STATUS REPORT
DUTCH BIODIVERSITY
2025

Naturalis
Biodiversity
Center

STATUS REPORT

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The slender-billed curlew is the most recent addition to the large group of known (and even larger group of unknown) species that have become completely extinct due to habitat loss, hunting, pollution, or the disappearance of species that they depend on. There are now 462 names on the list of species that have all but disappeared from the Netherlands since 1950; animals that used to swim in our rivers, fly in our sky, and wander around our land, but can no longer be found in our country.

FOREWORD

A while ago, someone once asked me: do you think people recognize just how much of a biodiversity crisis we have on our hands? I thought they did. Then he showed me a TV news report from October 10, 2024, which devoted 18.8 seconds to WWF's *Living Planet Report*. It stated that wild animal and plant populations worldwide have declined by an average of 73% over the past 50 years. That same report featured an item about the extinction of the landline telephone, which lasted 97 seconds. The Dutch news dedicated five times as much time to an old telephone as it did to the disappearance of three-quarters of all wild animals and plants on Earth.

This he claimed as proof that I was wrong, and that many people failed to appreciate just how devastating the loss of biodiversity is. I'm afraid he's right. Maybe not about our Naturalis bubble, but out there in the wider world, biodiversity is still seen as something distant and to do with fluffy animals. Many people know that things aren't going well, but in their day-to-day life, they don't really take much notice of it.

On the same day that I had this conversation, it was announced that the slender-billed curlew was officially extinct. It was last seen in the mid-1990s. This deeply upset me – not that I had a particularly strong connection with the slender-billed curlew. I'm not an avid birdwatcher, and if I ever did see it, I'm sure I would've mistaken it for a common curlew. But that's beside the point. For the first time in my life, a bird that was found right here in the Netherlands is now extinct. And it's never coming back. Gone. Forever. It only exists now in the collections of museums such as Naturalis. Accordingly, we've moved it to the 'Gallery of Honor': the repository where all extinct animals are kept. It's like awarding a posthumous medal. There it stands proudly, between the great auk and the passenger pigeon.

Then again, the news is not all bad. Take the great egret, for example: until the 1990s, it was rarely seen. Around the year 2000, we counted 30 specimens; by 2020, there were around 10,000, with more being spotted every year.

Or the white stork: by the late 1960s, there were only three breeding pairs left in the Netherlands. So rare had the bird become that the news reported the pairs' return from Africa or southern Europe every year. And now look at them: more than 1,500 pairs are breeding throughout the Netherlands.

When you hear these kinds of success stories, you might think that biodiversity is doing just fine. Unfortunately, this isn't the case. In fact, it's declining all around us. However, this does make it easier to understand why this is such a confusing topic for people. Are things going well or not at the moment? And how can we tell?

That's why we've produced this status report on Dutch biodiversity. In it, we've included everything we currently know about the state of nature in the Netherlands. Our role is to explain how things are right now, what the trends suggest, and where action is needed.

This will then hopefully allow members of the public to better interpret the messages they see and hear in the media every day. Our bird curator has done his bit, being interviewed on the evening news about the extinction of the slender-billed curlew – a wonderful report lasting two minutes and one second. I'll take that as a win.

Edwin van Huis
General Director,
Naturalis Biodiversity Center

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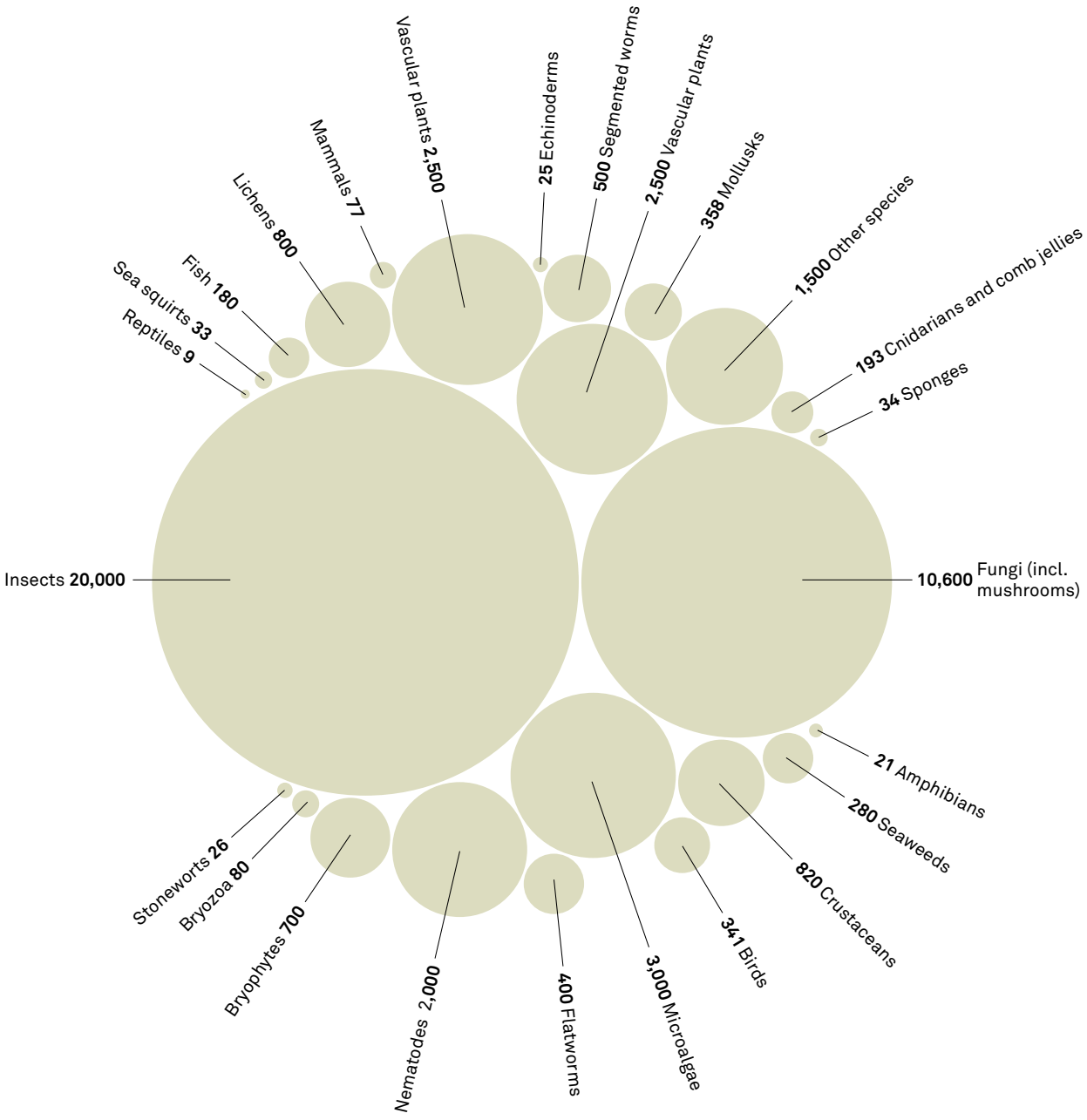
CONTENTS

FOUR-BANDED LONGHORN BEETLE | PHOTO: PETER H. VAN BRAGT

Over 47,000 species in the Netherlands



There are more than 47,000 eukaryotic species (organisms with a cell nucleus) in the Netherlands. It is difficult to give an exact number, partly because it depends on which species to include in the count and partly because we do not yet have an agreed-upon species list for some groups. The total number of species in this report is based on information from the Dutch Species Register (www.nederlandsesoorten.nl), supplemented by the latest data from taxonomic experts. These are "established" species that have reproduced in the Netherlands – including the Dutch part of the North Sea – for at least 10 consecutive years. In addition, a number of migratory species groups (birds, fish, and butterflies) include species that are regularly sighted in the Netherlands, but are not yet classed as "established".

SUMMARY
DUTCH BIODIVERSITY STATUS REPORT 2025

Dutch biodiversity is not doing well. This is having a direct impact on our living environment. Existing policies provide a foundation for a positive, biodiverse future, but their success depends on how they are implemented. To achieve the defined recovery targets, we need to use all the resources we have at our disposal. The latest scientific insights and monitoring techniques can serve as instruments to collectively turn the tide.

Dutch biodiversity is not in good shape. Species are disappearing from the countryside, while legally protected species are largely declining. The agreed nature targets for species, habitats, and water quality are moving further out of reach, in part because of continued problems posed by nitrogen, moderate to poor water quality, and lack of space.

The poor state of biodiversity has direct consequences for Dutch society. For one thing, the supply of clean drinking water and healthy food is under pressure – and if we lack clean air and the ability to enjoy our natural surroundings, our own physical and mental well-being is at risk. Biodiversity is not a luxury. It is the fundamental basis for a livable Netherlands, both now and in the years to come.

However, there are some glimmers of hope. Large mammals such as the beaver, otter, and wolf are making good progress, as is the white-tailed eagle. Measures to improve water quality are helping freshwater flora and fauna to recover. But after a long period of sharp decline, such small improvements do not mean that biodiversity in the Netherlands will be fine. Compared with other European countries, the Netherlands dangles at the bottom for meeting the targets under the EU's Water Framework Directive and unfortunately is a frontrunner in terms of the number of disappeared and endangered species.

Although existing policies have laid a foundation for a biodiverse future, the key to success lies in honoring existing commitments. A sound knowledge and understanding of our biodiversity is crucial to in order to effectively steer towards improvement.

That starts with the basics: monitoring species in the Netherlands. Most of these are not monitored, simply because they are too small to see or because of the absence of organized groups to monitor them. The good news is that more methods are becoming available to measure and monitor biodiversity, including AI-assisted image and sound recognition and DNA analysis. These techniques map out fungi and bacteria in the soil, phytoplankton and zooplankton in the sea, and insect species in the air, thus giving a voice to the silent majority of species.

The Netherlands can transform from a champion in biodiversity loss to a frontrunner in biodiversity knowledge and restoration, provided we have the drive to do so. By combining knowledge, technology, and policy, we can create the leverage needed to reverse biodiversity loss and make it a positive trend – not just to meet the targets that have been agreed, but to invest in our own biodiversity-inclusive future.

National Dashboard for Biodiversity

The National Dashboard for Biodiversity (dashboardbiodiversity.nl) tracks how biodiversity is doing in the Netherlands. Are we on track to achieve biodiversity restoration by 2030?

Developed by independent nature research institutions, the dashboard reveals how various pressure factors are affecting biodiversity in the Netherlands. Out of the 14 targets selected, seven are moving increasingly out of sight (red) and five require additional efforts to achieve (orange). The dashboard is updated annually using the latest data, taken in particular from the Environmental Data Compendium (Compendium van de Leefomgeving, CLO).

This status report provides an in-depth look at the indicators for the policy targets, with detailed information on the Dutch species groups.

NB: a similar dashboard for the Dutch marine biodiversity is currently being developed.

FOX | PHOTO: GETTY IMAGES

ABOUT THIS REPORT

READING GUIDE

Whether you are a policymaker or just generally interested in nature, this report is intended to give you an overview of the state of biodiversity in the Netherlands, with a firm focus on species. Species form the ecological networks that underpin our ecosystems and are often the focus of policy.

Good biodiversity is important for biodiversity itself and for ourselves. It is thanks to biodiversity that we can live, breathe, eat, and survive here on Earth. To restore biodiversity to a healthy state, it is essential that we give nature the space it needs, reduce the pressure factors on it, and work together to strengthen biodiversity. The National Dashboard for Biodiversity summarizes the commitments made and targets agreed, providing direction for our priorities when it comes to reversing biodiversity loss. The key to making progress is to understand our biodiversity. This report aims to contribute to that.

Species groups and numbers

There are more than 47,000 species in the Netherlands. Only a small proportion of these are explicitly mentioned in policy targets, despite the largely invisible majority being hugely important to the ecosystem functioning. In this report, we focus on species and groups relevant to policy, as well as others, even if we know very little about them. After providing some general overviews, we will look specifically at the state of the various groups. These include both broader groups and specific species mentioned in policy, but usually this will be a combination of both.

It transpires that more data are needed on most of the species to calculate firm trends or determine their status, using methods such as the Red List. In addition to the available data, the fact sheets for the different groups indicate the minimum number of species found in the Netherlands and how we might monitor those groups in the future. It is often difficult to determine the number of species in the Netherlands, partly because this is a matter of choosing which species should be counted and partly because there is not yet an agreed-upon species list for a number of groups. This choice determines, for example, how long an extinct species will continue to be included and when a species sighted only occasionally should be included in the count. The species list is determined by taxonomic experts and based on research – which is still evolving considerably, especially because of new DNA techniques.

Latest data

For this report, we used the most recently published data available to us, mainly from the CLO (publications up to April 30, 2025 were included). For species numbers, we drew on the Dutch Species Register as a basis, supplemented with information from published standard lists and from experts. In future editions, we will include new insights and data.

The urgent situation of Dutch biodiversity in the Netherlands requires immediate attention. We hope that both the insights from this report and future information will further underscore the need for action in light of the biodiversity crisis.

Biodiversity data now and in the future

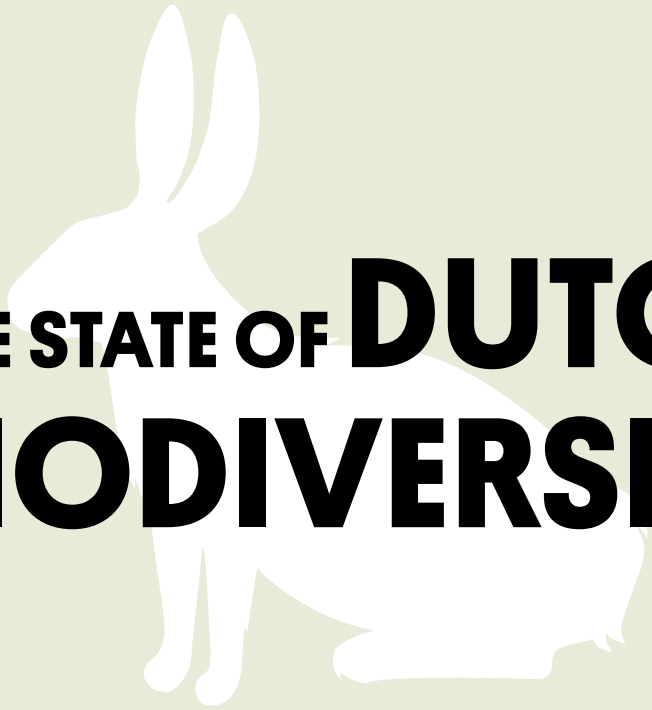
In this report, we provide a glimpse into new monitoring methods and how these innovations will improve our knowledge of biodiversity in the coming years. The Netherlands is blessed with an army of volunteers, who are responsible for many of the sightings. Meanwhile, most of the data come in through apps, such as ObsIdentify, and increasingly through cameras and microphones linked to experts or AI-based species identification. Over the coming years DNA-based methods, especially for freshwater & saltwater, for soil, and for small species, microorganisms & arthropods, provide revolutionary breakthroughs in understanding biodiversity – all with the help of accessible, (inter)national, integrated data and analysis infrastructures.

However, this report does not cover everything. For example, we have not included the Dutch Caribbean in this first edition. This region will certainly be covered in future editions, which will offer many valuable insights – especially given the growing interest in sightings and research on the islands.

We hope this report will not only prove informative, but also serve as inspiration for charting the course for biodiversity. We are of course open to suggestions and cooperation so we can harness scientific knowledge effectively and turn it into policies that create sustainable impact.

Koos Biesmeijer,
Vincent Merckx,
Willem Renema,
Merel Bozua-Hope

MIGRANT SPREADWING | PHOTO: WILLIAM VOORBERG



THE STATE OF DUTCH BIODIVERSITY

Species monitored on land have not fared well in the Netherlands over the past century. While some are benefitting from improved water quality, others are suffering from intensive land use and pollution, including with nitrogen. But when it comes to the largest species groups, the striking thing is how little we know about them.

The Netherlands is undoubtedly one of the most studied countries in the world in terms of biodiversity: some species, such as butterflies, have been monitored for a hundred years. When viewed together, the data show that these creatures have not been faring well in the Netherlands since then. The Red List of threatened species is long, and species that are currently still common seem to be on the decline.

However, if we zoom in on different species groups, the story is less clear-cut. While some species benefit from global warming and improved water quality, others suffer from intensive land use and pollution, including with nitrogen. For example, butterflies and birds on farmland continue to fare poorly (see p. 90 and p. 34).

By contrast, species that benefit from the warmer climate are slowly starting to do better. We are seeing this in sea fish, dragonflies and damselflies, and several other species (see p. 68 and p. 92).

Moreover, because of the changing climate, nature is in flux: every year, dozens of species of insects and other fauna enter the Netherlands as climate migrants. These are often species that have a varied diet and are able to live in a variety of habitats. For the same reason, native species that are not thriving in the warmer Netherlands are declining and retreating to more northerly areas.

Disproportionately distributed knowledge

It may be a while before climate change causes species to disappear altogether. In fact, the number of species is actually forecast to increase in the short term, rather than decrease. This can also be observed in the Living Planet Index (LPI), which captures biodiversity changes based on monitoring data for 376 species. The LPI is slowly increasing in the Netherlands, meaning that the

Biodiversity is about all species and their networks

populations of the species under observation are more frequently rising than falling. This trend is mainly caused by the expansion of species in freshwater and marshes. Other land-based species, especially in open natural and agricultural areas, are steadily declining (see Figure 1. Living Planet Index).

The mix of species is also changing, which has several consequences. Generalists (which place few demands on their environment) will increase, while specialists (which fulfill specific roles in the ecosystem) will decrease. This has implications for the interaction networks that form the basis of our ecosystems. As an example, the disappearance of seed dispersers, pollinators, and host plants can have a major impact on the species that depend on them.

It is important to stress that the LPI and species addressed in policy only make up a very small number of species, in a limited number of species groups (about 6–7% of all species in the Netherlands). For the vast majority of the approximately 47,000 species found in the Netherlands, insufficient data are available. Knowledge is disproportionately distributed: the most information by far is available on vertebrates (mammals, birds, fish, amphibians, and reptiles), but these make up less than 1% of the total number of species. The remaining 99% belong to other groups, such as arthropods (insects, spiders, and relatives), fungi, and algae. These are less visible, but often form the basis of food chains and therefore have a direct relationship with the ecosystem as a whole.

Mapping the state of biodiversity requires an overarching view

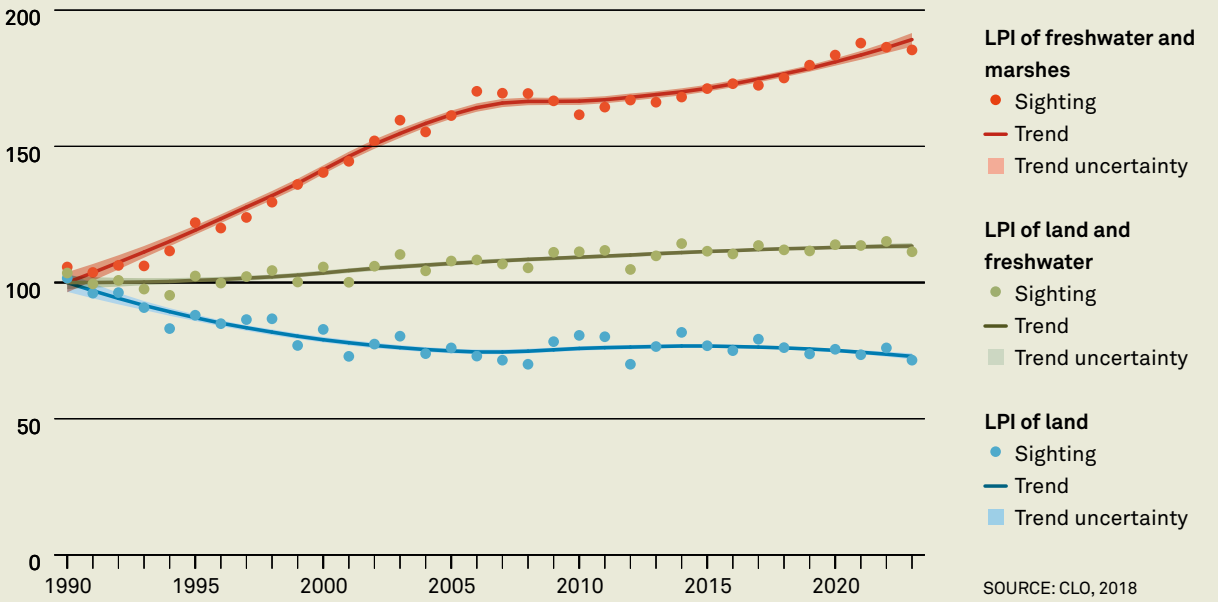
Precisely these lesser-known species groups harbor crucial species that harness sunlight (phytoplankton and other plants) and minerals (fungi and microorganisms), or act as recyclers within the system (soil fauna and fungi). They also play an essential role in controlling pests (parasitic wasps and other insects), pollinating wild plants and crops (mainly bees and hoverflies), and serving as a source of food (e.g. phyto- and zooplankton). New species in these groups are still routinely discovered.

Automated sighting

Biodiversity is about more than just species. Interactions within ecosystems and genetic diversity

Figure 1. Fauna on land and in freshwater (Living Planet Index)

1990–2024



SOURCE: CLO, 2018

RED SQUIRREL | PHOTO: GETTY IMAGES

Vertebrates make up less than

1%

of all species in the Netherlands

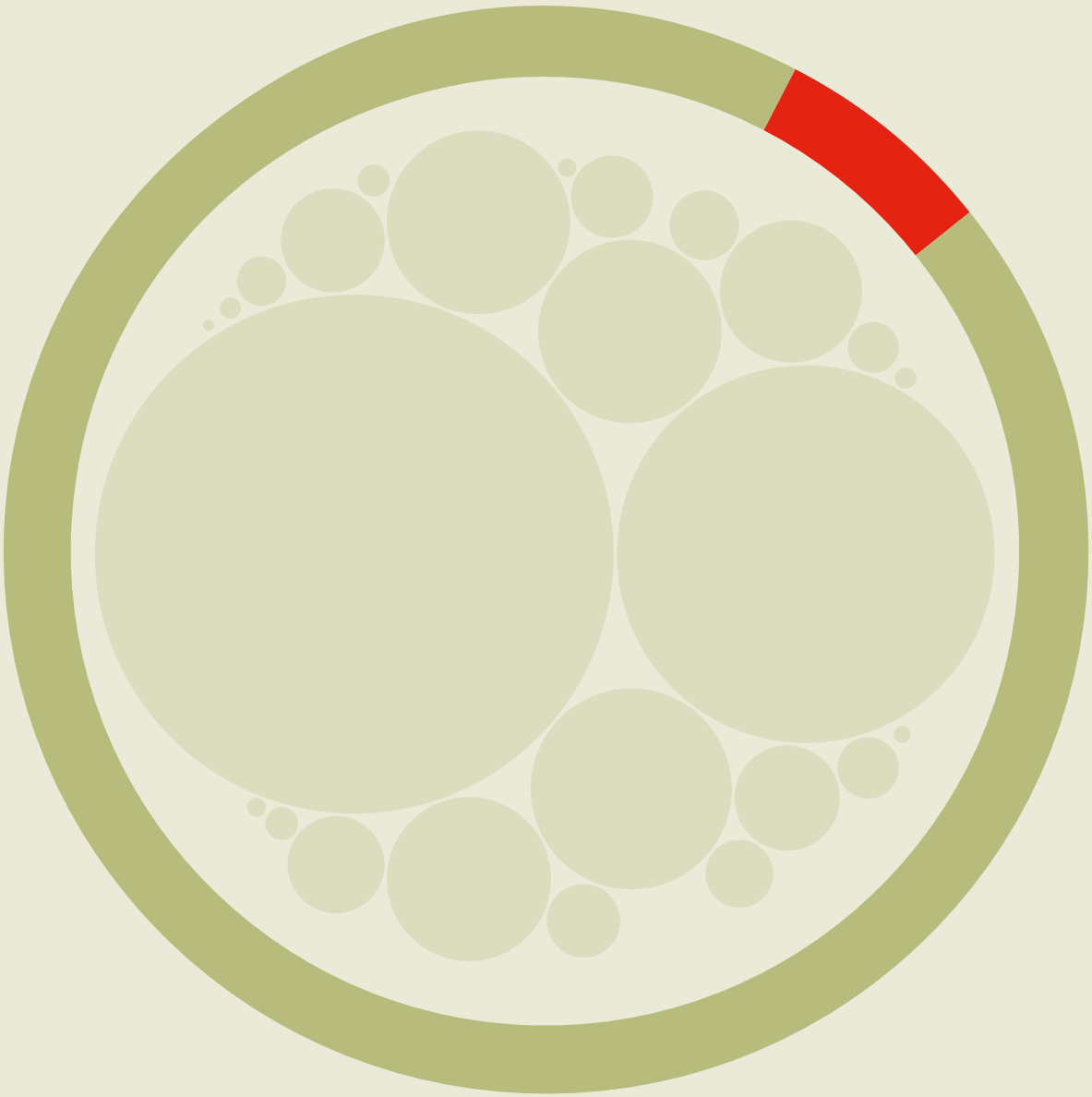
within a species are of equal importance. An increase in the number of species or a growing population does not automatically mean a healthier nature. Mapping the state of biodiversity requires an overarching view that looks not only at individual species, but also at the networks in which they live and that make up the ecosystem.

To improve forecasts on trends in biodiversity, more reliable data are needed in greater amounts on multiple species. Users of identification apps like ObsIdentify are adding millions of data points every year (see p. 112, “How technology is engaging the public in species counts”), but the data concerned are often only collected ad hoc. They can be used to estimate how a species is doing, but are not always suitable for monitoring trends in a statistically reliable way. Monitoring should therefore be scaled up considerably.

New technology may further automate and speed up species sighting in the future. Wildlife cameras or microphones can detect larger species 24 hours a day, making data collection less dependent on human observers. Moreover, technology can help make lesser-known species more visible. In addition, DNA techniques have great potential, especially for mapping the smaller, “invisible” species. Examples of the discoveries and insights we are gaining using these innovative methods, which can also be used for citizen science, are provided later in this report.

There are 47,000 species in the Netherlands

of which 6.5% are covered by biodiversity policy



Biodiversity policy in the Netherlands is a complex interplay of various EU and Dutch directives and legislation. The Red List contains 3,100 species (6.5%) that require legal protection.
By contrast, conservation status calculations are based on a paltry 500 species, leading to the conclusion that only about 6–7% of the total number of species in the Netherlands are covered by biodiversity policy.

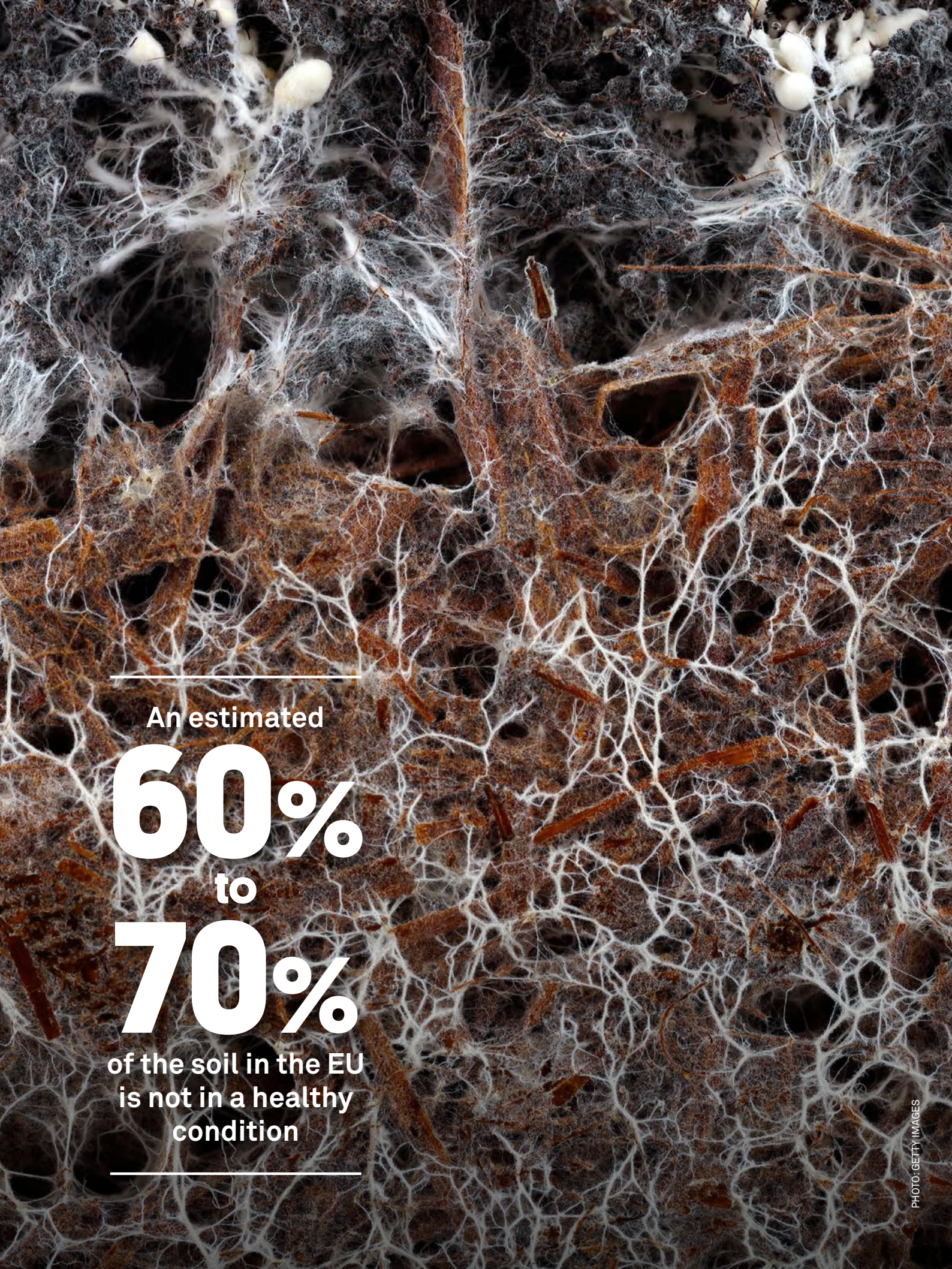


PHOTO: GETTY IMAGES

THE STATE OF THE DUTCH SOIL

Soil quality is deteriorating rapidly, brought on by increasing disturbance and pollution. It is estimated that 60–70% of the soil in the EU is not in a healthy condition. This also affects biodiversity, which has enormous social, environmental, and economic value for humans.

Soil is exceptionally biodiverse (see Figure 1): one teaspoon of soil easily contains more than a thousand species. Soil is not only the foundation of our food supply, but also retains water, nutrients, carbon, and greenhouse gases.

The term "soil biodiversity" refers to all organisms that live in or on the soil for at least one phase of their lives. This includes plants, but also an array of invertebrates, such as nematodes, tardigrades, potworms, springtails, mites, woodlice, spiders, and earthworms. Furthermore, as many as 400 out of a 1,000 species encountered may be soil fungi. There are also other microorganisms, such as bacteria, archaea, protists, and viruses.

All branches of the tree of life are represented in the soil. Just like above ground, all of these species are highly interdependent and form a complex food chain. As a result, the disappearance of a species can have far-reaching consequences for other species and, in turn, the functioning of the entire system.

Food chain depletion

According to estimates, 60–70% of soils in the EU are not in a healthy state. This is due to unsustainable land use and management, overexploitation, and pollutant emissions, most likely with major impacts on soil biodiversity (European Commission 2021).

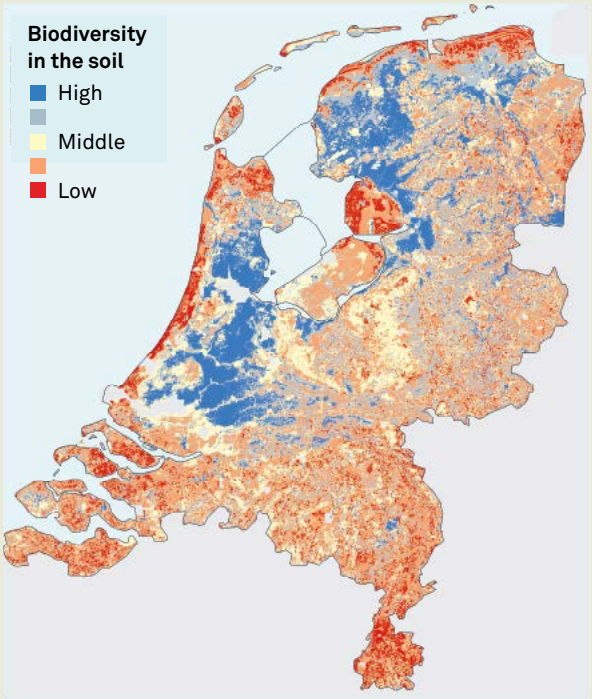
A limited number of long-term studies have been conducted in the Netherlands looking at soil biodiversity in more detail, for example as part of the National Soil Quality Monitoring Network (Van Esbroek et al., 1996, 1997; Schouten et al., 2018). These studies show that land use intensification generally leads to a decline in soil biodiversity and soil community complexity, with negative consequences for many ecosystem services (Van der Putten, 2019).

Research also shows that an increase in soil disturbance and pollution leads to a decrease in fungi, an increase in bacteria, and a loss of plant species (Tamis et al., 2005),

As most soil organisms are very small, it is difficult to paint the full picture of the state of soil biodiversity

TIGER WORM | PHOTO: GETTY IMAGES

Estimated soil biodiversity in the Netherlands



This map visualizes the estimated soil biodiversity, calculated based on data from 300 fixed monitoring stations. The estimate includes 11 variables: the abundance and species-richness of earthworms, potworms, nematodes, and microarthropods, as well as microbial community characteristics (C and N mineralization rate and leucine uptake rate) (Rutgers et al., 2019).

mycorrhizal fungi (Hannula et al., 2017; Van Strien et al., 2018), earthworms (Crittenden, 2014; Frazão et al., 2017), springtails, and mites (Siepel, 2018). A decline in soil biodiversity and the associated depletion of the food chain is leading to a loss of soil function and resilience (Van der Putten, 2019).

Only part of the picture

As most soil organisms are very small, it is difficult to paint the full picture of the state of soil biodiversity. Extended series of soil biodiversity observations exist only for visible species groups, such as plants, mushrooms, ground beetles, and larger soil organisms. These groups can serve as rough indicators of the soil condition (see Mushrooms, p. 52 and 54), but because they represent a very limited part of soil diversity and are usually high up the food chain, they do not provide a complete picture of how the entire ecosystem is faring.

In response to declining soil health, the EU has formulated a soil strategy, which aims to restore all soil ecosystems in the EU to good ecological health and improve their resilience by 2050 (European Commission 2021). In this context, a preliminary agreement was recently reached on the EU Directive on Soil Monitoring and Resilience, which contains descriptions and criteria for healthy soil, including some aimed at monitoring biodiversity. This is the first step to understanding and protecting soil biodiversity.

Since most soil-dwelling species can only be identified through specialist techniques and knowledge, we actually know very little about life in the soil, even here in the Netherlands. A soil biodiversity map of the Netherlands has been created based on data from the National Soil Quality Monitoring Network (Figure 2; Rutgers et al., 2019). However, the limited number of monitoring stations and lack of species information on microorganisms mean that any maps compiled from these data must be interpreted with care and are difficult to translate into quality indicators.

Box 1. eDNA

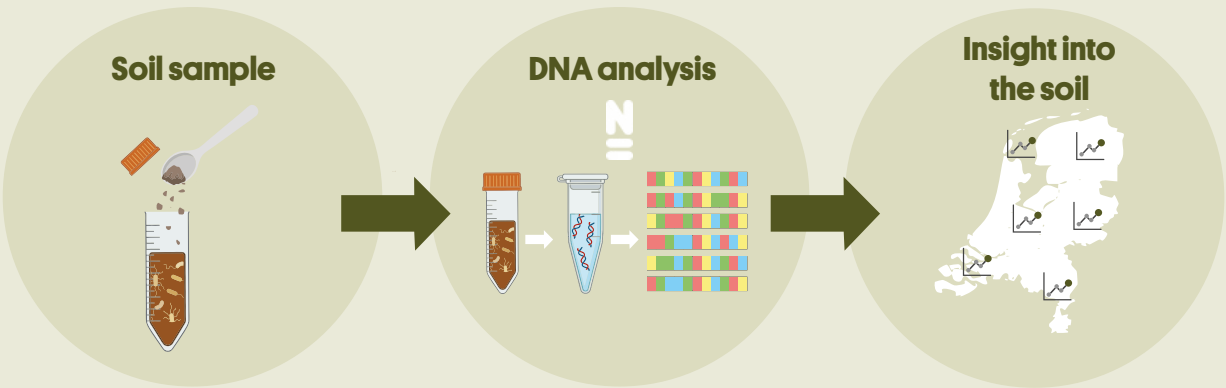
Thanks to environmental DNA (eDNA), all species in a soil sample can be determined by analyzing DNA traces. Species that are not physically present in the sample but were there previously (e.g. earthworms) and non-visible species such as bacteria and fungi can also be recognized from DNA traces left behind. With the eDentity project, Naturalis is working to develop a fast and affordable method to use standardized kits and robotic analysis to measure soil biodiversity quickly on a large scale across the Netherlands. eDentity builds on the ARISE project, as part of which researchers have been developing a database of DNA sequences since 2020 to name as many Dutch species as possible.

All branches of the tree of life are represented in the soil

Targeted monitoring

Biodiversity in Dutch soils is still insufficiently understood – especially when it comes to "hidden" species, which make up the vast majority of this diversity. Nevertheless, the scale-up and standardization of DNA techniques means that we can expect a breakthrough in this very soon (see Box 1). The data provided by these techniques will make it possible to create maps to show, for example, which types of fungi are found where in the soil and the changes occurring in them.

The same infrastructure should also allow targeted monitoring of the effects of disturbance and management. The data will be linked to data available on soil properties, land use, and biodiversity above ground. As a result, these maps will provide opportunities to shape soil management and design so as to preserve or even enhance soil biodiversity.



Only

14%

of the waters surveyed are of good quality

SMOOTH NEWT | PHOTO: GETTY IMAGES

BIODIVERSITY IN FRESHWATER

Water is typically cleaner now than it was in the past, which has had a positive effect on the number of species found in freshwater areas and marshes. After a period of sharp decline, biodiversity is gradually recovering. Even so, the quality of the water still remains below standard in most places.

The ecological state of our freshwater shows a mixed picture. First of all, this is due to the variation in freshwater systems: from large lakes and rivers to small ditches and ponds. Second, those various systems are home to a variety of groups of species, each responding to changes in the environment and climate in its own way.

Taken together, species in freshwater and marshes have shown an increase since 1990 after a long period of sharp decline. One major cause of this is the improvement in water quality in terms of a better nutrient balance and a reduction in pollutants. Chemical water quality does not yet meet the standards under the Water Framework Directive. In recent years, there has also been an increased focus on more natural banks and land development, while fish ladders provide better opportunities for fish, amphibians, and other groups.

Trends vary by species group. The otter, for example, is found in more areas than before. Water-dependent amphibians are becoming more prevalent, as are breeding birds in marshes, freshwater, and reed beds. Bat numbers around water and marshes are also increasing. However, water-dependent dragonflies and damselflies are declining again after a previous increase. The same decline is seen in freshwater fish stocks. Aquatic plants and macrofauna (smaller aquatic animals that are still visible to the naked eye) are mostly in moderate to poor condition.

Netherlands ranks bottom

The Water Framework Directive is an EU directive that aims to protect and improve the quality of all surface and groundwater in Europe. Member states must ensure that water bodies achieve a good ecological and chemical status by 2027. The Netherlands ranks at the bottom of the list of European countries for water quality (www.clo.nl/nl/43808).

The Netherlands is abundant in water and is characterized by intensive land use, making the land and water nexus particularly strong

Chemical pollution in water harms aquatic life communities

Water boards and authorities play a key role in water quantity and quality in the Netherlands. Ecological quality focuses on a healthy ecosystem with sufficient biodiversity, natural water flows, and healthy living conditions for aquatic plants and animals.

Most water bodies assessed under the Water Framework Directive (the surface water in rivers, large lakes, ponds, canals, larger ditches, the Wadden Sea, and coastal waters) are of moderate to poor ecological quality. Only 14% are of good quality. In the other water bodies, one or two groups of species are often found to be doing well (freshwater fish, aquatic plants, macrofauna, and algae having been measured).

Under the Water Framework Directive, ecological quality is measured not only by biodiversity, but also by limit values for pollutants such as heavy metals, drug residues, plastics, and pesticides. Given the traces of all of these chemicals, there is little to no body of water that has not been affected by human activity.

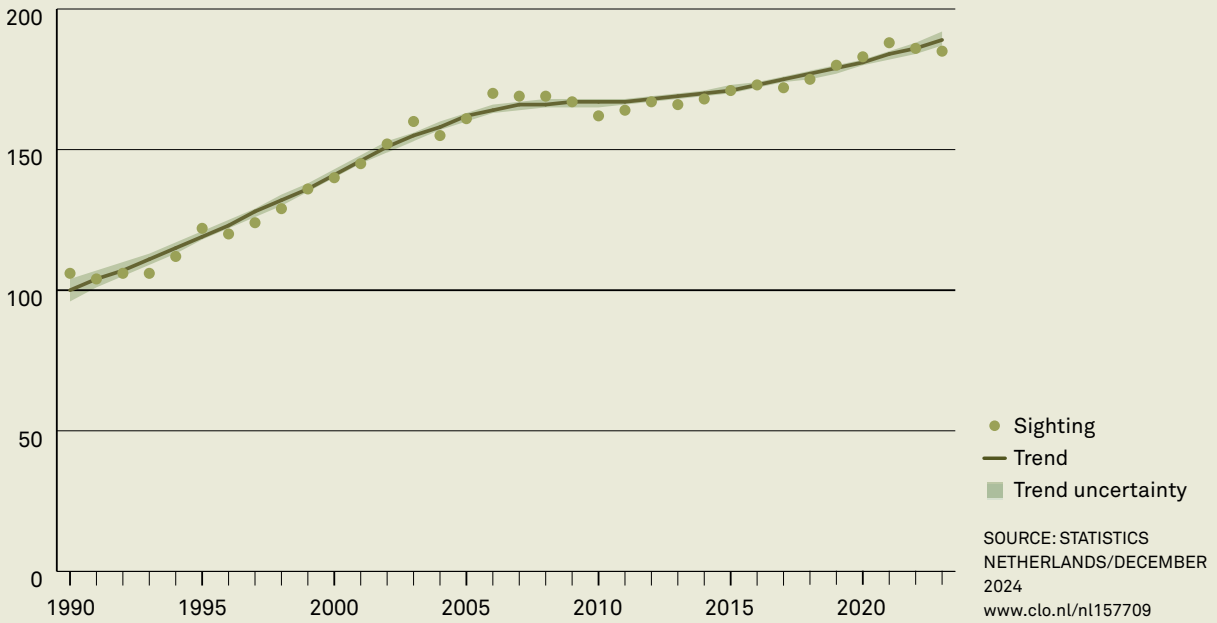
Degradation of ditches

Unacceptably high concentrations of crop protection products are found in many surface water bodies. These change the species composition of animal life and lead to a decline in the ecological quality of ditches (Teunissen-Ordelman & Schrap, 1996; Ieromina,2016). Despite all measures taken and attention focused between 1997 and 2023, the ecotoxicological standard is still exceeded at 40% of all surface water monitoring stations (www.bestrijdingsmiddelenatlas.nl); more often than not, however, the value only slightly exceeds the standard.

Even in natural areas, water quality is moderate to poor. This is caused by manure, pesticides, and industrial discharges in the surrounding areas. Recently, Natuurmonumenten – the Society for the Preservation

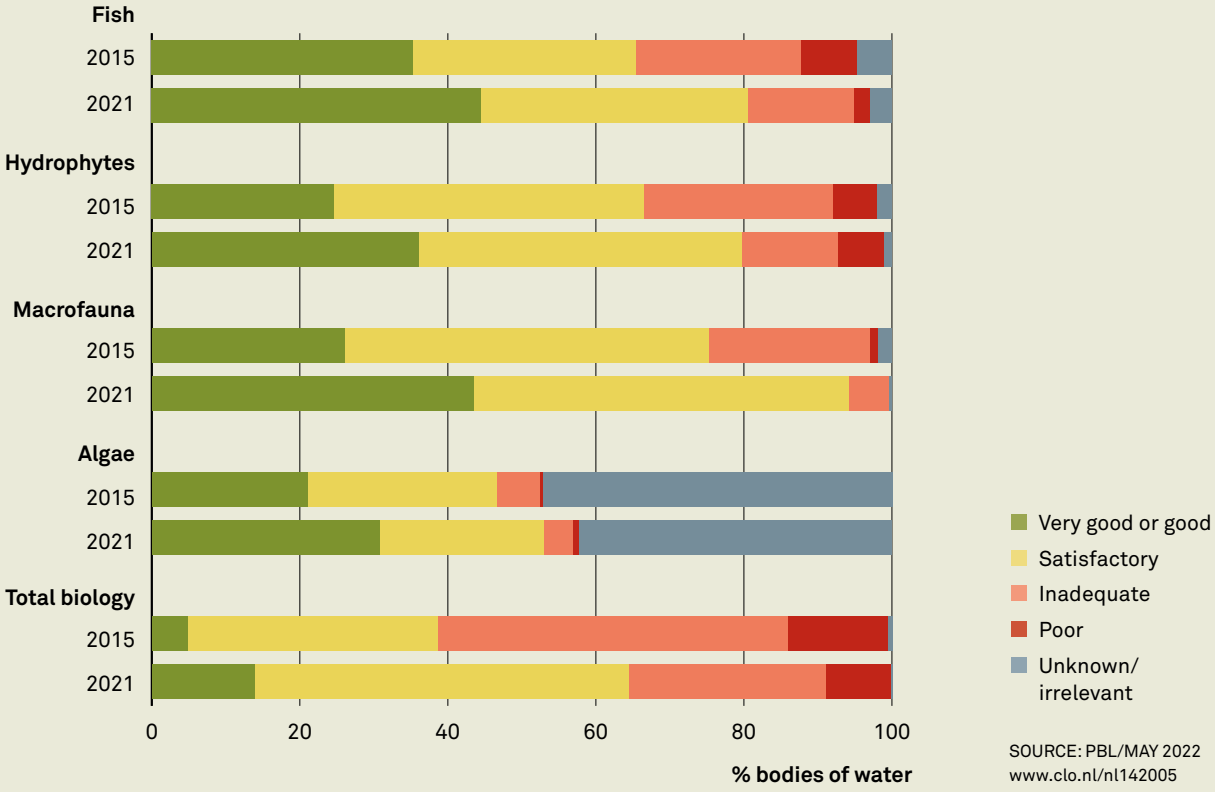
Fauna in freshwater and marshes

Index (1990 trend =100)



SOURCE: STATISTICS NETHERLANDS/DECEMBER 2024
www.clo.nl/nl157709

Biological quality in surface water according to the Water Framework Directive



SOURCE: PBL/MAY 2022
www.clo.nl/nl142005

of Nature in the Netherlands – surveyed 11 of its wetlands scattered throughout the country. It concluded that none of the areas exhibited good water quality, and six areas even showed a decline. According to the Natuurmonumenten report, this is causing serious damage to nature in all areas.

Self-cleaning ditches

Freshwater biodiversity is invaluable to our planet, but globally a quarter of freshwater species are threatened with extinction. Freshwater makes up only 1 to 2% of the Earth's total surface, but 10% of all animal species and even 50% of all fish species live in freshwater.

In a water-rich country like the Netherlands, the importance of water is even greater than elsewhere, if that is even possible. Our rivers, lakes, floodplain systems, ditches, and canals are home to a tremendous wealth of biodiversity. These small water bodies form a large part of the landscape: ditches form a network of 300,000 to 400,000 kilometers (Higler, 1994), on which many species depend. Ditches can be thought of as a huge water treatment plant (Scheffer & Cubben, 2005) that contributes to the ecosystem's functioning and the value of the landscape (Clean Water Benefits Coalition, 2006). Because these are smaller water bodies, with more banks and vegetation and less flowing water, natural processes in ditches contribute more to cleaning the water than elsewhere.


The Netherlands
has
1.5
times
more saltwater
than land area
PHOTO: PETER H. VAN BRAGT

BIODIVERSITY IN SALTWATER

Biodiversity in the saltwater bodies of the Netherlands is under pressure. Although there are some positive signs, there are factors that are impacting ecosystems, including human activity, climate change, and the introduction of non-native species.

The Dutch saltwater bodies – consisting of the Wadden Sea, the Southern Delta, and the North Sea – cover about one and a half times the land area of the Netherlands, yet far fewer species are found here: only about 2,000 have been documented. Several groups, especially smaller but potentially species-rich ones, have so far received very limited research attention, so additions are to be expected.

Trends in populations vary by area. In the Eastern Scheldt, they have been on the decline since 1990; however, the Western Scheldt is showing an increase. In the Wadden Sea and North Sea, numbers are stable (see Figures 1 and 2). There are several reasons behind these trends. In the Western Scheldt, for example, water quality has improved, partly because untreated wastewater from Brussels is no longer discharged there (clo.nl/nl159901).

The intensity of bottom trawling, rising temperatures, the growth of non-native species, and expansion of offshore wind farms have likely contributed to the decline of populations. However, insufficient data are available to pinpoint the extent to which these factors are putting pressure on water quality (Ministry of Infrastructure and Water Management, 2018).

Distorted picture

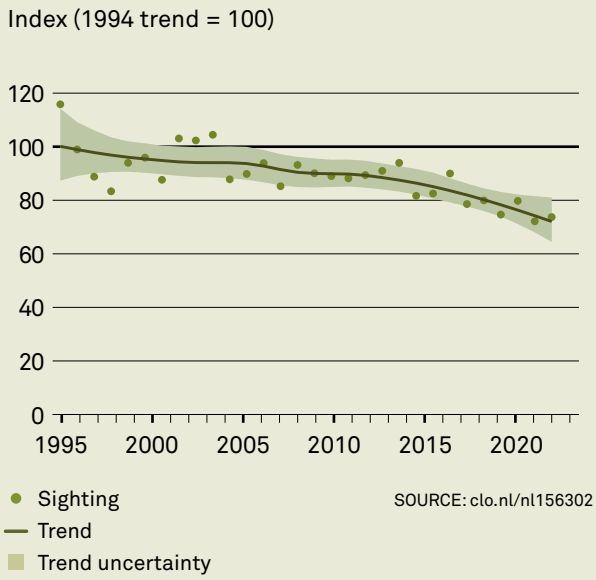
Then again, these trends provide a distorted picture. Current figures are compared with the situation in 1990, when saltwater ecosystems were already highly depleted. Characteristic habitats that supported many ecosystem functions, such as flat oyster reefs, bristle worm reefs and seagrass beds, had long since mostly or entirely disappeared.

Moreover, the data only relate to species listed in the CLO, which does not cover factors such as non-native newcomers. In the North Sea, the impact of this category of species on the ecosystem seems limited: only one new non-indigenous species has been reported there since 2017 (*Staat van de Noordzee*, 2023). In the Wadden Sea and Southern Delta, however, the number of new non-native species sighted is actually increasing (Van der Loos & Gmelig Meyling, 2019; Wadden Sea Quality Status Report, 2022). Many of these have also been sighted in the coastal waters of the North Sea, such as the file yoldia, the dwarf surf clam, and the brackish-water corbula.

That said, the rate at which new non-native species are reaching the Netherlands should not be the only factor. The population size and distribution of some species are increasing rapidly. This is best documented for shellfish species (Troost et al., 2024). For example, the Manila clam first established itself in the Netherlands in the Southern Delta in 2008. By 2022, the stock was estimated at about 52 million kilograms. Since 2019, this species has been sighted in the Wadden Sea, where it is now steadily expanding.

Figure 1. Populations of characteristic species in the Eastern Scheldt

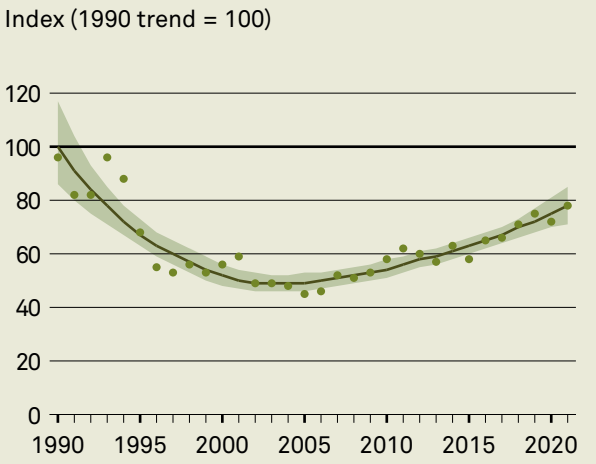
1994–2022 | 37 species evaluated



SOURCE: clo.nl/nl156302

Figure 2. North Sea fauna in coastal waters

1990–2021 | 107 species evaluated



SOURCE: clo.nl/nl159602

Fish, birds, and mammals

Trends vary within species groups. Marine mammals are in relatively good shape: gray and harbor seals have increased in number significantly in recent decades, both in the Southern Delta and the Wadden Sea (see Mammals, p. 36). As a result, they have not featured on the Red List for mammals since 2020. The harbor porpoise population is stable, but under pressure from bycatch and noise pollution, including from wind farm construction (*Staat van de Noordzee*, 2023).

Seabirds show a mixed picture. In the North Sea ecosystem, these occur in three groups: surface feeders, water column feeders, and bottom feeders. The first group meets the ecological targets, the other two to a lesser extent (*Staat van de Noordzee*, 2023). The northern fulmar, a surface feeder, is faring especially badly. Major pressure factors are disruption from human activity such as shipping, and the expansion of offshore wind farms (*Staat van de Noordzee*, 2023). Water column and bottom feeders are particularly sensitive to this (Peschko et al., 2024). Climate change and pollution may also play a role.

The population of fish caught for commercial purposes has declined since 1960 (clo.nl/nl007322), but appears to have recovered since the turn of the century thanks to reduced fishing. The populations of plaice, whiting, and herring are above the sustainability target, while those of sole and cod lie just below it (*Staat van de Noordzee*, 2023). The average size of fish has increased, but is still below the desired value. Furthermore, sharks and rays appear to be returning, also thanks to reduced fishing, although their populations are still far from pre-1950 levels (ICES, 2019).

Small shifts, major implications

The Southern Delta, coastal waters, and the Wadden Sea have an important role to play as a "nursery" for fish: species such as sole, plaice, and herring lay eggs in the North Sea, after which the larvae are washed to Dutch coastal waters and the fish spend their first and/or second year of life there. That nursery role declined sharply after 1990, but has been stabilizing since 2005 (CLO). This may be owing to the warmer water, which makes the fish more likely to migrate to the deeper North Sea.

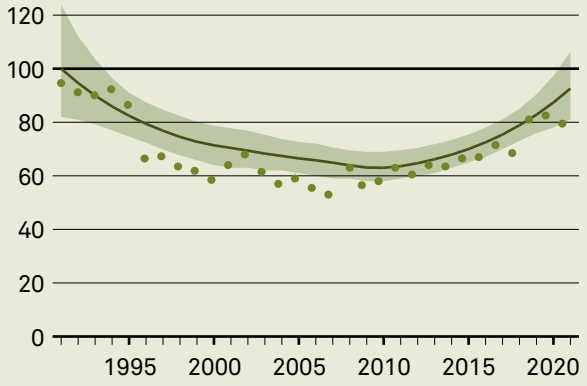
These shifts in the timing of seasonal patterns can have major impacts on the food web. There is evidence of changes to these, as with the nursery, but monitoring is not currently geared toward observing trends over the long term (Rademaker et al., 2024).

The same is true for the state of single-celled algae (phytoplankton or benthic diatoms) that form the basis of the food web. They produce organic matter

Figure 3. Bottom fauna in the North Sea

1990–2021 | 100 species evaluated

Index (1991 trend = 100)



SOURCE: clo.nl/nl159502

through photosynthesis that provides a source of food for fish, shellfish, and zooplankton. While phytoplankton levels appear to be decreasing in coastal waters, they are on the rise in the southern North Sea (Louchart et al., 2023). Again, more data are needed to confirm this.

More habitat types

Protecting biodiversity in saltwater requires a unified approach to protecting natural values, alongside other socio-economic interests that must be taken into account, such as maintaining the basic coastline, the energy transition, defense, and transportation. The current EU guidelines (two framework directives, the Common Fisheries Policy, and the Birds and Habitats Directives) all aim to achieve a healthy ecosystem, but each is structured differently or has slightly different objectives.

Moreover, only five habitat types are defined for saltwater; on land, there are 232. For more targeted protection, more small-scale habitats could help, such as the estuaries between the Wadden Islands that have an important nursery function for small pelagic fish (fish that live in the open sea, not near the bottom), seagrass beds, or flat oyster reefs. The dynamic sandy bottom in the southern part of the North Sea is also a unique habitat.

SEAWEED ZONE IN LAKE GREVELINGEN | PHOTO: PETER H. VAN BRAGT

THE RED LIST
THE BIODIVERSITY TRAFFIC LIGHT SYSTEM

The Red List shows the extent to which species are under threat. However, by no means all species and species groups are included. Techniques such as image recognition and eDNA can help provide a solution.

One of the foremost methods of estimating the status of a species is producing a Red List. In the Netherlands, such a list has been drawn up for 19 species groups. This contains a total of 462 extinct and 3,100 endangered species – 6% and 39% of the 7,954 species evaluated, respectively.

Whereas 28% of species assessed worldwide are on a Red List, in the Netherlands it is considerably more, at a striking 45%. The Netherlands has 47,000 species, so the Red List covers only a fraction of that. The proportion of species under threat according to the list varies greatly by species group. For example, it is 32% of species for which sufficient data are available in mammals, 44% in birds, 48% in mosses, 55% in bees, 62% in mushrooms, and 77% in reptiles.

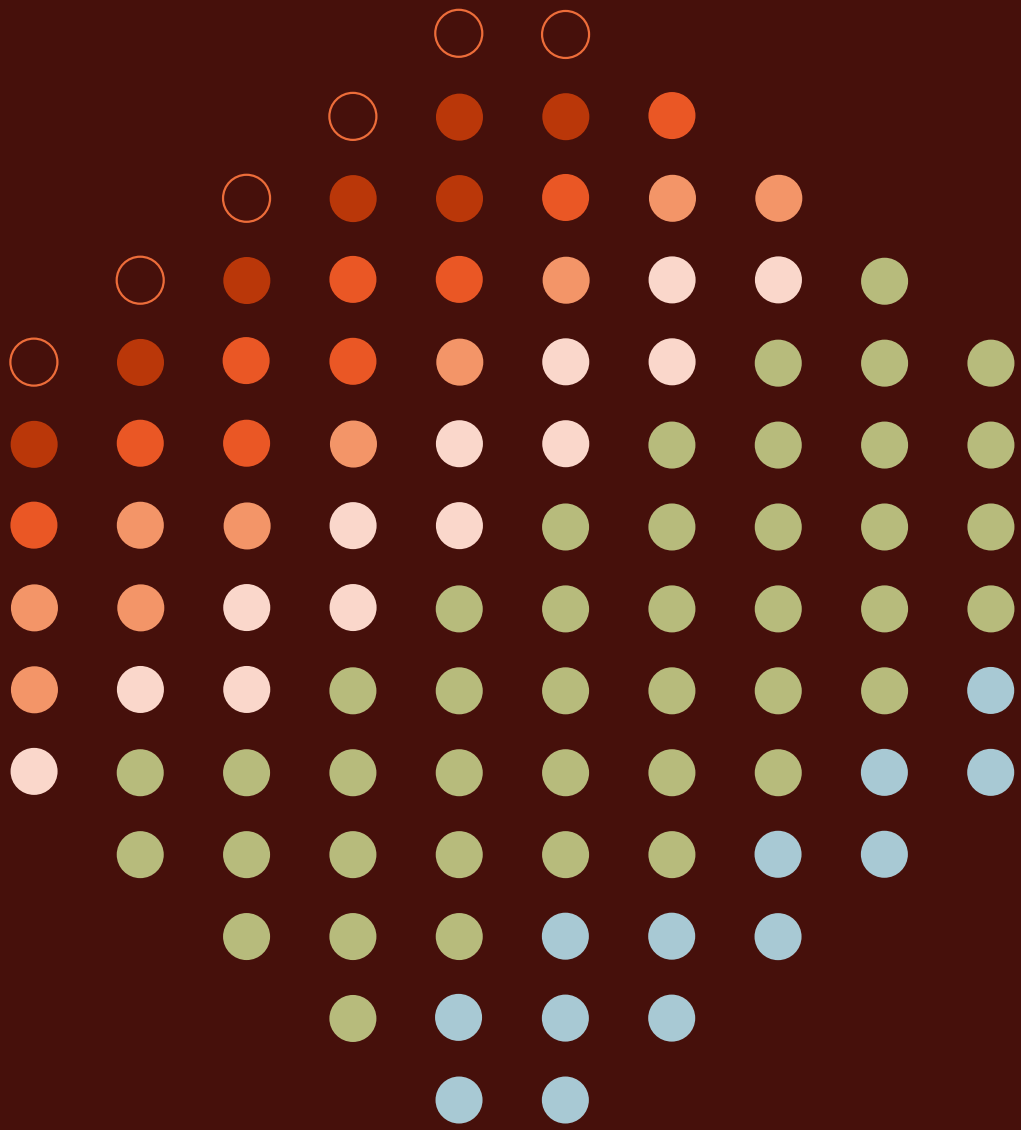
A vital tool

The way that a Red List is produced is as follows: based on the data available, researchers estimate a species' population size, distribution, and recent trends, and they may then be placed in one of the categories. Only species in one of the endangered categories (ranging from Extinct to Near Threatened) are entered onto the Red List. Not included are species in the Least Concern and Data Deficient categories, and those not evaluated (including species maintained by humans, such as the honeybee).

A Red List has no legal status, so the species on it are not automatically covered by specific conservation rules. However, the law does stipulate that the Dutch government is committed to protecting these species. Dutch provinces are responsible for taking the measures needed to maintain or restore a favorable conservation status of Red List species (Article 3.57(1)(c) of the Dutch Quality of the Living Environment Decree, *Besluit kwaliteit leefomgeving*). Additionally, municipalities and land management organizations are expected to include these species in policy and management. A Red List is therefore a crucial tool when it comes to protecting nature and species.

Dutch species on the Red List

2024 | 7,954 species evaluated



45% on the Red list

- 6% extinct
- 7% critically endangered
- 9% endangered
- 10% vulnerable
- 13% near threatened
- 42% not threatened
- 13% data deficient

● = 1%

Of the total 7,954 species evaluated in the Netherlands, 462 have become extinct (6%) and 3,100 are endangered (39%). These percentages will undoubtedly increase as Red Lists are produced for the rest of the Dutch species (83%).

SOURCE: clo.nl/nl132306

The 7,954 species evaluated represent

17%

of the total number of species in the Netherlands

STOAT | PHOTO: GETTY IMAGES

Contemporary techniques

In the Netherlands, Red Lists are made as coherent as possible by using the same criteria for all species groups. However, it is not always possible to make a fair comparison, as the quantity and quality of available data have a major impact. The same is true of calculation methods, which unfortunately vary quite a bit.

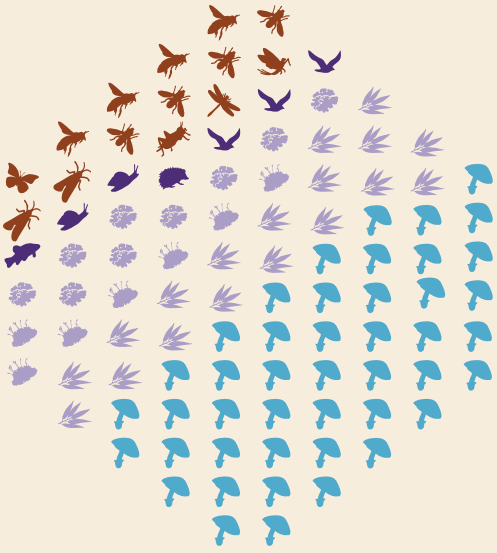
Also, Red Lists have only been produced for species groups that are well monitored and for which there are abundant data. For many other species groups, insufficient data are available to reliably assess their trend and population. Even for relatively well-monitored species groups, there are not enough data to establish a Red List that is updated more than once every 10 years.

Red List species are not automatically covered by specific conservation rules

Modern monitoring techniques, such as eDNA and image recognition, may allow us to better monitor some species groups in the future and provide more data, so that reliable Red Lists can be drawn up for these as well.

Maaike de Voogd and Koos Biesmeijer
Naturalis Biodiversity Center

Evaluated species on the Red List



= 1%

- Bees (4.2%)
- Butterflies (1.0%)
- Mayflies (0.8%)
- Caddisflies (2.2%)
- Dragonflies and damselflies (0.8%)
- Grasshoppers and crickets (0.6%)
- Stoneflies (0.3%)
- Hoverflies (4.0%)

14% insects

- Amphibians (0.2%)
- Terrestrial and freshwater mollusks (2.1%)
- Flatworms (0.2%)
- Reptiles (0.1%)
- Fish (1.2%)
- Birds (2.5%)
- Mammals (0.7%)

7% other animals

- Lichens (9.1%)
- Mosses (6.5%)
- Vascular plants (18%)

34% plants

- Mushrooms (45.6%)

46% fungi

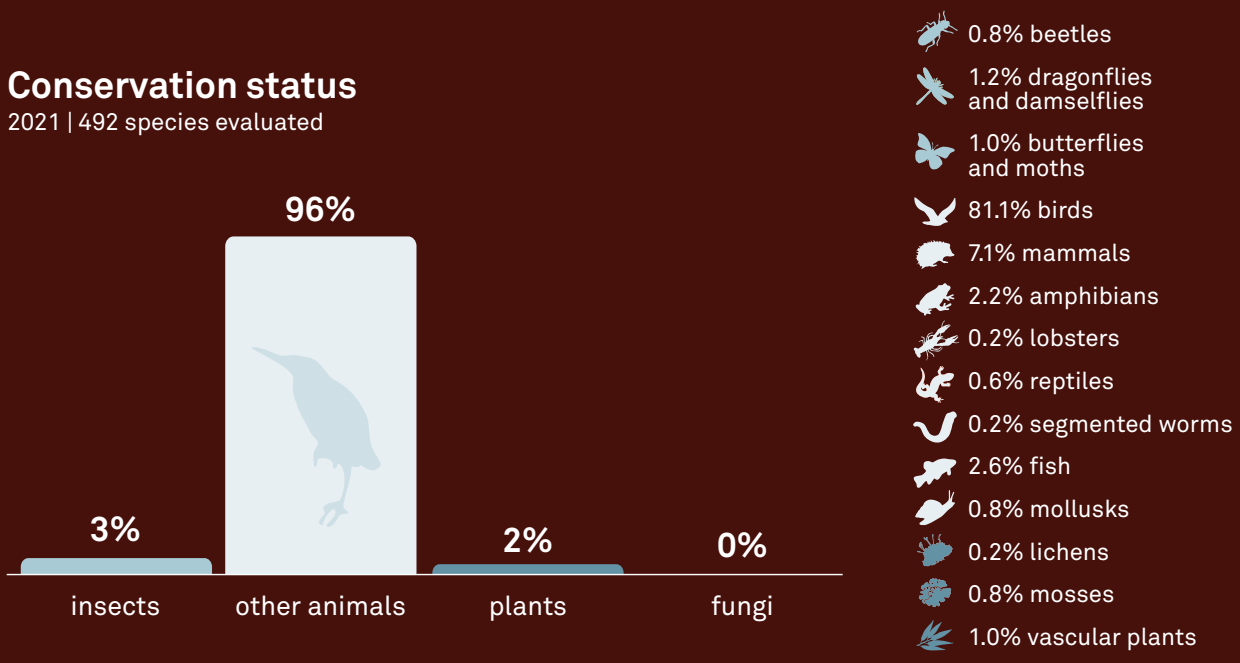
SOURCE: clo.nl/nl132306

Of the 7,954 species evaluated in the Netherlands, plants (34%) and mushrooms (46%) are represented the most, followed by insects (14%).

BLACKBIRD | PHOTO: WILLIAM VOORBERG

The conservation status

The protection of species is laid down in the EU's Birds and Habitats Directives. The question is whether the current measurement methods and reporting cycles provide sufficient insight to meet the 2030 and 2050 targets.



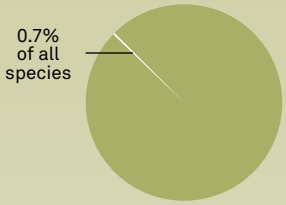
The Birds and Habitats Directives, aimed at ensuring a favorable conservation status for habitats and species, are at the heart of European nature policy. The conservation status is reassessed every six years based on distribution, population, habitat, and future prospects (using a traffic light model: from red to green, red being the most negative status).

The ultimate target is to achieve a favorable conservation status for all species and habitats under the directives by 2050 and, as an interim step, the goal is to recover at least 30% of species with a negative conservation status by 2030. In addition, the status of a species must not deteriorate. The next update will be submitted to the European Commission by the end of June 2025. The conservation status data in this status report refer to the most recent conservation status (clo.nl/nl160403).

The current six-year conservation status reports, based primarily on birds, provide a delayed and possibly incomplete picture of the state of biodiversity in a broad sense. The same goes for the effectiveness of our biodiversity policy. The Dutch Ministry of Agriculture, Fisheries, Food Security, and Nature has set up a Monitoring Improvement Program to evaluate and improve the effectiveness of monitoring (NBSAP 2025). Also, the National Dashboard for Biodiversity Dashboard shows how the Netherlands is progressing in terms of achieving its targets.

Advanced monitoring techniques are extremely valuable for effectively measuring the impact of nature restoration measures and making timely adjustments. So, too, is focusing on organisms with rapid response and life cycles that are not currently studied sufficiently. Integrating knowledge, technology, and policy gives the Netherlands an opportunity to reverse the negative biodiversity trend and ensure a sustainable future.

Birds

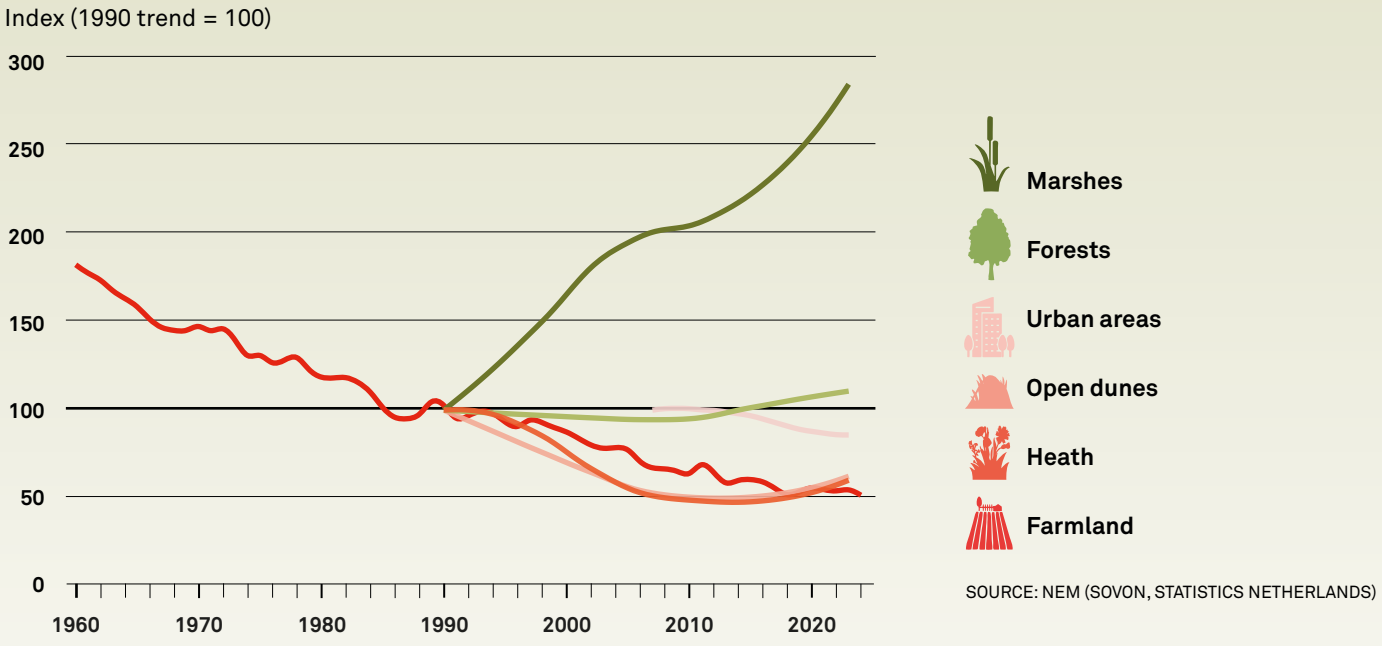


Number of species	341
Of which are exotics	19
Conservation status	✔
Red List	✔
Note	The Netherlands is home to 209 species of breeding birds; the remaining 132 are migrants and winter visitors. On top of that, there are many strays and occasional exotics.

EUROPEAN GOLDFINCH | PHOTO: GETTY IMAGES

Population trend of breeding birds

By landscape type | 185 species evaluated



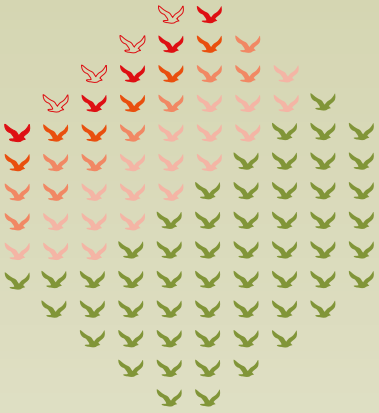
SOURCE: NEM (SOVON, STATISTICS NETHERLANDS)

The trend in breeding birds shows an increase of 28% since 1980, while about as many species are increasing in population (92) as decreasing (83). The positive trend is mainly caused by new arrivals such as the eagle owl, white-tailed eagle, egrets and Cetti's warbler, which are now commonly found and breeding in the Netherlands.

In general, breeding birds in forests, freshwater, and marshes are increasing in number, while species in open natural areas such as heath and dunes are declining. The largest drop is found among species on open farmland, whose numbers have fallen by 75% since 1960.

Red List

2016 | 196 species evaluated



= 1%

44% on the Red List

- 4% extinct
- 5% critically endangered
- 6% endangered
- 10% vulnerable
- 19% near threatened

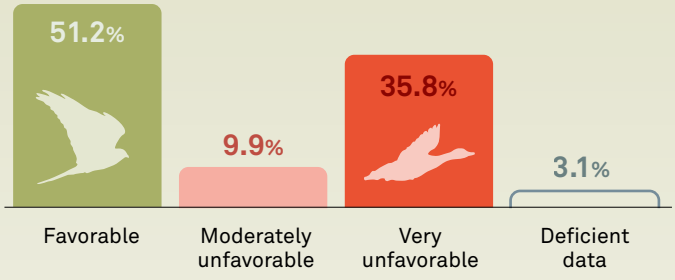
56% not threatened

SOURCE: clo.nl/nl132306

Many species showing a decline also appear on the Red List. While the number of species on the Red List has not increased since 2005, the threat level has.

Conservation status breeding birds

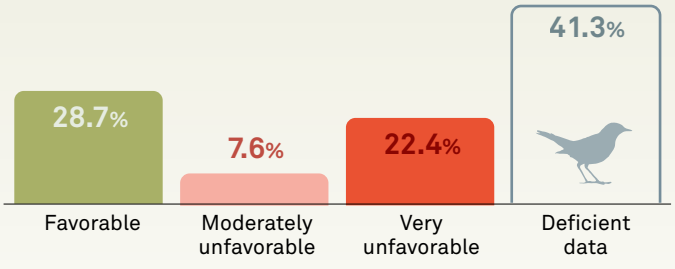
2021 | 162 species evaluated



We are far from the 2030 and 2050 policy targets on conservation status: only around 40% of species with a policy target are faring well. The number of species with a moderately or very unfavorable conservation status has stabilized at about 100 species of breeding birds (vs. around 75 in 1980) and 70 to 80 non-breeding bird species (vs. fewer than 60 in 1980).

Conservation status non-breeding birds

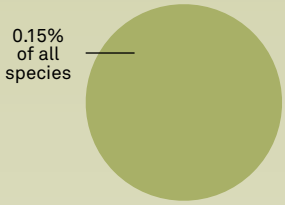
2021 | 237 species evaluated



Despite all the efforts and funding to protect birds and restore their habitat, these species are not showing improvement. Without current efforts, many more birds would most likely have been under threat or even disappeared, but these efforts alone are insufficient to meet the 2030 and 2050 targets.

SOURCE: (FOPPEN & VOGEL, 2022)

Mammals



Number of species	77
Of which are exotics	10
Conservation status	✔
Red List	✔
Note	Of the 77 mammals, three are marine mammals.

EUROPEAN HAMSTER | PHOTO: GETTY IMAGES

Trend of mammals

1995–2022 | 35 species evaluated

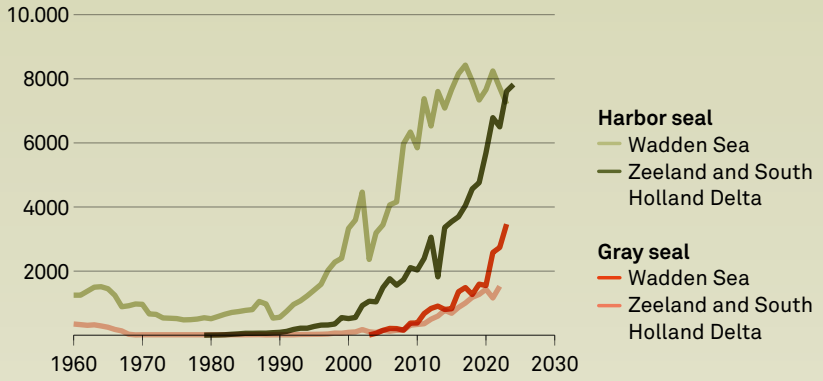
SOURCE: clo.nl/nl157108

The conservation status of mammals has been improving since 1990, but has stabilized since 2010. Eighteen species have increased in number, with otters, beavers, hamsters, bank voles, and Natterer's bats seeing strong improvement. Twelve species declined in number, but none of them sharply. Finally, four species have remained stable. For one species, the common vole, the trend is unclear.

By contrast, both species of seals and the harbor porpoise have greatly increased in numbers in recent decades, after having almost disappeared in the Dutch part of the North Sea.

Gray and harbor seals

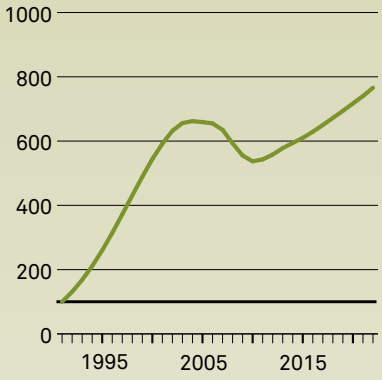
1960–2024



SOURCE: clo.nl/nl123121

Harbor porpoises in the North Sea

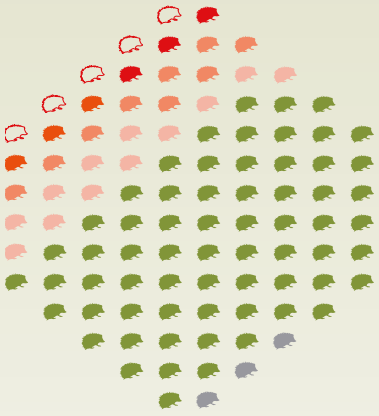
Index (1995 trend = 100)



SOURCE: clo.nl/nl125009

Red List

2020 | 59 species evaluated



32% on the Red List

- 5% extinct
- 3% critically endangered
- 3% endangered
- 9% vulnerable
- 12% near threatened

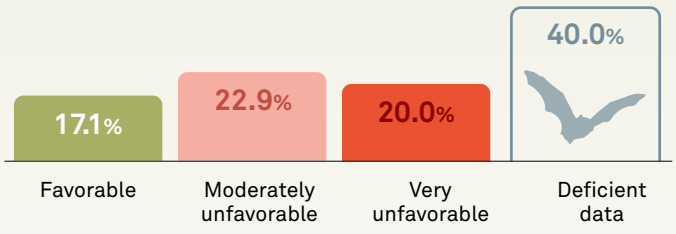
- 65% not threatened
- 3% data deficient

SOURCE: BASISRAPPORT RODE LIJST ZOOGDIEREN 2020 (VAN NORREN, DEKKER, & LIMPENS, 2020)

Because of the increases mentioned, a number of species have been taken off the Red List. Bats and species that are no longer hunted are doing better. The same is true for species that benefit from improved water quality. On the other hand, mammals in agricultural areas are actually struggling, as evidenced by the fact that 11 of the 16 species are on the Red List. The rabbit population has been in freefall since 2011, partly owing to a viral disease.

Conservation status

2013-2018 | 35 species evaluated

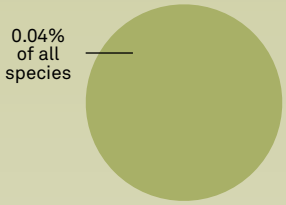


SOURCE: https://nature-art17.eionet.europa.eu/article17/species/report/

There are 26 mammals listed in the Habitats Directive, including 15 bat species and seven marine mammals. For seven of these species, the situation is favorable; for 15 species, it is either moderately or very unfavorable. Four dolphin species could not be assessed.

The measures taken are therefore helping to improve the trend, but the policy targets are often still not being met. This is true for seals and the harbor porpoise, for example, as well as for hamsters.

Amphibians



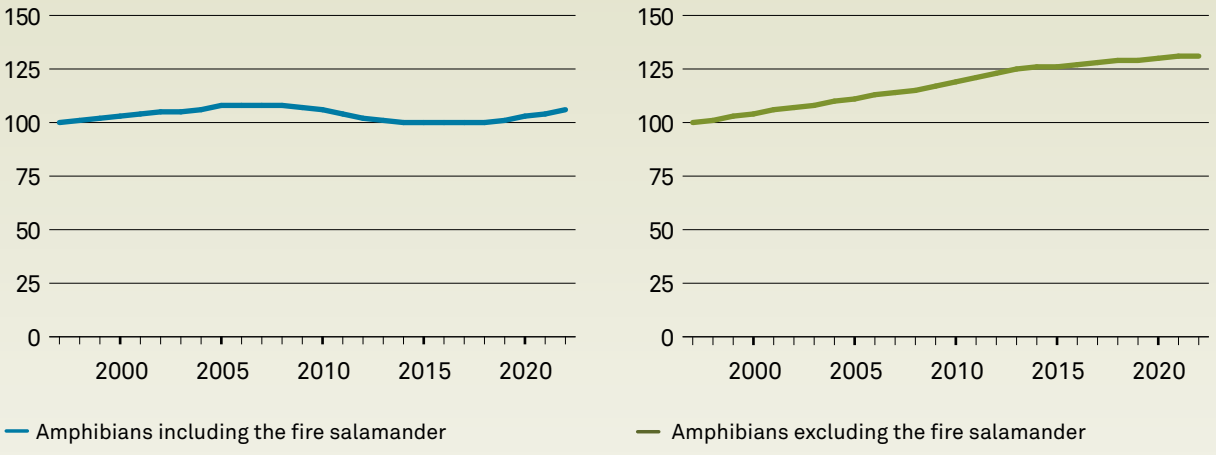
Number of species	21
Of which are exotics	5
Conservation status	✔
Red List	✔
Note	The Netherlands is home to seven species of salamanders (two non-native), 10 frogs (three non-native), and four toads.

FIRE SALAMANDER | PHOTO: GETTY IMAGES

Trend of amphibians

1997–2022 | 16 and 15 species evaluated

Index (1997 trend = 100)



SOURCE: clo.nl/nl107719

After a sharp decline in the last century, amphibians (frogs, toads, and salamanders) are again showing a steady increase. Most of the 16 species native to the Netherlands have increased in numbers over 25 years thanks to water quality improvement, construction of pools, restoration of adjacent habitats, and conservation measures such as reintroducing species to areas where they had disappeared. Eleven species have benefited from this, while three have remained stable. Two species are declining: the northern crested newt and the fire salamander. The latter species is in especially poor condition. In the case of the fire salamander and most likely the northern crested newt, the decline is due to a non-native fungal disease.

Red List

2023 | 16 species evaluated

= 1%

44% on the Red List

- 0% extinct
- 6% critically endangered
- 0% endangered
- 38% vulnerable
- 0% near threatened

- 56% not threatened

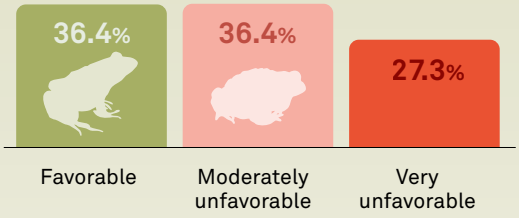
SOURCE: clo.nl/nl132306

Of the 16 species of amphibians, seven are on the Red List (44%). The tree frog, yellow-bellied toad, and the common spadefoot toad have seen their threat level reduce and have therefore been moved to a less serious category than on the previous Red List. The fire salamander has been put in a more serious category, as it has continued to decline.

(SOURCE: RAVON REPORT 2021.043)

Conservation status

2013-2018 | 11 species evaluated

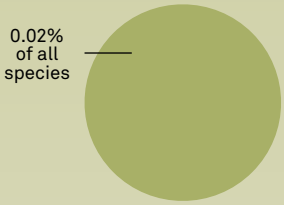


SOURCE: https://nature-art17.eionet.europa.eu/article17/species/report/

Eleven of the 16 amphibian species are protected in Europe under the Habitats Directive. The conservation status of most of these is moderately to very unfavorable – except for four frog species (pool frog, marsh frog, edible frog, and common frog), which are faring well and are either stable or slightly increasing in number. The species that continue to do poorly show different trends. In the case of the northern crested newt and yellow-bellied toad, there has been a sharp decline. The natterjack toad and moor frog are stable, while the tree frog, common spadefoot toad, and common midwife toad are even showing increases.

TREE FROG | PHOTO: CEES DETERMANN

Reptiles

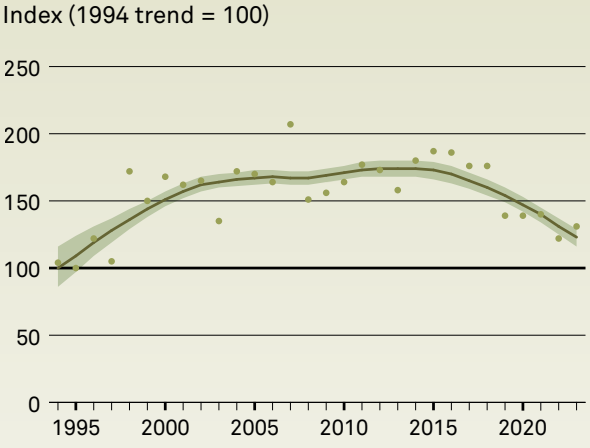


Number of species	9
Of which are exotics	2
Conservation status	✔
Red List	✔
Note	The Netherlands is home to seven species of native reptiles. Four are lizards and three are snakes.

COMMON ADDER | PHOTO: GETTY IMAGES

Population trend of reptiles

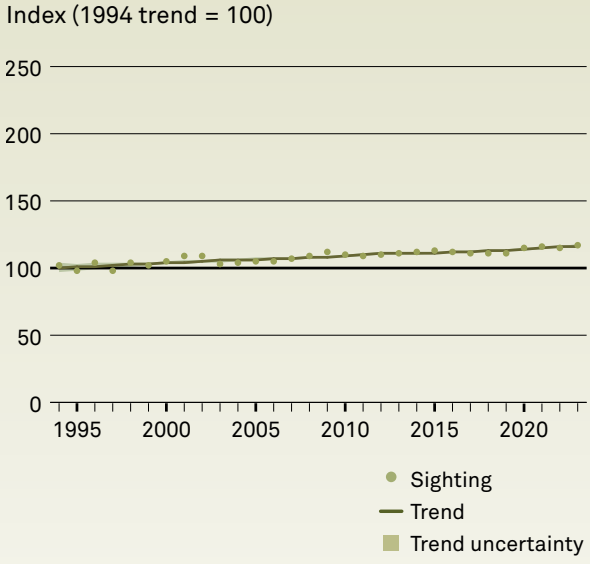
1990–2023 | 6 species evaluated



SOURCE: CLO.NL/ NL138421

Distribution trend of reptiles

1990–2023 | 6 species evaluated

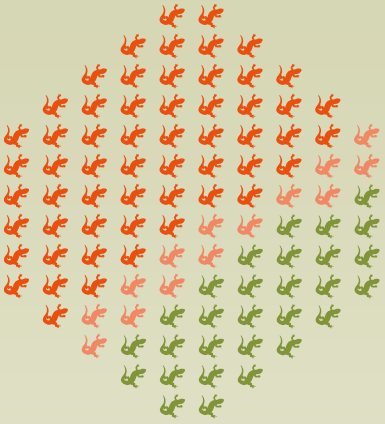


Among reptiles, we have broadly seen an expansion in their distribution and an increase in population compared with 1994. Over the last 12 years, however, the picture has become different: after a sharp increase until 2012, the numbers are now declining again. The distribution does show a stable positive trend over the entire period.

Viewed by species, there are clear differences. Populations of five of the seven species have been shrinking since 2012; the sand lizard and vivipa-rous lizard show sharp declines. Distribution has increased for all species, except the common adder and viviparous lizard. The latter is dependent on traditional landscapes and is probably still suffering from agricultural intensification and expansion in recent decades.

Red List

2023 | 7 species evaluated



= 1%

71% on the Red List

- 0% extinct
- 0% critically endangered
- 57% endangered
- 14% vulnerable
- 0% near threatened
- 29% not threatened

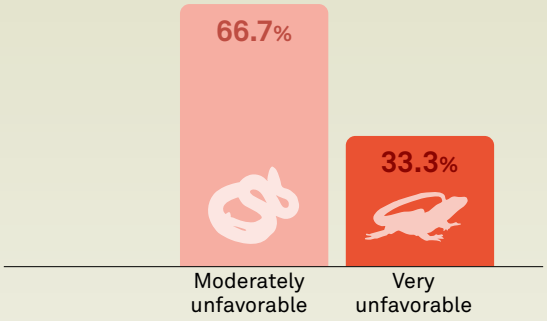
SOURCE: clo.nl/nl132306

Of the seven species of reptiles, five are on the Red List (71%). Compared to reptiles on the previous Red List, the common wall lizard is now less under threat. Accordingly, it has been moved to a less serious category. The status of the remaining species on the list has remained the same.

SOURCE: RAVON report 2021.043

Conservation status

2013-2018 | 3 species evaluated

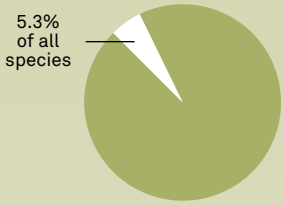


SOURCE: https://nature-art17.eionet.europa.eu/article17/species/report/

The smooth snake, sand lizard, and common wall lizard are mentioned in the Habitats Directive and are protected by EU law. All three show an unfavorable conservation status in the Netherlands due to sharp declines in recent decades. As of 2000, the smooth snake has declined in numbers, the sand lizard displays an erratic pattern, and the common wall lizard shows a sharp increase.

VIVIPAROUS LIZARD | PHOTO: GETTY IMAGES

Vascular plants



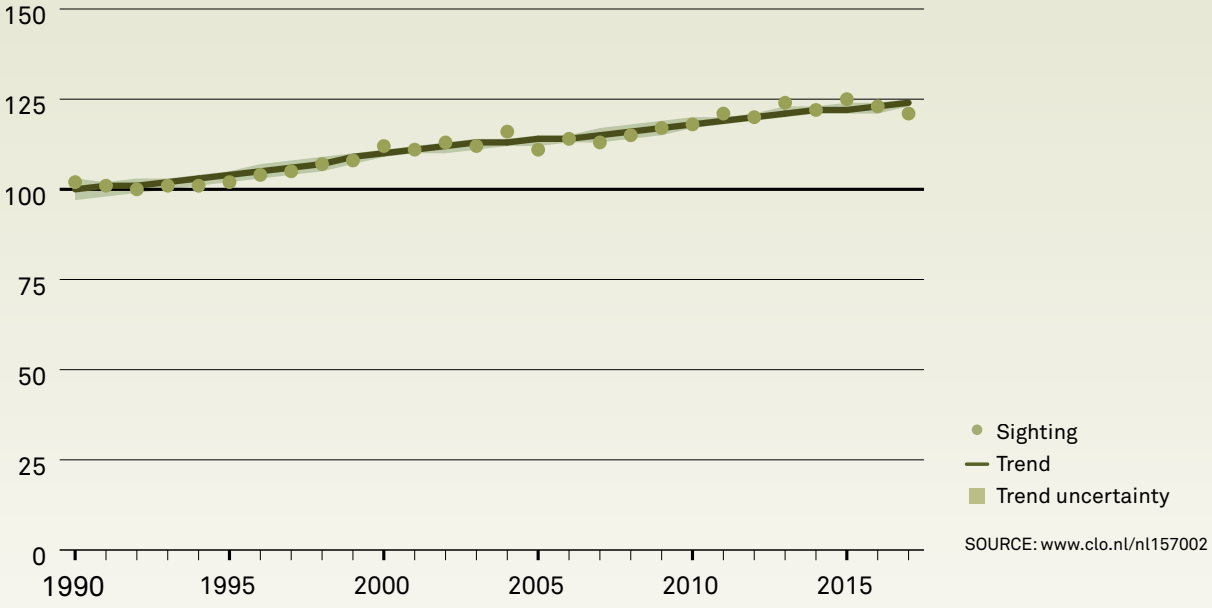
Number of species	Approx. 2,500 (of which 1,134 were originally native)
Of which are exotics	Approx. 1,000
Conservation status	✔
Red List	✔
Note	This group is composed of trees, shrubs, and herbs, as well as ferns, clubmosses, and their relatives.

SWAMP STONECROP | PHOTO: ED STIKVOORT

Distribution of vascular plants

1990–2017 | 926 species evaluated

Index (1990 trend = 100)



SOURCE: www.clo.nl/nl157002

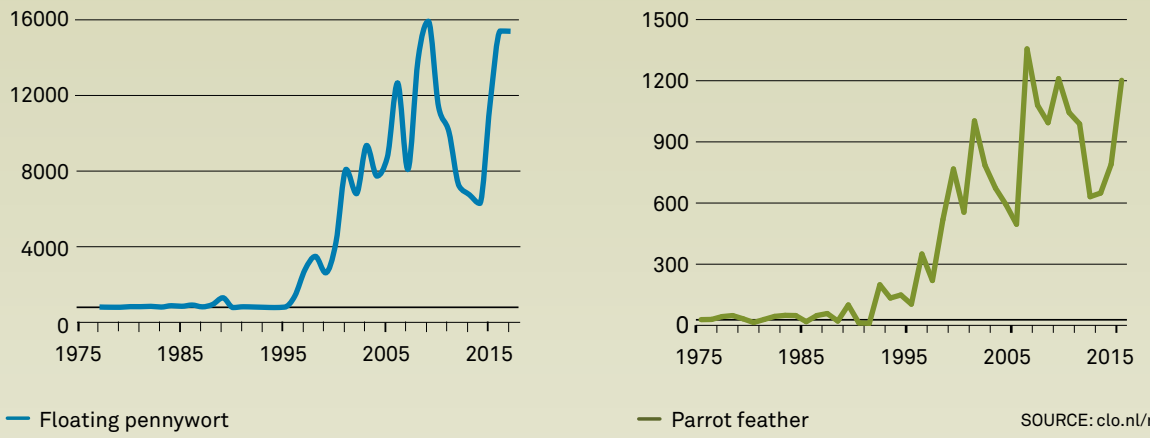
On average, species are increasing slightly in distribution. Nevertheless, the number of threatened species is rising again, although the degree of threat is somewhat less severe.

The differences between species are very large. In particular, species in nutrient-poor areas, grasslands, banks, forest edges, and waters are continuing to decline. At the other end of the spectrum are the exotics. These often show a huge increase in distribution and numbers. Some also pose problems for wildlife or water management, such as floating pennywort, parrot feather, and New Zealand pigmy weed.

Verspreiding van de exotische grote waternavel en parelvederkruid

Periode1976-2016

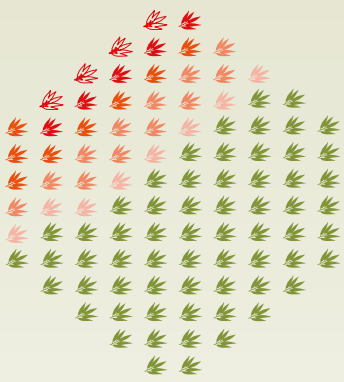
Index (aantal 1976 = 100)



SOURCE: clo.nl/nl139803

Red List

2012 | 1432 species evaluated



= 1%

37% on the Red List

- 4% extinct
- 5% critically endangered
- 8% endangered
- 12% vulnerable
- 8% near threatened

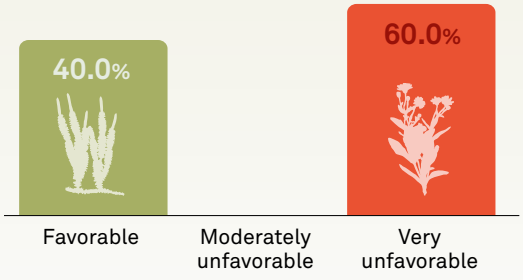
63% not threatened

SOURCE: BASISRAPPORT RODE LIJST VAATPLANTE 2012 (SPARRIUS, ODÉ, & BERINGEN, 2014)

Conservation status

2013-2018

4 species + the clubmosses (5 species) evaluated



SOURCE: nature-art17.eionet.europa.eu/article17/species/report/

Only a few species are protected under EU law and listed on the Habitats Directive, including the fen orchid and creeping marshwort. The fen orchid used to be common, but has declined sharply due to land development and water system modifications. With the help of nature restoration, including re-wetting of dunes, this species is beginning to recover in some areas. Still, this recovery is not universal.

Creeping marshwort is now springing up again in several places in the Netherlands after a long absence (since 1983). Its conservation status is very unfavorable, but targeted wildlife development is slowly helping the species to improve. The latter is also true of wolf's bane, whose sharp decline now seems to have leveled off. Clubmosses are improving as a group, but this is mainly thanks to a single species: marsh clubmoss.

THE RISE OF NON-NATIVE FLORA

The number of new wild flora species in the Netherlands is rising faster than ever before, largely due to human activity. In some cases, this can enhance biodiversity, but the large numbers of garden and aquatic plants being introduced also increases the likelihood of problematic invasive exotics.

The Netherlands' 4.5 million gardens have a combined area 10 times the size of the Hoge Veluwe national park. Non-native garden and aquarium plants make up a growing proportion of wild flora: out of the 2,500 species (Heukels' Flora, 24th edition) found in the wild, only 1,134 are originally native. The April 2024 standard list of Dutch names of cultivated plants, which consists of all cultivated species in nurseries and trade, includes nearly 10,000 names. Some of these species end up in the wild, where some of them manage to sustain themselves and become established. Most of the established species in the Netherlands are currently garden plants or similar. A small portion, 11%, become wild of their own accord.

Suffocation versus nutrition

Plants have been "escaping" from gardens – including planters and flower pots – for years. Some species, called adventives, unintentionally hitch a ride on tub plants or in products such as bird food, after which they end up in the wild. Others are actively planted, such as in parks and other public spaces. Because of the effect of urban heat islands, which are hot and rocky, plants from Mediterranean areas are especially prone to spreading. The same is true for aquatic and marsh plants. These are usually imported as pond or aquarium plants, which are removed from private water bodies when they grow excessively and end up in public waterways.

Plants have been escaping from gardens for years

Not all non-native species are necessarily harmful; they can also be an asset to our biodiversity. For example, newcomers such as the Mediterranean spurge and flowering currant bloom early in spring, providing a source of food for insects awakening from hibernation, and the fruits of the common snowberry and scarlet firethorn are ripe in mid-winter, making them a welcome food source for wood mice and migratory birds. However, a small percentage can develop into what is known as an invasive exotic, which can displace local flora and cause

Not all non-native species are by definition harmful.

major problems, such as reduced biodiversity, agricultural damage, or health hazards.

A well-known example is Japanese knotweed, which has been imported and escaped through botanical gardens. Another is the New Zealand pigmy weed, which overgrows on banks of fens and dune pools in the Netherlands. This plant forms thick "mats" that deprive the water beneath it of oxygen and allow little to no light through, causing life in that water to die from suffocation. These mats are displaying vegetations of the shoreweed association and other pionier associations that are already under pressure.

Nipping banned species in the bud

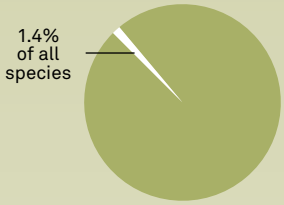
Plant imports in the Netherlands are subject to few regulations, giving relatively many species the opportunity to develop into invasive exotics. The Netherlands works with a blacklist of banned species, rather than a whitelist of permitted species. When a plant species is banned, growers usually look for an alternative that is as similar as possible to the banned plant. As a consequence, a blacklist may actually result in the cultivation of more variants.

It is tricky to predict which species pose a risk, but once they become established in the wild, they are difficult to control. That is why it is important to nip these species in the bud as early as possible or adopt preventive policy measures to limit their import and trade.

Leni Duistermaat & Barbara Gravendeel *Naturalis Biodiversity Center & Hortus Botanicus Leiden*

JAPANESE KNOTWEED | PHOTO: GETTY IMAGES

Bryophytes

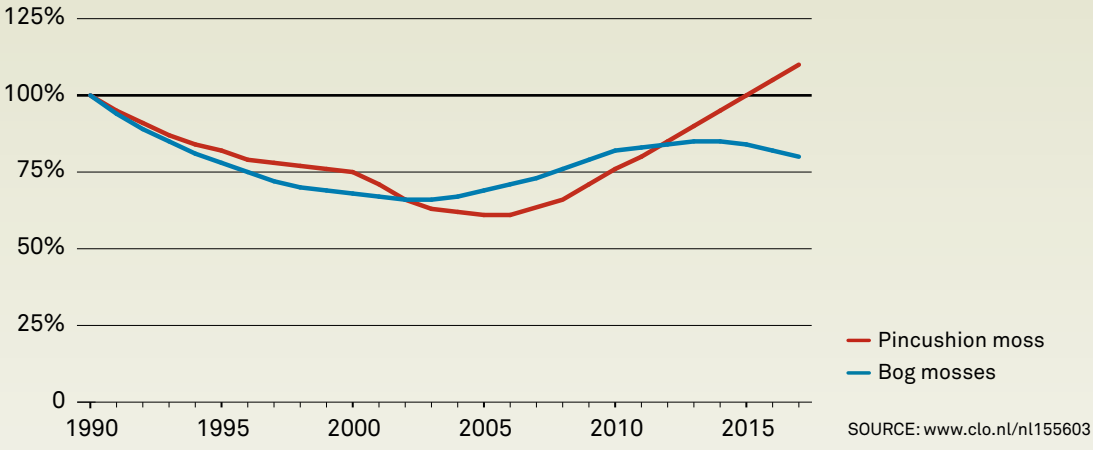


Number of species	Approx. 700
Of which are exotics	5
Conservation status	✔
Red List	✔

PINCUSHION MOSS | PHOTO: GETTY IMAGES

Distribution of large whitemoss and bog mosses

Index (1995 trend = 100)

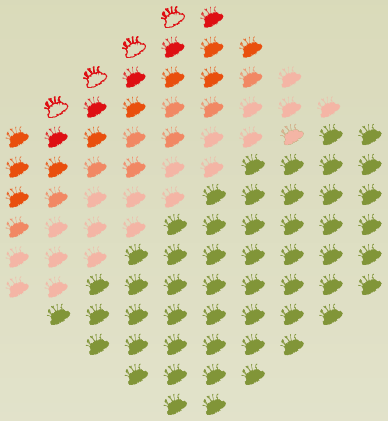


SOURCE: www.clo.nl/nl155603

Based on records in the Dutch National Flora and Fauna Database, pincushion moss and bog mosses, both mentioned in the Habitats Directive, show a positive trend after a clear decline from about 2005. Since 2015, however, bog mosses seem to be declining again.

Red List

2012 | 517 species evaluated



= 1%

48% on the Red List

- 4% extinct
- 5% critically endangered
- 10% endangered
- 8% vulnerable
- 20% near threatened

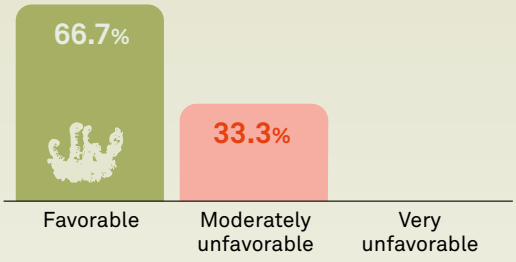
52% not threatened

SOURCE: clo.nl/nl132306

The Red List of bryophytes includes 246 (48%) of the 517 species evaluated. This is a slightly lower number than on the earlier list from 2000. Three of the five categories (Extinct, Critically Endangered, and Vulnerable) saw slightly fewer species listed, while the Near Threatened category remained the same and the Endangered category came to include more species. The main threats are fertilization and desiccation, which are causing species to decline especially in sparse and wet environments.

Conservation status

2013-2018 | 2 soorten + de veenmossen (30 soorten) beschouwd



SOURCE: https://nature-art17.eionet.europa.eu/article17/species/report/

Although the conservation status for large whitemoss and bog mosses is favorable, varnished hook moss has a moderately unfavorable conservation status. However, new populations have been discovered in the northwest of the province of Overijssel, where the species has been steadily increasing since the monitoring network was set up in 2004. Roger's bristlemoss was first encountered in the Netherlands in 1989, but there are not enough systematic sightings to indicate a trend.

VARNISHED HOOK MOSS | PHOTO: H. SIEBEL

SMALL PLANTS
WITH A MAJOR IMPACT

Bryophytes play vital roles in animal life and the climate. Moreover, along with lichens, they can be used to help determine environmental conditions. Thanks to genetic data, we now know exactly what species exist in the Netherlands.

Bryophytes are a crucial component of our biodiversity that are often overlooked. These small, non-flowering plants have a surprisingly large impact on a wide range of Dutch ecosystems, from forests and dunes to cities. Bryophytes serve as refuges for small animals such as insects, mites, and springtails. Birds feed on them and use them for nesting material. They also help improve the climate by retaining water, absorbing carbon dioxide, and producing oxygen.

Bryophytes often grow together with lichens: fungi that live in symbiosis with green algae and blue-green algae (cyanobacteria). These organisms can be used to determine air quality and other environmental conditions because they absorb both nutrients and pollutants. In particular, bryophytes and lichens growing on trees respond quickly to changes in air quality, which makes them good bioindicators. Until the 1980s, trees in many European urban areas were almost completely devoid of bryophytes and lichens because of acid rain.
Since then, these organisms have made a spectacular comeback. These days, nitrogen pollution is putting pressure on vulnerable species – but trends are hardly being converted into policy at present, and only one moss under the Habitats Directive is subject to monitoring (see page 46).

Protect, monitor, track

Together with the Bryophytes and Lichens Task Force (*Bryologische en Lichenologische Werkgroep*, BLWG), Naturalis has collected genetic data of virtually all Dutch bryophytes species. Those data were used to evaluate the identity of the previously known species, which resulted in an increased number of known Dutch bryophytes species from 600 to 700.

Because we now know exactly what species exist and in what habitats they occur, we are better placed to protect rare species in the future, monitor ecosystems, and track species trends. Monitoring bryophytes on bark, dead wood, and in the soil, for example, could provide vital missing information about the condition of our forests.

Michael Stech
Naturalis Biodiversity Center
Henk Siebel
BLWG

Brown shield moss is one of the most mysterious mosses in the Netherlands. The species, which grows on poor humus soil, is threatened with extinction.

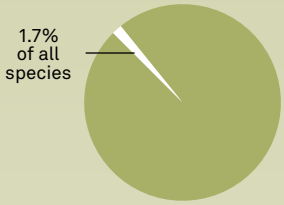
Around

100

new bryophytes species were discovered in the Netherlands thanks to genetic data

BROWN SHIELD MOSS | PHOTO: HENK SIEBEL

Lichens



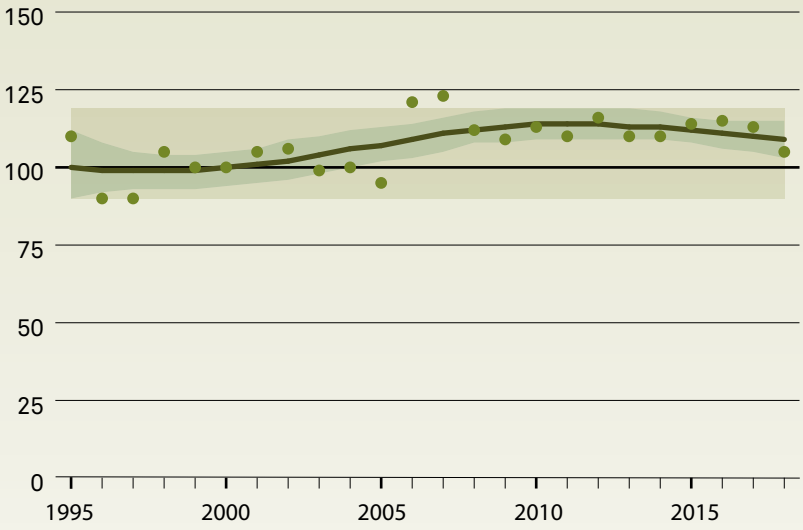
Number of species	Approx. 800
Of which are exotics	13
Conservation status	✔
Red List	✔

REINDEER LICHEN | PHOTO: GETTY IMAGES

Distribution of reindeer lichens

1995–2018

Index (1995 trend = 100)



The trend of reindeer lichens – the only lichens mentioned in the Habitats Directive – appears to have somewhat stabilized since 1995. However, according to the National Lichens Monitoring Network in the Netherlands, their conservation status in drifting sands and dunes is negative. Small species of drifting sand lichens in particular are in sharp decline.

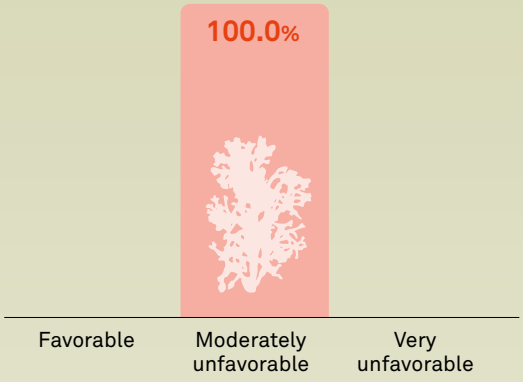
Reindeer lichen

- Sighting
- Trend
- Trend uncertainty

SOURCE: www.clo.nl/nl155603

Conservation status

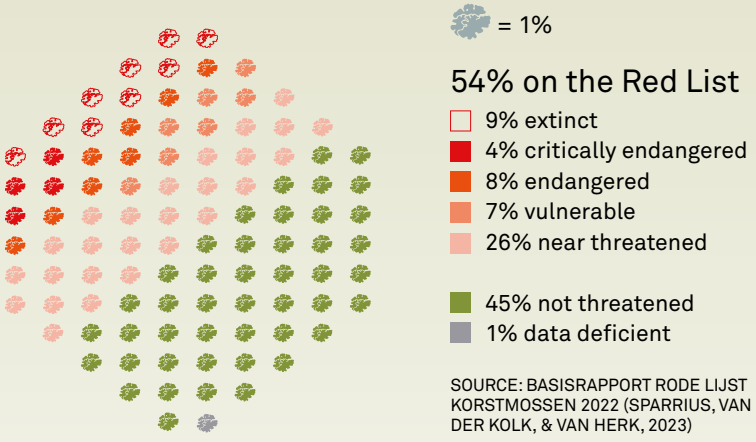
2013-2018 | 5 species rendiermossen evaluated



SOURCE: nature-art17.eionet.europa.eu/article17/species/report/

Red list

2022 | 727 species evaluated

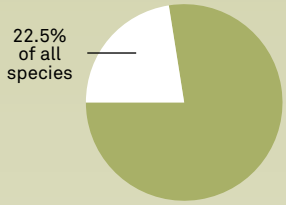


SOURCE: BASISRAPPORT RODE LIJST KORSTMOSSEN 2022 (SPARRIUS, VAN DER KOLK, & VAN HERK, 2023)

The Red List includes 389 (54%) of the 727 species evaluated; this percentage is about the same as the previous list from 2011. However, the numbers of species in the Extinct and Endangered categories has distinctly increased, while the number of species in the Near Threatened category has decreased. The main threads are nitrogen deposition, habitat loss, and climate change. Species present on non-calcareous rock on dikes and dolmens, oak woodlands, and solitary trees with acidic bark have declined recently.

Data from provincial monitoring networks show that the species diversity of lichens on trees has increased over the past 30 years, due to recovery after a period of sulfur dioxide pollution and as species benefit from climate change. The effects of ammonia on lichens have increased, including in Natura 2000 areas, according to results from the province of North Brabant. Even though ammonia emissions have decreased, nitrogen-sensitive species are still declining because ammonia has enriched and deacidified the bark of trees. However, nitrogen-favoring lichens on trees also declined by about 30% between 1998 and 2016.

Fungi and mushrooms

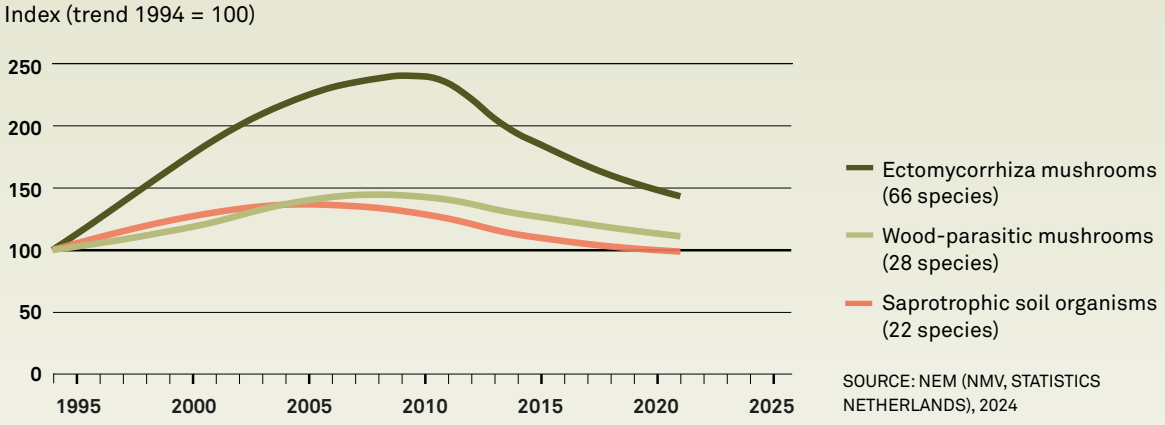


Number of species	10,600
Of which are exotics	226
Conservation status	–
Red List	✓
Note	This group consists of about 6,300 species of macrofungi (mushrooms) and about 4,297 microfungi, the latter having no fruiting bodies visible to the naked eye (i.e. smaller than 1 millimeter).

EAR-PICK FUNGUS | PHOTO: HENK HUIJSER

Distribution trend of mushrooms

1994-2021 | 116 species evaluated



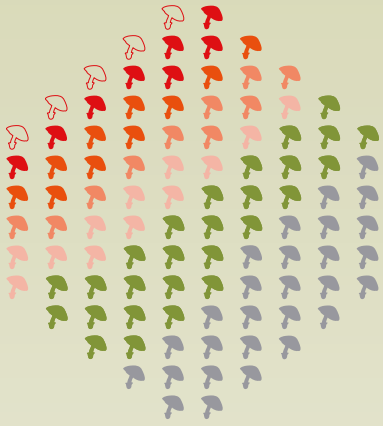
SOURCE: NEM (NMV, STATISTICS NETHERLANDS), 2024

Fungi are present everywhere across all ecosystems. Because they respond quickly to changing conditions, they serve as an important indicator of the state of biodiversity.

Knowledge of mushroom distribution and diversity is based on decades of work carried out by nature enthusiasts and the Dutch Mycological Society. For more than 25 years, there have been standardized monitoring networks under the Network of Ecological Monitoring (NEM) in which volunteers count mushrooms that grow in the forest, on the coastal dune ridge, and in marshes and bogs.

Red List

2009 | 3625 species evaluated



= 1%

45% on the Red List

- 5% extinct
- 8% critically endangered
- 10% endangered
- 10% vulnerable
- 12% near threatened
- 27% not threatened
- 28% data deficient

SOURCE: clo.nl/nl1052

The 2009 Red List of mushrooms is currently being revised. As of 2008, the state of Dutch mushroom biodiversity is unfavorable: 1,448 of the 3,625 species evaluated are under threat to some degree, and 171 species have disappeared from the Netherlands altogether.

Research into microfungi is usually conducted in specialist laboratories, mostly based on isolating the fungi themselves or their DNA from a variety of substrates. Only a fraction of microfungi species worldwide have been formally described. This is clear from the results of DNA-based detection techniques, in which many species remain unnamed. As a result, the state of Dutch biodiversity of microfungi is difficult to assess.

LOOKING TO THE FUTURE

Seeing what the naked eye does not – with DNA

Fungi are everywhere and form a significant part of our biodiversity. They, too, are affected by climate change, as well as by human activity. In view of the risks posed by pathogens to plants, animals, and humans, it is important to look closely at fungal biodiversity, especially in view of opportunities where fungi improve soil quality or protect agricultural crops from other pathogens. The only problem is that these are often not visible to the naked eye. It can also be difficult to distinguish where one species begins and another ends. Some fungi are miles in length (think of the fungal hyphae of some mushrooms) and hundreds of years old. Detecting fungal species is now becoming much easier thanks to DNA, and we are now mapping an increasing amount of this invisible biodiversity.

Through the ARISE project, the Westerdijk Fungal Biodiversity Institute has now named hundreds of species, including fragments of reference DNA that can be used to identify them. As a result, we will soon be able to instantly see which species are present in a sample of air, a scoop of soil, or a cup of water. Eventually, we will have the capability to identify all fungi with crucial functions in nature and determine their benefits or possible risks.

Ewald Groenewald (Westerdijk Fungal Biodiversity Institute)

MUSHROOMS

SYMBIONTS, DECOMPOSERS, AND PARASITES

Mushrooms are key indicators of nature's health. In recent decades, however, the population has changed: beneficial mushrooms are disappearing, and parasitic species are thriving. Nitrogen emissions, especially those from agriculture, are a major factor contributing to this.

When a mushroom sticks out above the ground, all we see is just the tip of the iceberg: 90% of the organism is underground, where the intricate fungal network is hard at work keeping the ecosystem in balance. Although the approximately 6,000 mushroom species in the Netherlands operate largely out of sight, they are indispensable for nature's functioning and ecosystem services. This means that any changes to fungi in the Netherlands serve as an indicator of how we treat nature. If something changes in the underground mushroom world, it becomes visible in the world above.

Downward spiral

Mushroom species can be broadly divided into three groups: symbionts, decomposers, and parasites. Symbionts provide plants with nutrients and water in exchange for carbon, while decomposers break down dead plant and animal remains. Parasites exert a negative effect on their host, weakening and possibly killing it off.

The Dutch mushroom population has changed significantly over the past 50 years. In short, symbionts have given way to parasites. Among the decomposers, specialists have given way to less-efficient opportunists, resulting in slower decomposition of organic material.

The decline of symbionts affects the entire ecosystem: trees do not receive enough nutrients and water, causing their health to deteriorate. This also negatively impacts plants and animals that depend on trees. This situation provides ample opportunities for parasites, who weaken the unhealthy trees further, sending nature's well-being into a downward spiral.

Nitrogen legacy

The main culprit here is nitrogen. Experiments show that nitrogen deposition is central to the disappearance of symbionts. As nitrogen deposition increases, the number of fruiting bodies (the visible part of the mushroom) decreases, as does the size of the fungal network that connects the mushroom to the tree.

Nitrogen from agriculture (ammonium) is also significantly worse for mushrooms than nitrogen from motor vehicles and industry (nitrate). When measures were implemented in the 1990s to curb nitrogen emissions from agriculture, this visibly impacted fungal

populations, with a gradual recovery observed until around 2015. When environmental conditions improve, mushrooms seem to respond relatively quickly.

Since then, however, there has been another decline. Increasing nitrogen deposition and climate change may play a role in this, but we must also consider the nitrogen legacy. Soil has a memory, so to speak, such that decades of neglect remain visible for years to come. If too much nitrogen is deposited onto Dutch nature for too long, the ecosystem could be heading toward a tipping point. Once it has passed that stage, small steps alone will not be enough to restore mushroom diversity. Damage that has accumulated over so many years cannot be quickly undone without more far-reaching measures. Preliminary research indicates that we may even have reached this tipping point already.

Bone-dry soil

Nitrogen is likely exacerbating the effects of climate change, and vice versa. Nitrogen interferes with water acquisition: tree root systems and their symbiotic fungal networks shrink, while needles and leaves build up a thick layer that makes it difficult for water to pass through. It also seems that nitrogen makes litter water-repellent: in areas with a high nitrogen load, the soil under the leaf litter layer is often bone dry, even after multiple rainstorms.

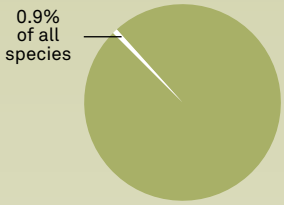
Because nature enthusiasts have been counting mushrooms for years, researchers can make firm statements about these changes. Mushrooms are sensitive to drought and the effects of climate change, which is especially noticeable in longer dry periods in late summer and autumn. As a result, years with reduced mushroom numbers have become more common. Modern DNA-based techniques could prove useful, in that these can be used to look directly into the soil to determine whether the species is still present or has disappeared. The combination of traditional and new methods provides opportunities to obtain a more complete picture of mushroom diversity.

Maintaining support for conserving Dutch nature depends on nature enthusiasts continuing their field recordings and on policymakers honoring their commitments to sustainable biodiversity. In that context, mushrooms are a vital indicator of how we treat our soil and soil life.

Thomas Kuyper
Wageningen University & Research

PANTHER CAP | PHOTO: HENK HUIJSER

Flatworms



Number of species	Approx. 400
Of which are exotics	5
Conservation status	–
Red List	✓
Note	A diverse group of worm species, many poorly studied. They are found in saltwater, freshwater, and on land. A significant number of new species are anticipated, especially within meiofauna and marine ecosystems.

FLATWORM | PHOTO: ROY KLEUKERS

Triclads flatworms are a specific group of flatworms, free-living on land and in water. For the Red List, 13 freshwater flatworms were evaluated. Four species were included on the list.

Within the group of land flatworms, the Netherlands has four native species. The number of non-native land flatworms is on the rise. These enter the country by hitchhiking with imported (potted) plants, both through the soil and "stuck" to parts of the plant or the plastic packaging material. A risk analysis performed in 2020 showed that there were seven non-native land flatworm species in the Netherlands (Thunissen et al., 2020), but the number has now increased to at least 14. Species have been found in surrounding countries that could also become established in the Netherlands. Little data are available on the effects of these species.

The effect of the New Zealand flatworm has been well studied; this species is on the EU list of invasive exotics, as it can cause severe local declines in earthworms. This is detrimental to soil fertility and animal species dependent on earthworms. Declining soil fertility may also result in decreased grassland productivity. The species is established in the United Kingdom and Ireland. It has not yet been found in the Netherlands, but is expected to be in the future.

Red List

2003 | 13 species evaluated

= 1%

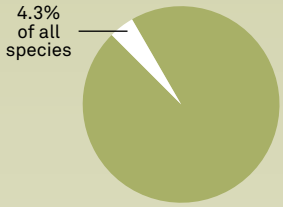
31% on the Red List

- 0% extinct
- 0% critically endangered
- 15,5% endangered
- 15,5% vulnerable
- 0% near threatened

- 54% not threatened
- 15% data deficient

SOURCE: clo.nl/nl132306

Nematodes



Number of species	Approx. 2,000
Of which are exotics	Approx. 50
Conservation status	–
Red List	–
Note	It is estimated that there are 1,000 to 2,000 species of nematodes in the Netherlands, in a variety of biotopes in terrestrial, aquatic, and marine soils.

NEMATODES | PHOTO: WUR OT, SIMONE BRANDT

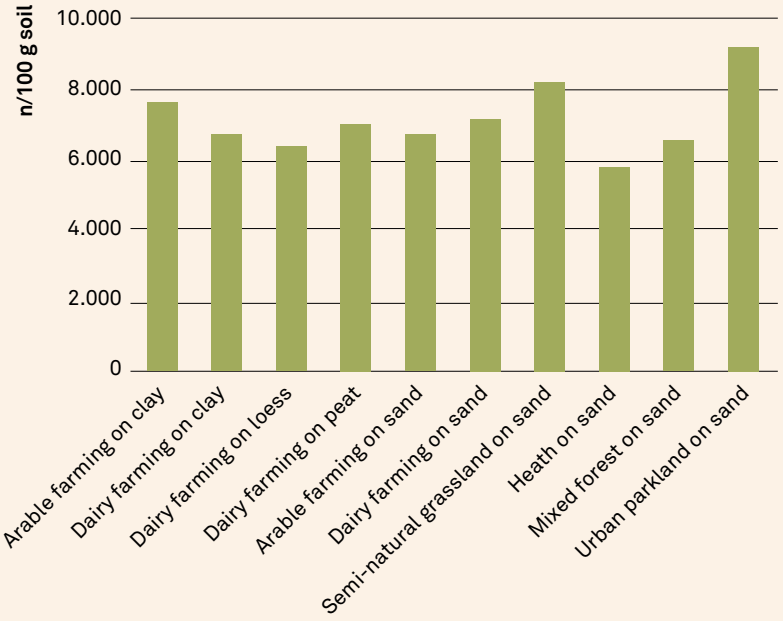
There is limited understanding of the state of this group of small roundworms, because research into nematodes has so far been patchy. However, there does seem to be an advance of problematic species from southern Europe due to climate change. A small proportion of nematode species can cause serious economic damage to agricultural and horticultural crops. There are strict EU policies on this, implemented by the Netherlands Food and Consumer Product Safety Authority.

In addition to the nematodes that live freely in the soil, there is a small group that occurs as parasites in humans or animals. Some specific species are widely cultivated and used commercially for biological control of insect larvae. Furthermore, a number of tropical species in Dutch greenhouses feature among the exotics.

Through their activities, nematodes affect other organisms and processes in the soil. As a result, they play a pivotal role in the functioning of soil food webs. They are involved in the conversion of organic matter into nutrients and influence the growth and biomass of their food sources, such as bacteria and fungi. In this way, they contribute to healthy ecosystems by enhancing soil biodiversity and the natural capacity to suppress diseases and pests.

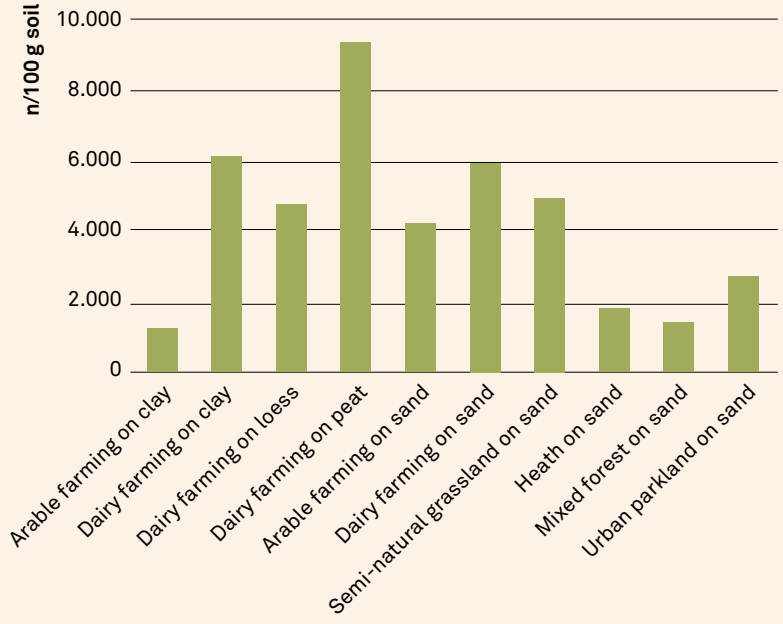
Quality indicators

Nematode species



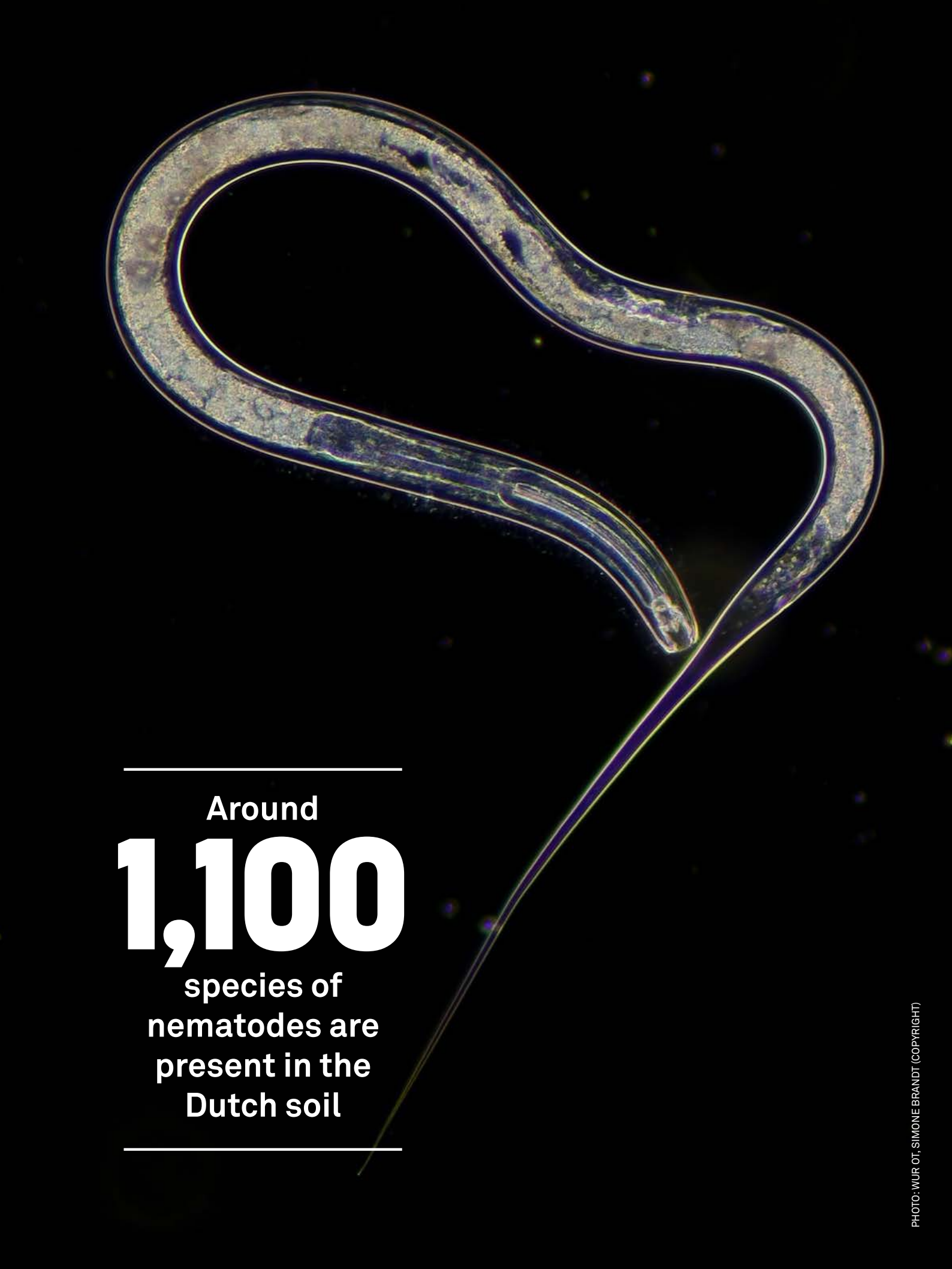
Nematodes have good potential to be used as bioindicators of soil quality. Much is already known about them, and they are easy to investigate, including with molecular techniques such as DNA analysis. They also clearly respond to numerous human activities in and on the soil. The TRIADE approach – a policy instrument for identifying ecological risks – uses nematodes as a field parameter.

Nematode numbers



Nematode densities and species counts for the 10 combinations of land use and soil type (references for biological soil quality).

SOURCE: SOIL ECOSYSTEM PROFILING IN THE NETHERLANDS WITH TEN REFERENCES FOR BIOLOGICAL SOIL QUALITY. NATIONAL INSTITUTE FOR PUBLIC HEALTH AND THE ENVIRONMENT (RIVM) REPORT 607604008/2007.



Around

1,100

species of nematodes are present in the Dutch soil

PHOTO: WUR OT, SIMONE BRANDT (COPYRIGHT)

NEMATODES
UNKNOWN BUT INDISPENSABLE

Nematodes are found in each and every type of soil and perform a wide range of functions there. That makes these worms a valuable tool for getting a better understanding of biodiversity in our soil.

For decades, we have been monitoring various ecosystems in the Netherlands, especially our water systems. Exactly what inhabits our soil, however, often remains a mystery. This makes it difficult to substantiate with figures how soil diversity is doing. This is because there is no accessible and reliable overview of which species are present in Dutch soils and in which quantities. One of the most promising groups of organisms to help us gain better insight into this are nematodes.

Bringers of balance

Nematodes are among the most common multicellular organisms in soil. These little worms are found in each and every type of soil and climate. Because nematodes are often no more than a few millimeters long and live hidden away, they are relatively unknown. However, they perform a variety of essential functions in the soil ecosystem. Their activities influence other organisms in the soil and, in turn, the functioning of soil food webs. Among other things, nematodes take up more nitrogen than they need. They then release the excess in the form of ammonia, which plants and bacteria can use for their growth. They also spread bacteria, fungi, and other microorganisms through the soil, allowing them to reach new food sources. This benefits plants and other soil dwellers. Furthermore, nematodes regulate the balance between bacteria and fungi, and can influence microbial species composition. They themselves provide food for other soil organisms.

At the same time, certain species of these “eelworms” can cause problems in agriculture, horticulture, and forestry. Plants affected by these organisms tend to experience reduced growth, resulting in a lower yield and harvest quality. Import and export restrictions are in place to prevent the spread of harmful nematodes.

Nematodes respond quickly to soil disturbance and enrichment

Moreover, a study published in Nature suggests that nematodes may be contributing to climate change (Van den Hoogen & Geisen et al., 2019): as the Earth continues to warm, Arctic nematodes eat more fungi and bacteria. This releases more nutrients, which accelerates

the breakdown of peat, resulting in higher greenhouse gas emissions.

From pristine to heavily polluted habitats

Since the 1980s, researchers have been exploring ways to assess soil quality using nematodes, similar to how water quality is currently evaluated. So far, this has not been successful, partly because current knowledge about nematodes is fragmented. Projects involving nematodes are often isolated and usually have a different primary focus.

Still, nematodes have enormous potential as a bioindicator of soil quality: they occupy key positions in soil food webs and respond quickly to soil disturbances and enrichment. One key practical advantage is that they are relatively easy to sample and analyze. There is also a clear relationship between their structure (particularly the shape of their oral cavity) and their function in the ecosystem. Besides, their widespread presence in every type of soil, from pristine to heavily polluted, allows comparisons to be made between different areas and conditions.

Fragmented knowledge

New methods offer new opportunities to better map out nematodes in Dutch soils. Thanks to DNA testing, we can identify juvenile nematodes and species that are difficult to distinguish from each other based on their appearance, or their morphology. This technique also makes it possible to process larger numbers of samples.

DNA testing helps us to identify nematodes that are difficult to distinguish from each other

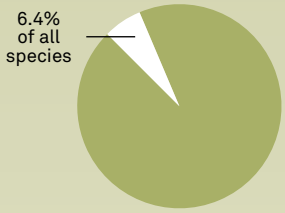
To make DNA testing more reliable, existing knowledge of the morphology and ecology of nematodes is crucial. A further limitation to this type of study is that it is virtually impossible to use it to determine the numbers of nematodes in the soil. Classical research (counting specimens in a sample under the microscope) remains essential to this, certainly in the coming few years.

To fully exploit the potential of nematodes as a bioindicator, we need to bring together the fragmented knowledge and analyze it through targeted research. This will require multi-year projects specifically centering on nematodes. By investing in this research, we can finally get a fuller picture of what is living in our soils and how healthy these ecosystems really are.

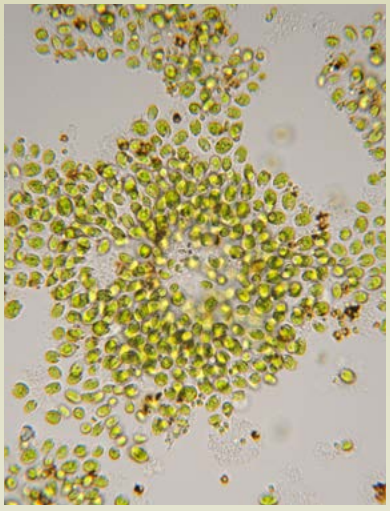
Harm Keidel
Soil biologist and PhD candidate,
Leiden University

DUNE CUP | PHOTO: RONALD VAN WIJK NATUURFOTOGRAFIE

Microalgae



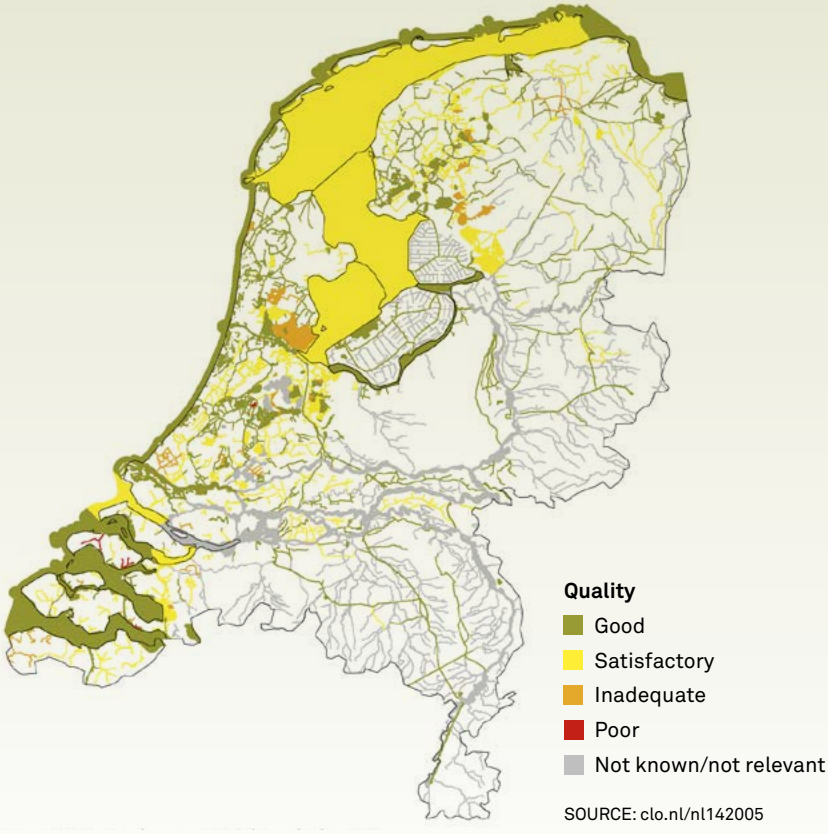
Number of species	Approx. 3,000
Of which are exotics	9
Conservation status	–
Red List	–
Note	Microalgae cover several taxonomic groups (generally single-celled organisms). The largest group are diatoms, of which there are about 2,245 in the Netherlands (in fresh and brackish water). The total number of microalgae is greater than previously identified.



MICROALGAE | PHOTO: GETTY IMAGES

Assessment of algae quality

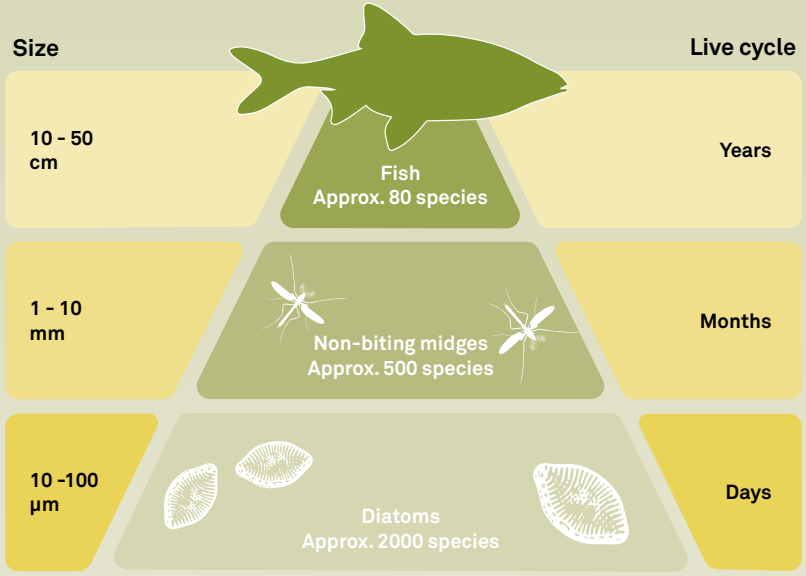
Water Framework Directive, 2021



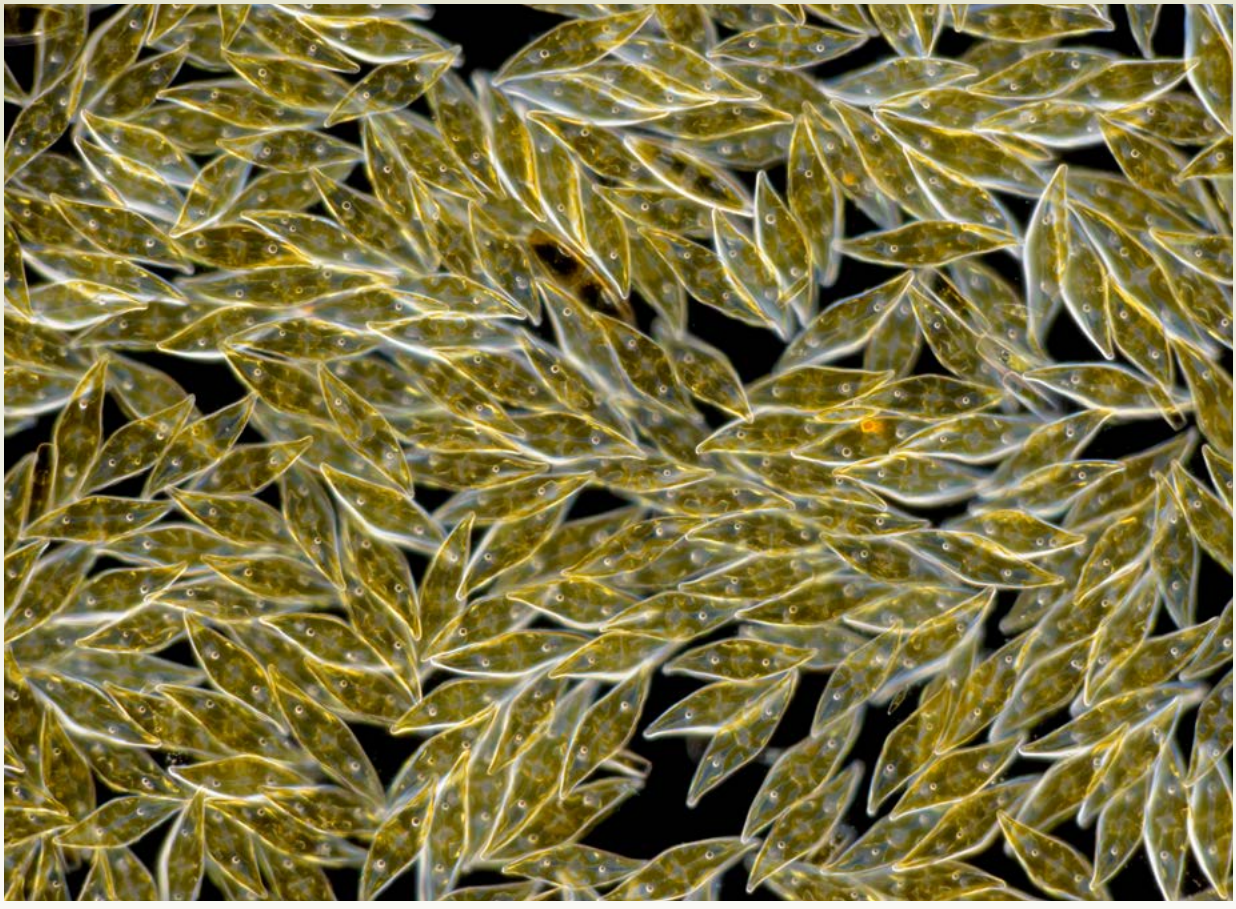
SOURCE: clo.nl/nl142005

Microalgae belong to the phytoplankton: the plant components of plankton that engage in photosynthesis. Diatoms, the largest group, play a crucial role as a biological indicator of water quality, because they respond quickly to changes in their habitat. They live both free in the water (saltwater and freshwater) and attached to plants, rocks, and other substrates. Because of their sensitivity to changes in factors including salinity, acidity, oxygen saturation, organic load, and nutrient richness, diatoms are used for Water Framework Directive monitoring in most European countries, including the Netherlands.

Sensitivity indicators



Diatoms in freshwater are an important biological indicator of water quality, as are fish and non-biting midges. Scientific research has shown that micro-organisms can provide a better picture of the influences of toxic pressures, for example, because their short reproduction time allows them to represent changes in the living community more quickly. Their size also makes them more sensitive to small changes in water than organisms higher up the food chain. In addition, changes in the community are easier to spot because their species diversity is greater.



DIATOMS | PHOTO: WIM VAN EGMOND

DIATOMS

THE CANARY IN THE COAL MINE FOR OUR WATERS

Diatoms produce 20 to 50% of all oxygen on Earth. They also serve as an ideal indicator of water quality in the Netherlands, but traditional monitoring methods are labor-intensive and time-consuming. DNA testing can make monitoring many times more efficient.

In the Netherlands, surface water – from ditches and ponds to rivers and lakes – is hugely important to public health, agriculture, recreation, and drinking water supply. However, increasing human activity is putting pressure on water quality. Practically no water body in the Netherlands meets the water quality standard under the EU's Water Framework Directive. Our waters are polluted with fertilizers, heavy metals, pesticides, microplastics, and other substances, which are harmful to the environment and to human and animal health.

Water authorities test the health of water once every three to six years. One way they do this is through diatoms: microscopic, single-celled algae found in both freshwater and saltwater. These engage in photosynthesis and have a fundamental function in ecosystems as suppliers of food and oxygen. Their share of global oxygen production is significant: estimates range from 20 to 50%.

Faster scanning

Diatoms respond quickly to changes in their habitat, making them an excellent indicator of water quality. Monitoring is currently carried out through traditional methods: samples are collected by hand and examined under a microscope, after which water quality is determined according to an international yardstick: the Specific Pollution Sensitivity Index (SPI). This process is costly and labor-intensive. Moreover, it requires far-reaching knowledge of taxonomy.

New DNA-based methods can streamline and speed up this process, but are only suitable if they provide the same reliable information as traditional methods. Researchers therefore spent two years examining diatom samples with a large number of water boards in two ways: one using traditional methods and another using DNA techniques, comparing DNA from samples with a database of known DNA barcodes.

The different research techniques did yield similar, albeit not exactly the same, results. This provides opportunities to develop a cheaper, faster DNA-based quick scan of water quality that is less reliant on specialist knowledge. Whereas a microscopic examination takes several weeks or months, a DNA scan can provide results within a week. This means that the method can be used more often and developments

in the water can be identified more quickly. However, for a more comprehensive analysis of the ecological system, DNA is not always sufficient. In such cases, we can revert to traditional methodology, which allows for more targeted research.

More often a negative picture

It is important to understand that there are still limitations in using DNA testing for water quality. The current reference list of DNA codes includes only 7% of all known taxonomic units (taxa) that we can identify with a microscope. Moreover, the taxa that do appear in the DNA database are fairly often species that are indicative of poor water quality (as they have a lower SPI value). As a result, DNA testing more often paints a more negative picture of water quality than traditional methods.

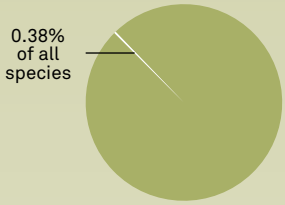
A DNA scan of water quality can provide results within a week

This does not mean that DNA testing is unreliable, though. The differences are explainable and lie within an acceptable range. DNA techniques do provide a slightly different picture of reality than traditional methods, and it is difficult to determine which of these pictures is "better". However, the benefits are clear: it gives us access to crucial microorganisms that are difficult to investigate through traditional methods.

Kevin Beentjes
Naturalis Biodiversity Center

DIATOMS | PHOTO: WIM VAN EGMOND

Fish

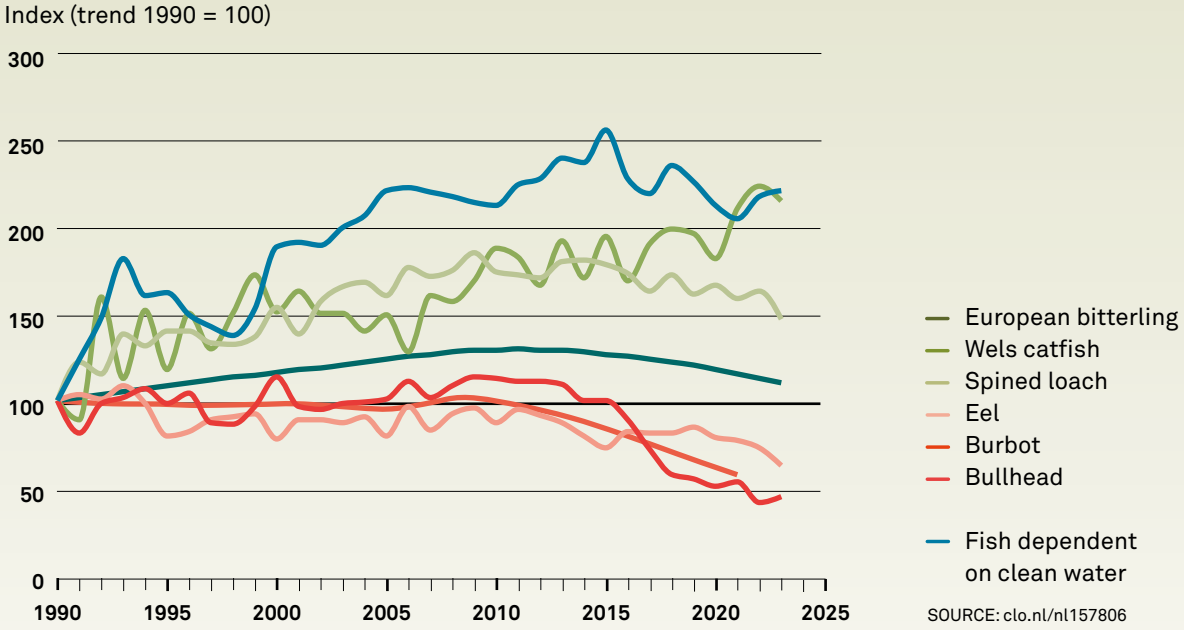


Number of species	Approx. 180
Of which are exotics	36
Conservation status	✔
Red List	✔
Note	59 of the 180 fish are saltwater fish.

LUMPFISH | PHOTO: MARION HAARSMA

Distribution trend of freshwater fish

1990-2023 | 6 species evaluated

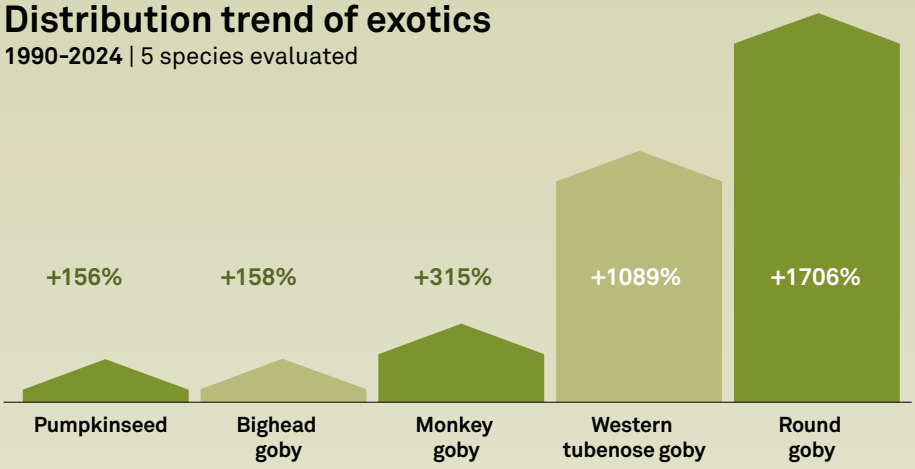


SOURCE: clo.nl/nl157806

Freshwater fish increased in numbers until 2012 due to improved water quality, but are now declining again, especially species dependent on clean water, such as the bitterling, stone loach, tench, and pike. Trends of 47 species of fish can be determined through the monitoring network of volunteers and water boards. The wels catfish and European bitterling show strong increases. Six species show moderate increases, including the nase, minnow, and sunbleak. Sixteen native species are stable; eight show moderate declines, including eels and burbots. The bullhead has declined sharply in numbers. The large number of exotics among Dutch fish shows a sharp increase, including four species of goby and the pumpkinseed. (RAVON balance 2024)

Distribution trend of exotics

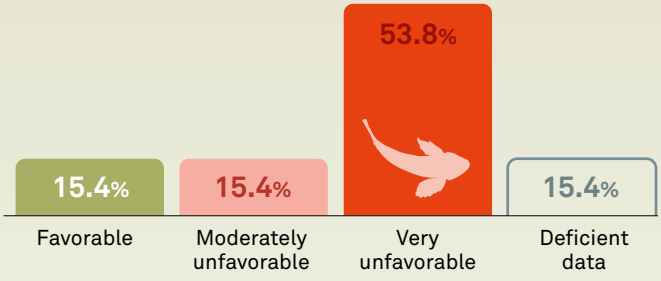
1990-2024 | 5 species evaluated



SOURCE: clo.nl/nl157806
https://www.ravon.nl/Soorten/Soortinformatie/kwabaal

Conservation status

2013-2018 | 13 species evaluated

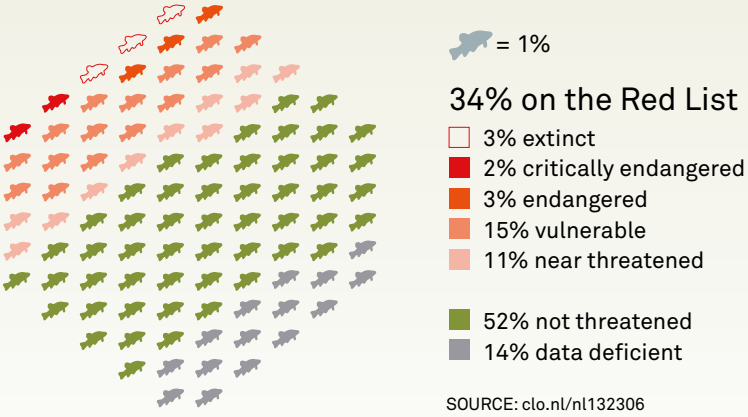


SOURCE: https://nature-art17.eionet.europa.eu/article17/species/report/

A number of fish species are protected under the EU's Habitats Directive. Of these, the spined loach is the only one that is faring well and has increased considerably in numbers. The other species have an unfavorable conservation status, but show different patterns: the European bitterling has increased sharply and been stable since 2010, and the weatherfish is more or less stable, while the bullhead is decreasing sharply due to displacement by exotic goby species. The Rhine sculpin, European river lamprey, and brook lamprey are too rare to calculate reliable trends.

Red List

2011 | 99 species evaluated, of which 59 saltwater fish



= 1%

34% on the Red List

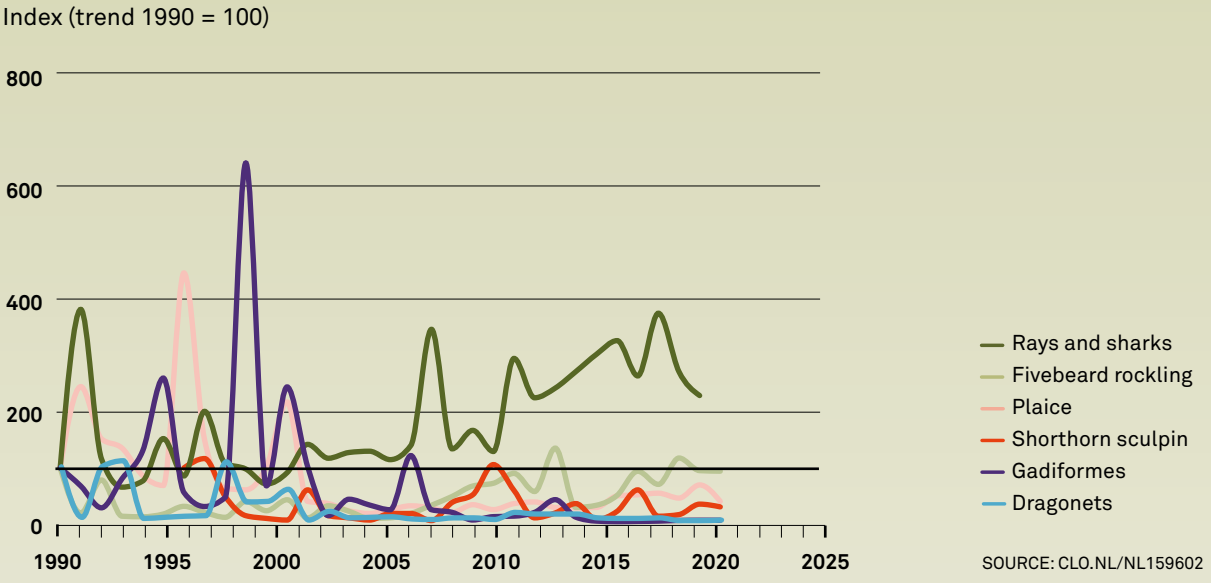
- 3% extinct
- 2% critically endangered
- 3% endangered
- 15% vulnerable
- 11% near threatened

- 52% not threatened
- 14% data deficient

SOURCE: clo.nl/nl132306

Population trend of saltwater fish

1990-2020 | 13 species evaluated



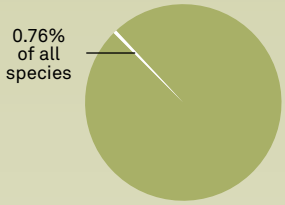
SOURCE: CLO.NL/NL159602

Saltwater fish show a predominantly declining trend in coastal waters. By contrast, the population size of marine fish in the North Sea outside coastal waters has been increasing slightly on average since the beginning of the century. However, trends do vary widely by species, meaning the overall trend offers little information about the group as a whole. Plaice numbers, for example, are increasing, while sole numbers show no recovery. Rays and sharks declined sharply in the 20th century, with a slight recovery in the 21st century owing to reduced fishing pressure.

In the Southern Delta, significant trends can be determined for 28 species through the Anemoon Foundation's monitoring network of volunteers. In the Eastern Scheldt, three species increased in number between 1994 and 2018, three species remained stable, and 14 species showed declines. Of the 26 Red List species, half are declining in numbers, while no clear trend can be identified for the other half.

The negative trend is strongly prevalent among gadiformes: cod, pollack, pouting, poor cod, and the tadpole fish are declining in numbers. For whiting, the trend is uncertain. The trend is neither stable nor positive for any of the gadiformes. Among flat-fish, flounder and sole in particular are declining, while dab and plaice are stable. Other species with moderate to strong declines in both the Eastern Scheldt and Lake Grevelingen are the eel, dragonet, fivebeard rockling, and shorthorn sculpin.

Mollusks

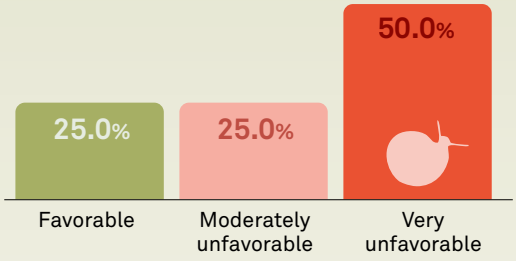


Number of species	Approx. 358
Of which are exotics	45
Conservation status	✔
Red List	✔
Note	A diverse group, including snails (land, freshwater, and saltwater snails), bivalves (including clams and cockles), as well as cephalopods and three other marine-only groups.

DOG WHELK | PHOTO: MICK OTTEN

Conservation status

2013-2018 | 4 species evaluated

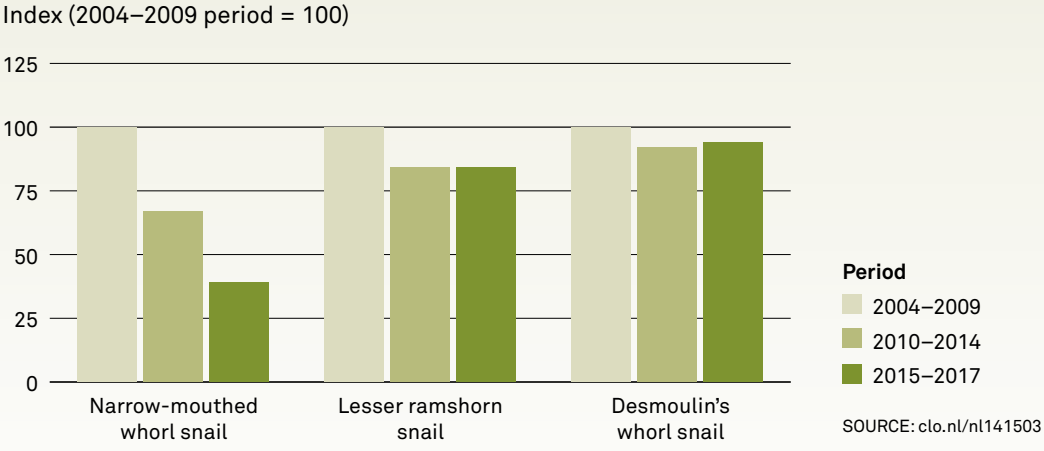


SOURCE: https://nature-art17.eionet.europa.eu/article17/species/report/

There are five Dutch species listed in the EU Habitats Directive: the terrestrial species narrow-mouthed whorl snail, Desmoulin's whorl snail, and Roman snail, as well as the freshwater species little whirlpool ramshorn snail and the thick-shelled river mussel. The latter species has not been sighted in the Netherlands since 1968 due to deterioration of the water quality in large and medium-sized rivers and streams, but is still found in surrounding countries.

Land snails in the Habitats Directive

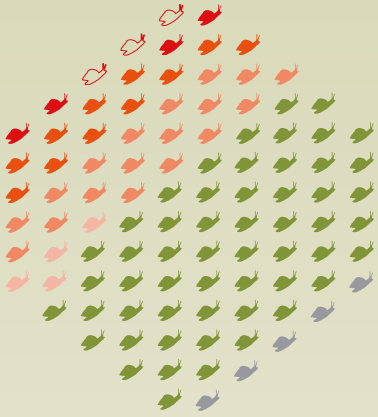
2004–2017



SOURCE: clo.nl/nl141503

Red List

2003 | 169 species evaluated



= 1%

40% on the Red List

- 3% extinct
- 4% critically endangered
- 11% endangered
- 18% vulnerable
- 4% near threatened

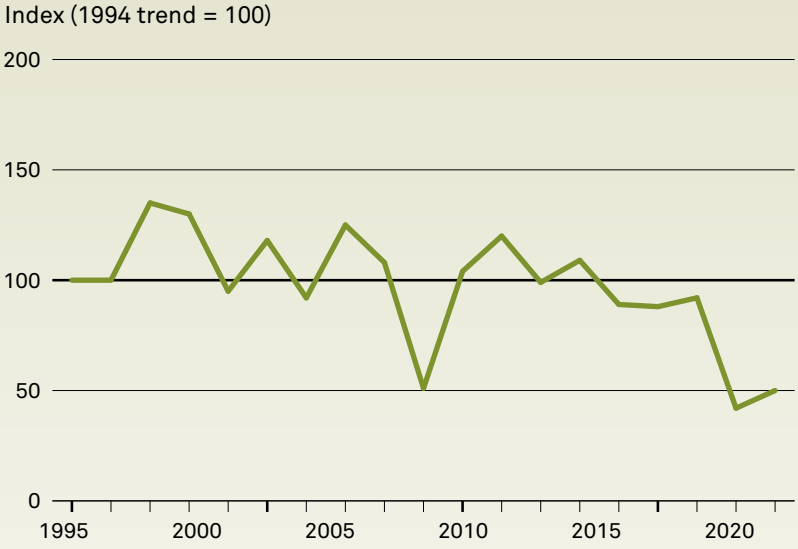
- 55% not threatened
- 5% data deficient

SOURCE: clo.nl/nl132306

A Red List for land and freshwater mollusks was established in 2004. This contains three species (fine-lined pea mussel, larger spire shell, and thick-shelled river mussel) that were sighted in the Netherlands until 1980 and are considered extinct. On land, the sandbowl snail (1977) and the plaited snail (1977) have disappeared from the Netherlands.

Typical species of the North Sea coast

1994–2012 | 8 mollusks evaluated



SOURCE: www.clo.nl/nl156201

In North Sea coastal waters, mollusks in particular have declined, possibly due to seabed disturbance, warming seawater, exotics, pollution and sand replenishment. One notable example is the dog whelk: due to TBT contamination (used in anti-fouling paint on marine vessels), females developed male sex organs. After the ban on TBT, the population recovered, but the use of bitumen for coastal reinforcement has again greatly reduced numbers along the North Sea coast.

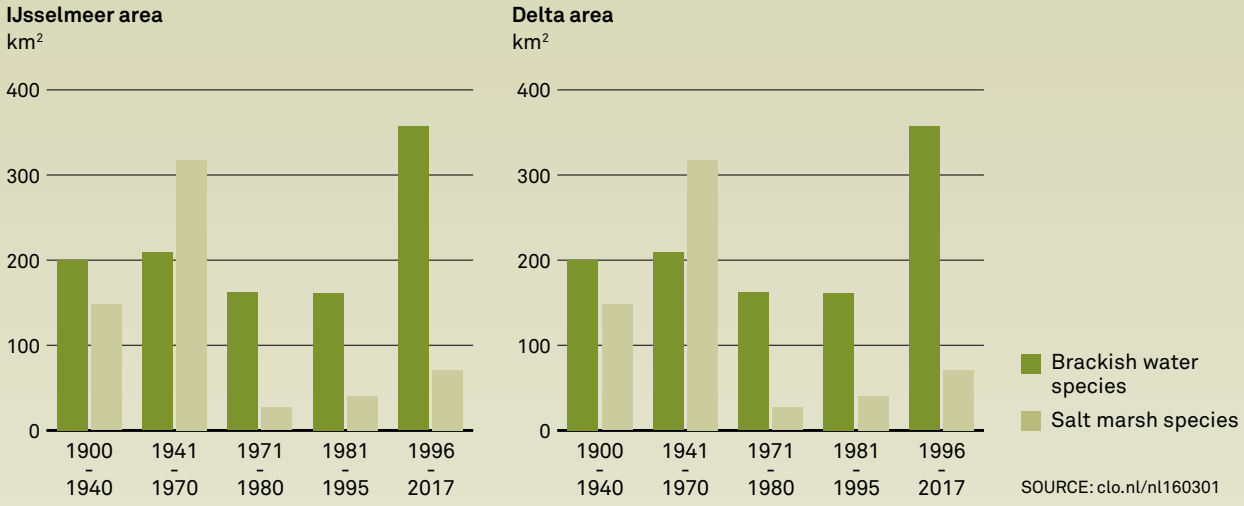
A relatively large proportion of mollusks in the Netherlands are non-native and some have been present in the Netherlands for a long time (e.g. the soft-shell clam and the zebra mussel). New non-native species are sighted regularly. The saltwater/brackish water species are often sighted first in the Southern Delta and several years later in the Wadden Sea. While the Pacific oyster has been actively introduced for shellfish culture, species such as the Manila clam and Atlantic jackknife clam have not been actively introduced in the Netherlands.

Nevertheless, they are numerous enough for ecological importance (food for predators) and commercial fishing.

Mollusks are of economic importance to shellfish fisheries, including the mussel, Pacific oyster, cockle, cut trough shell, and Atlantic jackknife clam. To protect species of commercial interest, stock size is measured before granting fishing licenses; the quantity and distribution of the species determines how much can be fished.

Mollusks in salt marshes and brackish water

1900–2017



SOURCE: clo.nl/nl160301

Changes in freshwater management during the last century have caused the originally distinct hydrobiological provinces to become increasingly similar. This is due in part to water shortages in the summer months, lower water levels, river water intakes that led to eutrophication, eutrophication and acidification of waters due to manure deposits, and atmospheric deposition (source: *Nederlandse fauna, Zoetwater mollusken*).

LOOKING TO THE FUTURE

The unexpected sea slug

Until recently, there were 65 species of nudibranchs known to inhabit the Dutch coast. Some are cryptic species, meaning that several species are very similar and thus difficult to distinguish from one another.

The first description of a sighting of a nudibranch in the Netherlands dates from 1765 and took place in the vicinity of Zierikzee. At that time, species were described and named based on aspects such as animals that had washed up on the shore or sighted in the tidal zone. With the rise of scuba diving combined with the internet and digital underwater photography, it became possible to observe these fascinating animals underwater as well, and report and share sightings. In recent decades, DNA profiling has become available as a research method, broadening the possibilities of sighting species already discovered or describing new ones. Thanks to this technique, two new species of nudibranchs have recently been added to the Dutch species list. Research into two other new species is nearing completion, bringing the tally to 69.

Western European sea slugs have been widely studied. It therefore came as a surprise when, in 2024, a previously unknown species of sea slug was found in Dutch coastal waters, via molecular research.

Sighted and photographed by Peter H. van Bragt, biologist and ARISE volunteer

MEIOFAUNA
SMALL BUT MIGHTY

Among the grains of sand live countless tiny animals called meiofauna. We still know very little about them, but an integrated approach that combines DNA testing with traditional taxonomic expertise should change that.

Although sandy beaches appear barren, they are home to meiofauna: animals only a few micrometers to a millimeter in size that live in the gaps between sand particles. They constitute a very large and diverse group, of which only a fraction has been studied. It is not known how many species there are, where they occur, and how they live. Everywhere researchers go, new species are found.

Vital link

DNA techniques are becoming increasingly important in ecology and biodiversity research, and meiofauna are no exception; this involves linking DNA from a sample to known DNA sequences in a database to see which species occur in it.

However, this method depends on how complete that database is, and in the case of meiofauna, it is anything but. Additional data are required to draw reliable conclusions about the condition of this group and their responses to environmental stressors.

This is crucial because, despite their small size, meiofauna are essential to the ecosystem. They serve as food for many different organisms, including fish, crabs, and mollusks, forming a vital link in the food chain.

In addition, meiofauna play a key role in nutrient recycling. By breaking down organic matter, they release essential nutrients such as nitrogen and phosphorus, which supports the growth of plants and algae.

New library

To fully harness the potential of new DNA techniques in scientific research requires a combination of modern science and more traditional taxonomic expertise. Special workshops have been organized along the North Sea to supplement the meiofauna database in a targeted manner, with researchers collecting samples along the coastline there. Taxonomic experts first identified the species, after which their DNA was entered into the database.

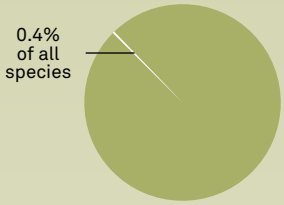
Everywhere researchers go, new species are found

The results are promising: more than twice as many DNA sequences could be matched using this new library. Moreover, dozens of presumably new meiofauna species were found, many of which have not yet been described.

Jan Macher
Naturalis Biodiversity Center

TARDIGRADE | PHOTO: FRANK FOX

Cnidarians and comb jellies



Number of species	Approx. 193
Of which are exotics	10
Conservation status	–
Red List	–
Note	The group of cnidarians (approx. 188 species) includes true jellyfish (11), hydrozoans (147), soft corals (2), and sea anemones (29). In addition, five species of comb jellyfish occur in the Netherlands.

WARTY COMB JELLY
PHOTO: MARION HAARSMA

In the Zeeland Delta, recreational divers and volunteers from the Anemoon Foundation are monitoring 21 species of cnidarians and three species of comb jellies. In the Eastern Scheldt, six species recorded increases between 1994 and 2018. Eight species remained stable, whereas another eight species decreased in number. The plumose anemone, a typical species of the large bays to which the Eastern Scheldt belongs, showed a stable trend.

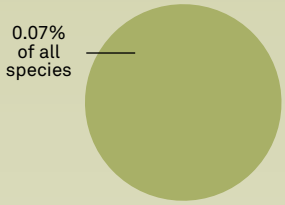
Although soft seabeds dominate the Dutch North Sea, there are also areas where hard substrate is present, such as the Borkum Stones and Cleaver Bank. These provide a suitable habitat for dead man's fingers and the dahlia anemone, among others. Scattered throughout the North Sea, these species may also occur on non-natural hard substrates such as shipwrecks, offshore industry installations, and erosion protection structures in wind farms.

The warty comb jelly is an non-indigenous species, originally from the Atlantic coast of North America, present in the Netherlands since 2006. This species is a very effective plankton eater. Consequently, the arrival of this species has had major adverse effects on fish stocks and fisheries in several places around the world. So far, no drastic effects have been observed in the Netherlands.

OATEN PIPES HYDROID | PHOTO: MARION HAARSMA

Cnidarians include true jellyfish, hydrozoans, soft corals, and sea anemones. These animals possess special stinging cells that allow them to paralyze prey and defend themselves against predators. They are found exclusively in aquatic environments, with most species living in saltwater. Many species have a life cycle with both a sessile polyp stage and a free-swimming planktonic medusa stage. Within this group, the hydrozoans are the most species-rich, with 147 species occurring in the Netherlands. Although they resemble true jellyfish, comb jellies are not classed as cnidarians. They have no stinging cells, but do have adhesive cells to catch food.

Sea squirts



Number of species	33
Of which are exotics	9
Conservation status	–
Red List	–
Note	Sea squirts (tunicates) occur exclusively in marine environments. They usually grow on hard substrates, with some species living solitarily and others forming a crust in colonies.

ROUGH SEA SQUIRT | PHOTO: MARION HAARSMA

In the Zeeland Delta, recreational divers from the Anemoon Foundation monitor 10 species of sea squirts, seven of which are non-native. In the Eastern Scheldt, between 1994 and 2018, three species decreased in number, four species remained stable, and three species increased. The species which increased are colony-forming sea squirts with non-native status, first recorded in the Netherlands between 1977 and 1999.

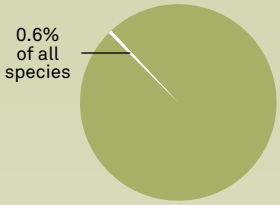
In the Wadden Sea, non-native species are monitored and data summarized in the Wadden Sea Quality Status Report. Five non-native sea squirts occur in this area. The data from the North Sea are insufficient to determine trends.

COMPOUND SEA SQUIRT | PHOTO: PETER H. VAN BRAGT

LIGHT-BULB SEA SQUIRT | SOURCE: MARION HAARSMA

JAPANESE WIREWEED | PHOTO: ROB AARSEN

Seaweeds

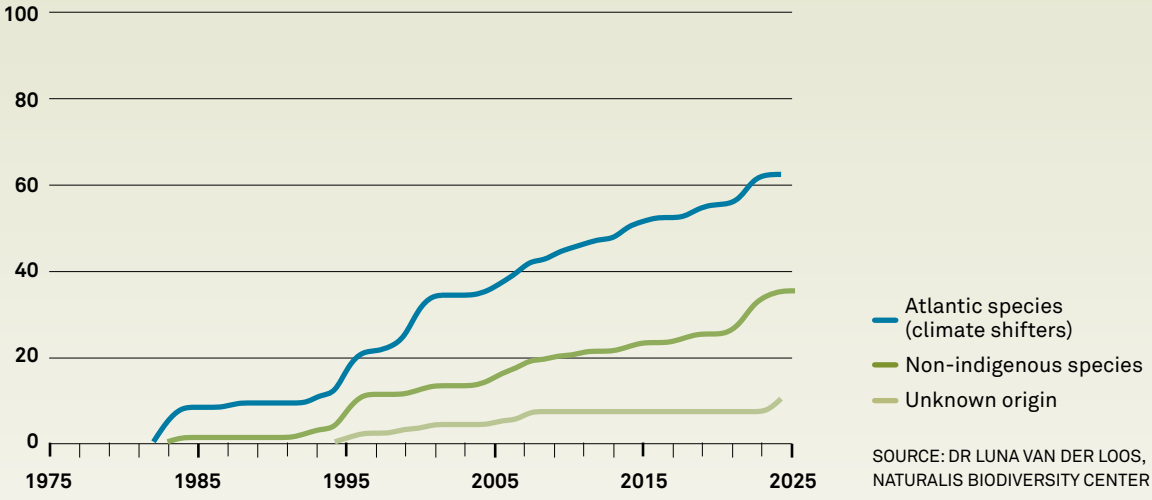


Number of species	Over 280
Of which are exotics	45
Conservation status	–
Red List	–
Note	Seaweeds, also called macroalgae, are a diverse group that includes green, red, and brown algae. They are predominantly found in saltwater, but there are also species that live in freshwater.

VARIOUS SEAWEEDS | PHOTO: LUNA VAN DER LOOS

The (cumulative) number of newly sighted seaweed species

1980-2025



SOURCE: DR LUNA VAN DER LOOS, NATURALIS BIODIVERSITY CENTER

UNRAVELLING HIDDEN SEAWEED

More and more seaweed species are making their way to the Netherlands, sometimes operating from very far away, but because of their similar or changing appearance, they are difficult to monitor. Seeweed forests still conceal many unknown species, including non-indigenous species that have been introduced to the Netherlands through human interference.

Seaweeds are important coastal inhabitants that are particularly common in tidal and shallow waters. It is critical to monitor these species; the dense forests that they make up provide a source of food and habitat for many other organisms.

Over 280 species are currently found in the Netherlands, including 81 green algae, 118 red algae, and 87 brown algae. That list, however, is far from complete. This is partly due to the introduction of new species and a high cryptic diversity, i.e. many species look very similar on the outside but, after DNA testing, are found to be genetically different from each other.

Long leaves or tiny filaments?

Many seaweeds change their appearance under different conditions, making them hard to identify. For example, there are sea lettuce species that form swollen and branched tubes in high salinity environments, but are more leaf-shaped in brackish water.
Other seaweed species may exhibit completely different external features at different stages of their life cycle. Sugar kelp is best known in its meter-long blade form, anchored to rocks with a claw-like foot, but in another stage of life it consists of microscopic filaments. This makes it difficult to properly map the distribution and seasonal patterns of species and quickly identify non-indigenous species.

New DNA techniques

The introduction of non-native species through human activity leads to an increase in biodiversity at species level in the Netherlands. The Southern Delta, In particular, is a hotspot for new, non-native seaweeds in Europe.

Based on current data, these non-indigenous seaweeds do not appear to be outcompeting native seaweeds. In the first few years after introduction, they increase rapidly, both in biomass and in distribution, sometimes dominating the entire seabed. In subsequent years, the

The list of seaweed species found in the Netherlands is far from complete

biomass fluctuates until equilibrium is reached or a new exotic takes over.

Non-indigenous species can be difficult to distinguish from native seaweeds, but new DNA techniques allow them to be identified more quickly. Since 1993, 34 exotic seaweed species have been found in the Netherlands, 11 of which have been spotted for the first time in the past three years.

Some species can only be distinguished from one another genetically

Species database

DNA techniques are necessary to unravel the species composition of seaweed forests. Some species can only be distinguished from each other at genetic level. Recent research has shown that not four, but 13 species of purple algae – best known in their dried form as the nori sheets used to roll sushi – occur on the Dutch coast. Four of the nine newly found species turned out to be non-indigenous species, native to the northern Pacific Ocean. Three had not yet been found in the entire north-east Atlantic. It is likely that they had been present in the Netherlands for much longer, but were not recognized.

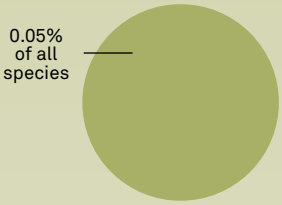
Also within sea lettuce species, DNA testing yielded four species not previously known in the Netherlands, including two non-native species. One of these occurs only in freshwater and was until then only identified in China.

These techniques make it possible to build a reliable database, enabling better monitoring of different species and detection of exotics – a goal that is being advanced with projects like ARISE and eDentity.

Luna van der Loos
Naturalis Biodiversity Center

KELP FOREST | PHOTO: AD ALEMAN

Echinoderms



Number of species	25
Of which are exotics	0
Conservation status	–
Red List	–
Note	This group includes starfish, sea cucumbers, and sea urchins. These animals live on or in the seabed and are found on both hard and soft surfaces.

COMMON STARFISH | PHOTO: MICK OTTEN

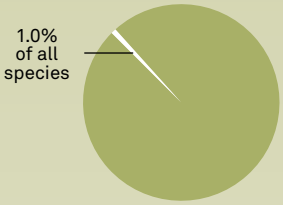
GREEN SEA URCHIN | PHOTO: MARION HAARSMA

Species within this group that burrow into the soil feed on organic matter. This contributes to a process known as bioturbation, which results in nutrients being recycled and the sediment being oxygenated. They play an important role as predators on mussel beds and are themselves a food source for fish, crustaceans, and others.
Two echinoderms are among the typical species of marine Natura 2000 areas: the serpent star (found on permanently flooded sandbanks) and the sea potato (in large bays). Because of the lack of data, reliable trends for these species cannot be established.

Recreational divers from the Anemoon Foundation monitor five species of echinoderms in the Southern Delta. In the Eastern Scheldt, these species remained stable or decreased in number between 1994 and 2018. Data from Rijkswaterstaat specifically cover species living on and in soft substrate.

Segmented worms

Bristle worms



Number of species	Approx. 500 (of which 223 are bristle worms)
Of which are exotics	12 (of which 10 are bristle worms)
Conservation status	✔
Red List	–
Note	Well-known species groups of segmented worms are earthworms, potworms, and leeches. However, the largest group is that of the relatively unknown bristle worms (polychaetes).

BRISTLE WORM | PHOTO: MARION HAARSMA

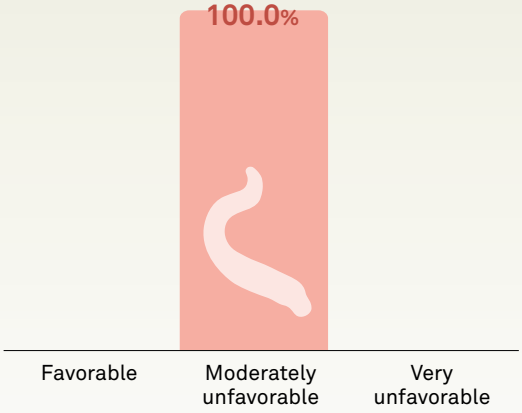
Bristle worms belong to the segmented worms and are found almost exclusively in marine environments. They show enormous variation in form and habitat, but most species live in sediment, where they play an important role in soil processes.

Since 1989, the number of bristle worms in the North Sea, Southern Delta, and Wadden Sea has generally declined. However, trends differ for individual species. For example, the population of the sandworm first increased, but later declined. The red thread worm has declined sharply in numbers, while the sand mason worm remains relatively stable.

Within the five marine Natura 2000 habitat types designated in Dutch waters, bristle worms make up a significant proportion of typical species. Monitoring data for bristle worms are primarily collected by the Dutch Directorate-General for Public Works and Water Management (Rijkswaterstaat).

Conservation status

2013-2018 | 1 species evaluated



SOURCE: nature-art17.eionet.europa.eu/article17/species/report/

A single medicinal leech

Around 30 species of leeches are known to occur in the Netherlands, one of which, the medicinal leech, enjoys protection under the EU Habitats Directive. This species has declined sharply due to habitat destruction and intense harvesting for medicinal uses. Today, it is used for the production of hirudin, an anticoagulant and in plastic surgery (Source: clo.nl/nl141703)

INSECTS

FEWER OF THEM, BUT MORE SPECIES

Ecosystems are coming under pressure due to the total mass of flying insects declining sharply in recent decades. Meanwhile, climate change in particular is resulting in more and more different species being found in the Netherlands.

The insect population is shrinking at an alarming rate. In less than three decades, the biomass or weight of flying insects has declined by as much as three-quarters, with major implications for biodiversity. This is not just a Dutch problem: worldwide studies show a similar pattern. Moreover, there is no single cause for the downward trend; instead, there seems to be a death by a thousand cuts. Insecticides, monoculture in agricultural areas,habitat loss, and climate change are all affecting the insect population.

This large decline has prompted a chain reaction in ecosystems. Insects serve as pollinators, decomposers, and above all as a source of food – or at least as a vital link in the food chain – for other species, including predatory insects and larger animals such as birds and mammals. To fulfil that role, they are needed in large numbers, otherwise the ecosystems will not last.

Paradoxical increase

The black-tailed godwit serves as a clear illustration of this situation. A one-day-old godwit chick eats 2,000 insects a day, mostly non-biting midges. After one week, that number increases to 9,000 a day. Without these insects, the animal cannot survive, even in a safe habitat. Protective measures are next to futile if the food is not available.

In less than three decades, the biomass of flying insects has decreased by three-quarters

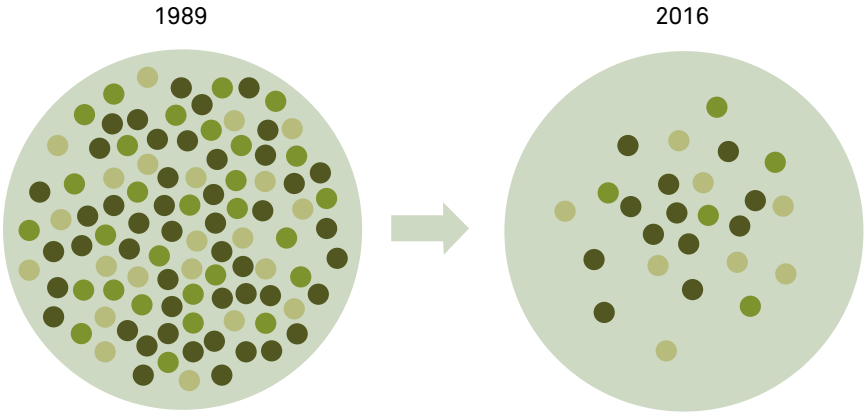
The same is true for predatory insects: Dragonflies and damselflies have deteriorated significantly over the past two decades; prior to that, the population had just recovered after bottoming out in the 1970s and 1980s because of water pollution. Dragonflies and damselflies are predators and thus depend on other insects to survive, but there are fewer and fewer of these around.

9,000

insects are eaten by a week-old black-tailed godwit chick every day

BLACK-TAILED GODWIT | PHOTO: GETTY IMAGES

Decrease in biomass of flying insects



Researchers found a 75% decline in the biomass of flying insects in German nature reserves over 27 years.

SOURCE: (HALLMANN ET AL., 2017)

The shrinking biomass is therefore a greater cause for concern than the quantity of different species. The latter figure is, somewhat paradoxically, actually increasing: according to the Dutch Species Register, the Netherlands is home to about 20,000 species, with more being continuously added. This is because most insects prefer warmer climates. However, species that were once abundant in the Netherlands now survive only in small numbers, causing them to disappear as a food source.

Depleted ecosystems

Insects are intertwined with the ecosystem in a variety of ways. Behind the downward trend is a complex interplay of factors, of which scientists have identified only a fraction. The studies available do indicate a multitude of factors associated with intense agriculture. Insecticides kill not only the targeted insects, but also their natural enemies and a range of insects unrelated to the crop.

Moreover, plant species diversity has declined on pastureland, which is mostly dotted with ryegrass; this is nutritious for livestock but not for insects. As the insects search for areas hospitable to them, they stumble upon the fragmented Dutch countryside, which consists of several parcels of natural areas isolated from one another. Non-flying insects, in particular, fail to survive the journey from one area to another. This leads to depleted ecosystems in nature, with only a limited number of insect species.

Large and complex

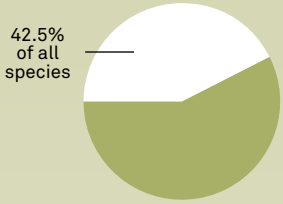
Insects respond quickly to changes in their habitat. Nitrogen deposition is a clear example of this sensitivity; when deposited, nitrogen alters the mineral composition of the soil and therefore the plants that grow there and serve as insect food. That effect is irreversible, and the European field cricket has fallen victim to this. Unfortunately, the countermeasure of adding extra lime to the soil in these areas proved counterproductive.

Thanks to their short life cycles, insect populations recover quickly under the right conditions. This makes them a reliable indicator of the impact of policies or other measures. However, our knowledge on this topic is limited: the insect world is large and complex, while the pool of experts is relatively small.

Scientists are now working with DNA, image recognition and other modern methods to gauge the insects' condition more quickly and comprehensively. This offers opportunities to shine more light on the insect decline. However, much more research is still needed on this.

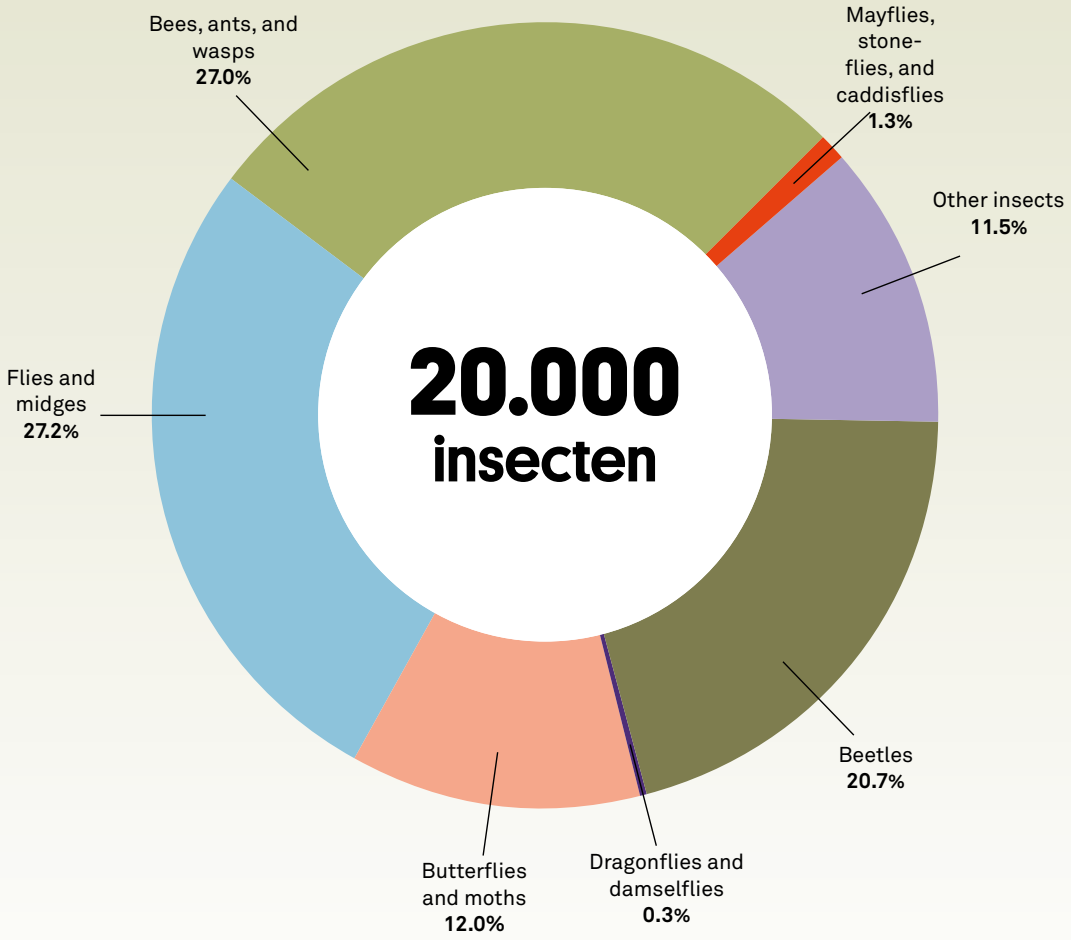
Aglaia Bouma & Jan Wieringa
Naturalis Biodiversity Center

Insects

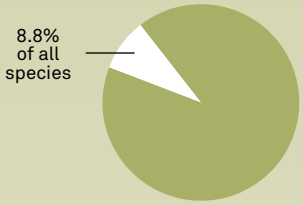


Number of species	Approx. 20,000
Of which are exotics	282
Conservation status	✔
Red List	–
Note	Insects play a hugely important part in our ecosystems as herbivores, pest controllers, pollinators, decomposers, food sources for other animals, and more. As it is such a large group, we focus here primarily on the species groups featured on the Red List and in the Habitats Directive.

VARIEGATED LADYBUG |
PHOTO: CEES DETERMANN



Beetles

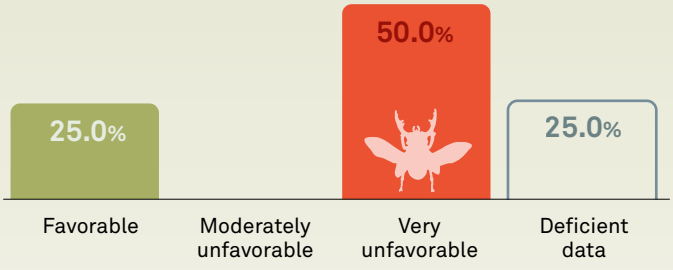


Number of species	4,145
Of which are exotics	75
Conservation status	✔
Red List	–
Note	There is a considerable diversity of beetles in the Netherlands. These creatures perform an array of vital ecological roles, such as breaking down organic matter (dung beetles and carrion beetles), hunting other insects (ladybugs and ground beetles) and eating plants (leaf beetles).

GARDEN CHAFER | PHOTO: CEES DETERMANN

Conservation status

2013-2018 | 4 species evaluated



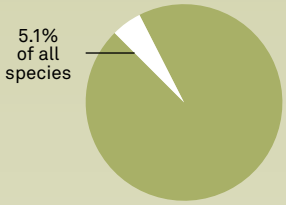
SOURCE: nature-art17.eionet.europa.eu/article17/species/report/

In addition to butterflies and dragonflies and damselflies (which are treated separately), four species of beetles are listed in the Habitats Directive. The stag beetle – the largest found in the Netherlands – is rare here, but little can be said about the trend as proper monitoring only recently began. *Dytiscus latissimus* was previously thought to be extinct, but after being rediscovered in 2005, it still seems to occur in at least three fens. *Graphoderus bilineatus*, a water beetle, has declined sharply, while *Cucujus cinnaberinus*, first discovered in the Netherlands in 2012, is actually expanding (clo.nl/nl141703).

The stag beetle is rare in the Netherlands

STAG BEETLE | PHOTO: GETTY IMAGES

Butterflies and moths



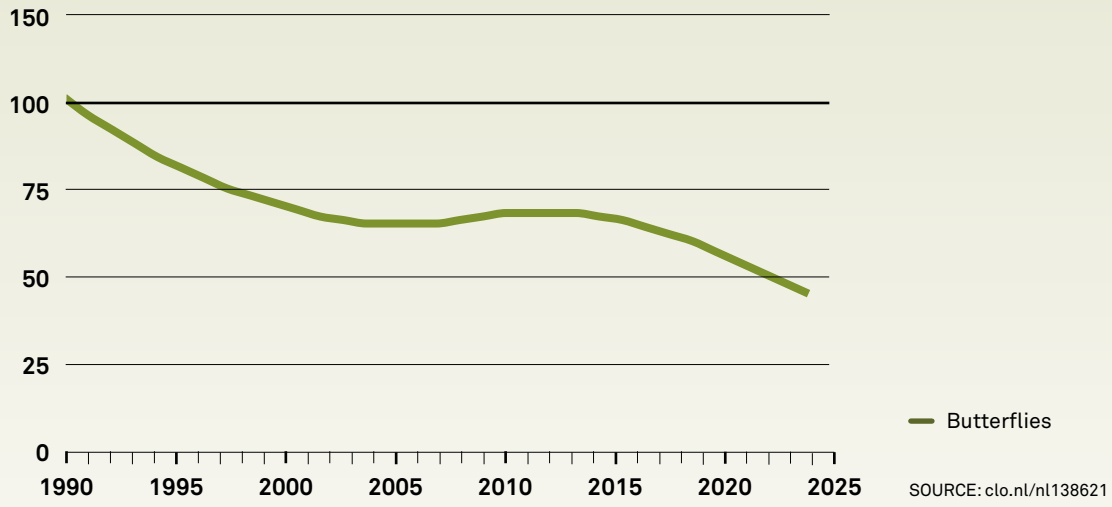
Number of species	Approx. 2,400
Of which are exotics	Approx. 30
Conservation status	✔
Red List	✔
Note	This group consists of the diurnal butterflies and the much more numerous, nocturnal moths. Whereas we have been observing butterflies for more than 100 years, there is still much to discover about moths.

SMALL COPPER | PHOTO: CEES DETERMANN

Population trend of diurnal butterflies

54 species evaluated

Index (trend 1990 = 100)

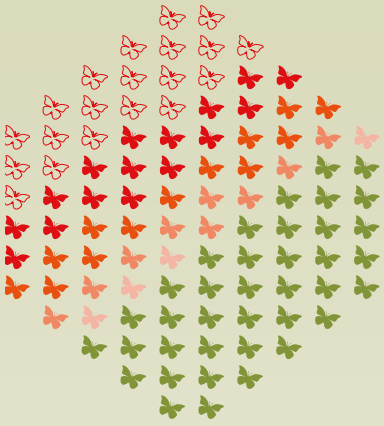


SOURCE: clo.nl/nl138621

The distribution of butterflies in our landscapes shrank by 67% between 1890 and 1990. Moreover, new figures from Statistics Netherlands and the Vlinderstichting (Butterfly Foundation) show that, in 2024, the number of butterflies reached the lowest level since counts began. Between 1992 and 2024, butterfly populations declined by an average of 56%. Compared with the late 19th century, there are now at least 84% fewer butterflies in our landscape.

Red List diurnal butterflies

2019 | 76 species evaluated



= 1%

62% on the Red List

- 20% extinct
- 16% critically endangered
- 13% endangered
- 9% vulnerable
- 4% near threatened

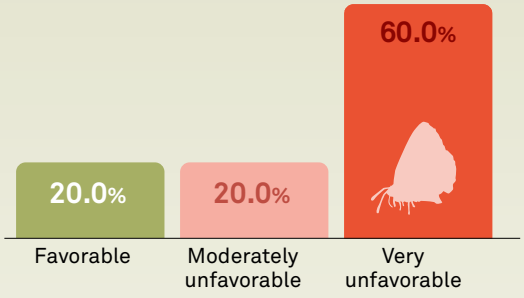
38% not threatened

SOURCE: BASISRAPPORT RODE LIJST DAGVLINDERS 2019 (VAN SWAAY, 2019)

Some species show a different pattern. For example, forest butterflies on the Red List, such as the purple emperor and the silver-washed fritillary, are faring better. These species are likely benefitting from the warmer climate and better quality of Dutch forests.

Conservation status

2013-2018 | 5 species evaluated

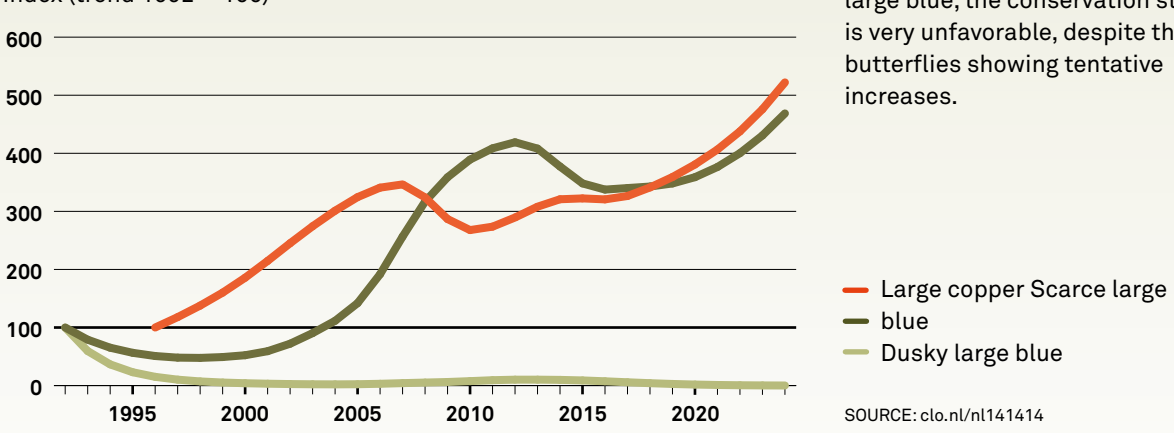


SOURCE: https://nature-art17.eionet.europa.eu/article17/species/report/

Of the butterfly species contained in the Habitats Directive, three are butterflies and two are moths. The two moths (Spanish flag moth and willowherb hawkmoth) are rare, but are expanding farther north owing to the warming climate. The conservation status for the three butterflies is very unfavorable. In the 20th century, three butterfly species disappeared from the Netherlands: marsh fritillary, large blue, and scarce heath. The Apollo butterfly is a migrant species.

Population trend of diurnal butterflies

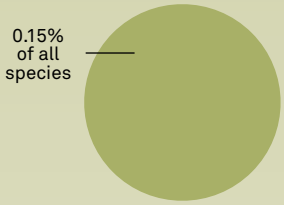
1992-2024 | 3 species evaluated



SOURCE: clo.nl/nl141414

Last year, the dusky large blue was no longer sighted, and for the large copper butterfly and the scarce large blue, the conservation status is very unfavorable, despite these butterflies showing tentative increases.

Dragonflies and damselflies

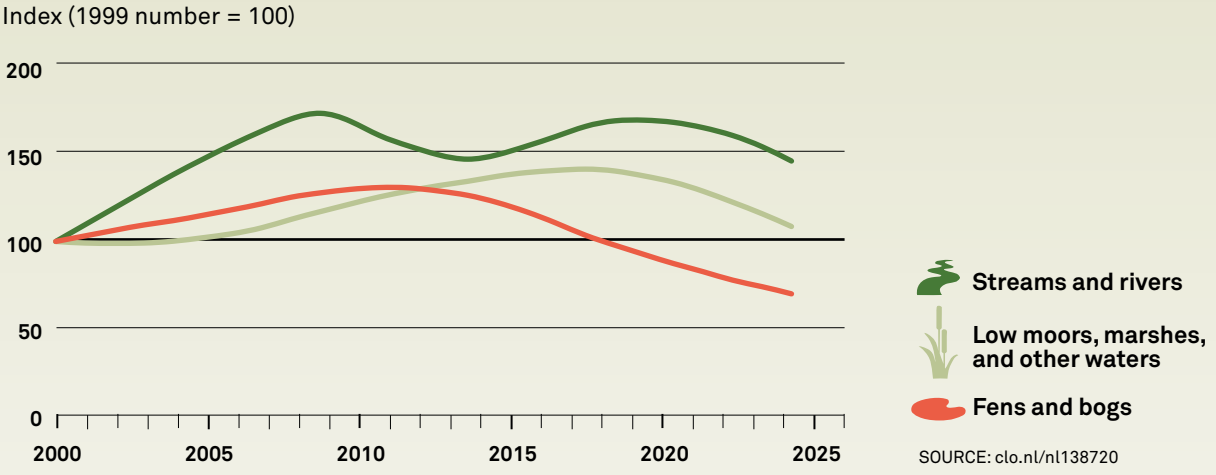


Number of species	69
Of which are exotics	0
Conservation status	✔
Red List	✔

COMMON SPREADWING | PHOTO: CEES DETERMANN

Population trend of dragonflies and damselflies

By landscape type | 47 species evaluated



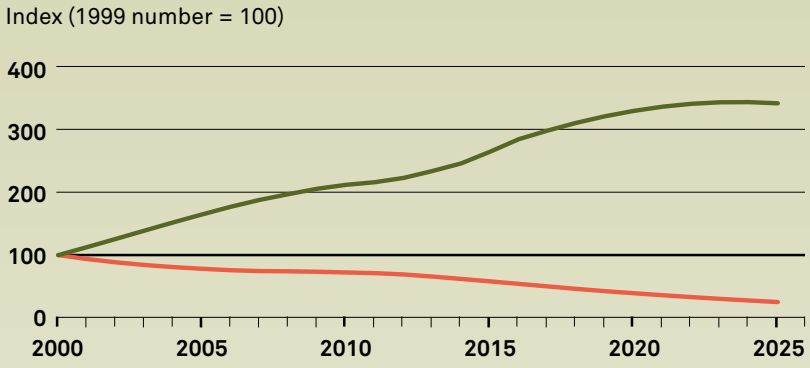
SOURCE: clo.nl/nl138720

Dragonflies and damselflies initially increased in both population size and geographical distribution in the 1990s, in part because of improved water quality and also due to climate change. Since 2008, a change can be observed, with distribution more or less having stabilized and population sizes decreasing.

The population trend of dragonflies and damselflies in 2024 was 28% lower than in 2008. Species that frequent streams and rivers are faring better than species inhabiting fenland and marshes, while the steepest decline is seen in species around fens and bogs.

Distribution trend of dragonflies and damselflies

By climate zone | 53 species evaluated

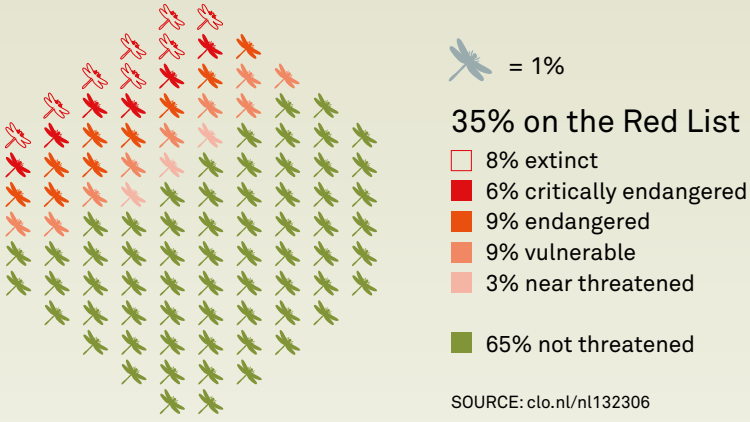


SOURCE: NEM (Vlinderstichting, Statistics Netherlands)

Strikingly, cold-loving species in the north show a sharp decline, while southern, heat-loving species have increased sharply. The cause for decline of northern species is likely a combination of heat stress and desiccation. Because of these opposing trends, the number of species on the Red List has hardly changed in recent years.

Red List

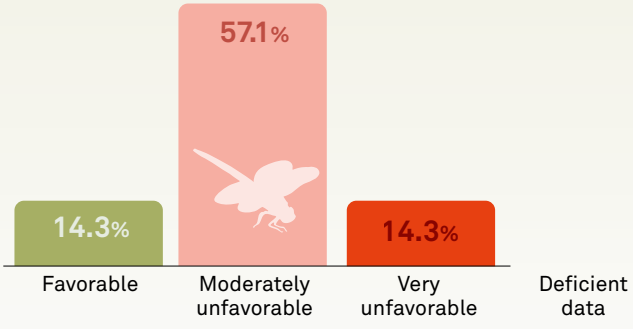
2011 | 65 species evaluated



SOURCE: clo.nl/nl132306

Conservation status

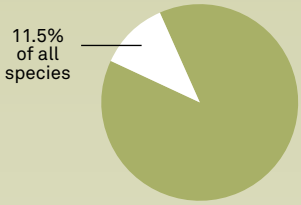
2013-2018 | 6 species evaluated



SOURCE: nature-art17.eionet.europa.eu/article17/species/report/

Nine dragonflies and damselflies are listed in the Habitats Directive. Some of these species continue to fare poorly. They show erratic patterns in distribution and numbers. For example, the green snaketail is increasing in number, but is found in only a few places in the Netherlands. The large white-faced darter has been declining sharply in numbers since 2010, but increasing in distribution. The green hawker is declining in both numbers and distribution, probably because invasive crayfish are causing a decline in water soldier, an aquatic plant important to the green hawker.

Bees, ants, and wasps



Number of species	Approx. 5,400
Of which are exotics	Approx. 90
Conservation status	–
Red List	✓ (bees only)
Note	This group includes parasitoid wasps (over 4,000), sawflies (over 500), bees (over 350), ants (over 100, of which 68 are native), and other wasp groups. The status of most species is not well known. None of these species are protected by EU law.

VERNAL COLLETES | PHOTO: CEES DETERMANN

Ants

42% of the native ant species are endangered according to the Ecological Atlas of Dutch Ants or *Ecologische atlas van Nederlandse mieren* (Boer et al., 2018). Nine species are in danger of extinction, with one already extinct. The red wood ant used to be protected, but are now only included in the Code of Conduct for Forest Management Species Protection. Six species are on the global Red List. The Netherlands is home to more rock ants than anywhere else in the world, especially in the Dutch dunes, as well as the very rare *Myrmica bibikoffi*. Some exotic ant species cause considerable problems, including the Argentine ant and the *Tapinoma nigerrimum*, which are found in urban areas.

ANT | PHOTO: RICK BUESINK

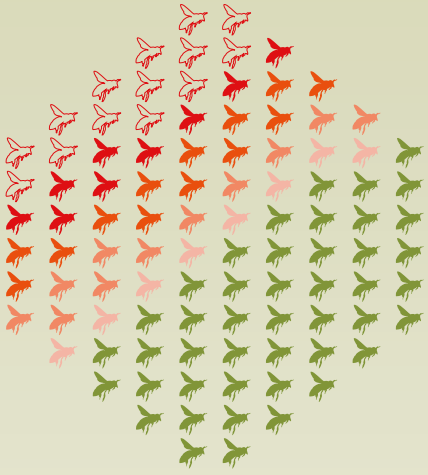
Wasps

Little is known about most parasitoid wasps, except those species used as natural enemies in horticulture. Of the other wasp species (about 350), at least 45% declined or even disappeared in last century (*De wespen en mieren van Nederland* (Peeters et al., 2004)). The invasive Asian hornet expanded rapidly after being introduced to southern France and feeds on a variety of insects, including honeybees kept by beekeepers.

PARASITOID WASP | PHOTO: CEES DETERMANN

Red List

2018 | 331 species evaluated



= 1%

55% on the Red List

- 14% extinct
- 9% critically endangered
- 13% endangered
- 11% vulnerable
- 8% near threatened

45% not threatened

SOURCE: clo.nl/nl132306

Of more than 350 species of wild bees, 181 are on the Red List and 46 have disappeared from the Netherlands. Of the 27 bumblebee species, seven have disappeared and 10 are on the Red List. Bees receive a lot of attention because most species are crucial for pollinating many wild plants and crops. Bees are included in the Nature Restoration Regulation, and EU member states will be required to monitor the status of wild bees within a few years. Through the National Bee Strategy, efforts are underway to restore wild bees in the Netherlands.

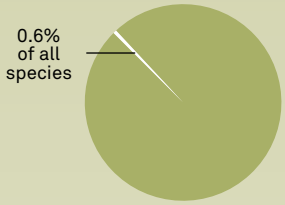
LOOKING TO THE FUTURE

Measuring biodiversity with AI image analysis

Mapping biodiversity with volunteers and professionals using manual counts and inventories takes a great deal of time. The use of drones and smartphones can help here. The FlowerPower project at Fontys University of Applied Sciences in Eindhoven has built an AI model that can not only recognize wildflowers, but also count them by species on a square-meter sample area. In this way, AI technology can be harnessed to gather valuable information about which plants occur in what area and in what numbers. This provides a more complete picture of local biodiversity. The technique is still developing, but the results are becoming more accurate. The project is now focusing on linking the AI model for monitoring wildflowers to a sensor, i.e. a smartphone and/or drone. One of the challenges is being able to identify a plant when it is not in bloom or when its flowers have already withered – but this is not impossible. Combining technology and biology opens up the possibilities. There are plans to incorporate the model and reference dataset with annotations into ARISE, including smartphone and/or drone connectivity, but there is still quite a bit of work to be done here.

Gerard Schouten, Fontys University of Applied Sciences

Mayflies, stoneflies, and caddisflies



Mayflies, stoneflies, and caddisflies are aquatic insects that are sensitive to changes in their habitats such as temperature, oxygen levels, and pollution, hence they are used by water boards and others as indicators of water quality. The term EPT, used for these indicators, comes from Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies).

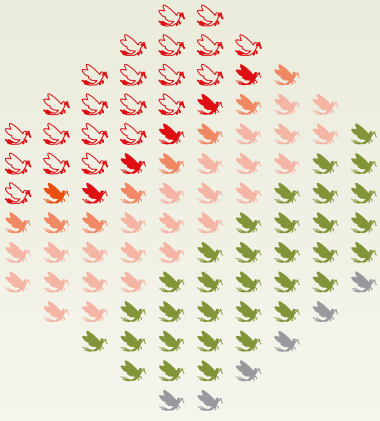
Mayflies

Number of species	64
Of which are exotics	Unknown
Conservation status	–
Red List	✓

MAYFLY | PHOTO: DAAN DRUKKER

Red List

2003 | 64 species evaluated



= 1%

61% on the Red List

- 22% extinct
- 5% critically endangered
- 1% endangered
- 8% vulnerable
- 25% near threatened

- 33% not threatened
- 6% data deficient

SOURCE: clo.nl/nl132306

Mayflies are insects with aquatic larvae and winged adults. They are mostly found around rivers, the higher sandy soils and the hilly South Limburg countryside. Clean, naturally flowing waters provide a habitat for most species. Some species are also found in still waters. In the right waters, hundreds of larvae can be found in a single square meter.

In the latter half of the 20th century, habitat destruction and declining water quality led to the disappearance of 26 species from the Netherlands. As water quality improved somewhat after the 1980s, two species returned. In addition, two others have recently been sighted as migrants.

Stoneflies

Number of species	28
Of which are exotics	Unknown
Conservation status	–
Red List	✓

STONEFLY | PHOTO: DAAN DRUKKER

Red List

2003 | 21 species evaluated

= 1%

90% on the Red List

- 42% extinct
- 5% critically endangered
- 5% endangered
- 33% vulnerable
- 5% near threatened

- 5% not threatened
- 5% data deficient

SOURCE: clo.nl/nl132306

Stoneflies are mainly found in and on the higher sandy ground, as well as the hills of South Limburg. The Springendalse Beek nature reserve in the eastern province of Overijssel and some streams in southern Limburg are each home to three species. Currently, only one species remains in most places with running water: the small dull brown (*Nemoura cinerea*). The decline of stoneflies is one of the most dramatic within Dutch fauna; most have disappeared as a result of pollution and straightening of streams and rivers. However, thanks to the restoration of the Roer river, one species has returned. In early 2010, a new species was also discovered in the Roer, whose population grew in 2025. Finally, the rediscovery of *Leuctra fusca* in 2024 suggests that the Geul river has at least partially recovered.

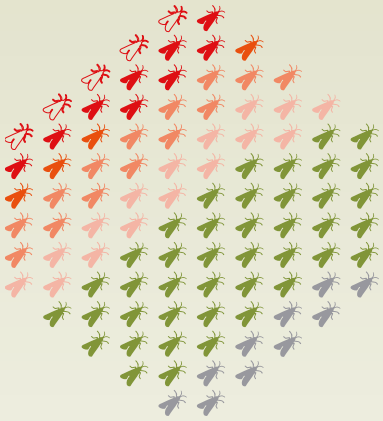
Caddiesflies

Number of species	184
Of which are exotics	Unknown
Conservation status	⊖
Red List	✓

CADDISFLY | PHOTO: CEES DETERMANN

Red List

2003 | 176 species evaluated



 = 1%

48% on the Red List

- 5% extinct
- 9% critically endangered
- 4% endangered
- 14% vulnerable
- 16% near threatened

- 42% not threatened
- 10% data deficient

SOURCE: clo.nl/nl132306

Caddiesflies are insects with hairy wings that look somewhat like moths. The low moorland and South Limburg hills are the richest in species, although as many as nine of them have disappeared from the Netherlands since 1758, likely due to habitat destruction and eutrophication. Some species that had disappeared from the Netherlands have recently resurfaced thanks to improvements in water quality. *Tinodes rostocki* was caught near Elsloo in Limburg in 2007. It remains to be seen whether this species will be granted "established" status.

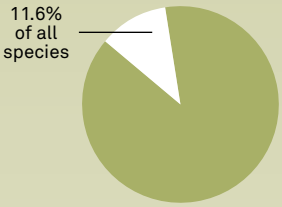
LOOKING TO THE FUTURE

Caddisflies as bycatch of moth monitoring nets

Water boards have been monitoring the larvae of caddisflies and mayflies using scoop nets as their standardized method for years. In recent years, citizen scientists have become increasingly adept at identifying caddisflies. Like moths, these nocturnal insects are attracted to light; as a result, moth enthusiasts using sheets or moth traps regularly come across them. It is then possible to identify them thanks to new determination tables and observation apps. After observers upload photos to Waarneming.nl, automatic image recognition is increasingly able to identify caddisflies and mayflies, which allows more and more new information about these insects to be gathered.

Roy Kleukers and Daan Drukker (EIS Kenniscentrum Insecten)

POPLAR | CEES DETERMANN



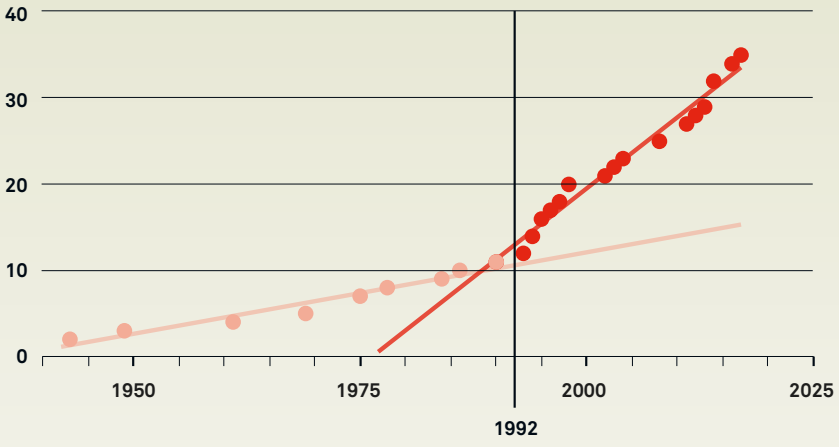
Flies and midges

Number of species	Approx. 5,450
Of which are exotics	Approx. 20
Conservation status	●
Red List	✔
Note	Within this group are 340 hoverflies which, along with bees, are our main pollinators.

FLESH FLY | PHOTO: CEES DETERMANN

Number of extinct species of hoverflies

Cumulative by year of last sighting
Periode 1940-2018 | 315 species evaluated



Hoverflies were split into a period before the trend shift in 1992 and thereafter.

Before the trend shift
Sighting
Trend

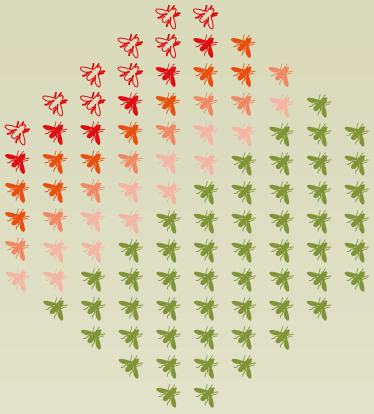
After the trend shift
Sighting
Trend

SOURCE: EIS KENNISCENTRUM INSECTEN

There has been an acceleration in the extinction of hoverflies since about 1990. This coincides with the widespread introduction into the Netherlands of neonicotinoids: nicotine-related insecticides. Pesticides are therefore suspected to be an important contributor to the decline of hoverflies. Other causes include intensification of landscape use and agriculture, eutrophication and acidification (due to excessive nitrogen and sulfur deposition), and climate change. Because these factors also apply at a national level, measures are also needed across the Netherlands to halt the decline of hoverflies.

Red List

2024 | 317 species evaluated



= 1%

46% on the Red List

- 9% extinct
- 6% critically endangered
- 10% endangered
- 8% vulnerable
- 13% near threatened

54% not threatened

WWW.CLO.NL/NL132306

Hoverflies have only featured in Dutch nature conservation policy since 2024. In that year, a Red List was drawn up, showing that 46% of native species are under threat or have even disappeared from the Netherlands already. Not only is hoverfly species diversity under pressure, but numbers are also in decline. A 40-year study carried out in the Veluwe region shows that there are 80% fewer hoverflies there today than in the 1980s.

DRONE BEE (A HOVERFLY) | PHOTO: CEES DETERMANN

MONITORING INSECTS AUTOMATICALLY

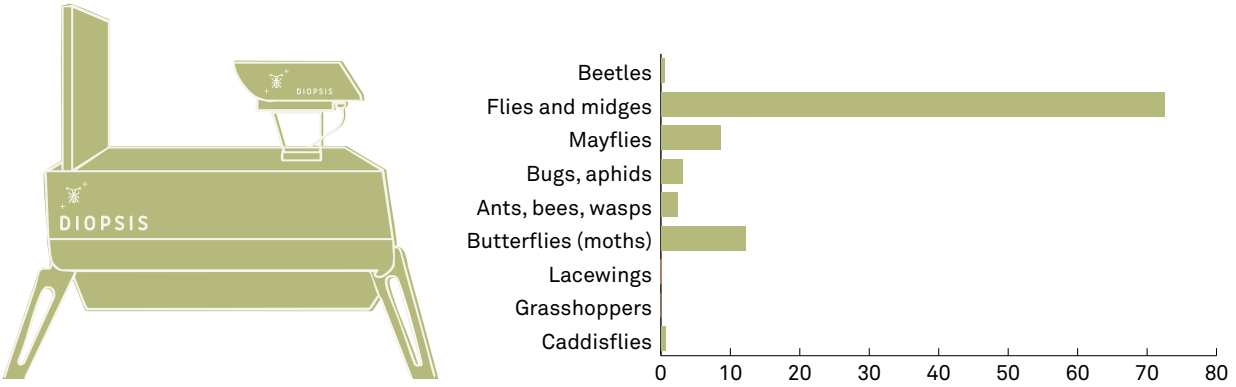
The DIOPSIS camera photographs, identifies, and monitors insects fully automatically. Moreover, the data generated by this system can support the recovery of other species, including the black-tailed godwit.

Monitoring insect biodiversity and biomass is traditionally done with malaise traps, pot traps, pitfall traps, nets, or walking transects to take counts. These methods provide reliable data and insights into the insect population, but are time-consuming and usually lethal to the insects collected. Innovative technologies make it possible to monitor insects in an efficient, autonomous, non-invasive, and non-lethal manner. One example is the DIOPSIS camera, a system in development since early 2019 by the DIOPSIS consortium (Naturalis Biodiversity Center, Faunabit, Radboud University Nijmegen, EIS Kenniscentrum Insecten, and COSMONiO/Intel).

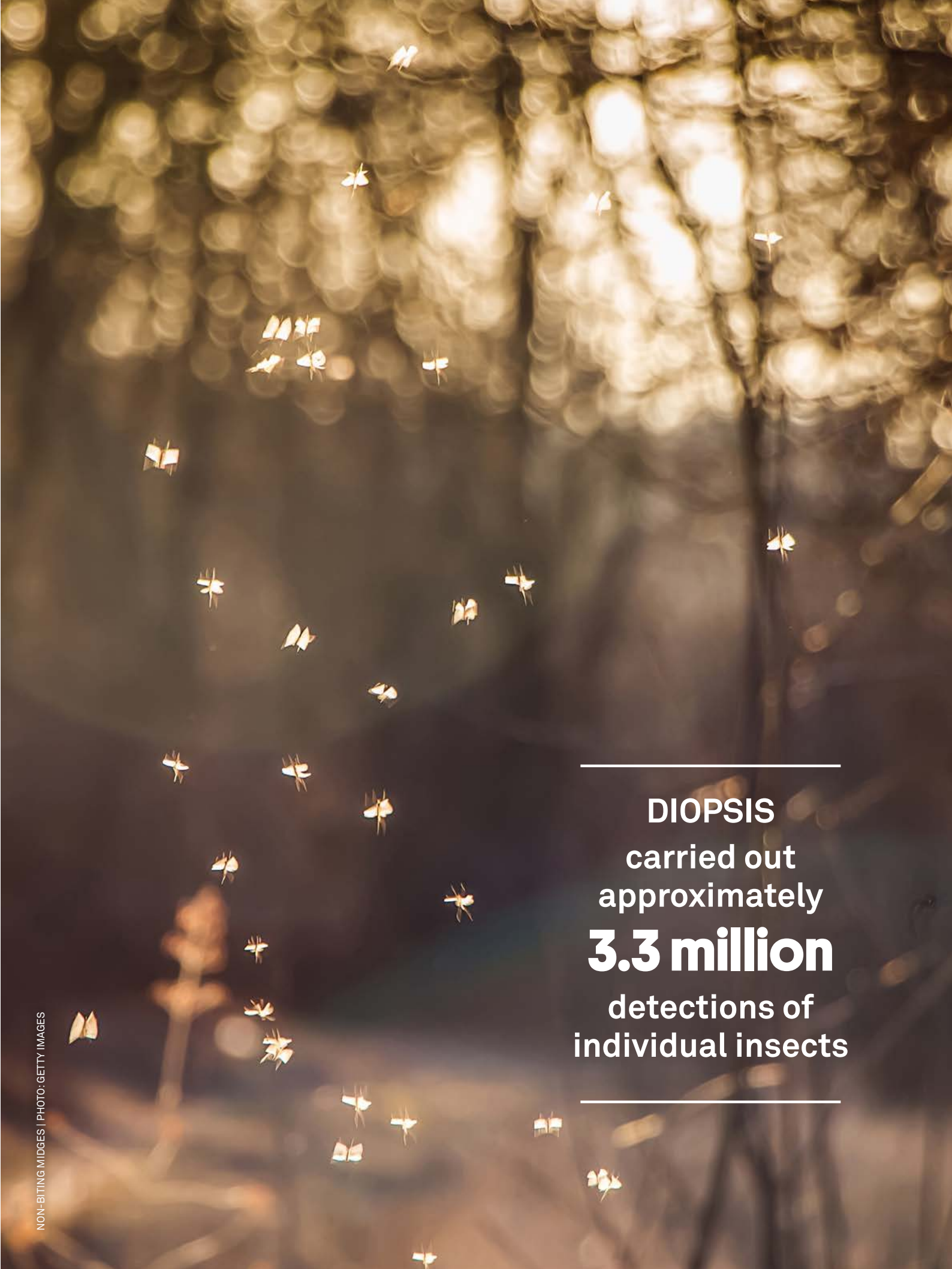
Over 70 locations

The camera is designed to photograph and identify insects in a fully automated way. The photos taken by this camera are analyzed with special image recognition software developed by Naturalis, which can identify insects, usually down to the family level. The algorithm also estimates the accuracy of that identification. Moreover, it measures the length of the insect and gives an estimate of its biomass on that basis.

Figure 1



The insect camera provides valuable data, producing images of a wide variety of flying and walking insects, including little-studied groups such as non-biting midges.



DIOPSIS
carried out
approximately
3.3 million
detections of
individual insects

NON-BITING MIDGES | PHOTO: GETTY IMAGES

A nationwide network of insect cameras will provide a wealth of reliable trend data

From 2021 until 2023, the camera was deployed at more than 70 locations in the Netherlands to monitor insects, taking more than 50 million photographs in the process. Image analysis of this data yielded a total of some 3.3 million detections of individual insects.

Vital food source

Long-term monitoring provides us with a better picture of how insects are faring in the Netherlands. We can use it to chart and understand trends in insect decline, and relate them to mitigation measures, where possible.

We can extract even more information from these data. Insects are a key source of food for other animals, especially birds and bats, including Red List species such as the black-tailed godwit and corn crake. Under the Dutch Environment and Planning Act, the conservation and restoration of Red List species is the responsibility of provincial governments (Article 3.57(1)(c), Quality of the Living Environment Decree). A better understanding of the food supply for these species and what policies help improve insect abundance can support this.

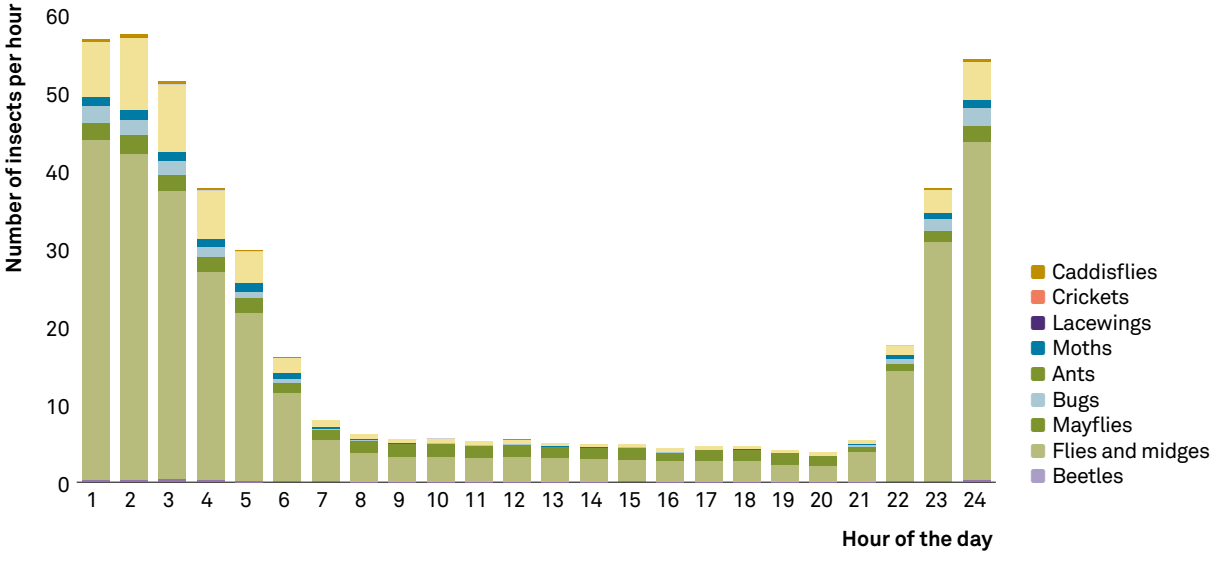
Non-biting midges

Other insectivorous species, such as the pond bat, are mentioned in the Habitats Directive and are therefore subject to the Environment and Planning Act. One of the largest species groups sighted by the cameras are non-biting midges (see "Flies and midges" in Figure 1 above), which are a crucial part of the pond bat's diet. The pond bat is not yet classed as endangered in the Netherlands, but its numbers have been declining for years, in part due to a shortage of food.

A nationwide network of insect cameras will provide a wealth of reliable trend data, including for species groups that play a major role in ecosystems but are hardly included in other monitoring networks. However, this does require long-term monitoring.

Chantal Huijbers and Laurens Hogeweg
Naturalis Biodiversity Center
Eelke Jongejans
Radboud University and **Stephan Peterse**
Faunabit

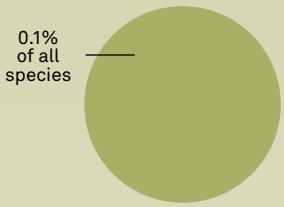
Figure 2



The LED lighting from the camera attracts nocturnal insects, which is reflected in the amounts of insects detected at night as opposed to during the day.

WHITE GARDEN SNAIL | PHOTO: CEES DETERMANN

Grasshoppers and crickets

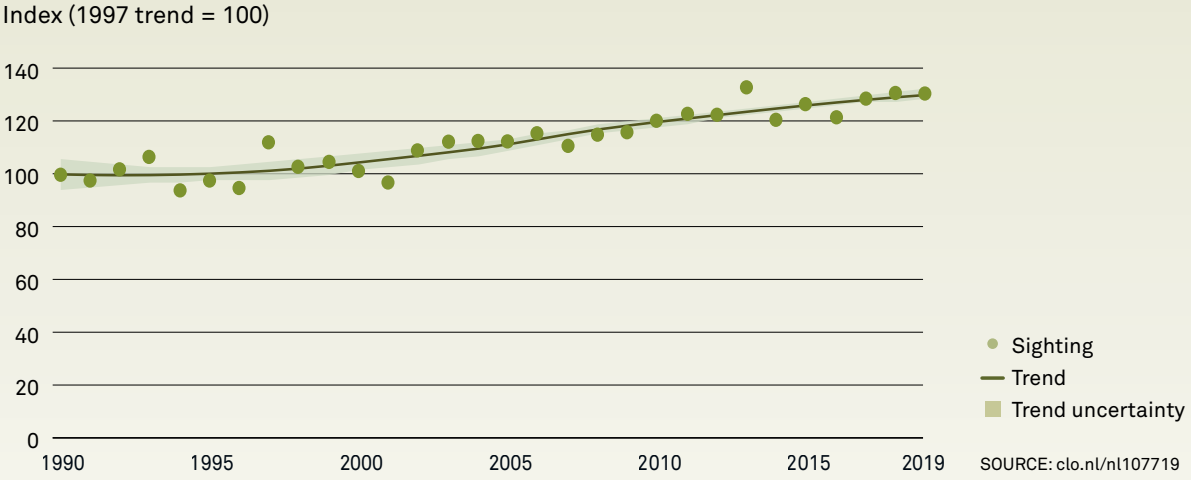


Number of species	50
Of which are exotics	5
Conservation status	–
Red List	✓
Note	The Netherlands is home to 50 species of grasshoppers and crickets. Thanks to two Atlas projects (1990–1995 and 2008–2015), we now have a good overview of this group. On top of that, many sightings are collected through Waarneming.nl, which allows Statistics Netherlands to determine annual trends for most species.

PHOTO: RENÉ KREKELS

Distribution trend of grasshoppers

1990–2019 | 35 species evaluated

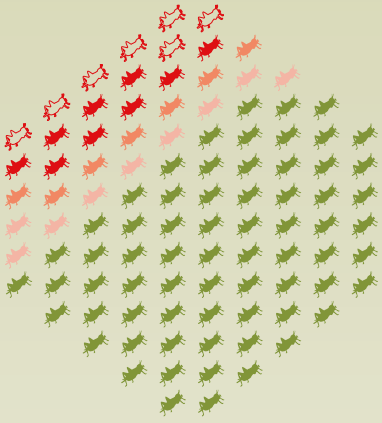


SOURCE: clo.nl/nl107719

Grasshoppers thrive on warmth, as demonstrated by the range expansion of southern species. As many as 12 species new to the Netherlands have been discovered since 1990, more than half of which can be related to the changing climate.
Grasshoppers achieve their greatest species diversity in open habitats on sandy soils. Because they are so abundant, they play an important role in grasslands, for example as bulk food for lizards and insect-eating birds. Shorthorned grasshoppers contribute to the grazing of grassland, by eating grasses, thereby contributing to floral diversity.

Red List

2012 | 44 species evaluated



= 1%

32% on the Red List

- 7% extinct
- 9% critically endangered
- 0% endangered
- 7% vulnerable
- 9% near threatened

68% not threatened

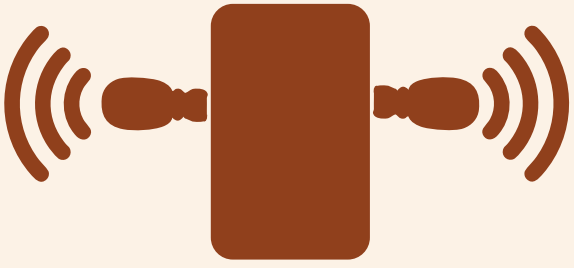
SOURCE: clo.nl/nl132306

The 2012 Red List contains 20 species of grasshoppers and crickets. Of these, three were considered extinct: the migratory locust, the rattle grasshopper, and the two-spotted groundhopper. However, the latter species was found again in the Veluwe in 2012.

LOOKING TO THE FUTURE

Using sound recognition as a tool for monitoring biodiversity

Applications with artificial intelligence (AI) can offer several solutions in measuring and monitoring changes in biodiversity. One such solution that Naturalis is working on, through projects such as Bioacoustic and ARISE, is AI sound recognition to assist with species identification. There are already several sound recorders on the market that can capture the frequencies of birds, bats, and insects such as crickets, grasshoppers, and cicadas. Along with input from experts, AI models are trained so they can tell exactly what species are present in an area. In the future, we might even be able to tell who is interacting with whom. Thus far, this technique has been successfully deployed for all bird species and a handful of grasshoppers and cicadas.

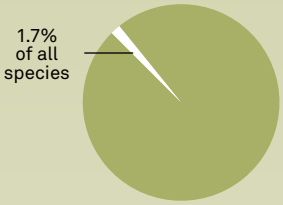


Naturalis is working hard to extend its application to amphibians, more insects, and even marine life. The beauty of this new technology is that it allows scientists to observe many more species than an individual or a wildlife camera ever could.

Dan Stowell, Bioacoustic AI project manager

STARFISH | PHOTO: MEREL BOZUA-HOPE

Crustaceans

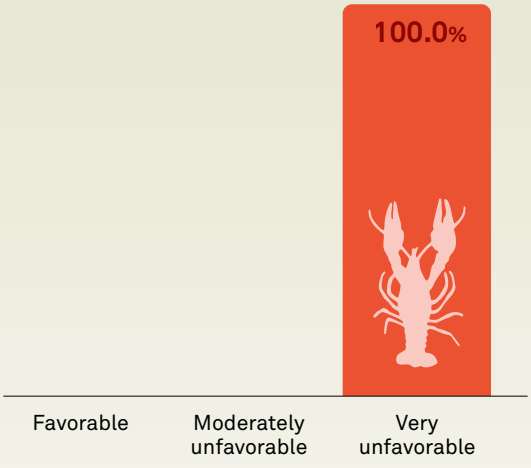


Number of species	Approx. 820
Of which are exotics	55
Conservation status	✔
Red List	–
Note	A diverse group of arthropods found in freshwater and saltwater, and to a lesser extent in brackish water and on land. Some species are parasites. Lobsters and shrimp are important for fishing.

LOUISIANA CRAWFISH | PHOTO: BRAM KOESE

Conservation status

2013-2018 | 1 species evaluated (European crayfish)



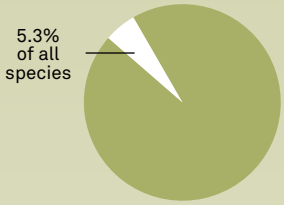
SOURCE: https://nature-art17.eionet.europa.eu/article17/species/report/

The state of Dutch crustaceans is reasonably well understood for some groups; particularly lobsters, crayfish, crabs, and shrimps. A lack of taxonomic knowledge makes the state of other groups much more difficult to assess.

We know that, on the one hand, species have disappeared due to loss of habitat. On the other hand, there are species new to the country such as climate shifters (in response to climate change) and alien species (due to human activity). Crawfish are a good example: the only native species has been reduced to a small area, while some 10 invasive species are thriving in Dutch waters. As a result, the conservation status of this native crayfish is very unfavorable.

An increase in knowledge has led to an increasing number of identified species, such as water fleas, opossum shrimps, hooded shrimp, isopods, and amphipods. The number of crustacean species is expected to increase further as our knowledge continues to expand.

Arachnids



Number of species	Approx. 2,500
Of which are exotics	Approx. 65
Conservation status	–
Red List	–
Note	In the Netherlands, mites are the largest group with about 1,557 species, while spiders are the best known with 705 species. In addition, harvestmen and ticks belong to this group, as well as pseudoscorpions (23 species) and short-tailed whip scorpions. The numbers of the latter are unknown. Because of their tropical origin, they are found exclusively in greenhouses.

Mites

Mites live in almost all habitats, can be parasitic or non-parasitic, and live on land or in water (both the sea and freshwater). Knowledge of many groups is fragmentary, but thanks to the work of a few researchers, water mites and land-based moss mites have been well studied.

Water mites (274 species) are good indicators of water quality, on the grounds of their complex life cycle, in which the larvae parasitize insects and thus depend on their hosts. In addition, water mites are sensitive to changes in their immediate habitat, with varying tolerances for pollution, acidity, oxygen levels, and other water parameters. Water boards therefore use these species in macrofauna research. Furthermore, they are specified in the Water Framework Directive. Twelve species of water mites have disappeared from the Netherlands.

Of the moss mites, 375 species are known; 13 species have not yet been scientifically published. The total number of species of mites in the Netherlands will certainly increase if more research carried out on these thus far poorly mapped groups.

WATER MITE | PHOTO: JASPER NANCE

Spiders

There is no Dutch Red List for spiders. One notable species, the great raft spider, does enjoy legal protection, as it is classified as “vulnerable” on the IUCN Red List. This species lives in riparian vegetation in low moorland lakes and waterways, and can become common in those habitats. It hunts aquatic insects and, exceptionally, fish and tadpoles.

A second notable species to inhabit Dutch wetlands is the diving bell spider, which builds a web underwater between aquatic plants, introduces air into it, and lives in its diving bell as if it were on dry land. The number of sightings of this species has declined sharply since 2010. Possible causes are deteriorating water quality and the Louisiana crawfish, an exotic that eats away all aquatic plants.

There has been a notable increase in non-native spiders emerging in garden centers and import companies, among others. The false wolf spider, for example, came in from southern Europe in 2007 and is now found across the Netherlands. The Australian grey house spider can also be found everywhere, although usually well hidden in cracks and crevices behind its characteristic web (see Figure 1). A few exotic species can cause medical discomfort through bites, but none of them have been able to establish and reproduce permanently in the Netherlands so far.

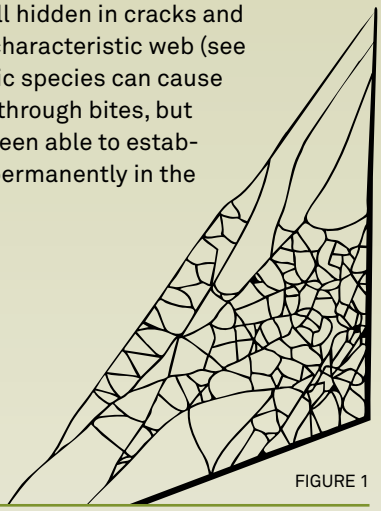


FIGURE 1

LOOKING TO THE FUTURE

Monitoring using image recognition

The rise of observation apps such as Waarneming.nl has greatly increased the number of recorded sightings of spiders and other species in recent decades. The Netherlands has an exceptionally high observation density, with approximately 3,000 reports per km² (worldwide average: 6 per km²). Automatic image recognition has been available since 2017. Nevertheless, the picture for spiders is distorted: some 40% of records concern only four common, conspicuous species (European garden spider, nursery web spider, wasp spider, and zebra spider), possibly due to their size and striking appearance. As a result, the smaller, less conspicuous of the approximately 700 Dutch spider species are underrepresented. Despite this bias, public reporting systems provide valuable data and help engage citizens in nature monitoring. Increasingly accurate automatic image recognition, combined with data from scientific collections (providing historical material and DNA analysis), can be used in advanced computational models to form an increasingly complete picture of biodiversity, including smaller species such as spiders.

Jeremy Miller
Naturalis Biodiversity Center

GREAT RAFT SPIDER | PHOTO: GETTY IMAGES

HOW TECHNOLOGY IS ENGAGING THE PUBLIC IN SPECIES COUNTS

Websites, apps, and AI are enabling more and more non-experts to contribute to species sightings – providing a significant boost to the development knowledge of Dutch biodiversity.

A number of species groups have been under monitoring for some time, sometimes by professionals, but often by volunteers. The latter is especially true for species groups that have their own fan club. Sovon, for example, has more than 5,000 members who observe birds, while Vlinderstichting volunteers monitor butterflies on more than 1,400 routes and count dragonflies and damselflies on more than 500 routes.

In addition to these organized sightings, other observers and sightings have proliferated over the past 25 years. These "opportunistic sightings" are increasingly used to determine biodiversity patterns and represent a growing proportion of total species sightings. Websites and apps such as Waarneming.nl have made it possible for non-experts to contribute. They can post photos on the platform, which are later reviewed and validated by experts.

Identifying species with AI

This leads to reliable sightings in locations not visited by experts. If we look at the hoverflies, for example, a group with more than 300 species in the Netherlands, we find that, around the year 2000, only 10% of sightings came from non-experts. This proportion had risen to 80% by 2010 and to 90% by 2020.

Research does show that non-experts have a greater tendency than experts to notice species that are common or large, have distinct color patterns, and occur in urban areas. It is not clear whether this is because experts are focused on the special species or non-experts are just not as adept at recognizing them.

A second, more recent revolution in species observation is automatic image recognition. For example, the popular app ObsIdentify can identify a photo of an animal, plant, or mushroom thanks to AI. It provides a species name, along with an indication of how reliable the identification is, which gives observers a direct insight into what they see before them. This sighting can then be saved, increasing our overall knowledge of our biodiversity.

Innovative technology

The majority of sightings of mushrooms, plants, mollusks, many invertebrates, and others, now come from the ObsIdentify app. Even for difficult-to-photograph groups such as fish, mammals, algae and seaweeds, and dragonflies and damselflies, 10 to 30% of sightings come from this new source (see Figure 1).

Not all species are easily identified in a photograph. There are often cryptic species that look identical, or distinctive features are not easily seen in a photograph.

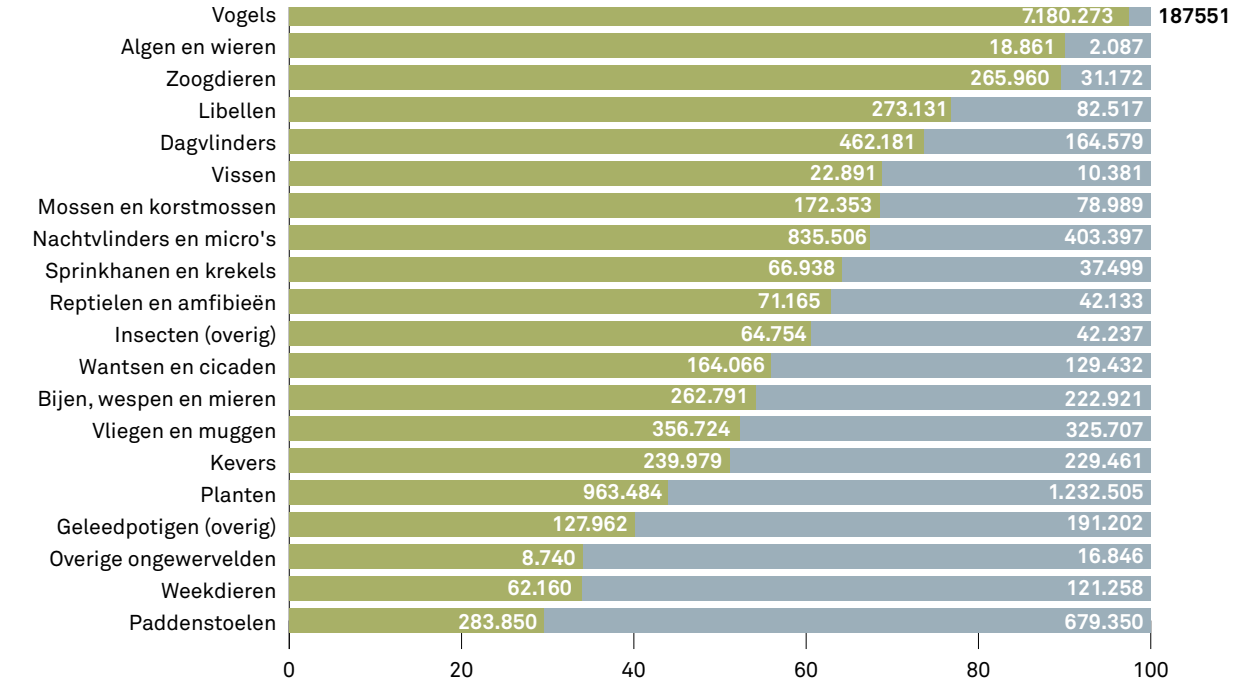
HOVERFLY | PHOTO: GETTY IMAGES

In 2020,

90%

of hoverfly sightings were recorded by non-experts

Figure 1: Number of sightings for species groups in 2024, by source



This figure shows the proportion of ObsIdentify sightings compared to "regular" sightings in 2024 uploaded to Waarneming.nl. There is a striking difference between species groups in the proportion of sightings reported through ObsIdentify. There is a higher proportion of ObsIdentify sightings for species groups that are easier to photograph. For species groups that are most popular with traditional observers or that require specific techniques to observe, ObsIdentify contributes relatively little.

SOURCE: Waarneming.nl | Adapted by Natuurpunt Studie

Non-expert sightings are increasingly being used to determine biodiversity patterns

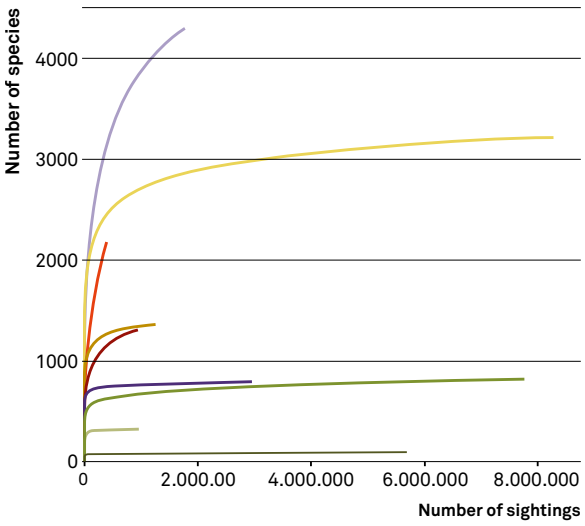
But even for the smaller, trickier groups of species, this innovative technology is very effective (see Figure 2). Reliable sightings of thousands of species of fungi, plants, beetles, flies, and wasps are available, and in many groups, the majority of species are sighted. The latter is evidenced by the deflecting curves showing that with more sightings, new species are no longer being discovered.

Much better coverage

As with any innovation, the pros and cons must be carefully considered. The benefits are better coverage of sightings across the Netherlands, more than the small number of experts could ever manage. The number of ObsIdentify users has increased dramatically in recent years, with more than one million in the Netherlands since 2020, including 515,000 joining in 2024 alone. The disadvantage is that the harder-to-identify species are less commonly observed, and each analysis needs to factor in the rise and change in user activity. Old data cannot be easily compared with new data, but this is a matter of time and smart analysis. On the whole, this is a very positive development for our knowledge about biodiversity of the Netherlands.

Koos Biesmeijer & Jordy van der Beek
Naturalis Biodiversity Center

Figure 2: Saturation curves of species under observation

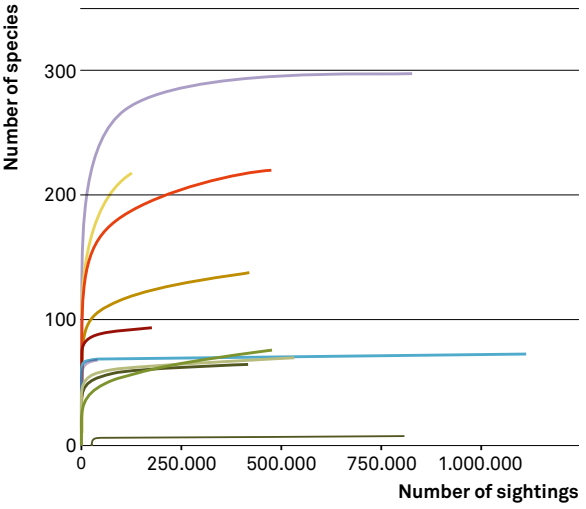


Species

- Fungi
- Plants
- Ants and wasps
- Micro moths
- Bugs and cicadas
- Macro moths
- Birds
- Bees
- Butterflies

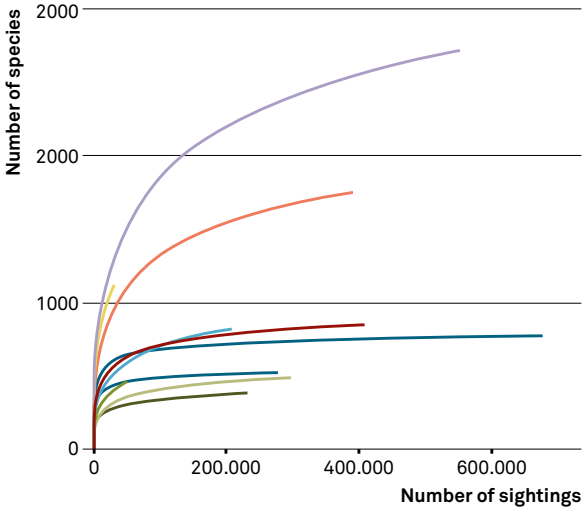
These saturation curve graphs show relationship between the total number of sightings and the number of species observations recorded on Waarneming.nl since its inception in 2004. For species groups that have been very well studied, this curve has fully flattened for the number of species found in the Netherlands. In less well-studied groups, the curve has not yet flattened completely. Only species with at least one sighting approved by admins were used. Uncertain and zero sighting, as well as sightings that were "rejected", "pending", or "(not yet) assessable", are not included in this analysis.

SOURCE: Waarneming.nl | Adapted by Natuurpunt Studie



Species

- Hoverflies
- Leaf beetles
- Fish
- Mammals
- Longhorn beetles
- Dragonflies and damselfies
- Fruit flies
- Reptiles and amphibians
- Grasshoppers and crickets
- Ladybugs



Species

- Flies and midges (other)
- Algae, seaweeds, and unicellular organisms
- Beetles (other)
- Lichens
- Mollusks
- Arthropods (other)
- Mosses
- Invertebrates (other)
- Spiders
- Insects (other)


People are
100%
dependent on nature
for drinking water, food,
resources, medicine, and our
spiritual well-being

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