A website (www.iucnredlist.org) and data portal (www.iucnredlist.org/resources/data-repository) showcasing these data in the form of species factsheets for all European dragonflies included in this study.
- The development of a separate European Dragonfly Conservation Plan coordinated by the IUCN Species Survival Commission (SSC) Conservation Planning Specialist Group that complements the European Red List of Dragonflies publication.

This European Red List is a completely revised second edition. It is a comprehensive, region-wide assessment of dragonflies and builds on the previous work done for the first *European Red List of Dragonflies* (Kalkman et al., 2010) and on the *Atlas of the dragonflies and damselflies in Europe* (Boudot and Kalkman, 2015; Kalkman et al., 2016), 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.

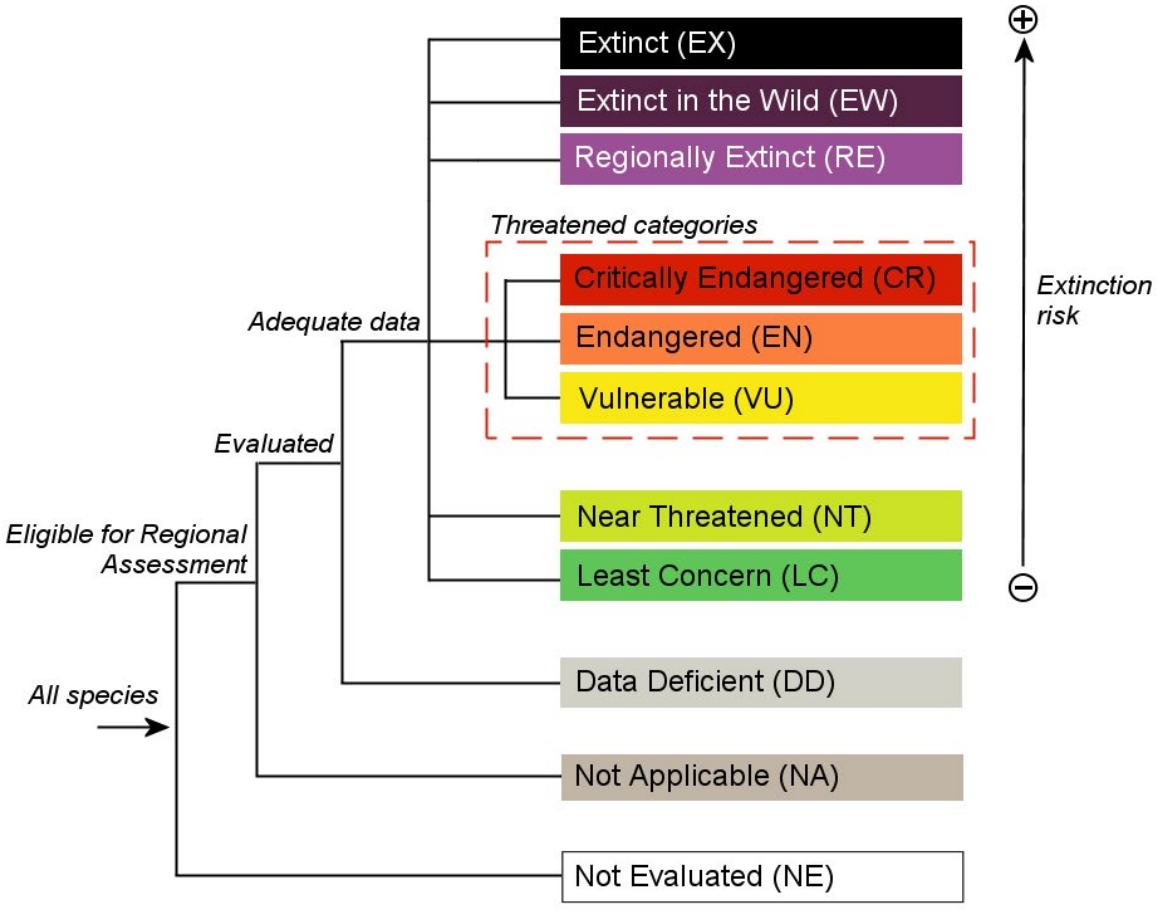

Figure 2. *The IUCN Red List Categories at the regional scale.*

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 the Urals 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 Caucuses) fall beyond the European scope of this European Red List.

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 Dragonflies (Kalkman et al., 2010) the EU region now includes Croatia but no longer includes the United Kingdom.

2.2 Taxonomic scope

The taxonomy largely follows the World Odonata List (Paulson et al., 2022) although it departs from this in a few circumstances. This is especially the case for some *Cordulegaster* taxa present in south-eastern Europe, where we used a conservative approach and considered some taxa as *bona fide* species as used in the European Atlas (Boudot and Kalkman, 2015). We also refrained from using the genus name *Corduliochlora*, which was created for the species *Somatochlora borisi*, as it has not been generally accepted because further in-depth analysis of related genera is required.

Subspecies were not assessed as in some cases their descriptions are not always accurate or even debatable, or they show intermediate forms or even hybridised which makes distinction in the field difficult and hence were not stored in the database at subspecies level. This did not allow to have data for trend analysis or even for producing distribution maps.

2.3 Assessment protocol

Assessments were based on the IUCN Red List Categories and Criteria Version 3.1 and the Guidelines for the application of the IUCN Red List Criteria at regional and national levels (IUCN 2012a,b, 2016), for which a correct interpretation of terms and application of criteria were ensured through training workshops.

Collaboration with national or regional schemes of most European countries, along with data supplied by the European atlas (Boudot and Kalkman, 2015) where necessary and by some privately-owned databases, made it possible to build a large database of European species' occurrences since the year 2000. Those records allowed for the calculation of necessary trend analyses and ranges used in the assessments

and informed the production of the distribution (range) maps.

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 (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). Population size reduction (Criteria A) and Geographic range (Criteria B) were the most often used criteria for assessing dragonflies in Europe. Provisional assessments were agreed within the expert group and later submitted to external scientists for an independent review and final agreement.

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 Spatial and trend analysis

In order to assess the status of the different species, the extent of occurrence (EOO), the area of occupancy (AOO) and trend of each species should ideally be known. With the increasing amount of data available it has become possible to estimate these values. National or regional Dragonfly Societies, some individuals, institutions, and data managers made their data available (see Acknowledgements) encompassing several countries and regions, and together with the data from the European atlas (Boudot and Kalkman, 2015) this gives a decent overview of the distribution of most species. Although data coverage in European Russia, Belarus, Moldova and Ukraine is poor, for the rest of Europe it is reasonable (Balkans and some Eastern European countries) or even excellent.

The EOO is calculated as the surface area of a convex hull around the records in Europe and EU27 from the period 2000-2020. This area does include unsuitable habitat, such as oceans, huge intensive farmland and mountains. The AOO is calculated as the sum of all 2 x 2 km squares, the required unit required for the estimation of AOO (IUCN, 2016), where a species has been found in the period 2000-2020, according to the IUCN guidelines. The number of individuals or the number of records is irrelevant.

The estimation of a trend is more complicated, and for previous assessments of European dragonflies a trend estimate based on the available data was not possible. Since the amount of data available has increased tremendously, we were able to estimate a trend per species for many countries and regions in the period 2010-2020. It was not possible to perform occupancy modelling (van Strien et al., 2013; Termaat et al., 2019) but instead we used the List Length method (Szabo et al., 2010) which was applied as frequentist, not Bayesian. We estimated the trend per species per country or region for which we estimated to have sufficient data for a reasonable trend calculation. This was done for Iberia (Spain and Portugal combined), France, Cyprus, Belgium (separately for the Flanders and Walloon regions), the Netherlands, United Kingdom, Germany (North Rhine-Westphalia, Saarland and Hessen, analysed separately),

Czechia, Denmark, Sweden, Finland, Lithuania, Slovenia and the Western Balkans (Albania, Bosnia and Herzegovina, Croatia, Kosovo, Montenegro, North Macedonia, Serbia and Slovenia combined).

There has been a strong increase in the number of records over the years, therefore it is likely that the number of locations with records also increased, even when a species is stable or declining. This has been done by including the number of records and number of observed species in the analysis. We used a binomial regression to estimate the likelihood of the observation of a species in a 10x10 km square in a year. Input is year, log of number of species, log of number of visits and square as random factor

$(N \sim year + \ln(species) + \ln(visits) + (1|Site10km)$

Year is thus the part that cannot be explained by increase in visits or effort (resulting in more species seen). This model is run with data from 2000-2020 and with 2010-2020 and in both cases the decline over the last ten years is calculated with a linear regression. The first value is suitable for species with a continuous trend but if there has been a change in trend recently the second is more representative of the actual trend over the last ten years.

By including the number of visits and number of species recorded this model can correct for an increase in monitoring effort. This is a very simple model that does not take timing of visits into consideration, targeted efforts to find specific species or other factors like that. It can therefore not be used as an accurate trend calculation, unlike occupancy modelling or trend calculations based on Pollard Walks (traditional transect surveys). Therefore, these trend estimates need to be seen as that, estimates. They are helpful but have been used with the necessary considerations. For several countries, UK, Netherlands, Flanders - Belgium and Germany formal trend analyses with occupancy modelling were recently calculated. These were used as a control, and the trends of both methods are generally in agreement.

Rio Genal, Andalusia, Spain. One of the last wild rivers in Spain and habitat of several threatened species such as the two Vulnerable species, Macromia splendens *and* Zygonyx torridus. © *Roy van Grunsven*

The trend estimates are primarily used to assess whether a species with a negative trend in well studied countries was likely to show a similar trend in other countries and regions. The trend estimates were not used to calculate a European or EU27 trend. This was not possible as we did not have an estimate for all countries. Therefore, this was done using the known distribution and trend estimates that were available for different parts of the distribution, e.g. if the Swedish, Finish and Lithuanian trends were similar we assumed that the same is true for e.g. Estonia. For many species this does give sufficient insight in the likely European or EU trend to assess whether the species qualifies for a specific Red List Category.

For some species, especially in eastern Europe, this was not possible as there was insufficient data available. In these cases, expert opinion was used. For species with a very small distribution such as *Pyrrhosoma elisabethae* and *Onychogomphus cazuma* an analysis on a 10x10 km grid is not meaningful and the trend estimate is based on the insight of experts.

All EOOs, AOOs and distribution maps were discussed with experts. This was done to assess whether the different values were realistic and did not include erroneous records that had a significant impact. Trends were also discussed and an expert opinion was asked for regions for which the experts had sufficient knowledge.

For the distribution maps, the records were plotted to Level 08 HydroBASINS (Lehner and Grill, 2013). For species where the lack of data gave a distorted image of the actual distribution, we included the species distribution models as worked out in Kalkman et al. (2022) as "possibly extant" if they improved the maps.

Although rather widespread in southwestern Europe, the riverine species, the Orange-spotted Emerald Oxygastra curtisii, *shows a declining trend. © Geert De Knijf*

3 Results and discussion

3.1 Diversity and endemism

All 146 dragonfly species recorded for the European region were considered in this project. The original list of species was based on Boudot and Kalkman (2015) and supplemented by recently published taxonomic revisions of findings of new species (see Appendix 1). Four species (*Platycnemis subdilatata*, *Anax junius*, *Stylurus ubadschii* and *Tramea basilaris*) that are only very occasionally observed in Europe without proof of reproduction were classed as Not Applicable for the European Red List, and the analysis here focuses on the 142 assessed species.

The full list of species assessed with their Pan Europe and EU Red List status can be access from the European Red List Data Repository: www.iucnredlist.org/resources/data-repository

With 94 species (64% of all European species), the suborder Anisoptera (the dragonflies) has a higher species richness than the Zygoptera (the damselflies), with 52 species (36%) in Europe and this is nearly the same for the EU (Table 2). The highest number of species is found in the families Coenagrionidae and Libellulidae, 34 and 40 species respectively. Figure 3 shows the distribution of dragonfly richness in Europe based on the data from the period 2000 to 2020. The highest diversity is found in the temperate regions of Europe, more or less from France and the Benelux east to Central Europe. This pattern can roughly be attributed to temperature and precipitation. From north to south, the diversity increases with increasing temperature but decreases again in the Mediterranean region due to lower precipitation and lower availability of freshwater habitats. Although high precipitation and moderate temperatures are found in the UK and Ireland, the diversity is much lower compared to continental countries at the same latitude. The apparently lower number of species in Eastern Europe, especially in Belarus, European Russia and Ukraine can be attributed to the rather low number of records available for these areas.

Circum-neutral bog with lots of floating leaves of Potamogeton polygonifolius, *habitat for* Coenagrion hastulatum, Leucorrhinia dubia, Leucorrhinia rubicunda *and* Sympetrum danae *in the Netherlands. © Roy van Grunsven*

Table 2. *Diversity and number of endemic dragonflies by family for Europe and for EU27.*

Order	Suborder	Family	Europe		EU27	
			Number of species	Number of endemic species	Number of species	Number of endemic species
Odonata	Zygoptera	Calopterygidae	4	1	4	1
		Lestidae	9	0	9	0
		Coenagrionidae	34	4	31	3
		Platycnemididae	4	2	4	2
		Euphaeidae	1	0	1	0
	Anisoptera	Aeshnidae	20	1	20	1
		Gomphidae	14	4	14	2
		Cordulegastridae	7	4	7	2
		Macromiidae	2	1	1	1
		Corduliidae	10	1	10	0
		Libellulidae	40	1	40	1
		Synthemistidae	1	0	1	0
Total			**146**	**19**	**142**	**13**

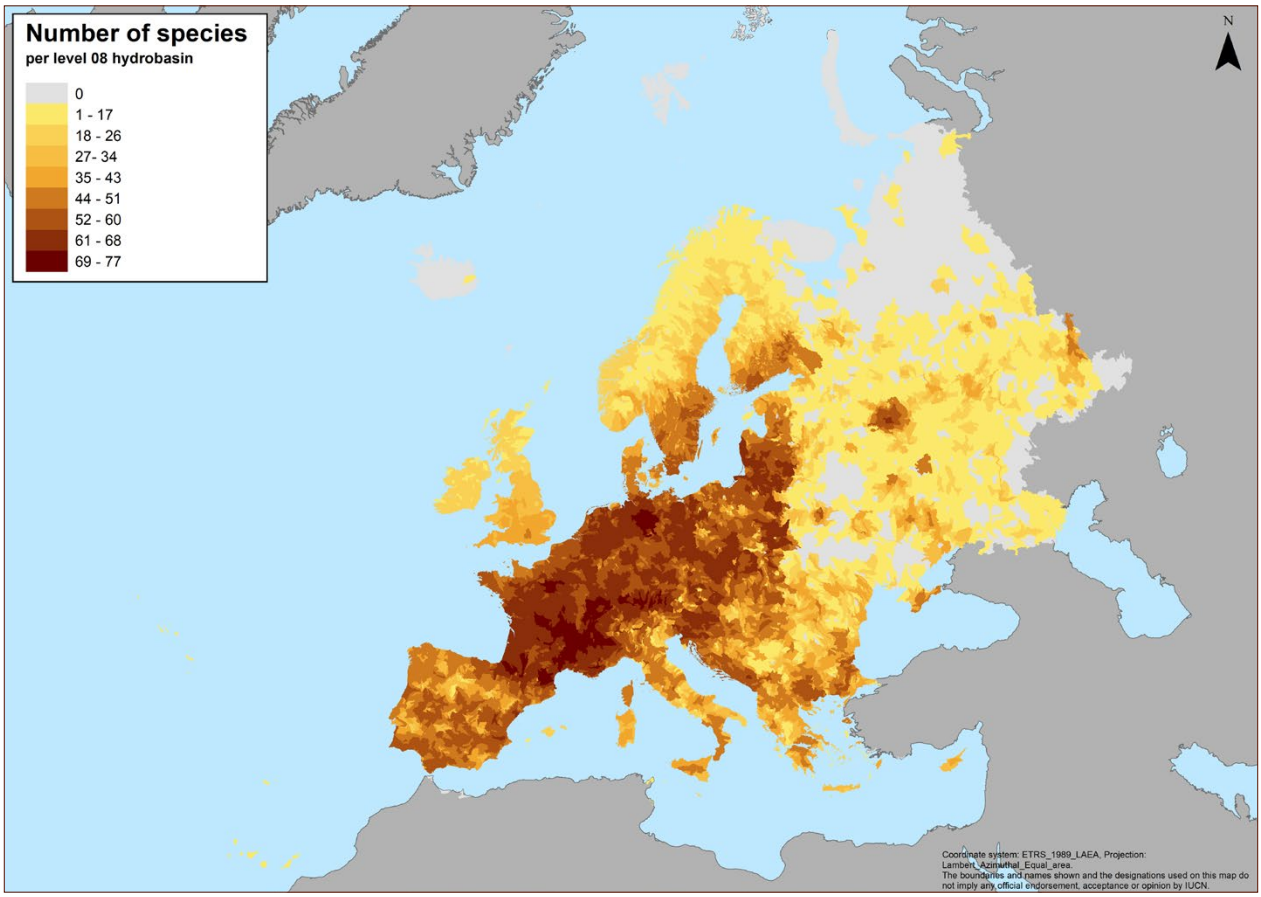

Figure 3. *Species richness of European dragonflies presented per HydroBASIN based on the data from the period 2000-2020. For all species richness maps (Figures 3, 4 and 8), the following presence, origin and seasonality codes were included: presence = extant, possibly extinct; origin = native, reintroduced, assisted colonisation; and all seasonality codes (resident, breeding season, non-breeding, passage, seasonal occurrence uncertain). For descriptions of these codes, see: https://www.iucnredlist.org/resources/mappingstandards.*

Nineteen species of European dragonflies are unique and hence endemic to Europe, not being found anywhere else in the world (Table 1) and 13 species are even restricted to the EU27 (Table 2). Those endemic dragonflies merit the necessary attention in European conservation policy, but only four out of the 19 are protected through the Habitats Directive. Most endemic species are found within the families of Coenagrionidae, Gomphidae and Cordulegastridae. Not less than 57% and 29% of the species within the Cordulegastridae and Gomphidae are endemic to Europe respectively. Based on their habitat preferences, 16 of the 19 endemic dragonflies in Europe are strictly confined to streams and rivers. Furthermore, *Gomphus pulchellus* occurs in both standing and running water as is also the case for the island-endemic species, *Sympetrum nigrifemur* and *Ischnura genei*.

Many European dragonflies have relatively large ranges, especially if compared to other insect groups such as butterflies and grasshoppers. This is particularly the case for many species occurring in Central and northern Europe, with ranges extending from western Europe to Siberia, and sometimes as far east as the Korean Peninsula and Japan. Not less than 19 species are confined to Europe and several more only just extend their ranges out of Europe, to North Africa, Türkiye or just east of the Ural Mountains in Russia. The highest number of endemic dragonflies is found in southwestern Europe, especially in Portugal, Spain and France (Figure 4). Some of them, such as *Gomphus simillimus*, *Platycnemis latipes* and *P. acutipennis,* have large ranges and are found from southern Iberia to northern France, and in the case of *Gomphus pulchellus*, even to northern Germany and the Czechia. The southwestern endemic species with the smallest range is clearly *Onychogomphus cazuma*, which is confined to some small streams in the mountain regions of Valencia, Cuenca, Albacete and Andalusia, Spain. Two species, *Coenagrion castellani* and *Cordulegaster trinacriae,* only occur in Italy, south of the River Po. As endemic species are often habitat specialists and have smaller ranges, they are rather prone to negative impacts and are therefore proportionally more threatened than non-endemic species.

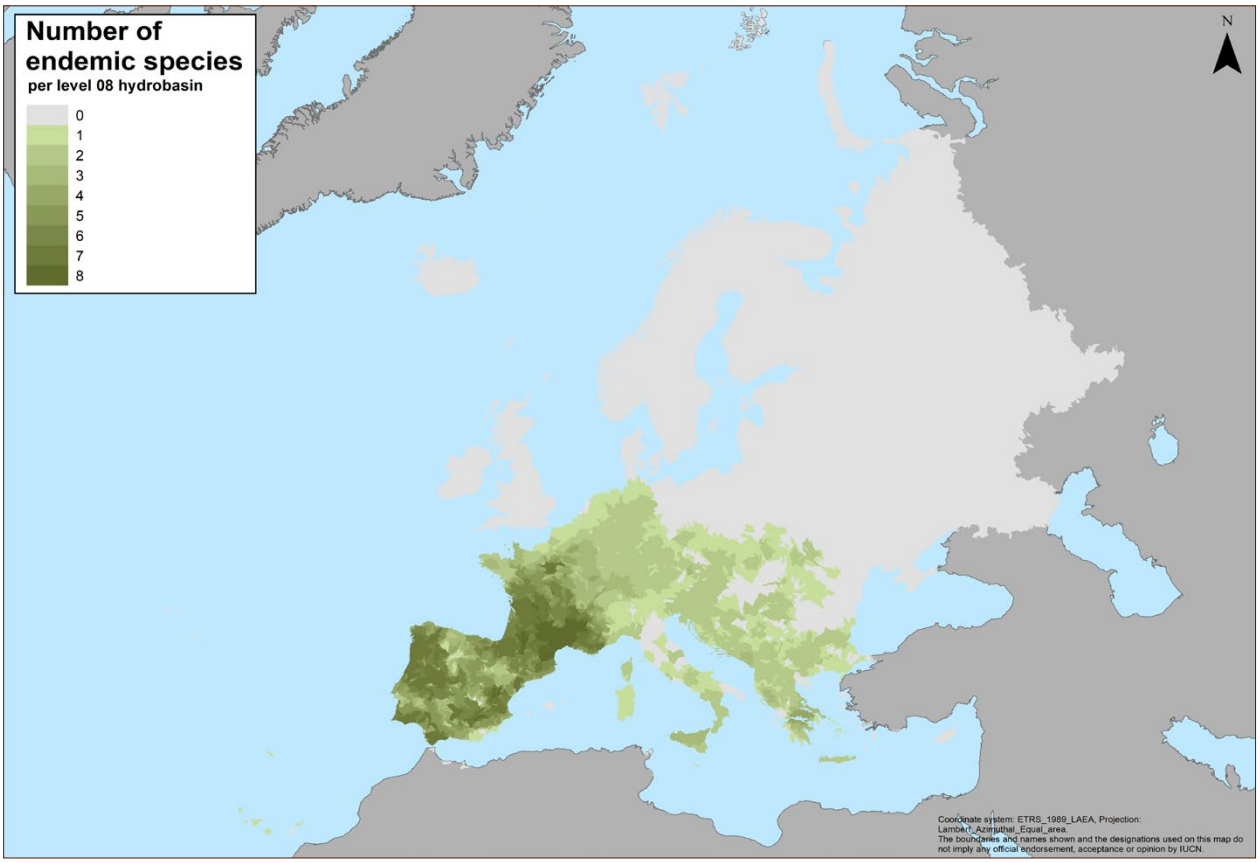

Figure 4. *European endemic dragonfly species richness presented per HydroBASIN based on the data from the period 2000-2020.*

Three species are endemic to the southern Balkans. *Cordulegaster helladica* is restricted to Greece, where *Pyrrhosoma elisabethae* also occurs, but the latter species is also found in southern Albania. The third species, *Somatochlora borisi,* is confined to the Rhodope Mountains in eastern Greece, south-eastern Bulgaria and European Türkiye.

Four European species are endemic to islands. *Coenagrion intermedium* and *Boyeria cretensis* are confined to Crete and are both assessed as Endangered. The other two island-endemic species are not uncommon and consequently considered Least Concern (LC). *Sympetrum nigrifemur* occurs on the Canary Islands and on the Madeira Archipelago and *Ischnura genei* is endemic to the Tyrrhenian islands of Corsica, Sardinia, Sicily, Malta, Capraia, Elba and Giglio.

Two species, both *Cordulegaster*, are confined to the hilly and mountainous regions of Europe. *Cordulegaster bidentata* occurs from southern Belgium, Germany and Poland to the Pyrenees Mountains, southern Italy and southeast to Greece. The other one, *C. heros,* is confined to the south-eastern part of Europe, roughly from Austria, Slovakia and western Ukraine to northern Greece.

3.2 Threat status of Odonata

In this second Red List assessment of the damselflies and dragonflies of Europe, 142 species have been assessed against the IUCN Red List Criteria. An additional four species were considered Not Applicable (NA) since there is no evidence that they have resident breeding populations in Europe or even reproduce occasionally, and they are considered as incidentally occurring as vagrants in Europe.

Of the 142 species assessed, a best estimate of 21.0% (29 species) of extant species for which sufficient data are available are threatened (i.e., assessed as Critically Endangered, Endangered or Vulnerable) on the European scale, with 1.4% being Critically Endangered, 6.3% Endangered and 12.7% Vulnerable (IUCN, 2022). In addition, 12.0% (17 species) were assessed as Near Threatened, with four species (2.8%) considered Data Deficient (Figure 5; Table 3). The situation for the 137 species within the EU is quite similar to that of Europe as a whole (Figure 6); 21.9% (30 species) of extant species for which sufficient data are available are assessed as threatened (with none considered Data Deficient), of which 1.5% are Critically Endangered, 7.3% Endangered and 13.1% Vulnerable. Similar to the Pan Europe region, a further 19 species (13.9%) were assessed as Near Threatened.

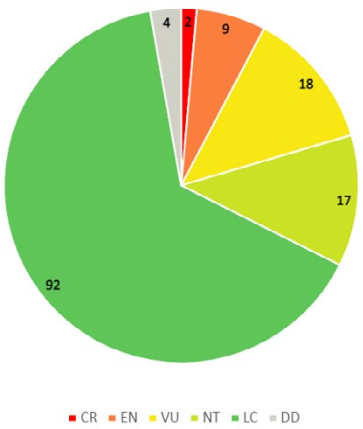

Figure 5. *Red List status of dragonfly species in Europe excluding NA.*

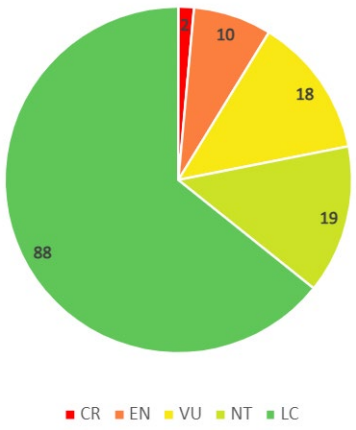

Figure 6. *Red List status of dragonfly species in the EU27 member states excluding NA.*

Table 3. *Threatened dragonfly species at the European and EU27 levels. Species endemic to Europe or to EU27 are marked with an asterisk (*).*

Family	Species	Common English name	Europe	EU27
Coenagrionidae	Ceriagrion georgifreyi	*Turkish Red Damsel*	CR	CR
Coenagrionidae	Pyrrhosoma elisabethae	*Greek Red Damsel*	CR*	CR
Aeshnidae	Aeshna juncea	*Moorland Hawker*	EN	EN
Aeshnidae	Boyeria cretensis	*Creten Spectre*	EN*	EN*
Coenagrionidae	Coenagrion caerulescens	*Mediterranean Bluet*	EN	EN
Coenagrionidae	Coenagrion intermedium	*Cretan Bluet*	EN*	EN*
Coenagrionidae	Ischnura intermedia	*Dumont's Bluetail*	EN	EN
Gomphidae	Onychogomphus cazuma	*Cazuma Pincertail*	EN*	EN*
Libellulidae	Orthetrum nitidinerve	*Yellow-veined Skimmer*	EN	EN
Libellulidae	Sympetrum danae	*Black Darter*	EN	EN
Libellulidae	Sympetrum flaveolum	*Yellow-winged Darter*	EN	EN
Coenagrionidae	Coenagrion hylas	*Siberian Bluet*	VU	EN
Aeshnidae	Aeshna grandis	*Brown Hawker*	VU	VU
Aeshnidae	Anax immaculifrons	*Magnificent Emperor*	VU	VU
Coenagrionidae	Coenagrion castellani	*Italian Bluet*	VU*	VU*
Coenagrionidae	Coenagrion hastulatum	*Spearhead Bluet*	VU	VU
Coenagrionidae	Coenagrion lunulatum	*Crescent Bluet*	VU	VU
Coenagrionidae	Coenagrion mercuriale	*Mercury Bluet*	VU	VU
Cordulegastridae	Cordulegaster helladica	*Greek Goldenring*	VU*	VU*
Cordulegastridae	Cordulegaster insignis	*Blue-eyed Goldenring*	VU	VU
Cordulegastridae	Cordulegaster picta	*Turkish Goldenring*	VU	VU
Corduliidae	Somatochlora borisi	*Bulgarian Emerald*	VU*	VU
Corduliidae	Somatochlora metallica	*Brilliant Emerald*	VU	VU
Libellulidae	Leucorrhinia dubia	*Small Whiteface*	VU	VU
Libellulidae	Leucorrhinia rubicunda	*Ruby Whiteface*	VU	VU
Libellulidae	Sympetrum depressiusculum	*Spotted Darter*	VU	VU
Libellulidae	Sympetrum vulgatum	*Vagrant Darter*	VU	VU
Libellulidae	Zygonyx torridus	*Ringed Cascader*	VU	VU
Macromiidae	Macromia splendens	*Splendid Cruiser*	VU*	VU*
Lestidae	Lestes macrostigma	*Dark Spreadwing*	NT	VU
Aeshnidae	Aeshna caerulea	*Azure Hawker*	NT	NT
Aeshnidae	Aeshna subarctica	*Bog Hawker*	NT	NT
Aeshnidae	Aeshna viridis	*Green Hawker*	NT	NT

Aeshnidae	Boyeria irene	*Western Spectre*	NT	NT
Coenagrionidae	Ischnura graellsii	*Iberian Bluetail*	NT	NT
Corduliidae	Somatochlora alpestris	*Alpine Emerald*	NT	NT
Corduliidae	Somatochlora sahlbergi	*Treeline Emerald*	NT	NT
Gomphidae	Gomphus graslinii	*Pronged Clubtail*	NT*	NT*
Gomphidae	Gomphus pulchellus	*Western Clubtail*	NT*	NT*
Gomphidae	Gomphus simillimus	*Yellow Clubtail*	NT*	NT*
Gomphidae	Onychogomphus costae	*Faded Pincertail*	NT	NT
Lestidae	Lestes sponsa	*Common Spreadwing*	NT	NT
Libellulidae	Leucorrhinia albifrons	*Dark Whiteface*	NT	NT
Libellulidae	Sympetrum pedemontanum	*Banded Darter*	NT	NT
Platycnemidae	Platycnemis acutipennis	*Orange Featherleg*	NT*	NT*
Synthemistidae	Oxygastra curtisii	*Orange-spotted Emerald*	NT	NT
Aeshnidae	Aeshna crenata	*Siberian Hawker*	LC	NT
Coenagrionidae	Coenagrion armatum	*Dark Bluet*	LC	NT
Coenagrionidae	Nehalennia speciosa	*Sedgling Damselfly*	LC	NT

Out of the 19 dragonfly species that are endemic to Europe, 42.1% are threatened (CR, EN or VU) and 21.1% are Near Threatened (Figure 7). Of the 13 endemic dragonfly species that occur in the EU27, 46.2% are threatened (CR, EN or VU) and 15.4% Near Threatened. An overview of the threatened species endemic to Europe and to the EU27 is found in Table 3. Three species (*Boyeria cretensis*, *Coenagrion intermedium* and *Cordulegaster helladica*) are confined to Greece, one species to Italy (*Coenagrion castellani*) and one species to France, Spain and Portugal (*Macromia splendens*). One threatened endemic species, *Somatochlora borisi*, occurs in the small border zone between Greece and Bulgaria and another species, *Pyrrhosoma elisabethae* is found in Albania and Greece.

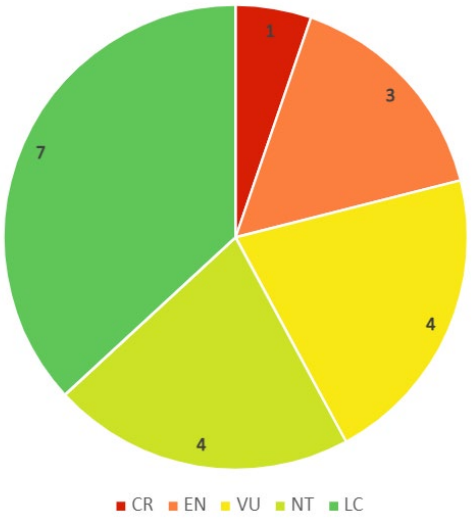

Figure 7. *Red List status of European endemic dragonfly species.*

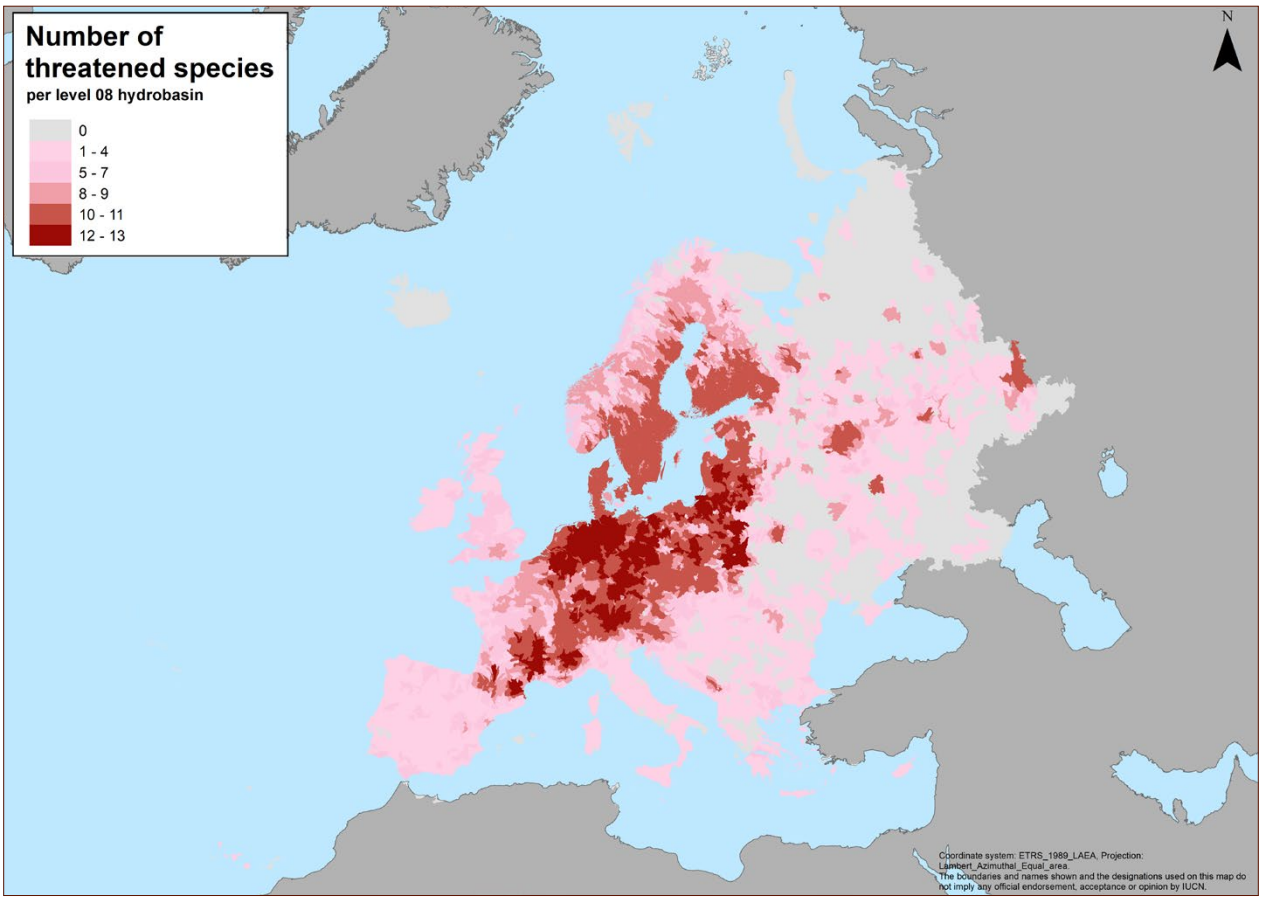

Figure 8. *Threatened (CR, EN, VU) dragonfly species richness in Europe presented per HydroBASIN based on the data from the period 2000-2020.*

The distribution of threatened dragonflies in Europe (Figure 8) reflects the geographical pattern of species richness in Europe very well. The highest number of threatened species are found in a broad belt approximately from southern France to southern Scandinavia and the Baltic states. This can be explained by the existence of threats affecting species with large distributions and the resulting co-occurrence of several threatened species at the same locality. Nevertheless, the distribution pattern of threatened species does not correspond with the distribution of the number of endemic species. Several of the endemic species have a small range resulting in a lower number of species present at the same locality. A more detailed analysis of the distribution pattern of threatened dragonflies will be given in the next section, 'Threatened dragonflies according to their habitat preference'..

An overview of the Red List status of dragonflies by family at the European regional level is given in Table 4. Considering the number of species present in Europe, the highest proportion of threatened species is found within the Cordulegastridae (43%). Furthermore, high proportions of threatened species are found within the Coenagrionidae, the Aeshnidae, the Libellulidae and the Corduliidae.

Table 4. *Red List status of dragonfly species by family at the European Regional level. Not Applicable species are excluded from % Threatened.*

Order	Suborder	Family	Number of species in Europe	CR	EN	VU	NT	LC	DD	NA	% Threatened
Odonata	Zygoptera	Calopterygidae	4	0	0	0	0	4	0	0	0%
		Lestidae	9	0	0	0	2	7	0	0	0%
		Coenagrionidae	34	2	3	5	1	21	2	0	29.4%
		Platycnemididae	4	0	0	0	1	2	0	1	0%
		Euphaeidae	1	0	0	0	0	1	0	0	0%
	Anisoptera	Aeshnidae	20	0	2	2	4	11	0	1	21.0%
		Gomphidae	14	0	1	0	4	8	0	1	7.7%
		Cordulegastridae	7	0	0	3	0	4	0	0	42.9%
		Macromiidae	2	0	0	1	0	0	1	0	50.0%
		Corduliidae	10	0	0	2	2	5	1	0	20.0%
		Libellulidae	40	0	3	5	2	29	0	1	20.5%
		Synthemistidae	1	0	0	0	1	0	0	0	0%
Total			**146**	**2**	**9**	**18**	**17**	**92**	**4**	**4**	**20.4%**

3.3 Threatened dragonflies according to their habitat preference

In order to have a better understanding of which habitats are most threatened, we assigned each species according to their habitat preference. A first level was made between occurring in lentic or lotic habitats. Species occurring in both lotic and lentic situations were included in the lentic group so that the lotic (rheophilic) group only includes species strictly dependent on habitats with running water. At a second level we divided the lotic species group into a group of species with a more southern European, often Mediterranean distribution, and a group that consists of species that occur in Western, Central and northern Europe. The lentic group was, for convenience, spilt up into species characteristics for rather nutrient poor systems (hereafter referred to as oligotrophic); species typical for nutrient rich ecosystems (hereafter referred to as eutrophic); species characteristic for temporary waters (aquatic habitats that falls dry during part of the year); and finally a last group of generalist species that occur in a wide range of habitats, sometimes in both standing and running water systems, that does not seem to have specific habitat requirements. The division was based on expert judgements by the authors and is in line with information on habitats provided by Boudot and Kalkman (2015) and Kalkman et al. (2018). We are well aware that each classification has its short-comings and that some species might fit in another or even several categories. In one region a species might occur in oligotrophic waters while in other parts of Europe it prefers rather eutrophic habitats. In these cases, we attributed each species to one of the groups where it mostly occurs at the European level.

As can be seen in Figure 9, most species are found in eutrophic waters, while the group confined to temporary waters contains the lowest number of species. Most threatened dragonflies are either found in southern streams and rivers and in oligotrophic waters. The other groups have only a few threatened species. The main habitat types occupied by threatened species can be seen in Figure 10.

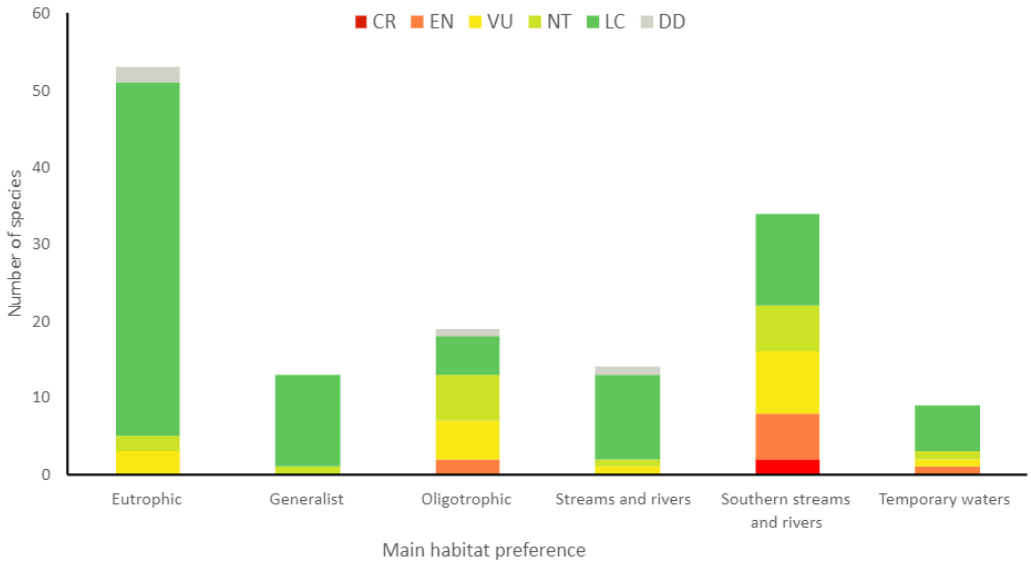

Figure 9. *Red List categories of all dragonfly species in the different aquatic habitat types in Europe.*

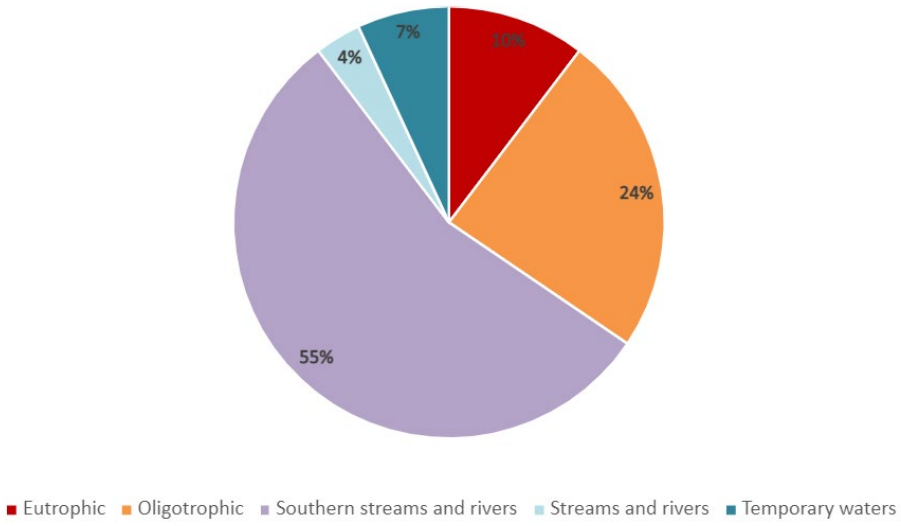

Figure 10. *Habitat preferences of the threatened dragonfly species (categories CR, EN and VU) in Europe.*

No less than 16 of the 29 threatened species in Europe are confined to southern streams and rivers. The only threatened rheophilic damselfly found further north is *Coenagrion mercuriale* (VU) which occurs in southwestern Europe up to southern UK and northern Germany.

Especially in southern France, Spain and Portugal many threatened dragonflies co-occur in the same streams and rivers (Figure 11). It is less clear on the map, but the highest number of threatened riverine species are found in south-eastern Europe, especially in Greece. Two species, *Coenagrion intermedium* and *Boyeria cretensis*, are confined to Crete. *Cordulegaster*

helladica and *Pyrrhosoma elisabethae* mainly occur in southern Greece, with the latter also being found on the island of Kerkira and in southern Albania, while *Somatochlora borisi* and *Cordulegaster picta* and *C. insignis* are confined to north-eastern Greece and adjacent parts of Bulgaria, European Türkiye, and with some outposts in North Macedonia and Romania. In Europe, *Ischnura intermedia* only occurs in the western part of Cyprus and *Anax immaculifrons* is restricted to Cyprus and the Greek islands of Karpathos, Ikaria and Rhodes. So, in southeastern Europe there are many threatened species but as they are often local and do not co-occur, the number of threatened species per HydroBASIN is relatively low.

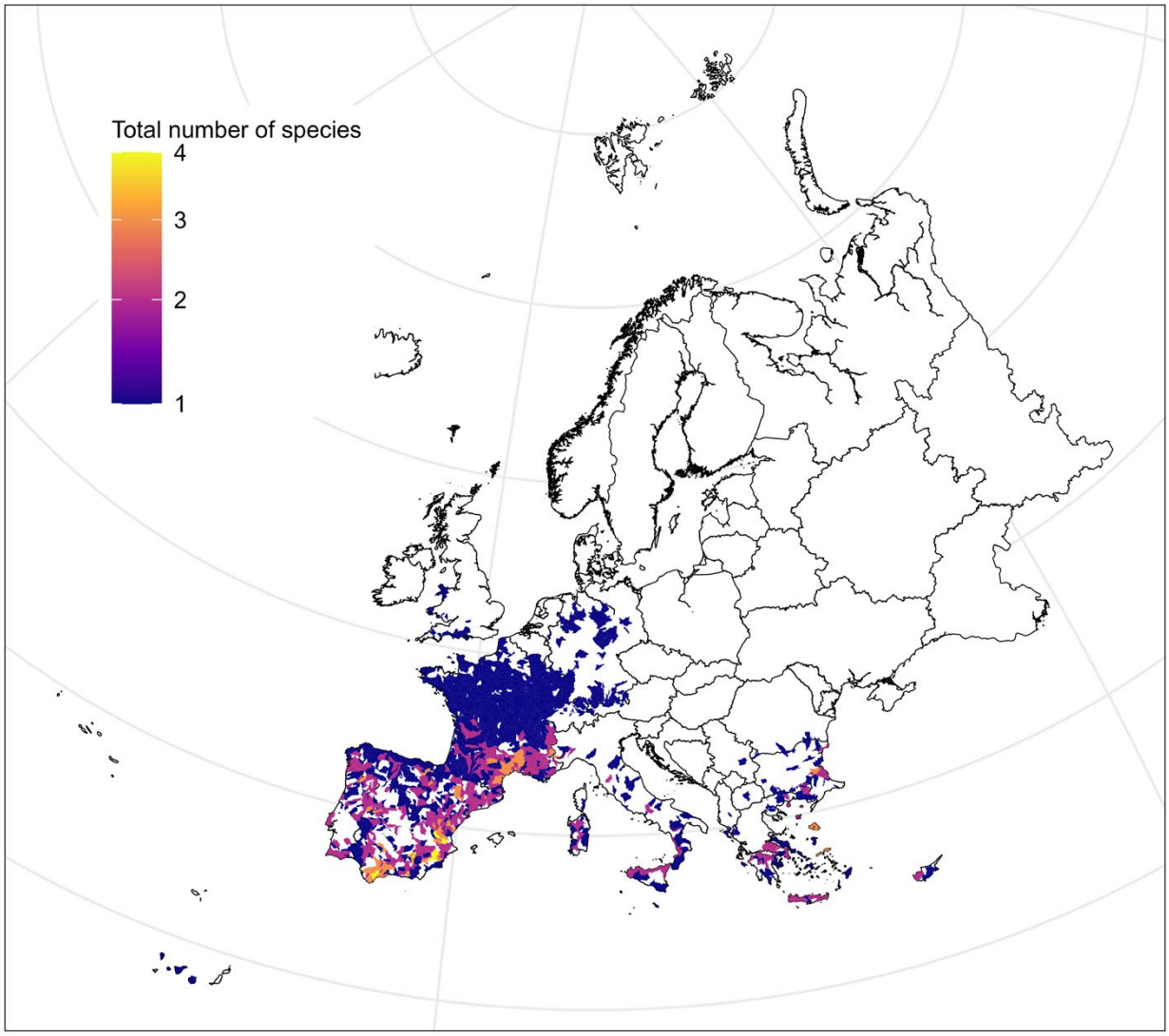

Figure 11. *Number of threatened dragonfly species confined to southern streams and rivers in Europe presented per HydroBASIN based on the data from the period 2000-2020.*

A second, and rather large, group of threatened species is confined to nutrient poor habitats, especially small water bodies. Not less than seven threatened and six Near Threatened species are linked to these habitats (Figure 12). Most of these species used to have large distributions from south-central Europe to northern Scandinavia, but during a rather short time period their occurrences have been fragmented and reduced over large parts of continental Europe. Two formerly widespread and not uncommon bog species, *Aeshna juncea* and *Sympetrum danae,* show a decline of over 50% during the last decade in Europe. Similar declines, although less severe, were also detected for *Coenagrion hastulatum*, *C. lunulatum*, *Leucorrhinia dubia*

and *L. rubicunda*. As there are no indications that this decline will be halted in the next decades, we expect them to go locally extinct in several countries and regions, especially in Western and Central Europe. Some other oligotrophic species such as *Aeshna caerulea*, that are more confined to northern Europe and especially Scandinavia, did also show a decline but this was less than 30% and they are hence considered as Near threatened. It is not unlikely that the threats to these habitats will have an impact in the near future on those northern European species as well. Figure 12 gives an overview of the number of threatened dragonflies typical for nutrient poor ecosystems. The highest number of threatened oligotrophic species is found in Belgium, the Netherlands, Germany, Denmark, the Alps, the Baltic countries, and the southern part of Scandinavia. This diversity pattern is likely over estimated as many of those species have already disappeared from a large number of HydroBASIN in the last decade.

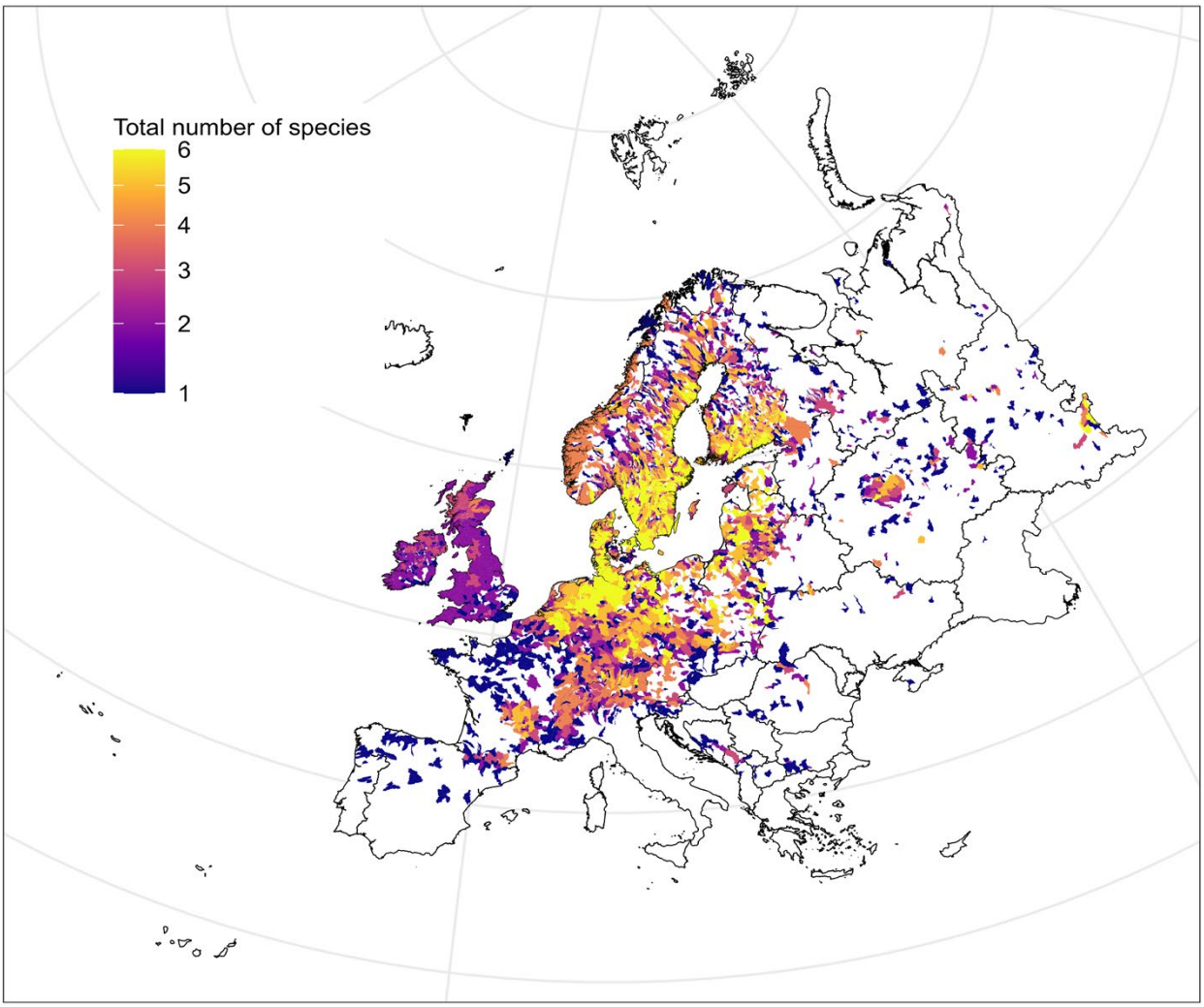

Figure 12. *Number of threatened dragonfly species confined to oligotrophic habitats in Europe presented per HydroBASIN based on the data from the period 2000-2020.*

3.4 Major threats to Odonata species in Europe

Human use of the landscape changes and varies over time, which also leaves its mark on the various threats that dragonflies are exposed to. In the previous two hundred years and especially in the 20th century, large-scale land conversions such as the draining of wetlands and channelization of waterways were carried out to create more agricultural land. In parts of Europe, as much as 75% of the original wetland area disappeared (Decleer et al., 2016; Naturvårdsverket, 2019) and several European countries have lost more than 80% of their original peatlands (Rydin and Jeglum, 2013). In addition to landscape transformation, water pollution and eutrophication of wetlands have hit dragonflies hard, especially in Western Europe during the 1960s–1980s (Kalkman et al., 2010, 2018).

Starting in the 1990s, restoration and regeneration of wetlands and waterways, improved water management and reduced eutrophication, have had a positive impact on dragonflies. Many species, and especially those associated with running water, initially recovered quickly, in particular in Western and Central Europe. It is nevertheless in this group that we find the largest proportion of the threatened species: as many as 17 out of 29, and another seven Near Threatened, are linked to watercourses in Europe. Nearly all of them were assessed as threatened or near threatened also in the previous European Red List (Kalkman et al., 2010).

The majority of these lotic species occur in the Mediterranean region where many waterways are threatened or destroyed because of increased water abstraction (especially for agriculture use), water pollution combined with increased nutrient loads, channelization, gravel abstraction, the use of pesticides and herbicides and the alternation of the river banks from near natural vegetation, often gallery forest, to unnaturally reinforced banks even to cementing shorelines and repeated and prolonged droughts due to climate change. Given the often-small size and low flows of these watercourses, any increased use and negative impact can make a significant difference in habitat availability. In some areas, entire populations have been lost because of water abstraction directly at the source. As the reproductive sites occupied by several of the species are generally small, they can also be easily destroyed by even minor, local changes such as changing farming methods or small dam or hydropower projects. Habitat destruction is a special concern for threatened dragonflies with small ranges of distribution such as *Pyrrhosoma elisabethae* (CR), *Boyeria cretensis* (EN), *Cordulegaster helladica* (EN) and *Onychogomphus cazuma* (EN).

Water abstraction is probably the most important threat for riverine species in the Mediterranean region, especially as this is expected to increase in the future due to precipitation deficits as a consequence of climate change. Even the largest rivers in Southern Europe are affected by less rainfall and drought, which is exacerbated by regulation of water flow, dam and reservoir construction, and pollution from nearby settlements and agricultural areas. In addition, the introduction of invasive crayfish in several rivers has led to a decline in dragonfly populations, which is also likely to continue.

Another distinct group of threatened dragonflies is linked to nutrient-poor conditions. Here we find seven of the 29 threatened species, with another six Near Threatened. Two additional species, *Aeshna grandis* (VU) and *Somatochlora metallica* (VU), are not entirely dependent on these habitats but suffer from similar threats. In contrast to most of the species in the riverine group, the dragonflies associated with nutrient-poor environments have large distributions. However, these are fragmenting at a high rate and particularly lowland populations throughout Europe and those along the southern fringes of their ranges are seriously threatened. Climate change is likely to make these sites unsuitable for these cold-adapted species in the near future. They already suffer from altitudinal range shifts and distribution shrinkage, which can result in rapid decline and local extinction.

The nutrient-poor habitats have crossed a threshold, with cascading effects dramatically adversely affecting the sites. Eutrophication,

loss of buffering (acidification) and desiccation have been exacerbated by climate change in recent decades and these factors reinforce each other. Further, the lack of climate adaptive management plans for dragonflies has contributed to their decline. Climate adapted management plans are urgently needed, and these should also focus on their terrestrial habitat where the presence of trees and shrubs near small water bodies is vital for shelter from the increasing heat. The species temperature index (STI) shows that the observed decreases or expansions can to a large degree be explained by the preferred temperature of individual species. For cold-adapted species, this means that higher average temperatures alone can explain a rapid decline (Termaat et al., 2019).

A third and much smaller group of threatened dragonflies are linked to shallow habitats such as vegetated marshes and small water bodies, some of which are ephemeral in nature and can therefore dry out in late summer. *Sympetrum flaveolum* (EN), *S. depressiusculum* (VU) and *Lestes macrostigma* (NT) are some examples of species adapted to temporary wetlands, with a late emergence and overwintering taking place as eggs embedded in plant material. Climate change however causes their habitats to dry out earlier, before the larval development is completed. A summary of the relative importance of the different threats is shown in Figure 13.

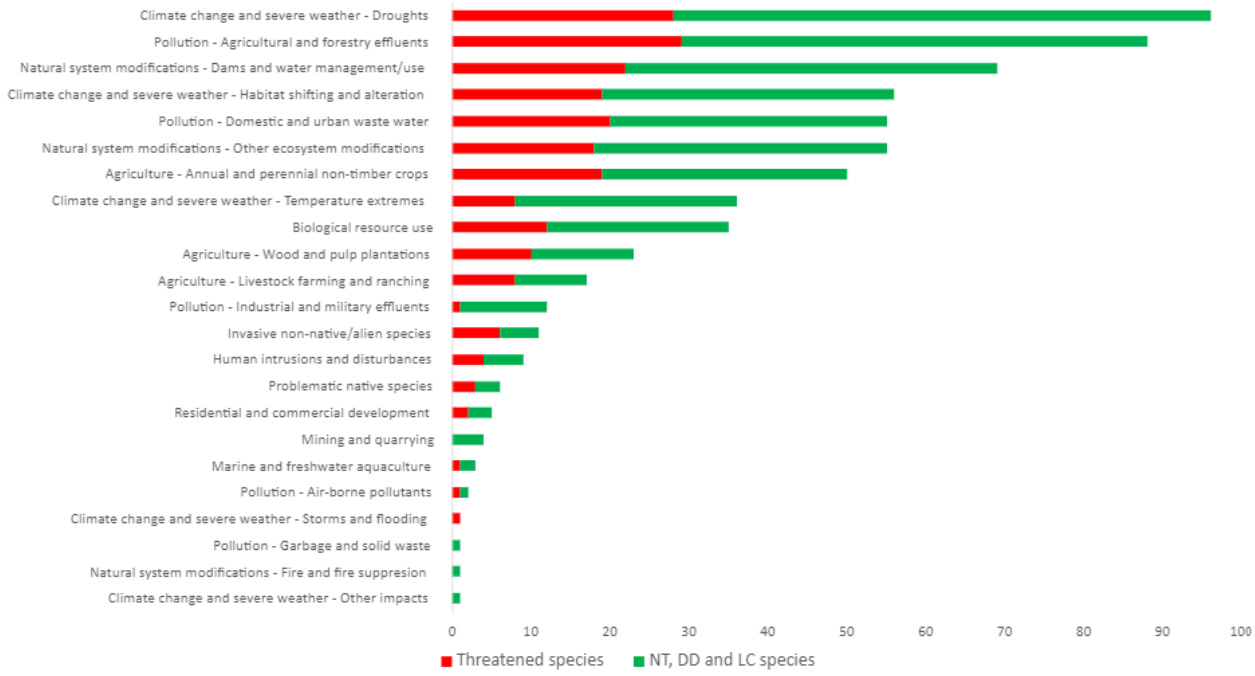

Figure 13 *Major threats to dragonflies in Europe.*

3.5 Population trends

We were able to estimate population trends for many countries in Europe. However, national trends for dragonflies are not available for all countries, often reflecting a lower number of data available and few observers in those territories. This is especially the case for Belarus, the European part of Russia, Ukraine and Moldova, but also for countries in the eastern Mediterranean (Albania, Bulgaria, Greece, North Macedonia) with different implications in both cases. Odonata occurring in north-eastern Europe are generally widespread with ranges

covering also western countries where trends can be estimated. Combining the trends in neighbouring countries with local expert judgments allows for an appreciation of the situation for a species in the region. On the contrary, several Mediterranean species have small ranges, especially in the Balkans, and the current level of recording effort is low in comparison to the conservation challenges.

Figure 14 shows the population trends of dragonflies in Europe over the period 2010-2020. Just 53 species or over a third (37%) of Europe's dragonflies show a stable trend, while not less than 43 species (30%) show a significant decline over the period 2010-2020. About a fifth (23%) or 33 are increasing and expanding, while we were not able at all to determine the trend of 13 species (9%). Nearly all of the species that are increasing and expanding are generalist or confined to eutrophic habitats. In this group we find many thermophilic species that have expanded their range in Europe during the last decades such as *Anax parthenope*, *Crocothemis erythraea* and *Sympetrum meridionale,* but also several species that are for the moment still confined to the Mediterranean such as *Trithemis kirbyi*, *Lindenia tetraphylla* and *Orthetrum chrysostigma*.

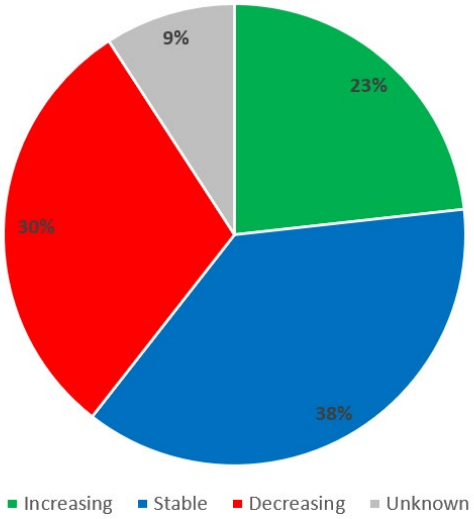

Figure 14. *Population trends of dragonflies species in Europe over the period 2010-2022. N/A species are excluded.*

3.6 Gaps in knowledge

Five taxa, *Coenagrion glaciale, Ischnura aralensis, Somatochlora graeseri, Onychogomphus flexuosus* and *Macromia amphigena*, could not be assessed and were considered Data Deficient. All these species have their main geographical range in Asia with only isolated outposts in the European part of Russia or in the case of *Onychogomphus flexuosus* in the southern Caucasus countries and further east. Due to the large area covered by European Russia and low prospection there, there is limited knowledge on the distribution and trends of Odonata in the region.

For some species it was difficult to determine trends as we do not have enough data for trend estimation. Often those species are in hard-to-reach or isolated regions such as *Coenagrion ecornutum* in the European part of Russia or *Somatochlora sahlbergi* in the far north of Scandinavia.

And finally, several species confined to the southern Balkans, especially Greece, are rather poorly studied, such as several *Cordulegaster* species. Trend estimations are hence nearly impossible but other IUCN criteria such as small geographical range and the number of locations can then be used. For several of these species, targeted investigations are required in the future to clarify their status and to provide a good baseline for future assessments.

3.7 Comparison with the previous European Red List of Dragonflies

Comparing the present Red List with the previous one (Kalkman et al., 2010), a significant increase in the number of Red List species can be seen (Table 5), both on the European regional level as for EU27. Especially the number of Endangered and Vulnerable species increased by nearly 50%. Many of these new threatened species are typical for nutrient poor or oligotrophic aquatic ecosystems. Despite a slight increase in the number of dragonfly species being found in Europe and in EU27, a lower number of species is now considered as Least Concern. Both indicate that the situation of dragonflies has dramatically declined over a period of only 10 years.

The lower number of Critically Endangered species is only due to the fact that we assess *Cordulegaster helladica* at the species level and not as three separate subspecies. This species is restricted to Greece and remains Endangered, and this is not a genuine change. As a result of the increased data availability and other sources of information, none of the dragonfly species present within the EU27 are now considered Data Deficient. All Data Deficient species in this European Red List are restricted to the European part of Russia and it is expected that new information and data on their presence, trends and pressures will not become available in the near future.

Table 5. *The number of dragonfly species in each Red List Category in 2010 (Kalkman et al., 2010) and in 2024. In the 2024 reassessment, the assessments of one species underwent regional adjustment following the IUCN Regional Guidelines (IUCN, 2012b); both the Pan Europe and EU-level assessments of* Ischnura fountaineae, *both the Europe and EU-level assessments were down-listed from NT to LC. The four Not Applicable species are excluded here.*

IUCN Red List Category	No. species Europe 2024	No. species Europe 2010	No. species EU27 2024	No. species EU27 2010
Critically Endangered (CR)	2	3	**2**	**3**
Endangered (EN)	9	5	**10**	**6**
Vulnerable (VU)	18	13	**18**	**13**
Near Threatened (NT)	17	15	**19**	**18**
Least Concern (LC)	92	96	**88**	**91**
Data Deficient (DD)	4	5	**0**	**3**
Total number of species assessed	142	137	**137**	**134**

4 Conservation measures

4.1 Conservation management of Odonata species in the EU

Targeted conservation management for Odonata is limited. It should primarily focus on the conservation of the specific habitats of the species and not on the species itself, in contrast to some large birds and mammals. Some species are protected under the European Habitats Directive and there are efforts to protect these species in several countries. This can entail regulations on the management of ditches with Water Soldier (*Stratiotes aloides*), where removal of this plant can harm populations of *Aeshna viridis* or restoration of habitats. In many cases protected species are merely monitored and contribute to the protected status of their habitat. Additionally, the occurrence of rare dragonfly species is taken into account in the management of nature reserves in countries such as Belgium, France, Germany and the Netherlands.

Several habitat types that harbour dragonflies that need protection are listed in the Habitats Directive and therefore are managed to maintain or improve this habitat. These include several types of heathland ponds and raised bogs that harbour many threatened dragonfly species but also several types of Mediterranean streams. To what extent this legislative protection results in effective protection and management that benefits these habitats and the dragonflies that occur here differs between countries.

4.2 Red List versus priority for conservation action

There is surprisingly very little overlap between protective status under the Habitats Directive and the Red List status of dragonflies or the endemic species in Europe. This results in a discrepancy between the conservation needs and conservation action. While the protection of rivers with *Ophiogomphus cecilia* and wetlands with *Aeshna viridis* should continue, the protection of *Pyrrhosoma elisabethae* (CR), *Boyeria cretensis* (EN) and *Onychogomphus cazuma* (EN) are more urgent, just to name a few. These species do not have a special protection status despite being threatened European endemics.

This discrepancy has been noted before. De Knijf et al. (2016) and Kalkman et al. (2018) described that the protected species are mainly West and Central European while the threatened species were primarily found in the Mediterranean. In the current Red List quite a few West and Central European species are included but again with very little overlap with the species mentioned on the Annexes of the Habitats Directive. The species listed on the Habitats Directive are mainly species from standing waters, especially fens and running water, while the threatened West and Central European species are primarily from oligotrophic habitats, heathland ponds and raised bogs.

The conservation action needed to safeguard different dragonfly species differs vastly. For some climate change is the main driver and the possibility to conserve populations through improvement of local management is limited. For other species, including some of the critically

endangered and endangered species, the main threats are habitat destruction, pollution and water abstraction. The establishment and strict protection of nature reserves, enforcement of bans on pollution and water abstraction at key sites is urgently needed to ensure the persistence of the most threatened species.

For threatened dragonflies such as Sympetrum danae *that are linked to nutrient-poor habitats, climate change is one of the main driving forces and the possibility of conserving populations through local management is limited.*
© Magnus Billqvist

5 Recommendations

After the assessments of the European dragonflies was completed, European dragonfly experts participated in February and March 2024 in conservation action planning workshops focusing on the endangered species. The project followed the IUCN SSC CPSG "Assess-to-Plan" (A2P) methodology which is designed to build consensus on the priority actions required over the next 5 to 10 years and to identify organisations that can take these actions. Recommended conservation actions were organised under three goals: *1)* Knowledge, tools, and expert capacity; *2)* Protecting, restoring, managing, and monitoring key habitats and populations; and *3)* Ensuring effective policy and planning support. An increased awareness permeates all three goals.

Each conservation action includes a goal and a set of associated sub-goals. The targets include European and national government agencies and local management authorities, funding agencies, NGOs, relevant business sectors, policy makers (local, national and regional), water management agencies, developers and their ecologists, the scientific community and places of learning (universities, institutes, schools), the main land-user groups (agriculture, grasslands, forestry), Natura 2000 site managers, municipal managers of public territory and parks, nature conservation area management bodies, groups with similar conservation interests (e.g. groups aiming to conserve freshwater habitats for other invertebrate species), and local communities in areas where action is most needed. See Moving from Assessment to Planning for Threatened European Dragonflies (De Knijf *et al.*, 2024) for these details.

5.1 Recommended actions

Much can be done at the European level but to guide and encourage action, work on the ground will need to be implemented, supported, and enabled at national, sub-national and local level and much benefit could be made from dialogue and collaboration between different stakeholders. National or subnational planning workshops aimed at tailoring and operationalising plans in the local context could catalyse uptake and progress.

To properly protect the threatened species there must be effective policy and planning support for dragonflies at European, national, and local levels. An update to the Annexes of the EU Habitats Directive can be a first step. But the EC can also take the necessary steps and action that conservation measures are taken for threatened European dragonflies. Other important factors are funding mechanisms for the protection and management of threatened species, European regulation on minimum water flow (e-flow), reduced risks from dams (stricter ecological guidelines for new dams, funding for dam removal). The European Red List must also work through at the national level. The national countries must also take their responsibility for the European threatened species that occur at their national territory. This is even more important for very localised species, often endemics that are threatened. This must include not only associated protection and planning, but also adequate implementation and enforcement of existing laws and regulations, but also the necessary conservation actions.

To achieve adequate protection, restoration and management of priority habitats and populations of threatened dragonflies, several measures are required. Natural flow rates and clean water in European rivers and streams should be a focus of course. In priority oligotrophic

wetlands, water levels should be maintained or restored, while nutrients and other risks are excluded. In protected areas, threatened species should be conserved effectively with species-specific planning and urgent measures for the most pressing cases. Climate change is an overarching threat to many species, so climate-adapted management plans that include dragonflies should be established for the planning and management of wetlands and their surroundings.

As the results of the assessments conclude, the most urgent measures needed are the conservation of smaller watercourses in the Mediterranean area. Stopping, often illegal, water abstraction and mitigating the effects of prolonged drought is vital for Europe's most threatened dragonflies, which depend on streams and rivers. Management plans for these systems need to be prioritised, developed and implemented.

More research and European-wide monitoring are needed to be able to carry out adequate conservation. Improved knowledge of threatened species population trends and their drivers as well as development of dragonfly indicators and an established data sharing platform are essential. For this, a European network of dragonfly experts providing knowledge, tools, and expertise to support effective dragonfly conservation is essential. Dragonfly experts are unevenly distributed across Europe. This makes it difficult to maintain regular contact and information exchange with authorities to ensure that dragonflies are considered and protected adequately. For this reason, the Dragonfly Conservation Europe (DCE), a European society was recently established. Nurturing volunteers through funded programs and well-targeted Citizen Science initiatives can also help. Capacity building through education will be important over the next 5-10 years and priority countries or regions include Greece and other countries in south-eastern Europe such as Albania, Bulgaria, Romania and North Macedonia.

5.2 Application of project outputs

The European Red List of Dragonflies is part of a wider initiative aimed at assessing the status of European species. The current European assessments of dragonflies and damselflies, this report and the A2P (De Knijf et al. 2024) provide key resources for policy makers, conservationists, NGOs, environmental planners, and other stakeholders across the region. The results of this project can be applied at a regional scale to prioritise sites and species for inclusion in regional research and monitoring programs and to identify internationally important biodiversity sites. Red Lists are a dynamic tool that will evolve over time as species are reassessed according to new information or situations. By making this widely and freely available, we hope to stimulate and support research, monitoring, and conservation action at local, regional and international levels. All species assessed in this project will be included in the IUCN Global Red List (www.iucnredlist.org).

5.3 Future work

During the process of compiling data for this European Red List, several knowledge gaps have been identified. Across Europe, there are significant geographical, geopolitical, and taxonomic differences and other challenges regarding the quality of available data on species distribution and status. More data will be needed for future further analyses to provide deeper insights into the conservation needs of the European species and the effects on their populations of land-use policies and natural resource use.

There is an apparent need to collate information from all ongoing or planned data collection initiatives and for a wider European dragonfly conservation action plan to be researched and developed. Few European countries have any kind of organised and systematic monitoring

program for dragonflies, and many have only basic data on the species' distribution and population status at best. It is hoped that both regional and international research will be stimulated to expand monitoring and improve the quality of data. The information and analysis can then be updated and improved, so that conservation measures can be given as solid a scientific basis as possible.

If dragonfly assessments are updated at regular intervals, they will allow tracking changes in the status of these species over time via the production of a Red List Index. This indicator has been developed for e.g. birds, mammals, amphibians, and reptiles at the European regional level and has been adopted as one of the key biodiversity indicators to monitor progress towards halting the loss of biodiversity in Europe. By regularly updating the data presented, we will be able to track the changing fate of European dragonflies to 2030 and beyond.

There is a great need for an overall European action plan for the conservation of dragonflies. However, few European countries have any form of organised and systematic monitoring program which is needed to be able to follow the development of species such as Aeshna juncea. *© Geert De Knijf*

References

De Knijf G., Billqvist M., van Grunsven R., Lees C. + others (2024). *Moving from Assessment to Planning for Threatened European Dragonflies*. A report to the European Commission by the IUCN SSC Dragonfly Specialist Group and the IUCN SSC Conservation Planning Specialist Group. Conservation Planning Specialist Group, Apple Valley, MN, USA

Boudot, J.-P. and Kalkman, V.J. (Eds.). (2015). *Atlas of the European dragonflies and damselflies*. KNNV publishing, the Netherlands. https://www.researchgate.net/publication/291165298_Atlas_of_the_European_dragonflies_and_damselflies

Corbet, P.S. (1999). *Dragonflies: Behaviour and Ecology of Odonata*. Harley Books, Colchester.

Cordoba-Aguilar, A., Beatty, C.D. and Bried, J.T. (Eds.). (2022). *Dragonflies & Damselflies: Model Organisms for Ecological and Evolutionary Research*. Second Edition. Oxford University Press. https://doi.org/10.1093/oso/9780192898623.001.0001

Decleer, K., Wouters, J., Jacobs, S., Staes, J., Spanhove, T., Meire, P. and van Diggelen, R. (2016). Mapping wetland loss and restoration potential in Flanders (Belgium): an ecosystem service perspective. *Ecology and Society* 21: 1-32. https://doi.org/10.5751/es-08964-210446

De Knijf, G., Adriaens, D., Van Elegem, B. and Paelinckx, D. (2013). Natura 2000 habitattypen - Meer dan flora! *Natuur.focus* 12: 109-120. https://www.natuurpunt.be/publicaties/natuurfocus-2013-3-natura-2000-habitattypen-meer-dan-flora

De Knijf, G., Termaat, T. and Ott, J. (2015). Conservation of European dragonflies and damselflies. In: J.-P. Boudot & V.J. Kalkman (eds). *Atlas of the European dragonflies and damselflies*. KNNV publishing, the Netherlands. https://www.researchgate.net/publication/289506984_Conservation_of_European_dragonflies_and_damselflies

European Environment Agency (2024). *Land Use*. Modified 7 Mar 2024. https://www.eea.europa.eu/en/topics/in-depth/land-use

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. (2016). *Guidelines for Using the IUCN Red List Categories and Criteria*. Version 12. Gland, Switzerland: IUCN Standards and Petitions Subcommittee. http://www.iucnredlist.org/documents/RedListGuidelines.pdf

IUCN. (2017). *METADATA: Digital Distribution Maps on The IUCN Red List of Threatened Species™*. Version 5.2. Cambridge, UK: IUCN. https://nc.iucnredlist.org/redlist/resources/files/1539099276-METADATA_for_Digital_Distribution_Maps_of_The_IUCN_Red_List_of_Threatened_Species_.pdf

IUCN. (2022). Guidelines for Appropriate Uses of IUCN Red List Data (Version 4.0). Incorporating as Annexes, the (1) Guidelines for Reporting on Proportion Threatened (ver. 1.2), (2) Guidelines on Scientific Collecting of Threatened Species (ver. 1.1), (3) Guidelines for the Appropriate Use of the IUCN Red List by Business (ver. 1.1) and (4) Guidelines for the Appropriate Use of IUCN Red List Data in Harvesting of Threatened Species (ver. 1.0). Gland: IUCN. https://www.iucnredlist.org/resources/guidelines-for-appropriate-uses-of-red-list-data

Kalkman, V.J., Boudot, J.-P., Bernard, R., Conze, K.-J., De Knijf, G., Dyatlova, E., Ferreira, S., Jović, M., Ott, J., Riservato, E. and Sahlén, G. (2010). *European Red List of Dragonflies*. Luxembourg: Publications Office of the European Union. https://data.europa.eu/doi/10.2779/84650

Kalkman, V.J., Boudot, J.P., Bernard, R., De Knijf, G., Suhling, F. and Termaat, T. 2018. Diversity and conservation of European dragonflies and damselflies (Odonata). *Hydrobiologia* 811: 269-282. https://doi.org/10.1007/s10750-017-3495-6

Kalkman, V.J, Boudot, J.-P, Futuhashi, R., Abbott, J.C., Bota-Sierra, C.A., Guralnick, R., Bybee, S.M., Ware, J. and Belitz, M.W. (2022). Diversity of Palaearctic dragonflies and damselflies (Odonata). *Diversity*, 14: 966. https://doi.org/10.3390/d14110966

Lehner, B. and Grill, G. (2013). Global river hydrography and network routing: baseline data and new approaches to study the world's large river systems. *Hydrological Processes* 27(15): 2171-2186. https://doi.org/10.1002/hyp.9740

Minot, M., Besnard, A. and Husté, A. (2021). Habitat use and movements of a large dragonfly (Odonata: *Anax imperator*) in a pond network. *Freshwater Biology* 66 (2): 241-255. https://doi.org/10.1111/fwb.13632

Naturvårdsverket. (2019). Våtmarker i Sverige. The Swedish Environmental Protection Agency. Accessed: 17 March 2023. https://www.naturvardsverket.se/amnesomraden/vatmark/vatmarker-i-sverige/

Paulson, D., Schorr, M., Abbott, J., Bota-Sierra, C., Deliry, C., Dijkstra, K.-D. and Lozano, F. (Coordinators). (2022). World Odonata List. OdonataCentral, University of Alabama. Accessed: 01/12/2022. https://www.odonatacentral.org/app/#/wol/

Rydin, H. and Jeglum, J.K. (2013). *The Biology of Peatlands*. 2nd ed. Biology of habitats series (Oxford, 2013; online ed., Oxford Academic, 8 May 2015). https://doi.org/10.1093/acprof:osobl/9780199602995.001.0001

Szabo, J.K.; Vesk, P.A.; Baxter; P.W. and Possingham, H.P. (2010). Regional avian species declines estimated from volunteer-collected long-term data using List Length Analysis. *Ecological Applications* 20(8): 2157-2169. https://doi.org/10.1890/09-0877.1

Termaat, T., van Strien, A.J., van Grunsven, R., De Knijf, G., Bjelke, U., Burbach, K., Conze, K.-J., Goffart, P., Hepper, D., Kalkman, V.J., Motte, G., Prins, M.D., Prunier, F., Sparrow, D., van den Top, G.G., Vanappelghem, C., Winterholler, M. and WallisDeVries, M.F. (2019). Distribution trends of European dragonflies under climate change. *Diversity and Distributions* 25: 936–950. https://doi.org/10.1111/ddi.12913

van Strien, A.J., Termaat, T., Kalkman, V., Prins, M., De Knijf, G., Gourmand, A.-L., Houard, X., Nelson, B., Plate, C., Prentice, S., Regan, E., Smallshire, D., Vanappelghem, C. and Vanreusel, W. (2013). Occupancy modelling as a new approach to assess supranational trends using opportunistic data: a pilot study for the damselfly *Calopteryx splendens*. *Biodiversity and Conservation* 22: 673-686. https://doi.org/10.1007/s10531-013-0436-1

Appendix 1. Taxonomic changes and new species in Europe since the first European Red List assessment

Summary of changes in taxonomy and occurrence between the 2010 first assessment and this 2024 reassessment of the European dragonflies.

2024 Reassessment	2010 Assessment	Comment
Brachythemis impartita	*Brachythemis leucosticta*	Changes in the taxonomic identity of the taxon present in Europe
Chalcolestes parvidens	*Lestes parvidens*	Moved genus
Chalcolestes viridis	*Lestes viridis*	Moved genus
Coenagrion castellani	partim of *Coenagrion mercuriale*	New: previously included within the assessed concept *of Coenagrion mercuriale* as a subspecies
Coenagrion glaciale		Not assessed in the 2010 ERL
Coenagrion mercuriale	Revised species concept	Now split up in two distinct species, see also *C. castellani*
Cordulegaster helladica	*Cordulegaster helladica* ssp. *buchholzi*	Assessed at the species-level in the reassessment
"	*Cordulegaster helladica* ssp. *helladica*	Assessed at the species-level in the reassessment
"	*Cordulegaster helladica* ssp. *kastalia*	Assessed at the species-level in the reassessment
Ischnura intermedia		New record for the ERL region
Ischnura senegalensis		New record for the ERL region
Macromia amphigena		New record for the ERL region
Onychogomphus forcipatus	*Onychogomphus forcipatus* ssp. *albotibialis*	Assessed at the species-level in the reassessment

“	*Onychogomphus forcipatus* ssp. *forcipatus*	Assessed at the species-level in the reassessment
“	*Onychogomphus forcipatus* ssp. *unguiculatus*	Assessed at the species-level in the reassessment
Orthetrum ransonnetii		New record for the ERL region
Stylurus flavipes	*Gomphus flavipes*	Moved genus
Stylurus ubadschii	*Gomphus ubadschii*	Moved genus
Tramea basilaris		New record for the ERL region

European Commission

IUCN

RED LIST

SSC
Species Survival Commission

IUCN
Dragonfly
Specialist
Group