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ENVIRONMENTAL REPORT

North Rhine-Westphalia 2020

INFORMATION ABOUT THE COVER PHOTO

Tiger and Turtle is an interactive art installation at Angerpark, a rewilded former slag heap at a zinc works in Duisburg. With its immanent dialectic of speed and deadlock, *Tiger and Turtle* refers to the situation of change in the region and its turn towards renaturation and restructuring," say the sculptors Heike Mutter and Ulrich Genth. The installation resembles a roller coaster and links back neatly to the environmental data and diagrams in this report. It was built as part of the RUHR.2010 European Capital of Culture and partly financed by the state of North Rhine-Westphalia using funds from the Emscher-Lippe regional ecology program.

ENVIRONMENTAL REPORT
North Rhine-Westphalia 2020

FOREWORD

Ladies and Gentlemen,

Soil, water, air, and biodiversity are all essential to human life. But these natural resources are vulnerable and not available to us in unlimited quantities. What condition is our environment in? How is it coping with the strains it is being put under? The Environmental Report North Rhine-Westphalia 2020 lifts the lid on these questions. Using an extensive set of environmental indicators, up-to-date data, well-founded analysis, and national and international frameworks, the report paints a comprehensive picture of our environment focusing on the following topics:

- Climate, energy, efficiency
- Environment and health
- Waste, soil, water
- Nature and rural areas

We take great pride in seeing many of the indicators moving in the right direction and initiatives in North Rhine-Westphalia having a positive impact, as the latest Environmental Report shows. For example, greenhouse gas emissions in North Rhine-Westphalia declined to 227 million metric tons in 2019, a decrease of 38 % compared to 1990. The first step toward reducing greenhouse gas emissions by at least 2 % by 2020 was achieved in 2017.

We have also made clear progress when it comes to air quality in our cities: The air in North Rhine-Westphalia has become cleaner. A number of technical and organizational measures are having a proven effect, including the air quality plans drawn up by district government. Particulate matter pollution in urban environments has decreased steadily in the past few years and is now significantly below the annual limits. We have also achieved notable reductions in nitrogen dioxide pollution, with the number of municipalities reporting measurements above annual limits falling from 27 in 2017 to just 8 in 2019. In 2020, limits were complied with at all sample sites in North Rhine-Westphalia for the first time. The annual mean at the traffic measuring stations declined by an average of approximately 17 % year on year. Complying with these limits across the board is an important milestone in our efforts to improve air quality.

There is also an urgent need for action when it comes to land usage. The state government aims to counteract the use of open countryside – especially agricultural land. With this in mind, we have put together a package of measures to promote intelligent and efficient land development to further contain land usage. After all, there are limits to the amount of land we can use. Diverging requirements lead to usage conflicts, making soil and land increasingly scarce as a natural resource. The package of measures to promote intelligent land usage will help to further reduce the amount of land being consumed in North Rhine-Westphalia going forward.

There are also limits to our water resources. At first glance, it might appear that water is available in abundance, with countless reservoirs and lakes, as well as some 50,000 kilometers of streams and rivers, dotted around North Rhine-Westphalia. However, water is a natural resource that is highly dependent on the weather and climatic conditions. Our climate is changing markedly, and we are experiencing extended periods of drought as well as heavy rainfall events, even here. Water resources may become overstrained in certain areas. We must prevent potential conflicts of usage by being proactive and working together. Unrestricted access to drinking water must always be a top priority, which is why we are enshrining this principle in state water laws.

The condition of our forests is also a cause for concern. Storms with hurricane-force winds, extended periods of extreme heat and drought, unprecedented levels of bark beetle infestation, and substance deposits in the soil have decimated the trees in our forests over the past few years. In many areas, large patches of brown, dead spruce forest can be seen with our own eyes. It is high time that we act, which is why we are striving to create more diverse, climate-stable mixed forests, supported by our reforestation concept and subsidy programs. Mixed forests are the key to species diversity, plus they are more resistant and pose less risk than coniferous forests in a changing climate.

These examples underline the importance of the Environmental Report as a yardstick of our efforts to protect our environment. This report provides an in-depth look at the condition of our environment and acts as a compass to show us where we need take action to conserve the natural world.

The NRW Sustainability Strategy is also part of our efforts in this area. The strategy, a revised version of which was adopted on September 22, 2020, presents North Rhine-Westphalia's contribution to realizing the global 2030 Agenda in consideration of the challenges and opportunities specific to the state. At its core are a diverse range of principles and goals defined in line with the United Nations' 17 Sustainable Development Goals. The strategy is also based closely on Germany's National Sustainability Strategy, with the aim of ensuring that efforts at a national and state level complement each other.

In December 2020, the state government also adopted a draft version of Germany's first climate change adaptation legislation. With this new law, we want to send a signal that we value adapting to climate change just as highly as protecting the climate. The aim of the legislation is to improve our resilience against the adverse effects and risks of climate change and minimize the damage to the natural world and society as a whole. We intend to start a new chapter in our environment and nature conservation policy focused on our two cornerstones, the NRW Sustainability Strategy and climate change adaptation laws, as well as the continuation of our biodiversity strategy, a nature conservation report planned for fall 2021, our forest management and reforestation concept, and many other initiatives. The Environmental Report provides a snapshot of the current situation and serves as a basis for successful and lasting environmental protection in our state.

I would like to thank everyone involved in putting this Environmental Report together. I hope you enjoy reading this report and find it just as interesting and insightful as I do. Let's work together on protecting North Rhine-Westphalia's environment – it's worth our while.

Regards,

Ursula Heinen-Esser
Minister for the Environment, Agriculture,
Conservation and Consumer Protection
of the State of North Rhine-Westphalia

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METHODOLOGY

The 5th Environmental Report is published on the basis of the North Rhine-Westphalia Environmental Information Act (Umweltinformationsgesetz) adopting the Public Access to Environmental Information Directive (2003/4/EC) and the German Environmental Information Act (Umweltinformationsgesetz). It contains information about the quality of our environment and the stresses and strains our environment is exposed to.

The report is structured in line with the state's environmental indicators | www.umweltindikatoren.nrw.de. This set of indicators is largely consistent with the set approved by the Conference of Environmental Ministers (Umweltministerkonferenz) and is included in the reporting of the Federal Government/Federal States Working Group on Climate, Energy, Mobility and Sustainability (Bund-Länder-Arbeitsgemeinschaft Klima, Energie, Mobilität und Nachhaltigkeit), as well as the Länder Initiative on Core Indicators (Länderinitiative Kernindikatoren) | www.liki.nrw.de. It also accounts for a large majority of the indicators used in the NRW Sustainability Strategy (Nachhaltigkeitsstrategie) | www.nachhaltigkeit.nrw.de.

Environmental indicators are statistical parameters that provide information about particular circumstances, conditions, or changes. They have been linked up with the goals of the state government or legal requirements and reviewed using trend analysis that is then used nationwide. The analysis usually determines linear developments over the past 10 years, with upward-facing arrows indicating rising trends, horizontal arrows showing stagnation, and downward-facing arrows pointing to declines. Green is a positive trend, amber a stagnating trend, and red a negative trend. Trends are not presented if they are not significant, if they are not based on a minimum of 7 values, or if there is a gap in the data.

Much of the data presented in this report is reported to the German federal government and the European Union according to defined standards. Every year, for instance, North Rhine-Westphalia reports nitrate data from its 115 groundwater measuring stations to the European Environment Agency (EEA) through the German Environment Agency (Umweltbundesamt). Only the groundwater measuring stations located in areas of farmland (60 stations) are used for reporting under the EU Nitrates Directive (91/676/EEC).

Alongside this form of representative data gathering, the report also contains data with other formulations, methods, and/or observation intervals that can provide differentiated results that cannot be discussed in full detail in this report. One example is the evaluation of the chemical and quantitative status of groundwater, which takes place every 6 years. The 3rd groundwater assessment took place in North Rhine-Westphalia on the basis of annual investigations of some 1,500 Water Framework Directive measuring stations between 2013 and 2018. Nitrate is just one of the parameters investigated.

Climate, energy, and efficiency in North Rhine-Westphalia

Increase air in mean annual temperature

1.7 °C

since 1881

State temperature record

41.2 °C

in Duisburg-Baerl and Tönisvorst in July 2019

Apple blossom – start of full spring

17 days

earlier in the year since 1951

Trend ↘

Resource productivity

26%

increase compared with baseline year of 1994

Trend →

Delivered energy productivity

45%

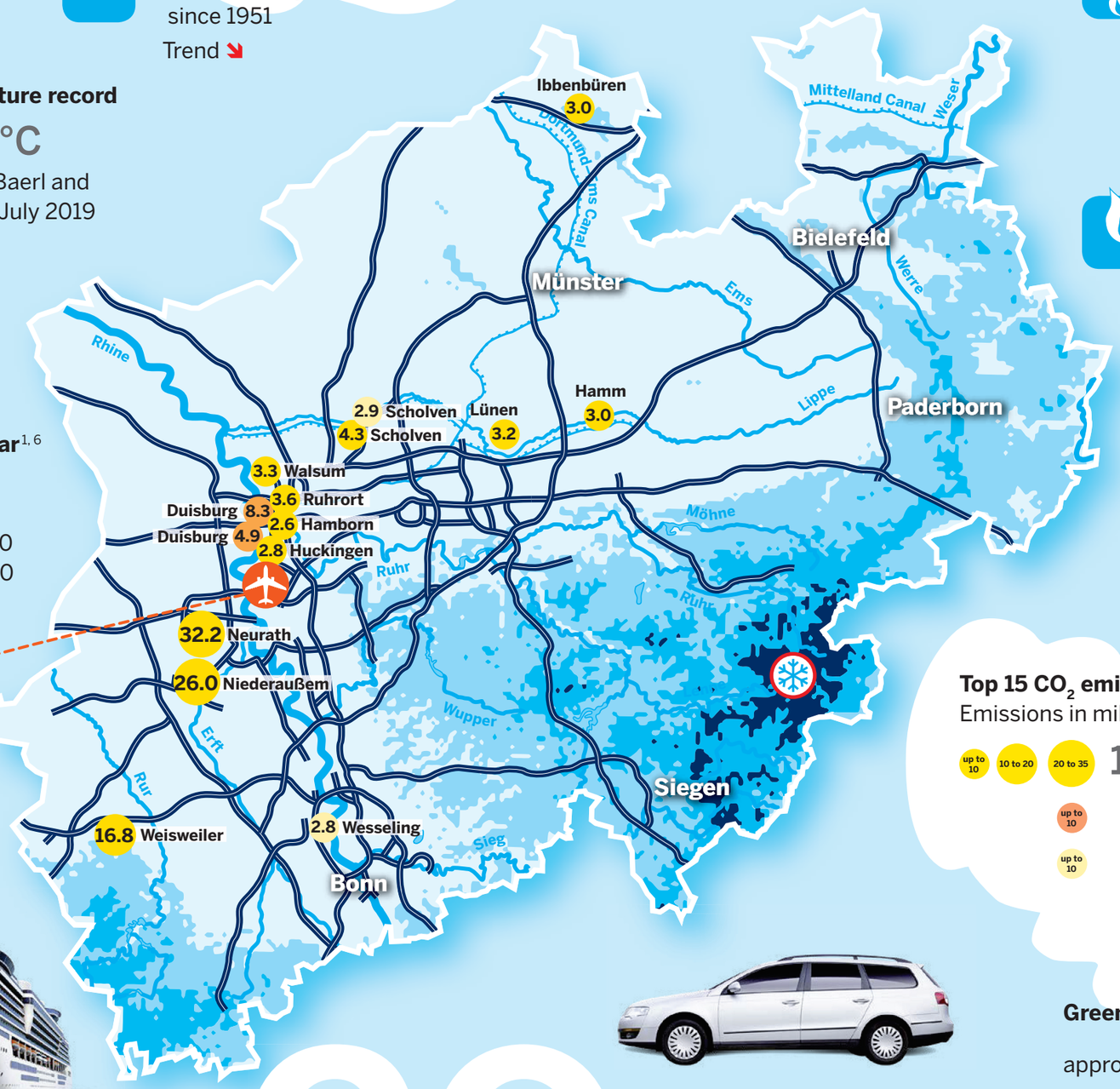
increase compared with baseline year (1991)

Trend ↗

Primary and delivered energy consumption

Trend ↘ 3,729 petajoules

Trend → 2,119 petajoules



Decrease in no. of snow cover days[1, 5]

31 days

at the Kahler Asten weather station since 1955

No. of snow cover days per year[1, 6]

1990–2019

- Up to 20
- > 20 to 40
- > 40 to 60
- > 60

CO_2 emission round-trip

Düsseldorf–Auckland, New Zealand[3]

approx. 9.7 t per person

Top 15 CO_2 emitters in 2018[2]

Emissions in million t

- up to 10 / 10 to 20 / 20 to 35: 11 power plants
- up to 10: 2 metalworking plants
- up to 10: 2 crude oil refineries

CO_2 emissions on a cruise ship

2-person cabin, 9 days, 6 ports of call[4]

approx. 3.3 t per person

CO_2 emissions in a mid-size car

12,000 km, combustion engine[3]

approx. 2.0 t

Share of renewable energies

14% of gross power consumption

5% of primary energy consumption

Trends ↗

Greenhouse gas emissions

approx. 227 million t CO_2 equivalents

in 2019, i.e., approx. 12.6 t per capita

Trend ↘

Sources: 1 DWD 2020, LANUV 2020 ▪ 2 LANUV 2020 ▪ 3 atmosfair 2020 ▪ 4 myclimate Germany 2020 ▪ Map: Geobasis NRW 2014

Definitions: 5 Full snow cover ≥ 10 cm ▪ 6 Morning snow depth > 1 cm

CLIMATE CHANGE, IMPACTS, AND ADAPTATION

THE TIME TO ACT IS NOW!

According to a recent publication jointly authored by four German scientific institutions, "The current, human-induced climate change is without parallel in the history of humankind, and it brings with it living conditions with which humanity has never before been confronted" (from *Fakten aus der Wissenschaft zu aktuellen Debatten rund um den Klimawandel*) |↗ www.umwelt2020.nrw.de/001. The result? Melting ice sheets and rising sea levels, changing air and ocean currents, burning forests and dying coral reefs, hurricane-force winds and floods, tremendous heat and extended periods of drought.

In a special report published in October 2018 entitled *Global Warming of 1.5 °C*, the IPCC writes that human activity has already caused global warming of roughly 1.0 degree Celsius (°C) compared to pre-industrial levels. Given this fact and many other scientific sources, the inter-institutional EU report *Global Trends to 2030. Challenges and Choices for Europe* paints a very gloomy picture: "An increase of 1.5 degrees is the maximum the planet can tolerate; should temperatures increase further beyond 2030, we will face even more droughts, floods, extreme heat and poverty for hundreds of millions of people; the likely demise of the most vulnerable populations – and at worst, the extinction of humankind altogether."

WHAT IS THE GREENHOUSE EFFECT?

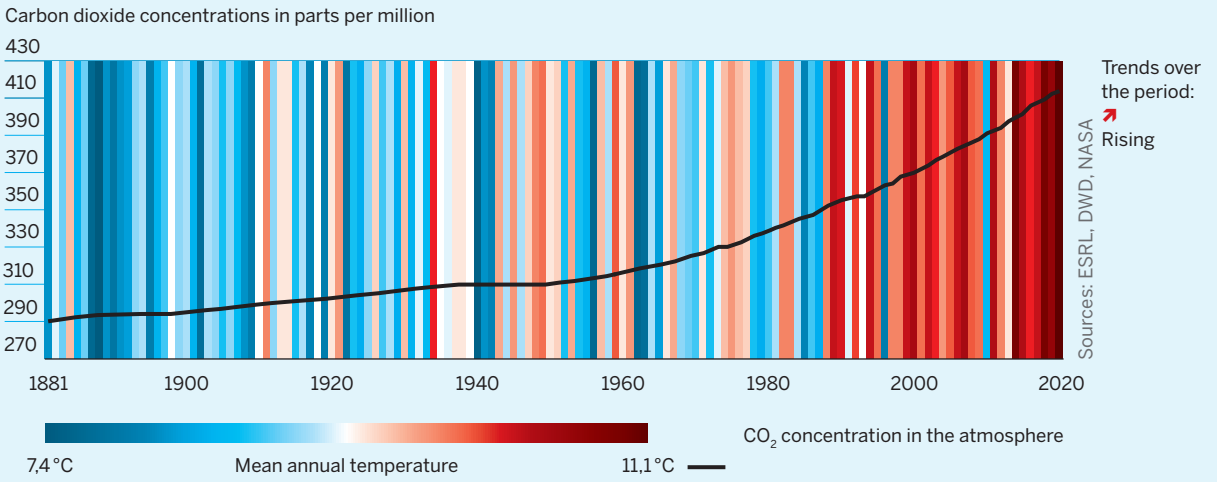
The greenhouse effect refers to the effect of greenhouse gases such as carbon dioxide (CO_2), methane, and nitrous oxide on the atmosphere |→ page 21. Put simply, shortwave solar radiation warms the surface of the earth, which emits longwave radiation that is largely absorbed by greenhouse gases and clouds and is radiated in all directions. The downward flow of this radiation warms the lower layers of air and the surface of the earth, accounting for the greenhouse effect. While the greenhouse effect makes it possible for life to exist on earth, excessive greenhouse gas emissions lead to global warming.

RISING MEAN AVERAGE TEMPERATURES – OBSERVED AND PROJECTED

Without question, the impact of global climate change can already be seen clearly in North Rhine-Westphalia. Examples include an increased risk to health due to heat stress – especially in our urban agglomerations – crop failures, record low water levels, increased extreme weather events, and a massive increase in forest damage |→ pages 90, 71, 17 and 86. Since the start of regular weather observations in 1881, the mean annual temperature in North Rhine-Westphalia has already risen by 1.7 °C. At 11.1 °C, 2020 set a new annual mean temperature record |→ figures 1 and 2, |↗ www.umwelt2020.nrw.de/002, |↗ www.umwelt2020.nrw.de/003.

The German Meteorological Service recently calculated results for North Rhine-Westphalia for various climate scenarios based on representative IPCC projection pathways. According to the findings, a further rise in temperatures is virtually guaranteed. A temperature increase to between roughly 12.0 and 13.9 °C on average over the course of a year for a 30-year period from 2071 to 2100 can be expected under projections for the RCP 8.5 "business-as-usual" scenario, which assumes very high radiative forcing (mean 70% of 21 individual runs, see spaghetti plot |→ figure 2). A temperature increase to between roughly 10.4 and 12.3 °C can be expected for this period under the moderate RCP 4.5 "stabilization" scenario (mean 70% of 12 individual runs). By contrast, hopes of a mean annual air temperature of between roughly 9.7 and 11.1 °C for the final three decades of the 21st century remain under the RCP 2.6 scenario, which is largely compliant with the Paris Agreement and assumes a very ambitious reduction in greenhouse gas emissions (mean 70% of 11 individual runs).

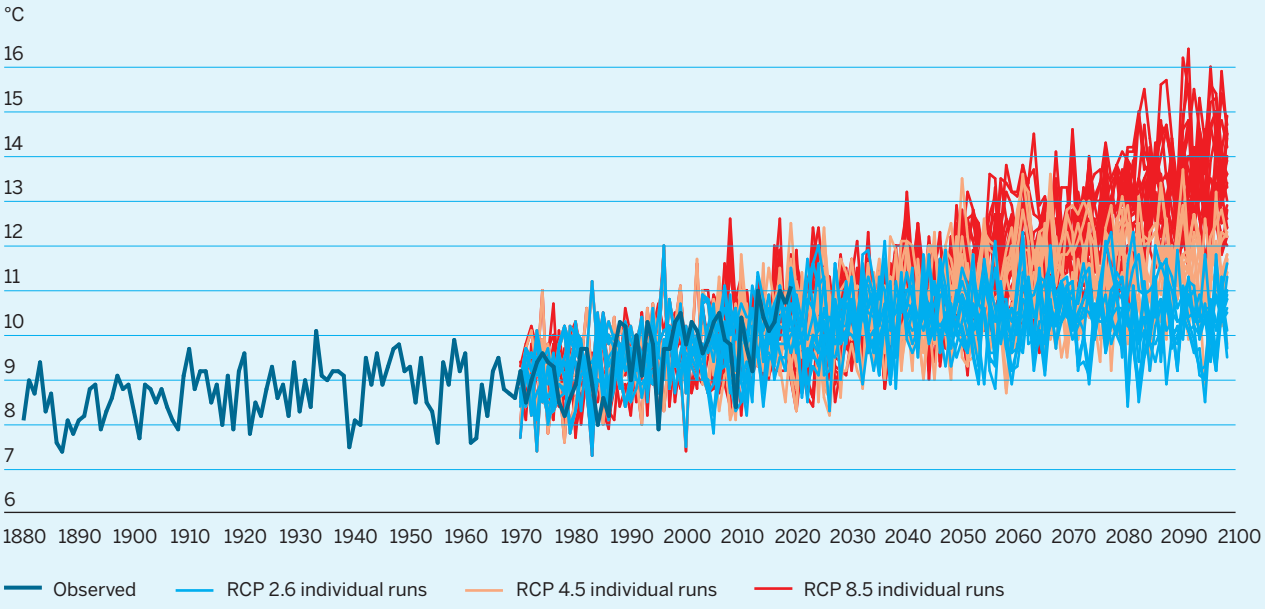
Figure 1 **NRW environmental indicator: warming stripes and global carbon dioxide concentration**



Seen here are the annual mean temperatures in North Rhine-Westphalia since the start of regular observations in 1881 using Hawkins' warming stripes with a bipolar sequential color scale ranging from 7.4 °C (dark blue, 1888) to 11.1 °C (dark red, 2020). The CO_2 concentration in the global atmosphere, which plays a significant role in the greenhouse effect, is superimposed over the stripes to illustrate the connection between temperature and CO_2 concentration (determined using Antarctic ice cores or measured on Mauna Loa; in 2020, it stood at 412.5 parts per million). The trend toward rising annual mean temperatures and CO_2 concentrations are significant.

www.umwelt2020.nrw.de/004

Figure 2 **Observed and projected mean annual air temperature in NRW between 1881 and 2100**



In the 30-year period from 1881 to 1910, the annual mean temperature in North Rhine-Westphalia stood at 8.4 °C. In the period from 1991 to 2020, it rose by 1.6 °C to stand at 10.0 °C. A trend calculation for the period between 1881 and 2020 indicates a significant rise in the annual mean temperature of 1.7 °C. The 21 projected individual runs for the RCP 8.5 "business-as-usual" scenario suggest a mean annual air temperature of roughly 12.0 to 13.9 °C for the 30-year period from 2071 to 2100, whereas the 12 individual runs of the RCP 4.5 "stabilization" scenario suggest an increase of roughly 10.4 to 12.3 °C. By contrast, the 11 individual runs for the RCP 2.6 "climate change mitigation" scenario, which is largely compliant with the 2015 Paris Agreement, suggest a mean annual air temperature of roughly 9.7 to 11.1 °C for the final three decades of the 21st century (mean 70% of the model ensemble).

TEMPERATURE THRESHOLD DAYS AND PRECIPITATION TRENDS

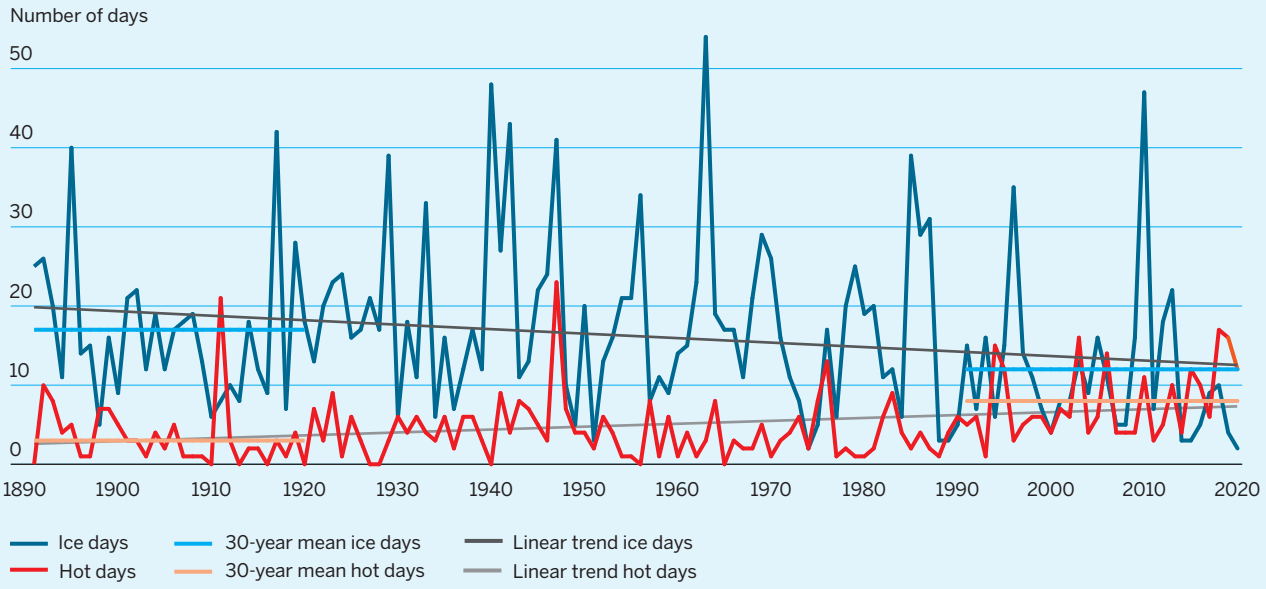
Temperature threshold days – days on which certain daily high or low temperatures are exceeded or fallen short of – serve as a particularly clear indicator of climate change. These threshold days provide information about years with very warm or cold days or phases and are used, along with other indicators, to monitor the impacts of climate change in North Rhine-Westphalia |↗ www.umwelt2020.nrw.de/005. Compared to the period between 1891 and 1920, the number of hot days in NRW (daily high temperature of at least 30 °C) more than doubled to 8 in the 30 years from 1991 to 2020. By contrast, the number of ice days (daily high temperature of less than 0 °C) decreased by roughly 30% compared to the period between 1891 and 1920 to 12 days in the period from 1991 to 2020 |→ figure 3.

The German Meteorological Service has also calculated climate scenarios for North Rhine-Westphalia with regard to temperature threshold days (mean 70% of 21 or 11 individual runs respectively). Under projections for the RCP 8.5 "business-as-usual" scenario, the state can expect to see roughly 9 to 35 hot days and 0 to 5 ice days a year in the 30-year period from 2071 to 2100. The projections under the RCP 2.6 "climate change mitigation" scenario – which call for roughly 2 to 16 hot days and 2 to 13 ice days on average per year in the final three decades of the 21st century – are significantly more bearable |↗ www.umwelt2020.nrw.de/006.

CLIMATE ANALYSIS FOR NORTH RHINE-WESTPHALIA

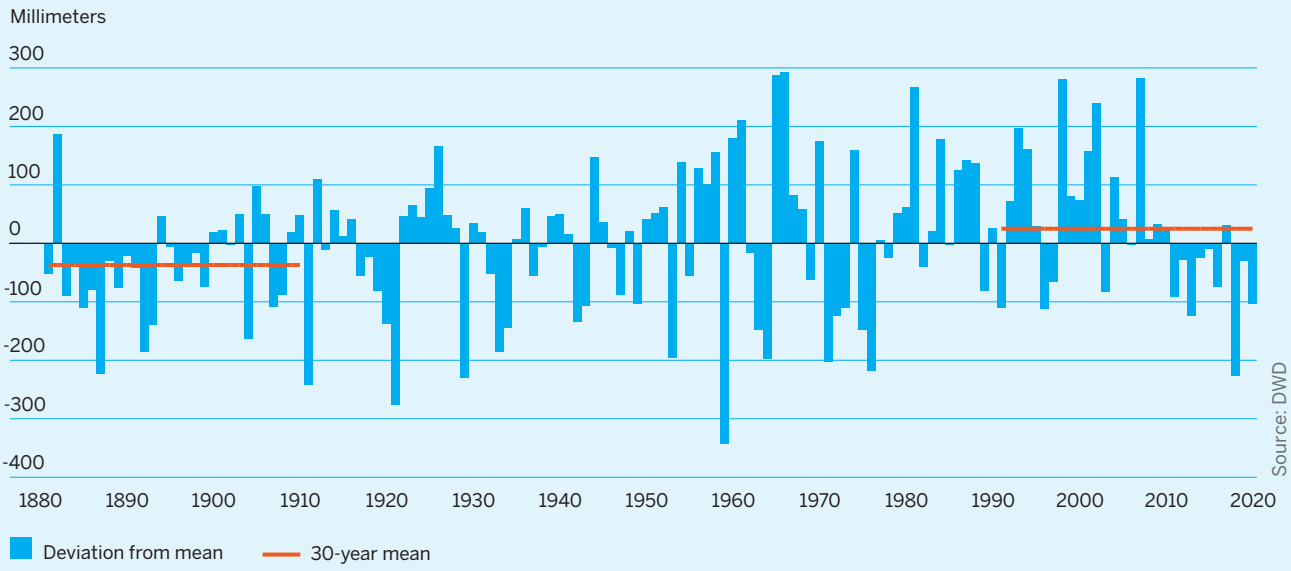
Roughly 23% of the settlement area, equating to approximately 6.9 million people, is affected by significant heat stress in summer. Significant heat stress usually occurs in built-up, inner-city areas affected by extensive soil sealing. The climate analysis looks at air exchange and areas affected by heat while considering the ecological balance between spaces in order to facilitate their use in planing, among other things. The findings can be viewed in a report |↗ www.umwelt2020.nrw.de/007 and in a technical information system |↗ www.klimaanpassung.nrw.de.

Figure 3 **Hot days and ice days in NRW**



On hot days, the temperature exceeds 30 °C. Ice days, on the other hand, are marked by uninterrupted frost. The 30-year period between 1891 and 1920 saw an average of 3 hot days a year. That number rose to 8 in the period from 1991 to 2020. A trend calculation for the entire period between 1891 and 2020 indicates an increase of 5 hot days. The period between 1891 and 1920 saw an average of 17 ice days a year, falling to just 12 in the period from 1991 to 2020. A trend calculation for the period between 1891 and 2020 indicates a decrease of 7 ice days. The trend toward more hot days a year is as statistically significant as the trend toward fewer ice days a year.

Figure 4 **Deviations from long-term annual average total precipitation in NRW**



Average annual total precipitation in North Rhine-Westphalia for the period 1881 to 2020 was 845 millimeters. In the 30-year period between 1881 and 1910, the average value was 37 millimeters below the long-term mean. In the most recent 30-year period, 1991 to 2020, it was 25 millimeters above average. The lowest precipitation total was observed in 1959 at 501 millimeters, whereas the highest precipitation total was observed in 1966 at 1,138 millimeters. A trend calculation for the entire period from 1881 to 2020 indicates a significant increase in total precipitation of 83 millimeters.

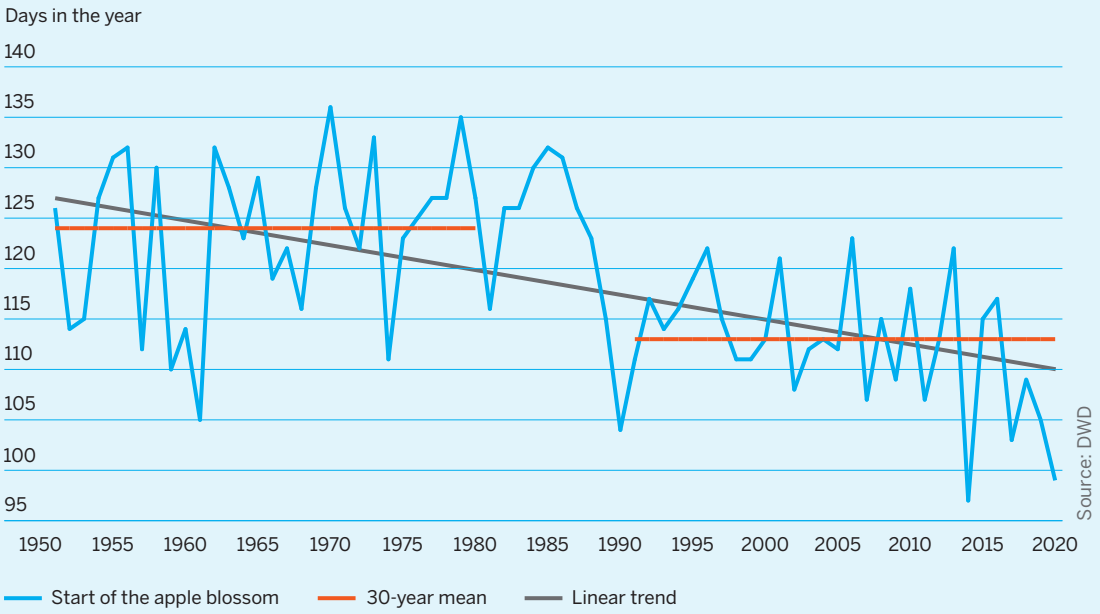
Rising air temperatures promote evaporation and influence the water cycle and precipitation through the water vapor content (humidity) of the air. The variations in mean precipitation over the years are significantly more pronounced than the variations in air temperature. As a result, decades with above-average and below-average annual precipitation have alternated irregularly since the start of regular weather observations. Although the measurements since 1881 indicate a statistically significant increase in mean annual precipitation in North Rhine-Westphalia of roughly 83 millimeters |➔ figure 4, 9 of the last 10 readings fell short of the average of 845 millimeters for the period as a whole. It remains to be seen whether this trend continues.

EARLY SPRING ONSET AND MORE HEAVY RAIN EVENTS

Phenology is the study of periodic events in biological life cycles and looks at long time series that are closely related to weather and climate. As a result, these time series are often used to analyze changes in the climate. In North Rhine-Westphalia, the onset of the apple blossom, which marks the start of what is referred to as "full spring," has shifted forward by 11 days in the past 30 years compared to the period between 1951 and 1980 |➔ figure 5. To name just a few examples, an earlier onset of full spring is associated with a higher risk of late frosts, which is seen as a significant risk in fruit and vegetable cultivation, as well as a change in the return of migratory birds and consequences for feeding relationships – some of them serious.

North Rhine-Westphalia is located in the westerlies, which is characterized by variable weather conditions and moderate temperatures. Climate change, however, is altering the conditions responsible for those weather patterns. The effects include a disruption in the jet stream. This fast-flowing air current, situated at an altitude of 8 to 12 kilometers above sea level, causes the changes in weather typical for central Europe. If it is disrupted, weather conditions can remain stable for weeks at a time, favoring extreme weather situations with unusually high precipitation and severe storms, as well as long periods of drought and heat. The record temperature of 41.2 °C in Duisburg-Baerl and Tönisvorst (located west of Krefeld), which was measured in the summer of 2019, is likely to still be fresh in everyone's minds, as is the year 2018, which saw Storm David (known in Germany as Storm Friederike) claim lives and

Figure 5 **NRW environmental indicator: apple blossom – start of full spring**



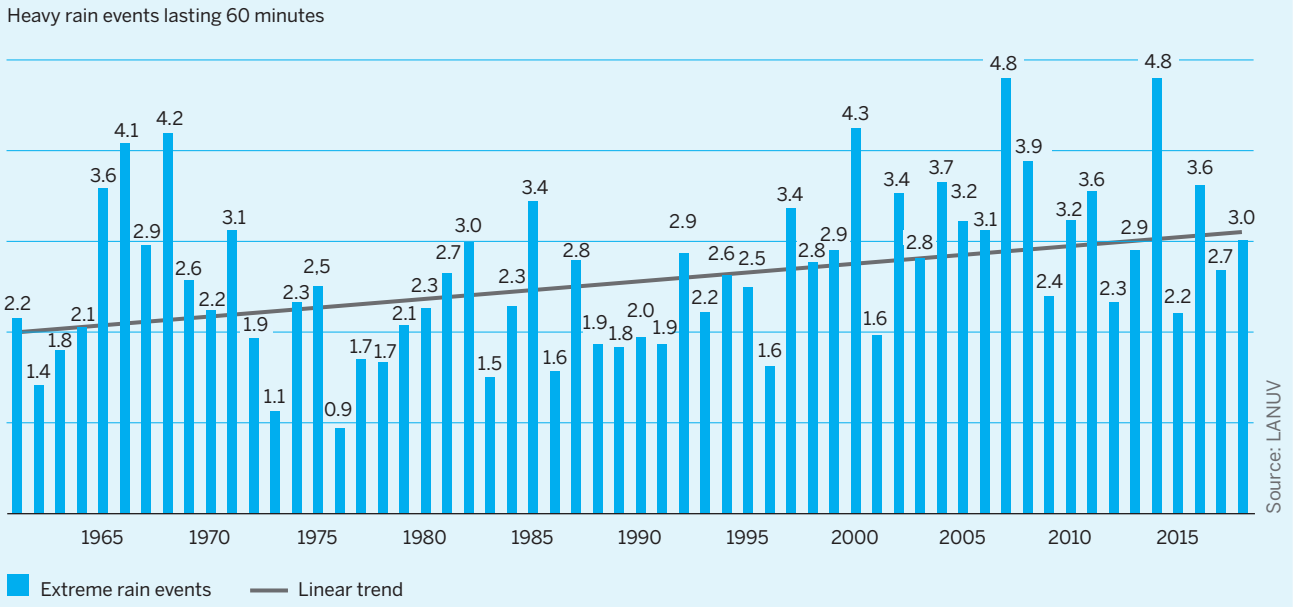
The onset of the apple blossom marks the annual start of full spring. The difference between the mean values of the onset of blossom in the 30-year periods 1951 (earliest date on record) to 1980 and 1991 to 2020 was -11 days (from the 124th day of the year, May 4, to the 113th day of the year, April 23). The start of full spring has therefore shifted from May to April. A trend calculation for the entire period from 1951 to 2020 even indicates a significant shift forward of 17 days. This indicator is an example of how ecosystems react to changing environmental conditions and shows that climate change has also arrived in North Rhine-Westphalia.

www.umwelt2020.nrw.de/008

cause billions in damage before bringing Germany one of the driest and warmest summers on record. Residents of North Rhine-Westphalia may also recall the 2014 Pentecost weekend storms – with wind speeds of up to 142 kilometers per hour, six deaths in North Rhine-Westphalia, dozens of people injured, and billions in damages – as well as the 100-year flood in Münster later that summer, with up to 122 liters of rain in a single day. These memorable incidents are just a few of the recent extreme weather events in our region.

Storms have always occurred. According to the IPCC's Fifth Assessment Report, however, even Europe can expect to see an increase in the frequency of extreme weather events, particularly warm temperature extremes and heavy rain events. Extreme value analyses of rainstorms for North Rhine-Westphalia seem to confirm the IPCC's findings, with long-term precipitation records in a state-wide measurement network indicating a significant increase in the frequency of heavy rain events figure 6, www.umwelt2020.nrw.de/009.

Figure 6 **Mean number of heavy rain events a year in North Rhine-Westphalia**



The mean number of heavy rain events lasting 60 minutes – a duration characterized by relatively short heavy rain events – was derived on the basis of high-resolution precipitation data from up to 159 measuring stations. The values ranged from 0.9 heavy rain events in 1976 to 4.8 heavy rain events in 2007 and 2014. The average intensity stood at roughly 15 millimeters per hour. A trend analysis for the period from 1961 to 2018 indicated a statistically significant increase of 1.1 heavy rain events.

HOW NORTH RHINE-WESTPHALIA IS ADAPTING TO CLIMATE CHANGE

In its 2013 Climate Protection Act (Klimaschutzgesetz), North Rhine-Westphalia agreed to take steps not only to protect the climate, but also to mitigate the negative consequences of climate change. With 66 measures in 16 fields of action, the Strategy for Adaptation to Climate Change (Anpassungsstrategie) – part of the 2015 Climate Protection Plan (Klimaschutzplan) – aims to promote adaptation to the consequences of climate change ↗ www.umwelt2020.nrw.de/010.

Adapting to climate change is a responsibility that involves everyone. With the German Strategy for Adaptation to Climate Change (Deutsche Anpassungsstrategie), the German federal government has created a framework that is subject to further development in cooperation with Germany's individual states ↗ www.umwelt2020.nrw.de/011. Regional governments, district government, businesses, associations, research, and academia, as well as ordinary citizens, are called upon to join the state government in adapting to climate change in the way they act. The state government provides support in the form of sensitization measures while providing ideas and inspiration through information and advice, setting up financial support programs, and offering planning guidance ↗ www.umwelt2020.nrw.de/012, ↗ www.umwelt2020.nrw.de/013.

In December 2020, the state cabinet adopted a draft of its own climate adaptation act and released it for hearings by associations. North Rhine-Westphalia will take on a pioneering role in this regard, as a comparable act has yet to be passed either at state or federal level. The act lays down targets and legal foundations related to climate adaptation measures, as well as rules regarding implementation, updating, and reporting. Its aim is to mitigate the impact of climate change, reduce impending damage, increase climate resilience, and contribute to national and international climate adaptation efforts based on the obligations outlined in the Paris Agreement under the United Nations Framework Convention on Climate Change.

CLIMATE PROTECTION AND ENERGY

COMMITMENT TO THE PARIS AGREEMENT

The state government is committed to the 2015 Paris Agreement. The agreement defines the internationally binding target of "holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change." North Rhine-Westphalia intends to achieve a largely greenhouse-gas-neutral economy through a variety of technologies, with a focus on using renewable energies in the energy sector, the heating market, industry, and mobility.

GREENHOUSE GAS EMISSIONS DOWN SHARPLY OVERALL

Greenhouse gases prevent heat from escaping into space. Through the greenhouse effect, they cause the atmosphere to heat up |➔ page 13. The primary greenhouse gases are CO_2, methane and nitrous oxide. Because their impact on the greenhouse effect differs greatly (the global warming potential of nitrous oxide is 260 times higher than CO_2), greenhouse gas emissions are stated in CO_2 equivalents. CO_2 and some nitrous gas emissions arise during the combustion of fossil energy sources such as coal, oil, and natural gas. Methane comes mainly from bituminous coal mining and agriculture, which also causes the lion's share of nitrous oxide emissions.

North Rhine-Westphalia maintains an inventory of greenhouse gas emissions, in line with the specifications of the IPCC. It reports the emissions of CO_2, methane, nitrous oxide, and other greenhouse gases from technical applications by sector. In 2018, total emissions in North Rhine-Westphalia stood at 261.2 million metric tons of CO_2 equivalents (roughly 14.6 metric tons per capita) and were therefore 29% lower than in the reference year (1990) |➔ figure 7, |↗ www.umwelt2020.nrw.de/014. Of the greenhouse gas emissions, 49.8% were attributable to the energy sector, especially the generation of power using lignite and bituminous coal. Additional significant sectors included industry (20.9%) and transport (12.5%), as well as residential and commercial applications (10.8%). Agriculture was responsible for 2.9% of all emissions, with product applications such as refrigerants for air conditioning accounting for 1.6%. Fugitive emissions from fuels, produced by industries such as the mineral oil and gas sector, were behind 1.3% of emissions, with waste accounting for a share of 0.2%.

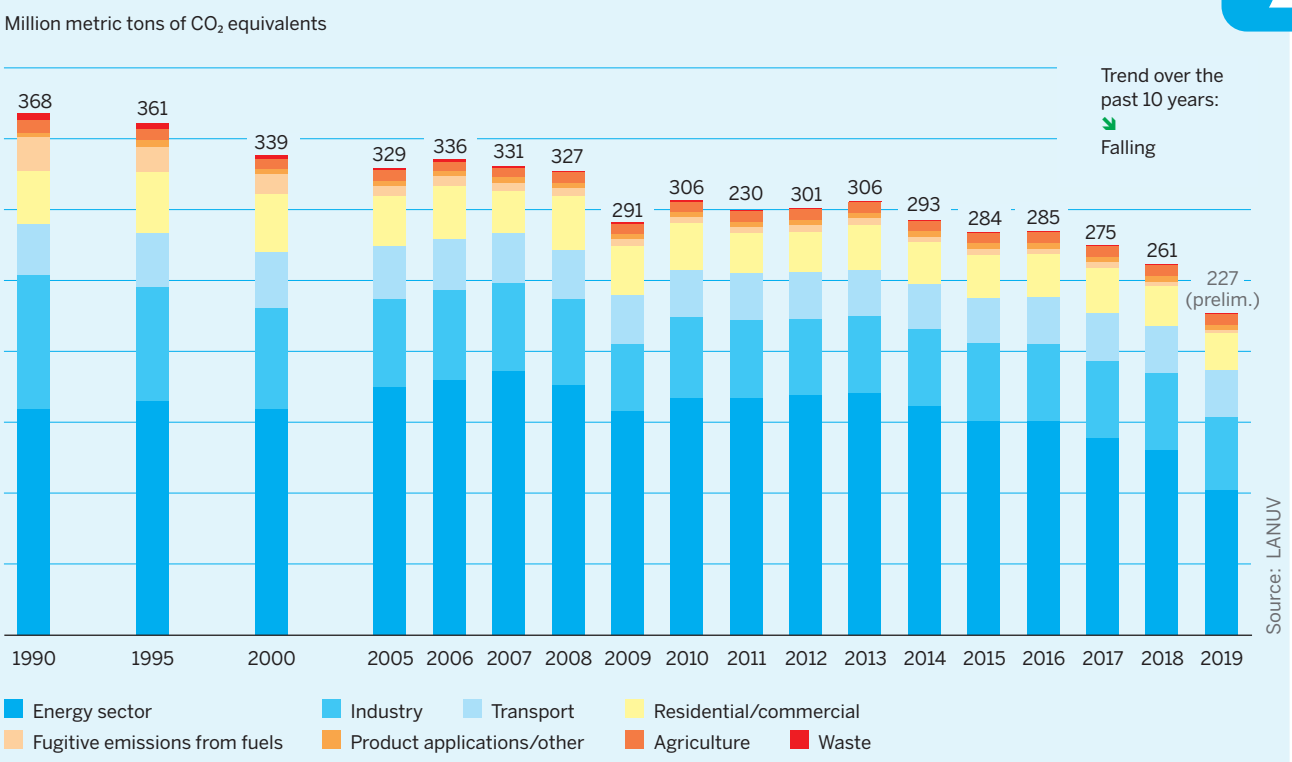
COAL PHASE-OUT BY 2038 IS A DONE DEAL

The Bundestag and Bundesrat adopted the Coal Phase-out Act (Kohleausstiegsgesetz) on July 3, 2020, laying out the steps for a gradual phase-out of coal-fired power generation by 2038 at the latest. Between now and 2030, North Rhine-Westphalia will account for the largest share of lignite-fired power station shutdowns, thereby making a substantial contribution to climate change mitigation. The Structural Development Act (Strukturstärkungsgesetz), which has also been adopted, calls for EUR 40 billion in aid for states with a large coal sector. More than EUR 4 billion in compensation has been earmarked for power plant operators. The federal government will provide the coal-mining region along the Rhine with up to EUR 14.8 billion as part of the Structural Development Act. An economic and structural program that defines guidelines for the use of the structural funding has already been drafted as part of an extensive participatory process in the affected regions. It is designed to provide incentives for value creation and employment while advancing the fields of the future derived from the region's strengths, including energy and industry, resources and agribusiness, innovation and education, and land and infrastructure.

|↗ www.umwelt2020.nrw.de/015

Following the decline in greenhouse gas emissions as a result of the global financial crisis in 2008 and 2009, the reductions after 2013 were related in part to the mild weather conditions and in part to the decline in emissions in the energy sector due to the deactivation of generating units for burning fossil fuels and low capacity utilization, even though new gas-fired power plants went online. Since 2013, the reduction in this sector has stood at 40.2 million metric tons of CO_2 equivalents. Further significant changes since 2013 have been seen among residential and commercial applications (-3.7 million metric tons of CO_2 equivalents), fugitive emissions from fuels (-1.6 million metric tons), and transport. The latter segment, however, recorded a 0.8-million metric ton increase in emissions.

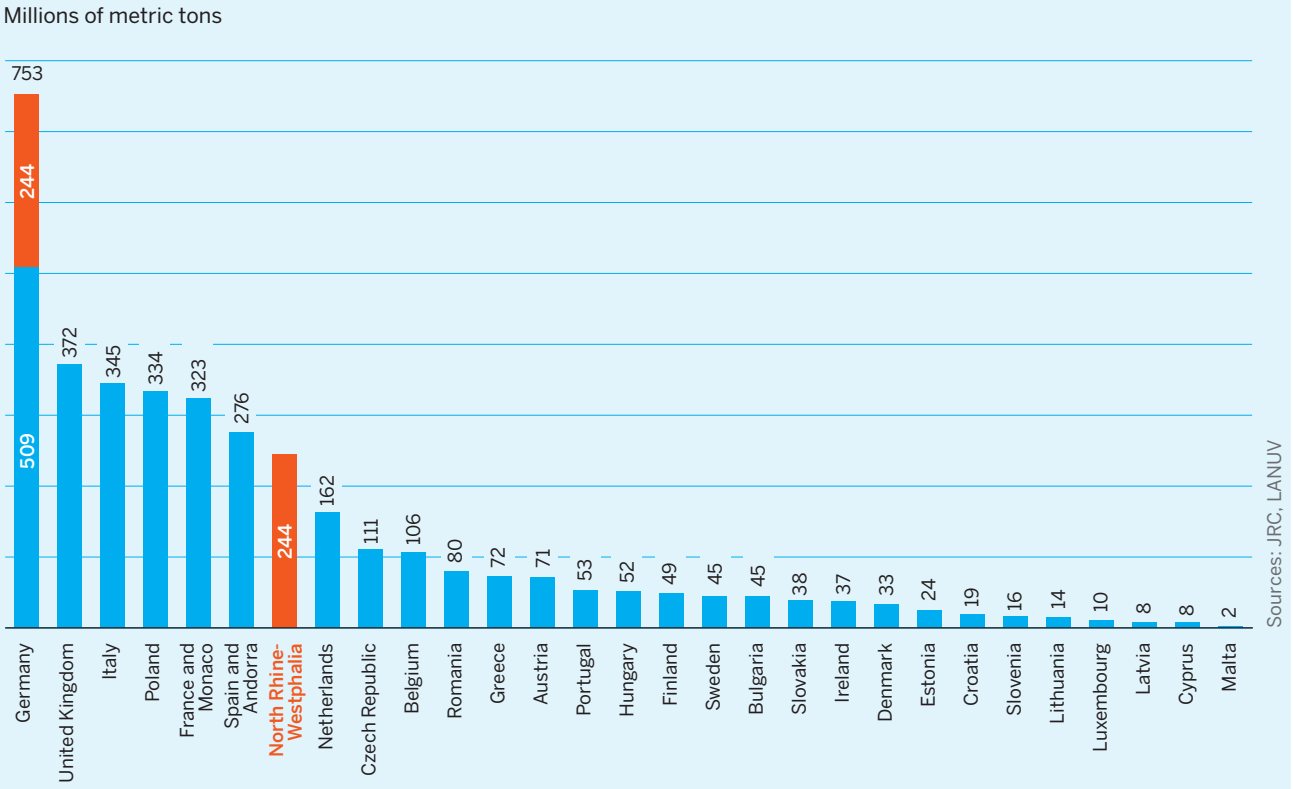
Figure 7 **NRW environmental indicator: greenhouse gas emissions**



In 2018, the state emitted 261.2 million metric tons of climate-damaging CO_2 equivalents. The preliminary value for 2019 stood at 227.0 million metric tons of CO_2 equivalents. As a result, the state has already achieved its interim target of reducing emissions by at least 25% by 2020 as compared to the 368.1 million metric tons in the reference year (1990), as defined in North Rhine-Westphalia's Climate Protection Act. Further efforts will be necessary to achieve the target of reducing emissions by at least 80% by 2050 as compared to the baseline year (1990), which is also outlined in the Climate Protection Act. An amendment with more ambitious targets is slated for the first half of 2021.

www.umwelt2020.nrw.de/016

Figure 8 **Carbon dioxide emissions in the European Union in 2018**



As the world's third-largest emitter, the 28 EU member states at the time were responsible for around 3.5 billion metric tons of CO_2 in total in 2018 (6.7 metric tons per capita, primary energy sources). Germany accounted for a share of 22% and, at 752.7 million metric tons of CO_2, was the largest EU emitter (9.1 metric tons per capita). In a direct comparison with EU member states, North Rhine-Westphalia was the seventh-largest emitter, with 244.2 million metric tons of CO_2 (13.6 metric tons per capita). The world emitted roughly 37.9 billion metric tons of CO_2 in 2018. China, the world's largest emitter, was responsible for 11.3 billion metric tons of CO_2 (8.1 metric tons per capita), followed by the United States of America at 5.3 billion metric tons (16.1 metric tons per capita), and the EU.

In 2018, a good two-thirds of the total emissions in NRW were covered by EU Emissions Trading System (EU ETS), the EU's main climate protection tool. Every emitter under the ETS is required to buy emissions allowances. The aim of the program is to reduce greenhouse gas emissions in the energy sector and the energy-intensive industrial sector ↗ www.umwelt2020.nrw.de/017. As illustrated in → figure 8, North Rhine-Westphalia's CO_2 emissions, which account for 93.5% of the state's greenhouse gas emissions, are ranked seventh compared to other regions throughout the EU. The preliminary total volume of greenhouse gas emissions for 2019 stands at 227 million metric tons of CO_2 equivalents (roughly 12.6 metric tons per capita). That number marks a significant year-on-year decline of around 34 million metric tons, or 13%, equating to a roughly 38% reduction in emissions compared to the reference year (1990). The decline is primarily attributable to a reduction of roughly 28 million metric tons of CO_2 equivalents in the energy sector due to higher prices within the ETS, the transfer of individual lignite generating units to the security standby *(Sicherheitsbereitschaft)*, and the shutdown of bituminous coal power plants.

SHARE OF RENEWABLE ENERGIES SEES MODERATE RISE

Renewable energies – such as wind energy, bioenergy, solar energy, and hydropower – are based on natural processes. Unlike fossil energy sources, they are virtually inexhaustible. Renewable energies play a decisive role in decarbonizing the energy sector. The systematic and consistent expansion of renewable energies is therefore one of the main goals of North Rhine-Westphalia's climate change mitigation policy.

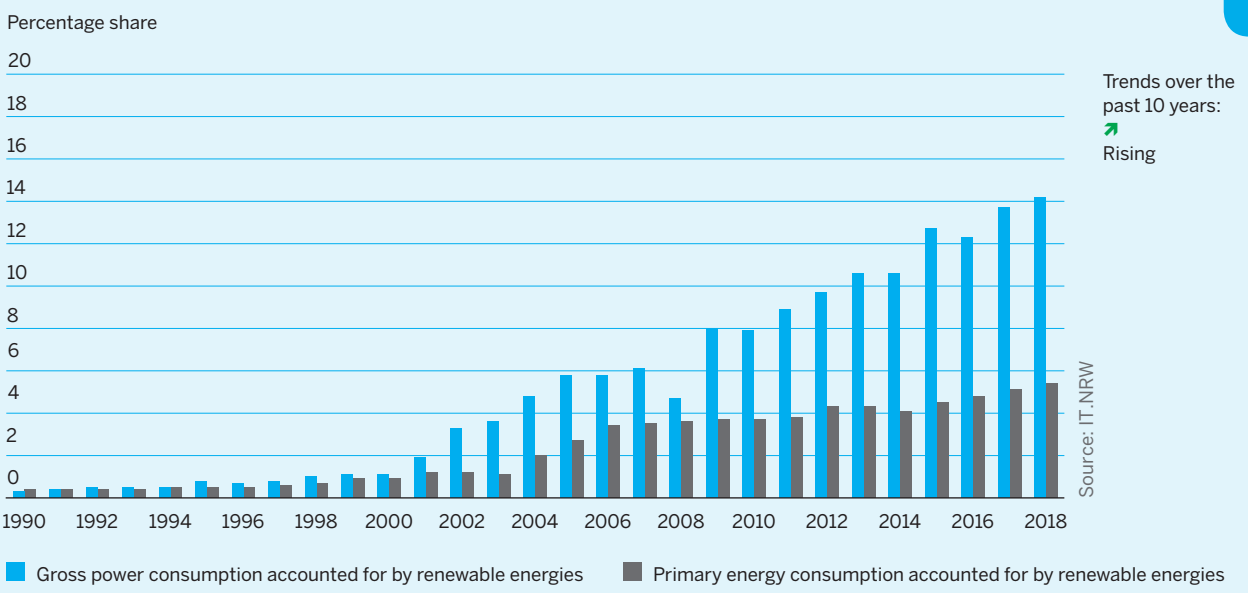
PROJECT ENERGIE2020 – MAKING ENERGY CONSUMPTION DIGITAL

By acting as prosumers, private households can actively help shape the energy market and generate their own renewable energies. Energie 2020 guides them through the digital energy world and motivates them to reduce energy consumption in housing stock and invest in CO_2-saving technologies. Information, educational campaigns, digital advisory services, and training show private households the potential associated with sustainable energy and digitalization. As a result, the project spearheaded by the regional consumer organization Verbraucherzentrale Nordrhein-Westfalen – with financial support from the European Regional Development Fund; the Ministry for Environment, Agriculture, Conservation and Consumer Protection; and numerous municipalities and districts – makes a contribution to achieving the climate change mitigation targets.

↗ www.energie2020.nrw

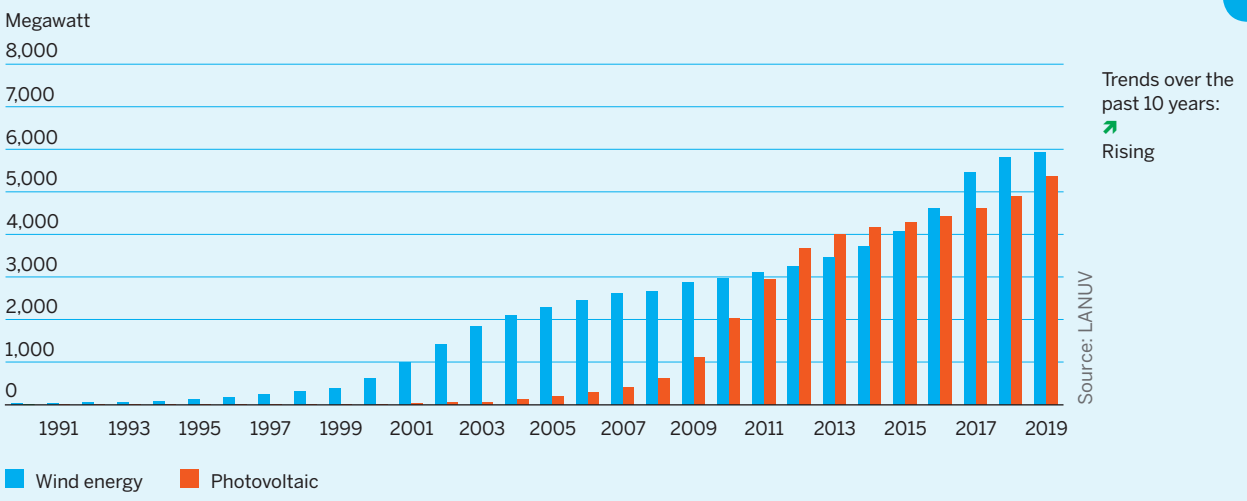
Figure 9 NRW environmental indicator: renewable energies

Sub-indicator: share of gross power consumption and primary energy consumption



In 2018, the share of gross power consumption accounted for by renewable energies increased to 14.2%. The state government aims to significantly increase the share of gross power consumption accounted for by renewable energies in order to make a substantial contribution to the national goal of at least 65% by 2030. Between now and 2050, the state will pursue an accordingly ambitious expansion strategy in light of the federal target that calls for achieving a greenhouse-gas-neutral energy sector in Germany by 2050. The share of primary energy consumption accounted for by renewable energies stood at 5.4% in 2018. This sub-indicator was determined using methods defined by the State Working Group on Energy Accounting (Länderarbeitskreis Energiebilanzen).

Sub-indicator: onshore wind energy and photovoltaic capacity development



In 2019, North Rhine-Westphalia had 3,708 wind power stations with an output of roughly 5.9 gigawatts and 282,314 photovoltaic power stations with around 5.4 gigawatts. According to an estimate, wind energy covered approximately 8.1% of gross power consumption, with photovoltaic covering some 3.3%. Thanks to the switch to a tendering system as prescribed in the German Renewable Energies Act (Erneuerbare-Energien-Gesetz), 2017 saw the most significant growth in the recent past. The state's target is to double installed capacity by 2030 as compared to 2018 (from 5.4 to 10.5 gigawatts for wind power stations, and from 4.6 to 11.5 gigawatts for photovoltaic power), mainly by reducing regulatory obstacles and providing greater funding for photovoltaic power.

www.umwelt2020.nrw.de/018

According to the methods used by the State Working Group on Energy Accounting (Länderarbeitskreis Energiebilanzen), renewable energies accounted for 14.2% of gross power consumption in North Rhine-Westphalia in 2018 |➔ figure 9. More recent, preliminary estimates suggest that renewable energies accounted for 16.2% of gross power consumption in 2019. Half of that total was attributable to wind energy, with one-fifth attributable to photovoltaic generation |➔ figure 9, |↗ www.energieatlas.nrw.de.

Nevertheless, the expansion of wind energy has recently slowed significantly, with 37 new wind power stations and an output of 125 megawatts a year going online in 2019. One of the main reasons for the slow expansion rate lies in a loophole in the German Renewable Energies Act (Erneuerbare-Energien-Gesetz) regarding renewable energy communities and invitations to tender completed on the initiative of North Rhine-Westphalia in May 2020. In the first three quarters of 2020, however, 45 wind power stations were put into service in North Rhine-Westphalia – more than in any other German state during this period. By contrast, the expansion of photovoltaic power increased year on year for the fourth year in a row in 2019, with 18,400 newly installed systems and an output of 471 megawatts.

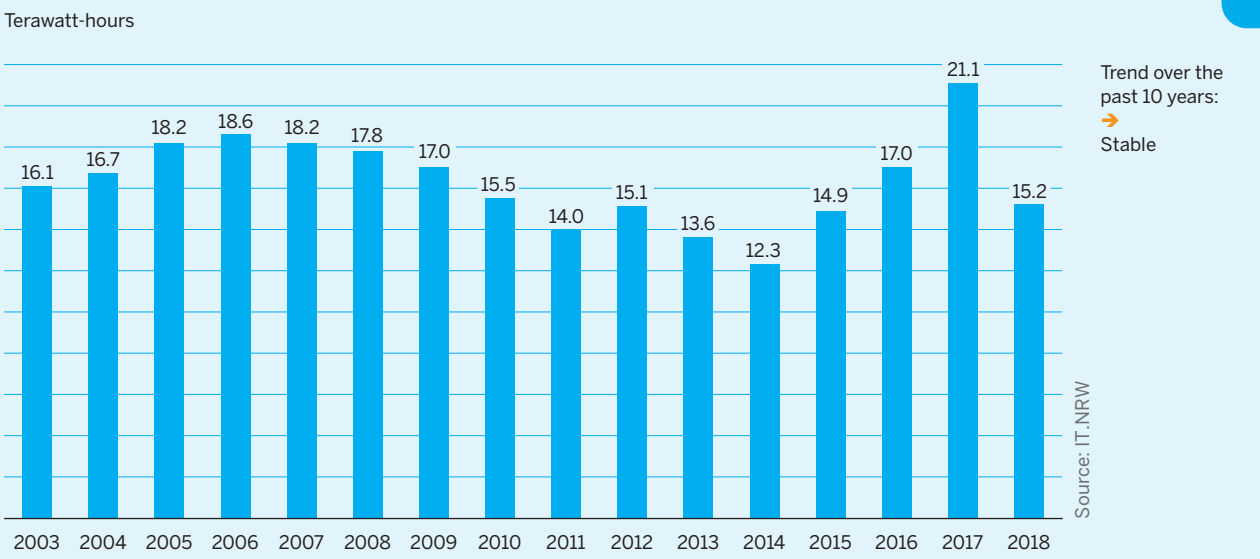
Between now and 2030, the state government aims to significantly increase the share of gross power consumption accounted for by renewable energies (in order to make a substantial contribution to the national goal of at least 65%) and to double the installed capacity of wind and photovoltaic energy power plants compared to 2018.

COGENERATION STAGNANT

The initial focus with regard to cogeneration, or combined heat and power generation (CHP), was to increase the efficiency of conventional thermal power stations, as CHP plants combine the generation of electric power with district heating and thermal heat. In an industrial context, it is also associated with process heat. Cogeneration makes it possible to increase the total utilization rate to up to 90% of the primary energy employed while also reducing the use of resources and CO_2 emissions by over 35%. The sizes of the generation systems vary greatly and range from district heating plants for municipal use and cogeneration plants for city blocks to micro CHP systems for single- and multi-family homes. Cogeneration works with nearly all fuels, including wood, biogas, and fossil fuels. In 2018, the net electricity volume generated in NRW stagnated at

Figure 10 **NRW environmental indicator: net electricity generation from cogeneration**

CHP



The net electricity volume generated by CHP plants in North Rhine-Westphalia stood at 21.1 terawatt-hours in 2017 (14.4% share of total net electricity generation) and at 15.2 terawatt-hours in 2018 (11.3% share of total net electricity generation). The trend toward stagnation can be explained by the deactivation of older coal and CHP plants, among other factors. Moreover, mini and micro CHP systems with less than 1.0 megawatts of electric power were not included in the calculation. The state government's target is to increase the volume of electricity from cogeneration to around 30 terawatt-hours a year by 2030.

|↗ www.umwelt2020.nrw.de/019

15.2 terawatt-hours |→ figure 10. One of the main reasons for this development was the deactivation of older coal and CHP plants. The KWK.NRW information campaign |↗ www.kwk-fuer-nrw.de provides consulting for companies, municipal governments, and private consumers while also supporting the design and financing of CHP projects and much more.

NEW CLIMATE ACTION AND ENERGY POLICY GOALS

Climate protection is a key task for the future in the public service sector. In 2013, North Rhine-Westphalia set binding greenhouse gas reduction targets in its own Climate Protection Act (Klimaschutzgesetz) |↗ www.umwelt2020.nrw.de/020. The target set in the act – of reducing greenhouse gas emissions by 25% compared to the base year (1990) – was achieved in 2017. However, the act's target of cutting greenhouse gas emissions by at least 80% (compared to 1990) by 2050 does not meet the requirements under the Paris Agreement. An amendment currently under review therefore calls for the target to be raised. The state parliament is expected to make a decision in the first half of 2021.

At EU level, a reduction in emissions of currently 40% to 60% is being discussed as a climate change mitigation target for 2030. A decision is slated for 2021. At federal level, the Federal Climate Change Act (Bundes-Klimaschutzgesetz), which entered into force in late 2019, provides the framework. Its goal is to reduce greenhouse gas emissions by at least 55% (compared to 1990) by 2030. It also sets out how much CO_2 each sector is allowed to emit and defines greenhouse gas neutrality by 2050 as a long-term target.

Climate scientists are discussing even more ambitious targets, including efforts to raise the target for 2030 and achieve climate neutrality well before 2050. For example, the recently published Agora study *Towards a Climate-Neutral Germany* employs scenarios that also factor in economic conditions to show that a 65% reduction in greenhouse gases by 2030 would be reasonable. In its 2020 environmental report, the German Advisory Council on the Environment (Sachverständigenrat für Umweltfragen) also states that Germany would need to be climate neutral no later than 2038 to make an appropriate contribution to the 2015 Paris Agreement, basing its findings on an emission budget guided by the size of the population and the assumption of a linear reduction in CO_2.

The state employs a wide variety of climate change mitigation measures. For example, the IN4climate.NRW initiative |↗ www.in4climate.nrw supports the energy-intensive industrial sector in going climate-neutral. Developing a hydrogen economy along the Rhine, in the Ruhr Valley, and with international partners such as the Netherlands plays a key role in the initiative's plans and enjoys the support of the state government. To take concrete steps toward establishing a hydrogen economy, the state of North Rhine-Westphalia recently published a Hydrogen Roadmap |↗ www.umwelt2020.nrw.de/021. Additional measures for promoting climate action include a significant increase in subsidy rates for charging stations to support the expansion of electromobility and the progres.nrw – Markteinführung program, which provides financial assistance for battery storage systems, solar thermal power installations, and geothermal drilling |↗ www.umwelt2020.nrw.de/022.

North Rhine-Westphalia's Climate Protection Plan (Klimaschutzplan) is also undergoing further development at the present time. In the future, the state government's climate change mitigation measures will be subject to an audit process. The Klimaschutz.NRW Advisory Board (Beirat Klimaschutz.NRW) – consisting of representatives from labor unions, society, industry, municipal governments, environmental organizations, the scientific community, and public administration – was set up to oversee this process.

In 2019, the Ministry of Economic Affairs, Innovation, Digitalization and Energy of the State of North Rhine-Westphalia presented a strategy for climate-friendly, safe, and affordable energy |↗ www.umwelt2020.nrw.de/023 that envisions renewable energies as the main pillar of the future energy sector. Between now and 2030, the installed capacity of wind and photovoltaic energy is set to double compared to 2018. Other goals set by the state government include making a substantial contribution to the national target of covering at least 65% of gross power consumption through renewable energies by 2030 and more than 80% by 2050.

RESOURCE EFFICIENCY

INCREASING EFFICIENCY – KEY GOALS OF POLICYMAKERS

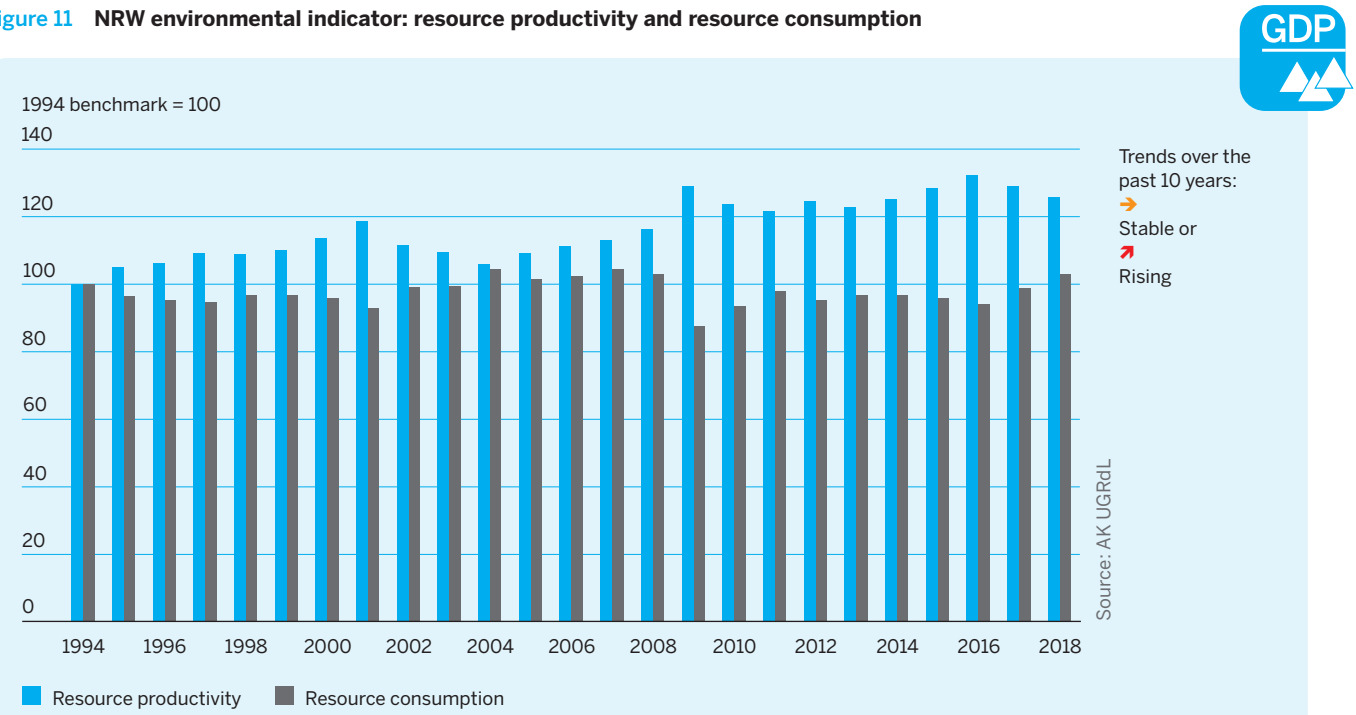
The economical, efficient management of natural resources – such as non-renewable resources and fossil energy sources, as well as soils |➔ page 60 and food – is a yardstick for sustainability on both a small and a large scale, for households, public institutions, companies, and entire national economies alike. That is because the exploitation of resources (especially finite resource reserves) results in direct environmental damage and indirect consequences for the climate. As a result, we urgently need to increase resource and energy efficiency and improve resource conservation by implementing circular economy measures |➔ page 56 so as to ultimately reduce resource and energy consumption levels.

STAGNANT RESOURCE PRODUCTIVITY

North Rhine-Westphalia is rich in abiotic resources, both mineral-based (such as gravel, sand, and natural stone) and energy-related (such as lignite). At the same time, it plays a role in the global economy's resource flows. Its resource consumption (abiotic direct material input, or DMIa), as presented in |➔ figure 11, considers the extraction of abiotic resources from the domestic environment, the import of abiotic goods from abroad, and the trading of abiotic goods between the German states. In 2018, resource consumption stood at approximately 392 million metric tons (28% of the total German resource consumption). According to estimates, roughly 40% of the abiotic resources consumed here were imported.

Resource productivity is a measure of the efficient use of resources and reflects the relationship between gross domestic product (GDP, a measure of economic performance) and DMIa. It depends on both the economical, efficient use of resources and the economic structure – the mix of more material-intensive industries, such as mining, and less material-intensive industries, such as the service sector. As a result, the situation is challenging for North Rhine-Westphalia in its role as the German state with the highest resource consumption (having even recorded an increase in recent history) and stagnating resource productivity |➔ figure 11.

Figure 11 **NRW environmental indicator: resource productivity and resource consumption**



In 2018, resource productivity – the relationship between the gross domestic product and the consumption of abiotic, non-renewable resources – stood at 125.7. The trend analysis revealed a significantly stagnant trend. Given the substantial rise in resource consumption as reflected by the index (roughly 392 million metric tons in absolute figures), an appreciable decoupling of gross domestic product and resource consumption has yet to occur. The state government's resource productivity target is based on the national target (the federal government takes a more extensive look at total resource productivity) and equates to an increase of 1.5% a year, or 30 index points, to a value of roughly 165 between now and 2030.

|↗ www.umwelt2020.nrw.de/024

The state supports a more resource-efficient approach to doing business in the manufacturing sector though the Efficiency Agency NRW (Effizienz-Agentur NRW, EFA) ↗ www.umwelt2020.nrw.de/025. Its focus is on increasing material and process efficiency while making a contribution to the circular economy. The EFA offers methods of identifying and leveraging potential in relation to product design, manufacturing processes, carbon footprint, and CO_2 accounting. Its efficiency and financing advisory services, which support research and development projects or investments, trigger investments in the three-digit millions as part of roughly 250 projects a year.

At municipal level, the Ecological Project for Integrated Environmental Protection, or ECOPROFIT (Ökologische Projekt für integrierte Umwelttechnik), helps businesses get started with corporate environmental management. Since 2000, over 2,000 companies in North Rhine-Westphalia have successfully completed an ECOPROFIT project, saving each of them more than EUR 40,000 in operating costs a year ↗ www.umwelt2020.nrw.de/026.

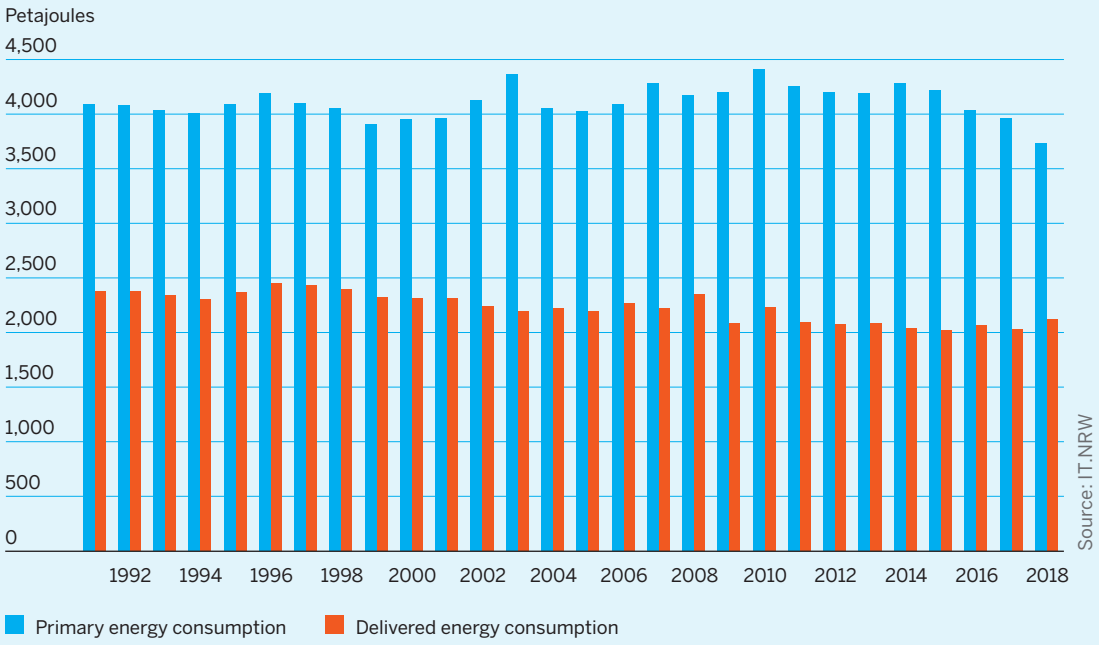
REBOUND EFFECT

It is an undisputed fact that increases in efficiency result in tremendous benefits. But there is a catch: the rebound effect, which can make the beneficial effects of potential savings or increases in efficiency difficult or impossible to attain. Often, increases in efficiency reduce the price of products or services, leading to a change in consumer behavior. As a result, consumption rises, at least partially diminishing the effect of any savings. For instance, efficiency gains in engine technology are usually employed to build more powerful, faster, and heavier cars with the same mileage and fuel efficiency as previous models, in some cases leading owners to drive more than before. The increasingly popular sport utility vehicles, or SUVs, stand out as an example.

RISING ENERGY PRODUCTIVITY

→ Figure 12 presents primary energy consumption in relation to delivered energy consumption. To present primary energy consumption, the volume accounted for by all energy sources is added together prior to their conversion into directly useable secondary energy sources such as electricity, gasoline, and heating oil, taking renewable energies into account. Despite falling on the whole, the state's primary energy consumption remains high due to an

Figure 12 **NRW environmental indicator: primary and delivered energy consumption**



Primary energy demand stood at 3,729 petajoules in 2018, equating to 208 gigajoules per inhabitant. The energy demand of a two-person household stands at roughly 11 gigajoules a year. The lion's share was accounted for by mineral oils and mineral oil products (37%), gas (23%), lignite (20%), bituminous coal (15%), and renewable energies (5%). Delivered energy consumption stood at 2,119 petajoules in 2018 following the conversion of primary energy sources and their transport. While primary energy consumption fell, delivered energy consumption stagnated. The previous state target of reducing primary energy consumption by between 12% and 18% between 2010 and 2020 (and by 45 to 59% by 2050) is currently being revised as part of a climate audit.

www.umwelt2020.nrw.de/027

economic structure centering on energy-intensive industries and high traffic volume, among other factors. At 1,394 petajoules, mineral oils and mineral oil products accounted for the largest share of primary energy consumption ↗ www.energieatlas.nrw.de. Delivered energy consumption ultimately provides an insight into the amount of energy consumed as electricity, heat, or fuels after the conversion of primary energy sources and their transport.

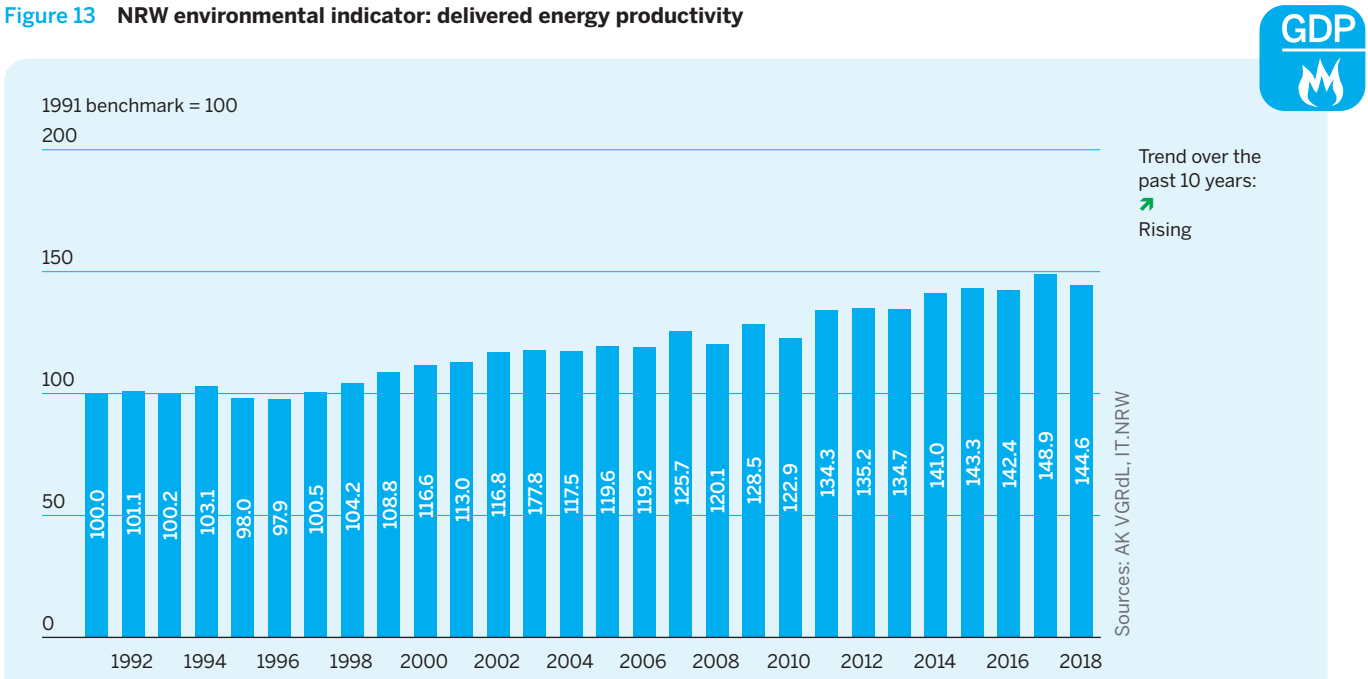
Delivered energy productivity is considered a measure of efficiency in the use and management of energy resources. As a quotient of gross domestic product and delivered energy consumption, it indicates the value of goods and services produced and rendered in relation to the volume of delivered energy consumed. In North Rhine-Westphalia, delivered energy productivity has increased by 45% compared to 1991 → figure 13. The state government's target is to increase delivered energy productivity by between 1.5% and 1.8% a year by 2050.

With this target in mind, the EFA and the EnergyAgency.NRW (EnergieAgentur.NRW) support companies and municipal governments in taking steps to save energy and increase efficiency ↗ www.umwelt2020.nrw.de/028. The EnergyAgency.NRW links energy research, technical development, demonstration, and market introduction with advisory services and professional training. In 2019 alone, the agency held some 1,000 initial consultancy and motivation sessions for the private and public sector. Its responsibilities include acting as a point of contact for the Modular Energy Efficiency Model (modulares Energie-Effizienz-Modell, mod. EEM) and managing the EnergyRegion.NRW (EnergieRegion.NRW) and EnergyResearch.NRW (EnergieForschung.NRW) clusters ↗ www.umwelt2020.nrw.de/029, ↗ www.umwelt2020.nrw.de/030.

Roughly one-third of total delivered energy in Germany is used to heat buildings and water. As a result, energy-efficient construction and renovation are the key to lower household energy consumption. Between 2006 and September 2019, the Reconstruction Loan Corporation (Kreditanstalt für Wiederaufbau, KfW) approved approximately 143,000 loans with a volume of around EUR 10 billion for the energy renovation of buildings in North Rhine-Westphalia. During that same period, 171,000 applications for energy renovation grants with a volume of roughly EUR 320 million were filed, allowing people in North Rhine-Westphalia to make some 835,000 residential units more energy efficient.

At around 34 million metric tons of CO_2 equivalents in 2018, transport accounted for the third-largest share of green-

Figure 13 **NRW environmental indicator: delivered energy productivity**



Delivered energy productivity is a measure of how efficiently energy is being used. It reflects the relationship between gross domestic product and energy consumed as electricity, heat, or fuels after the conversion of primary energy sources and their transport. The value of 100 refers to the level achieved in the base year (1991). In 2018, energy productivity in North Rhine-Westphalia stood at roughly 145 – 45% higher than at the start of the time series. The state government's target is to increase delivered energy productivity by 1.5% to 1.8% a year between now and 2050, bringing it up to a value of at least 240.

↗ www.umwelt2020.nrw.de/031

house gas emissions in the state |➔ page 21. On top of that, the transport sector is responsible for nearly one-quarter of delivered energy consumption and numerous challenges, such as nitrogen dioxide emissions and traffic noise pollution |➔ pages 38 and 43. Energy- and resource-efficient mobility is therefore another key element for policymakers. As a result, the Climate Protection Plan, which is currently undergoing an audit process, will contain measures ranging from financing public transit infrastructure and promoting cycling, walking, and rail transport, to integrated urban and transportation planning, expanding electromobility, and promoting hydrogen fuel cell vehicles. The state's energy strategy also takes a look at ways to transform transportation |↗ www.umwelt2020.nrw.de/032.

FOOD: LESS LOSS, MORE LOVE!

Food waste and the wasting of agricultural commodities is not only a question of resource efficiency, but also a major ethical problem. Around the world, more than 900 million people suffer from hunger. Food waste also has a negative impact on the environment and plays a significant role in climate change, nitrogen pollution, freshwater consumption, a shift in land use, and biodiversity loss. As a result, the United Nations has placed the topic of food waste on its 2030 Agenda for Sustainable Development. One of the targets under Goal 12, "Ensure sustainable consumption and production patterns," is to "halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses," by 2030 (Goal 12.3).

The state has long been committed to fighting food waste through an exchange of ideas, networking, research, analysis, education, and best-practice projects. Examples include an exploratory study on food waste at colleges and universities, a project with the State Food Bank Association (Landesverband der Tafeln) regarding the development of distribution centers, and the MehrWertKonsum coaching project initiated by the Verbraucherzentrale consumer organization |↗ www.umwelt2020.nrw.de/033.

ONE-THIRD OF ALL FOOD IS WASTED

According to the Food and Agriculture Organization of the United Nations (FAO), only two-thirds of the food produced worldwide every year gets eaten. The rest goes missing along the value chain, is appropriated to produce animal feed, is used to generate energy or in industrial applications, or lands in the trash. In Germany, roughly 12 million metric tons of edible food gets thrown away every year. At around 52%, private households account for the lion's share, followed by the food industry, the food service sector, wholesalers, and retailers. Agriculture also accounts for up to 1.4 million metric tons in additional food losses.

Environment and health in North Rhine-Westphalia

Population density[1]
17.9 million people
34,112 km² total area
526 people/km²

Noise pollution
Night > 55 dB(A)
1.5 million people affected

Day, evening, night > 65 dB(A)
1.1 million people affected

Nitrogen dioxide concentration in urban settings
17 µg/m³ Trend ↘
Annual average

Particulate matter concentration in urban settings
Annual averages
15 µg/m³ PM_{10} Trend ↘
10 µg/m³ $PM_{2.5}$ Trend ↘

NO_x

Nitrogen oxide emissions
268,000 t in 2016

Motor vehicle stock[2]
12.2 million
of which 4.0 million are diesel vehicles and 66,078 are electric vehicles

Top 3 mercury emitters in 2019
Reduction in emissions compared to 2016

Weisweiler power station	Niederaußem power station	Neurath power station
26%	26%	18%

Municipalities with air quality plans[4]

Length of state road network[3]
29,527 km
Highways, main roads state roads, and municipal roads

Ozone concentration in urban settings
8 Hourly averages with more than 180 µg/m³ in 2020

Selection of important airports
6

Nuclear facilities[5]
3 interim storage/ enrichment facilities
5 decommissioned/ being dismantled/ in secure containment

Approx. 20,000 **plants requiring monitoring** under immission control law[4]

Sources: 1 IT.NRW 2019 ▪ 2 KBA 2020 ▪ 3 IT.NRW 2020 ▪ 4 LANUV 2020 ▪ 5 MWIDE 2020, Wikipedia 2020 ▪ Map: Wikipedia 2020, Geobasis NRW 2014

AIR POLLUTANTS

CLEAN AIR – ESSENTIAL FOR A HEALTHY LIFE

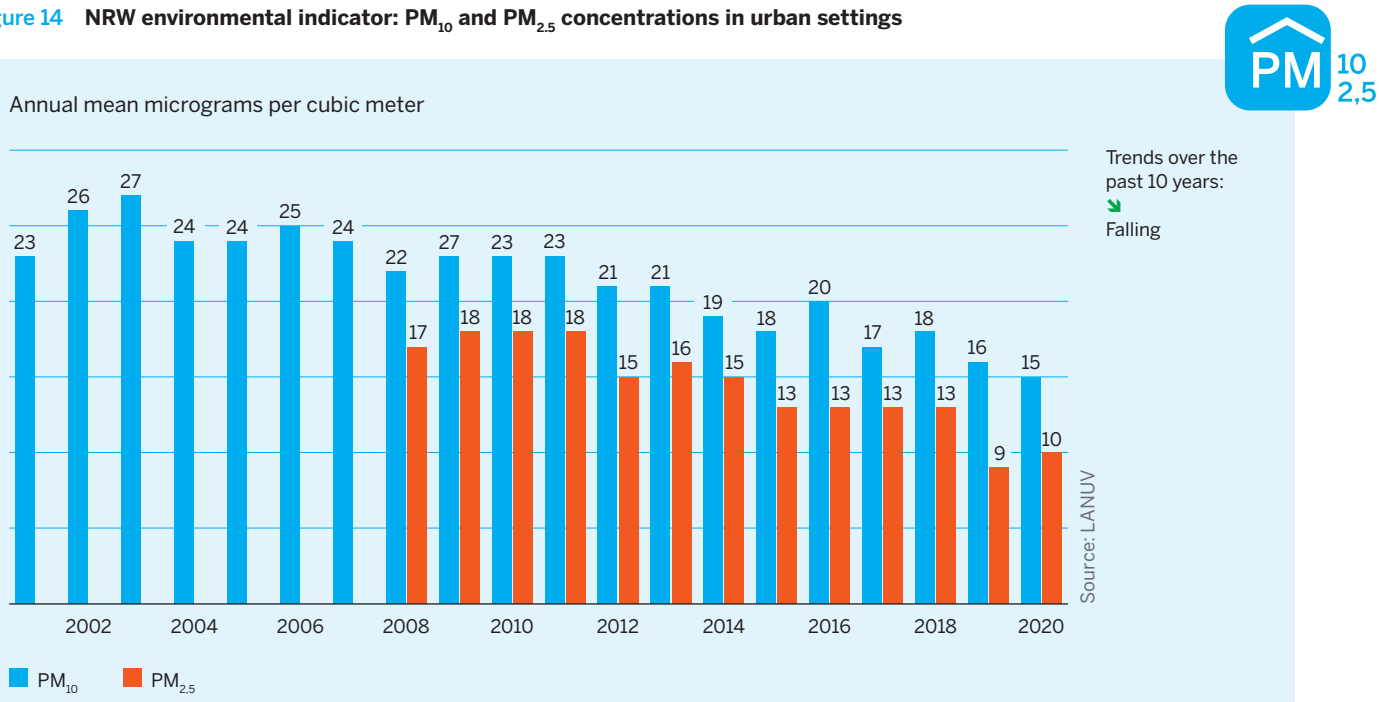
Our health can be negatively affected by air pollutants, for example by breathing in particulate matter, nitrogen oxides, ozone, persistent organic pollutants such as dioxins and polychlorinated biphenyls (PCBs), and heavy metals www.umwelt2020.nrw.de/034, pages 48, 64, and 40. As a result, recording, measuring, and improving air quality are some of the environment ministry's most important tasks www.umwelt2020.nrw.de/035.

The European Environment Agency (EEA) estimates that pollution from particulate matter with a diameter of 2.5 micrometers or less ($PM_{2.5}$) was responsible for 859 years of life lost per 100,000 inhabitants in Germany in 2018 alone. According to those same estimates, nitrogen dioxide pollutants was responsible for 125 years of life lost, with ground-level ozone pollutants responsible for 56 years of life lost. No threshold has been identified below which no damage to health is observed. Any reduction in these pollutants is a bonus for public health.

PARTICULATE MATTER POLLUTION POSES A RISK

Particulate matter is a mixture of particles consisting of solid and liquid components that is released into the air we breathe through processes such as combustion. Road traffic is the main source of particulate matter in urban areas, with exhaust gases, brake dust, and tire wear acting as the main culprits page 58. Industrial emissions are another major source. Agriculture also generates particulate matter through direct emissions and particle-forming ammonia in slurry and manure, as do small boilers in homes and vessels on inland waterways. Particulate matter with a diameter of 10 micrometers or less (PM_{10}) can enter the lungs through the nose or mouth. Particulate matter with a diameter of 2.5 micrometers or less ($PM_{2.5}$), a subset of PM_{10}, can be transported to the main bronchi or the alveoli. Hazardous materials such as heavy metals or carcinogenic polycyclic aromatic hydrocarbons can be attached to the particles, potentially causing inflammation, respiratory illnesses, and cardiovascular diseases. There are also indications that particulate matter can increase the risk of lung cancer. In Germany, particulate matter levels are decreasing steadily, thanks mainly to the renovation and upgrading of industrial facilities and efforts to equip diesel vehicles

Figure 14 **NRW environmental indicator: PM_{10} and $PM_{2.5}$ concentrations in urban settings**



In 2020, the average background levels of PM_{10} in urban settings was 15 micrograms per cubic meter, while the average $PM_{2.5}$ level was 10 micrograms per cubic meter. Both of these figures were significantly lower than the EU annual limits of 40 and 25 micrograms per cubic meter respectively. The graph shows the annual means for PM_{10} (usually 25 measuring stations) and $PM_{2.5}$ (9 measuring stations) in urban residential areas. The state government aims to limit PM_{10} concentrations to under 20 micrograms per cubic meter in accordance with WHO guidelines, and has succeeded in doing so in urban environments since 2014.

www.umwelt2020.nrw.de/036

with particle filters for the creation of low-emissions zones |→ figure 14, |↗ www.umwelt2020.nrw.de/037. Based on the latest findings, the World Health Organization (WHO) recommends reducing EU-wide PM_{10} and $PM_{2.5}$ limits significantly from 40 and 25 micrograms per cubic meter respectively to 20 and 10 micrograms per cubic meter respectively.

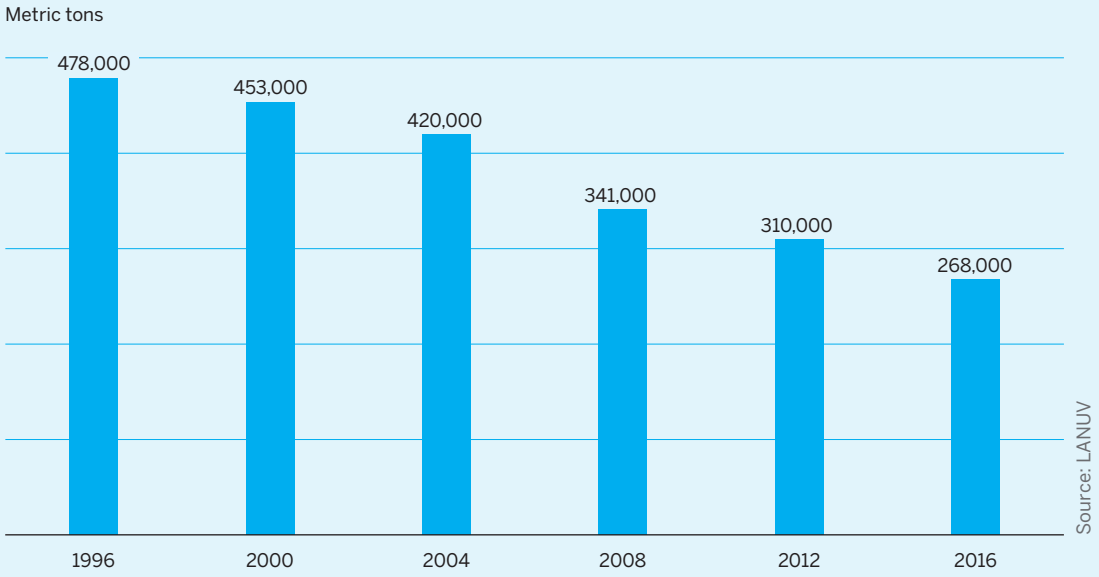
NITROGEN DIOXIDE LIMITS MET FOR THE FIRST TIME

Nitrogen oxides (NO_x) are byproducts of combustion processes in industrial facilities, power stations, and engines. Emissions from chimney stacks are dispersed far and wide through the air, contributing to background emissions. By contrast, exhaust gases from road vehicles have a direct impact on local residents |→ figure 15. Nitrogen dioxide (NO_2) is hazardous to our health. It irritates the mucosal tissue throughout the respiratory tract, and the resulting inflammation can exacerbate the effects of other airborne pollutants. Increased concentrations of NO_2 can lead to respiratory and cardiovascular diseases. What is more, NO_2 is an important precursor for ground-level ozone formation in the summer months. Vehicles with internal combustion engines, particularly those running on diesel, are the main emitters of nitrogen dioxide in urban environments. A total of 4.0 million of the 12.2 million vehicles registered in North Rhine-Westphalia are diesel-powered (as of October 2020), and they emit more nitrogen oxide overall than gasoline-powered cars. Nitrogen dioxide emissions from diesel vehicles only began to decline following the introduction of the Euro 6/VI and Euro 6d-TEMP emissions standards. Inland waterway vessels also make a notable contribution to local nitrogen dioxide emissions, particularly in towns and cities on the banks of the Rhine. These emissions are usually limited to the immediate vicinity of the river, such as waterside promenades.

In 2015, the European Commission took legal action in Germany after multiple German conurbations exceeded the annual mean nitrogen dioxide limit of 40 micrograms per cubic meter of air by significant margins. The case is currently with the European Court of Justice. Lawsuits were also filed to force changes to air quality planning and ensure compliance with NO_2 limits. Of the 14 suits filed against North Rhine-Westphalia, 13 have been settled out of court. The settlements involve resolving a comprehensive set of measures that have proven successful in the past and implementing them as part of air quality planning. Measures include retrofitting buses with systems to reduce nitrogen oxide emissions, implementing environmentally friendly traffic routing, setting up “eco-lanes” for low- or zero-emissions vehicles and mass transit, adjusting speed limits, adding new bike lanes, and making improvements to local public transport networks.

NO_2 concentrations have declined consistently in urban environments |→ figure 16. In 2019, 16 sample sites in 8 municipalities (Dortmund, Düsseldorf, Essen, Gelsenkirchen, Hagen, Cologne, Oberhausen, and Wuppertal) exceeded the annual mean of 40 micrograms per cubic meter. In 2020, however, all major conurbations in North Rhine-Westphalia met the NO_2 annual mean limit for the first time. The annual mean at the traffic measuring stations declined by an average of approximately 17% year on year. At 39 micrograms per cubic meter, the highest NO_2 annual mean in 2020 was measured in the Bilk district of Düsseldorf and on Graf-von-Galen-Ring in Hagen.

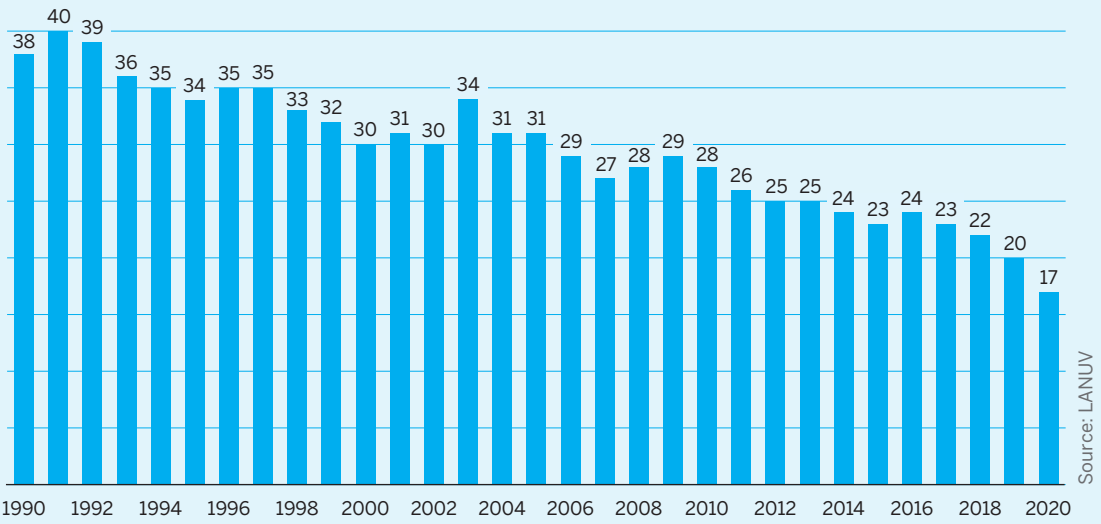
Figure 15 **NRW environmental indicator: nitrogen oxide emissions**



By 2016, nitrogen oxide emissions in North Rhine-Westphalia had declined by 44% since records began in 1996 to stand at 268,000 metric tons. The main polluters were industrial facilities, which accounted for 151,000 metric tons, and road traffic with roughly 71,000 tons. A total of 47,000 metric tons was attributable to the remaining emissions from other forms of transport and small boilers. All told, North Rhine-Westphalia emits roughly one-quarter of all NO_x emissions in Germany.

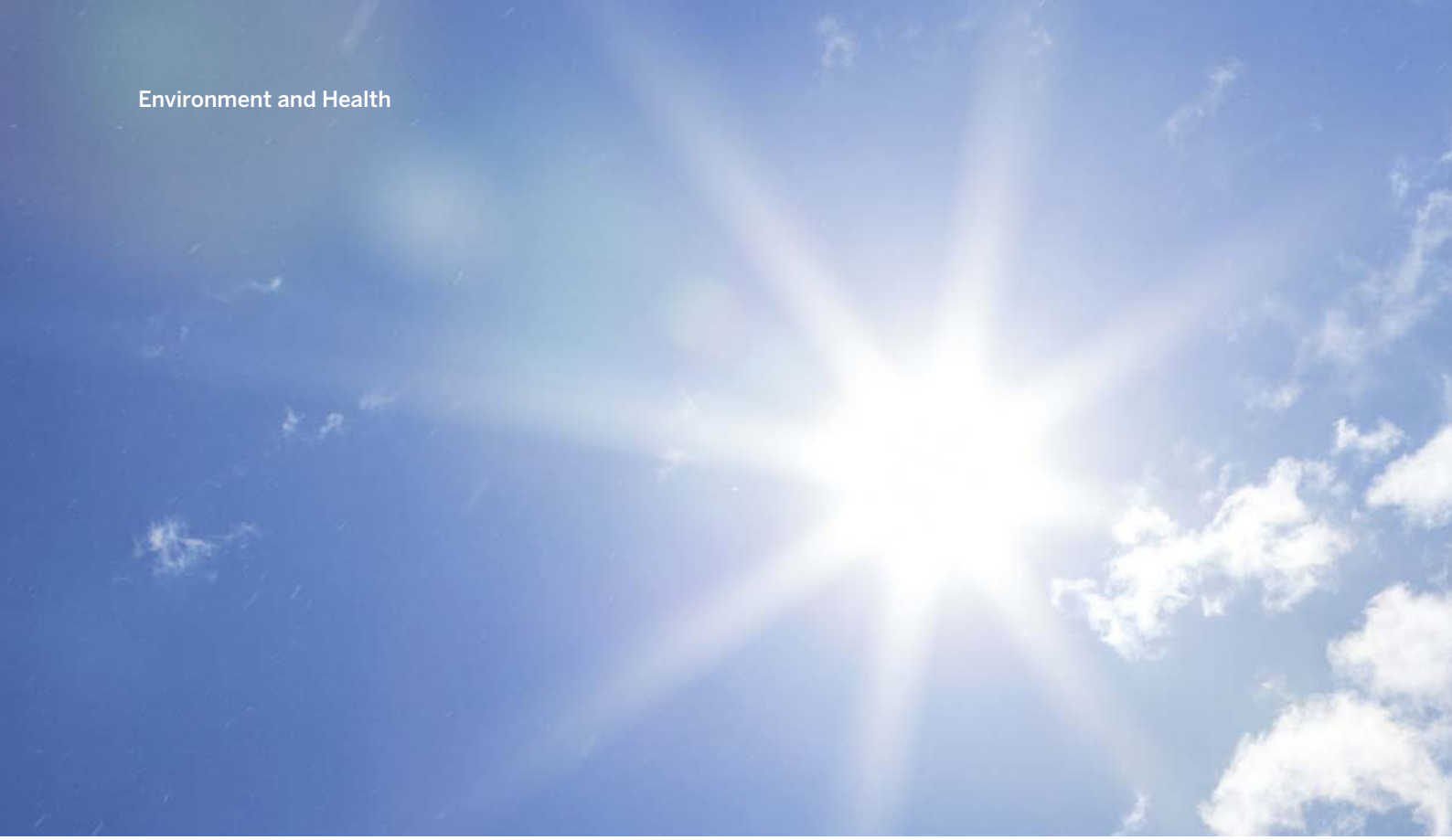
www.umwelt2020.nrw.de/038

Figure 16 **NRW environmental indicator: nitrogen dioxide concentration in urban settings**



In 2020, the annual mean nitrogen dioxide concentration in urban settings taken from 22 measuring stations stood at 17 micrograms per cubic meter. As a result, nitrogen dioxide concentration in residential areas away from highly frequented roads and industrial facilities fell significantly short of the EU-wide statutory annual mean limit of 40 micrograms per cubic meter. The EU annual limit for nitrogen dioxide concentration was complied with at all measuring stations on highly frequented inner-city roads in built-up areas for the first time in 2020. The state government aims to achieve compliance with EU limits across the board.

www.umwelt2020.nrw.de/039



MERCURY, THE MOST POISONOUS NON-RADIOACTIVE ELEMENT

In our latitudes, mercury enters our environment primarily through coal-fired power stations. The chemical, heavy and cement industries, as well as waste and wastewater treatment, also dispense mercury. Microorganisms convert mercury deposits in the soil or in water into organic methylmercury, which can then enter the food chain. Particularly Seafood and predatory fish, such as tuna and eels, are considered to be polluted. Methylmercury is liposoluble and highly toxic. It can permeate the blood-brain barrier and penetrate the placenta, damaging the brain and central nervous system and putting unborn and young children at a particularly high risk |↗ www.umwelt2020.nrw.de/040. Germany is one of Europe's largest mercury polluters, and North Rhine-Westphalia is estimated to account for one-third of Germany's mercury pollution. In 2019, the largest mercury emitters were the lignite-fired power stations in Neurath (471 kg), Niederaußem (327 kg), and Weisweiler (200 kg). However, their emissions have been reduced considerably compared to previous years.

Clevischer Ring in Cologne is another example of how effective efforts to cut pollution have been. In 2017, the annual mean here was 62 micrograms per cubic meter, but had declined to 35 micrograms per cubic meter by 2020.

STRONG FLUCTUATIONS IN OZONE LEVELS

Ground-level ozone (O_3) is not a direct emission. Instead, it is produced under intense direct sunlight through photochemical processes involving oxygen, precursor pollutants such as nitrogen oxides, and volatile organic compounds, which are released by the use of solvents and fuel combustion, among other things. In humans, ozone can impair respiratory function and cause inflammation of the airways, along with respiratory complaints. People who are susceptible to such issues or have underlying health conditions, such as asthma, are particularly vulnerable and must avoid physical activity when ozone levels are high. If ozone levels exceed an hourly mean of 180 micrograms per cubic meter, the general public is informed through the media.

Ozone concentrations in urban environments have fluctuated significantly over the past few years depending on the climatic conditions, making it hard to recognize any kind of trend. On average, there were 8 hourly mean values of more than 180 micrograms per cubic meter of ozone in 2020 |→ figure 17. However, the increase in the number of hot days due to global warming raises the prospect of more ground-level ozone forming |→ page 15.

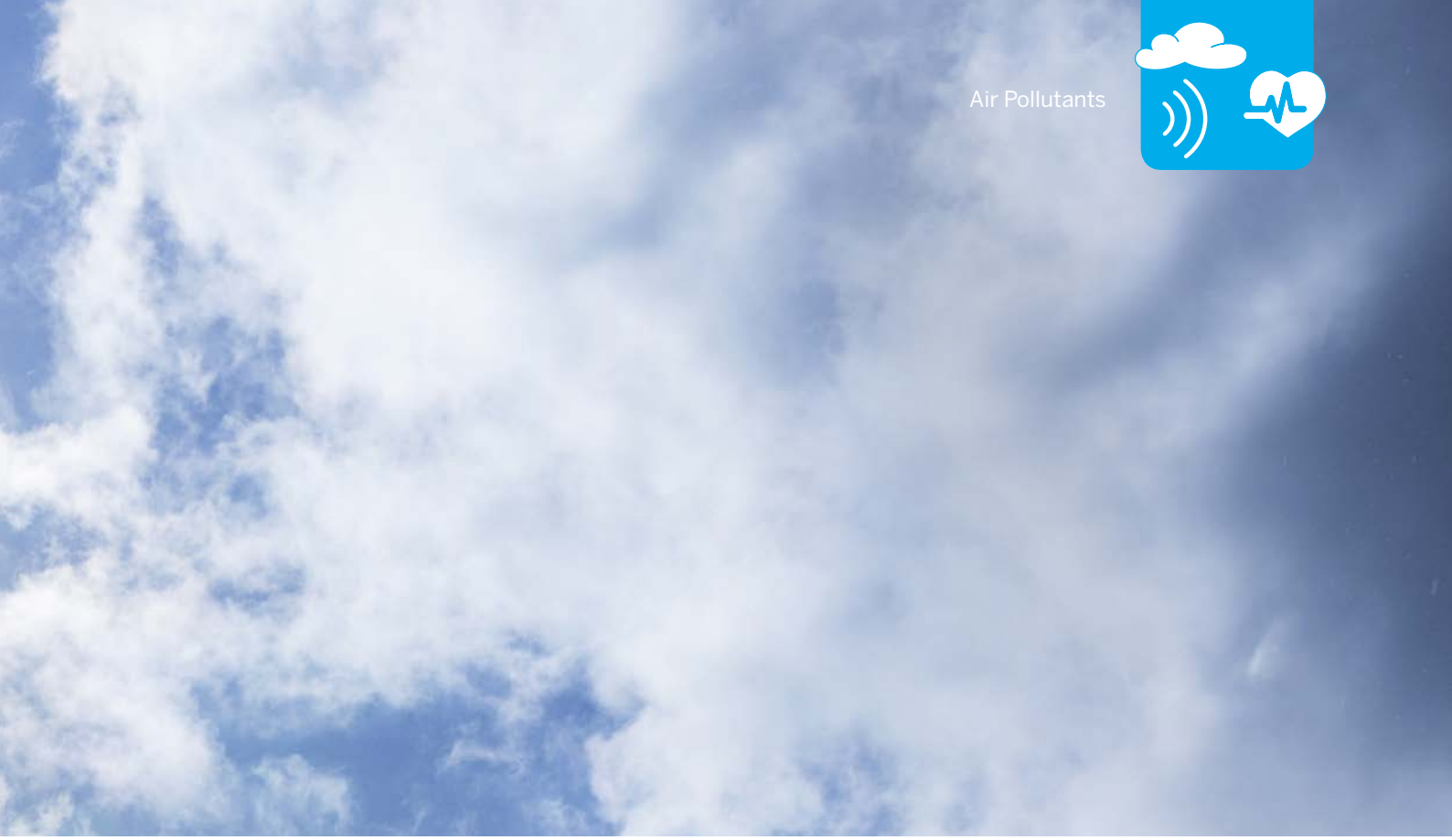
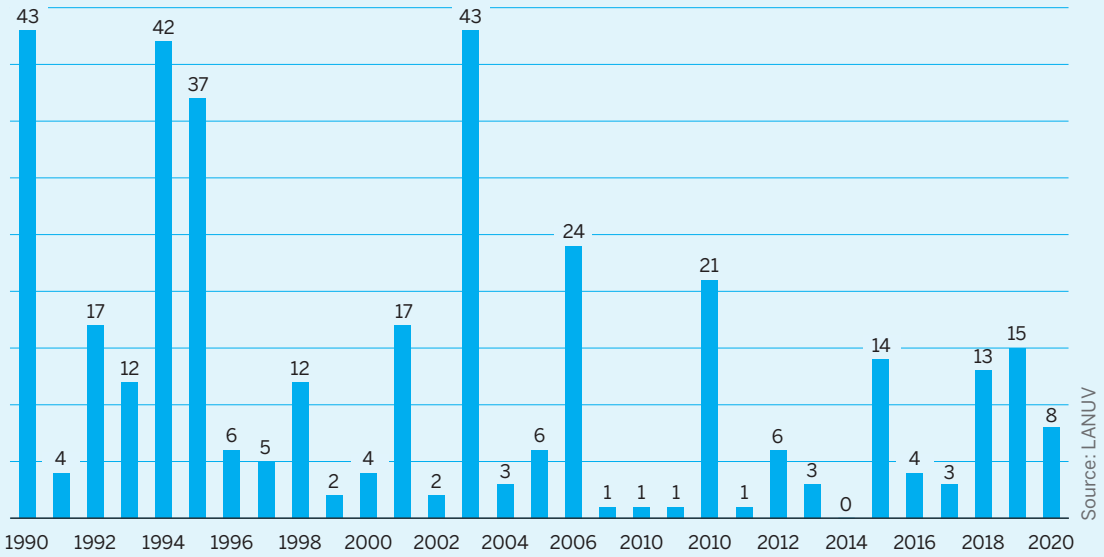


Figure 17 **NRW environmental indicator: ozone concentration in urban settings**

O3

Number of hourly mean values > 180 micrograms per cubic meter



Trend over the past 10 years:
–

Source: LANUV

In 2020, there were 8 hourly mean values on average exceeding the notification threshold of 180 micrograms per cubic meter at the 20 measuring stations in urban environments. The alarm threshold of a one-hour mean value of 240 micrograms per cubic meter was not exceeded at all. Despite a general decline in elevated ground-level ozone concentrations, there are major fluctuations between different years, making attempts to calculate a trend unfeasible. Besides emissions of precursor substances, high ozone figures also depend a great deal on periods of fine weather in the summer.

www.umwelt2020.nrw.de/041

NOISE, LIGHT, ELECTROMAGNETIC FIELDS

TOO MUCH TRAFFIC NOISE POLLUTION FOR 1.5 MILLION PEOPLE

Noise pollution is defined as constituting sounds that are disruptive, harmful, or even damaging to health. Excessive noise causes the body to release more stress hormones and activates both the autonomic nervous system and the hormone system, affecting blood pressure, heart rate, and other cardiovascular factors. These cardiovascular and metabolic changes usually take place unconsciously while we sleep, via the autonomous nervous system. The potential long-term consequences of permanent noise pollution range from sleep disruption to cardiovascular diseases, including heart attacks.

A study conducted by the German Environment Agency (Umweltbundesamt, UBA), focusing predominantly on elderly people, found that the risk of requiring medical treatment due to high blood pressure was almost twice as high among people exposed to a noise level of up to 55 dB(A) through their bedroom window than among those subject to a maximum noise level of 50 db(A).

The EU Environmental Noise Directive provides an EU-wide approach to reducing noise pollution. Environmental noise is defined as the noise created by road, rail, and air traffic, as well as by industry. Municipalities are obliged to draw up and publish noise maps for agglomeration, primary road and rail transport routes, and major airports every five years. The latest results are published in the environmental noise portal ↗ www.umwelt2020.nrw.de/042. Noise action plans are created on the basis of these noise maps if the day-evening-night noise level (LDEN) is equal to or greater than 70 dB(A) or the night noise level (LNight) is equal to or greater than 60 dB(A) in the vicinity of homes, schools, hospitals, or other protected buildings.

In North Rhine-Westphalia, some 1.5 million are exposed to over 55 decibels of noise at night, while 1.1 million

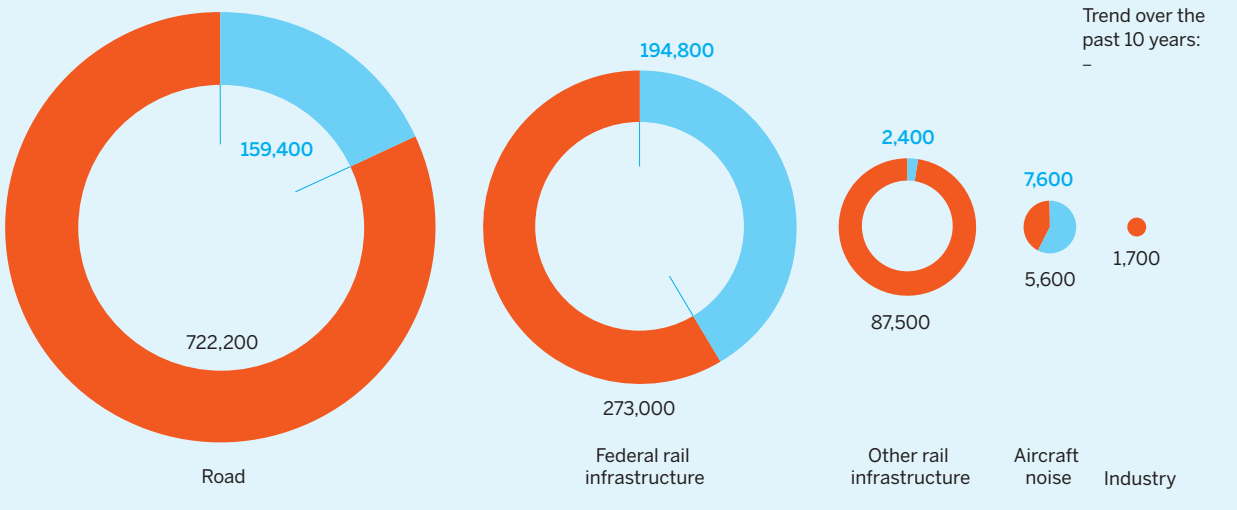
60 DECIBELS TWICE AS LOUD AS 50 DECIBELS – THE LOGARITHMIC DECIBEL SCALE

The scale used to define loudness is the sound pressure level, which is normally measured in A-weighted decibels, or dB(A). A whisper is roughly 30 dB(A), a normal conversation around 55 dB(A), and a vacuum cleaner approximately 70 dB(A). Sounds above 100 dB(A) are uncomfortable to humans, and anything above 120 dB(A) can cause pain. However, given that the decibel scale is logarithmic, 100 dB(A) is not twice as loud as 50 dB(A). Loudness is always perceived subjectively, but an increase in around 10 dB(A) results in volume roughly doubling. In other words, sound pressure levels of 60 dB(A) are around twice as loud as 50 dB(A).

Figure 18 **NRW environmental indicator: noise pollution**

Sub-indicator: noise pollution (night)

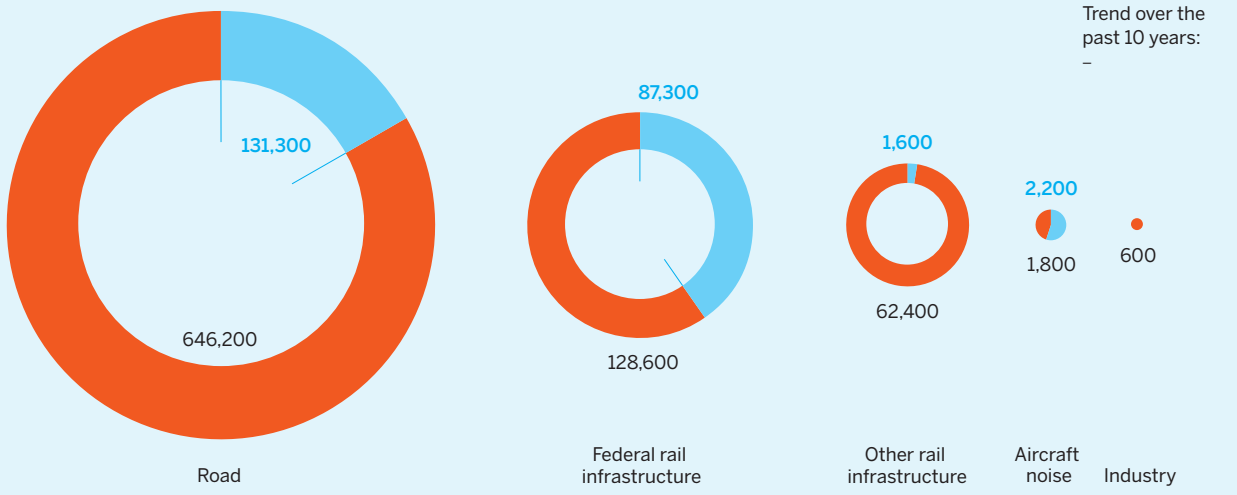
Number of people exposed to > 55 A-weighted decibels according to 2017 noise map



Around 1.5 million people, or 8% of the population of North Rhine-Westphalia, are exposed to sound pressure levels of over 55 dB(A). Three-quarters of those impacted by road traffic noise live in agglomeration. A sound pressure level of 55 dB(A) is equivalent to a normal conversation, while 60 dB(A) is around the same as the noise of an office. The WHO recommends noise levels that are significantly lower than the limits and guidelines for environmental noise currently in place in Germany |➔ figure 19.

Sub-indicator: noise pollution (day, evening, night)

Number of people exposed to > 55 A-weighted decibels according to 2017 noise map



The current noise map for day, evening, and night shows that around 1.1 million people, or 6% of the population of North Rhine-Westphalia, are exposed to sound pressure levels higher than 65 dB(A). A level of 65 dB(A) is roughly the same as the noise level in a cafeteria, while 70 dB(A) is equivalent to a vacuum cleaner. Of the people affected, 79% live in agglomeration. The state government aims to significantly reduce noise pollution in residential areas in line with WHO guidelines by 2030.

|↗ www.umwelt2020.nrw.de/043

people are exposed to constant noise levels of more than 65 decibels |→ figure 18. Frequently, people are exposed to multiple sources of noise pollution.

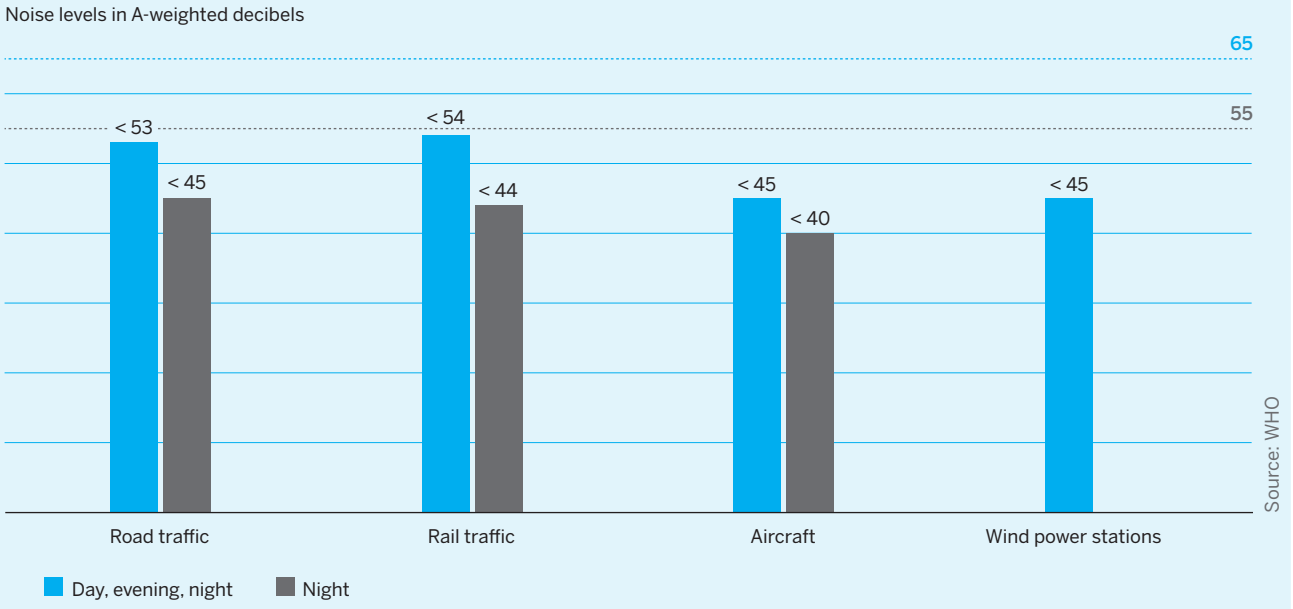
North Rhine-Westphalia has a dense network of airports and airfields. Night-time arrivals and departures, as well as flights late in the evening and early in the morning, have a particularly adverse effect on local residents. Some 13,200 people in North Rhine-Westphalia are exposed to sound pressure levels north of 55 dB(A). Protection from aircraft noise is defined in the German Act on Protection against Aircraft Noise (Fluglärmschutzgesetz) and is primarily ensured through passive measures such as noise-protection structures and restrictions on facility usage. The Ministry for Environment, Agriculture, Conservation and Consumer Protection has defined noise protection zones for the major airports in Düsseldorf and Cologne/Bonn as well as six other airports |↗ www.umwelt2020.nrw.de/044.

STRICTER GUIDELINES FOR ENVIRONMENTAL NOISE

The WHO Regional Office for Europe published new guidelines for environmental noise in 2018, which were drawn up on the basis of the latest noise pollution research findings and include recommendations on how to keep people safe from environmental noise from road traffic, rail transport, aircraft, and wind power stations. The guidelines specify levels at which noise is expected to begin impacting people's health or causing significant nuisance, as well as recommended measures to reduce the effect |→ figure 19. The WHO guidelines are in some cases significantly lower than the statutory immission guidelines and limits applicable in Germany |↗ www.umwelt2020.nrw.de/045. Although not directly comparable, the two sets of guidelines do show where urgent action needs to be taken. To use an example, immission limits for road and rail transport on newly constructed routes in residential areas are 59 dB(A) during the daytime and 49 dB(A) at night. In spa areas or areas with hospitals or care homes, the limits are 57 dB(A) during the day and 47 dB(A) at night. The values defined by the German Act on Protection against Aircraft Noise (Fluglärmschutzgesetz) to determine the location of protection zones around passenger airports are 65 dB(A) during the day and 55 dB(A) at night.

The WHO's guidelines will be analyzed and subject to expert appraisal and consultation at a variety of political levels in the near future. Only then will we see how and to what extent German noise protection laws need to be adapted.

Figure 19 **WHO Environmental Noise Guidelines**



In its Environmental Noise Guidelines for Europe, the WHO recommends reducing noise pollution, as noise can be damaging to health and impact sleep once it reaches a certain level. Under the guidelines, aircraft noise during the day, evening, and night should be reduced to under 45 dB(A) on average and to under 40 dB(A) on average during the night.

ARTIFICIAL LIGHT SOURCES: A BLESSING OR A CURSE?

Life without artificial outdoor lighting is hard to imagine. Streetlights, illuminated advertising, building lighting, floodlights, and other forms of lighting help us find our way and keep ourselves safe. They also increase the appeal of towns, cities, and buildings in the darkness. The ubiquity of lighting and its sometimes indiscriminate use also has a negative effect (beyond the obvious energy consumption).

Glare and overly brightened rooms can prove to be a nuisance. Light may be essential to all forms of life, but light immissions at the wrong time or at the wrong spectrum can affect our body clocks and influence our sleep rhythms, health, and productivity. Effects can include changes to how we release melatonin (an antioxidant hormone that helps regulate our immune system and our body clock), an increased risk of breast and prostate cancer, and metabolic syndromes. A great deal more research is required on the effects of light pollution, including on flora and fauna. Artificial light can disrupt plants' growth cycles, act as traps for insects, disturb birds' flight routes, scare bats away from their roosts, and do plenty of other damage. What is more, light pollution can also impair astronomic observation. The Milky Way is barely visible in North Rhine-Westphalia, aside from at the Dark Sky Park in the Eifel National Park.

The circular on light immissions, measurements, analysis, and mitigation (Lichtimmissionen, Messungen, Beurteilung und Verminderung) governs whether light pollution is considered to have a reasonable or harmful impact on the environment ↗ www.umwelt2020.nrw.de/046. The State Agency for Nature, Environment and Consumer Protection also defines a catalog of measures to mitigate against or reduce light pollution in its brochure on artificial outdoor lighting (Künstliche Außenbeleuchtung) ↗ www.umwelt2020.nrw.de/047.

ELECTROSMOG

Artificially created electrical, magnetic, and electromagnetic fields – commonly known as electrosmog – vary greatly in terms of their physical properties, range, and influence on the human body. Some symptoms have been well researched and proven in a scientific environment.

For example, the kinds of low-frequency electric and magnetic fields that occur in overhead lines and household electrical devices can cause low levels of electrical current in the human body that overlap the body's own nervous system flows. If these currents reach a certain level, they can trigger arrhythmia and other symptoms.

High-frequency electromagnetic fields – the likes of which are emitted by microwaves, cell phones, cordless phones, and wireless routers – primarily cause a warming of temperatures. They penetrate the body just under the skin, are absorbed, and converted into heat. If the radiation reaches a certain level, it can damage body tissue.

The German Ordinance on Electromagnetic Fields (Verordnung über elektromagnetische Felder) specifies relevant limits to protect the general public ↗ www.umwelt2020.nrw.de/048. These limits apply to stationary transmitter and electricity facilities such as high-voltage power lines. So far, no scientific evidence has been found that electromagnetic fields are damaging to health if limit values are complied with. Nevertheless, the effects of weak fields – including potential links with leukemia in children and magnetic fields near high-voltage power lines – remain a hotly disputed issue. As a precaution, the WHO and the German Commission on Radiological Protection (Strahlenschutzkommission) recommend avoiding unnecessary disturbance and minimizing artificially created electromagnetic fields where possible ↗ www.umwelt2020.nrw.de/049.

POLLUTION AND FOOD

DIOXINS AND DIOXIN-LIKE PCBS IN RAW MILK

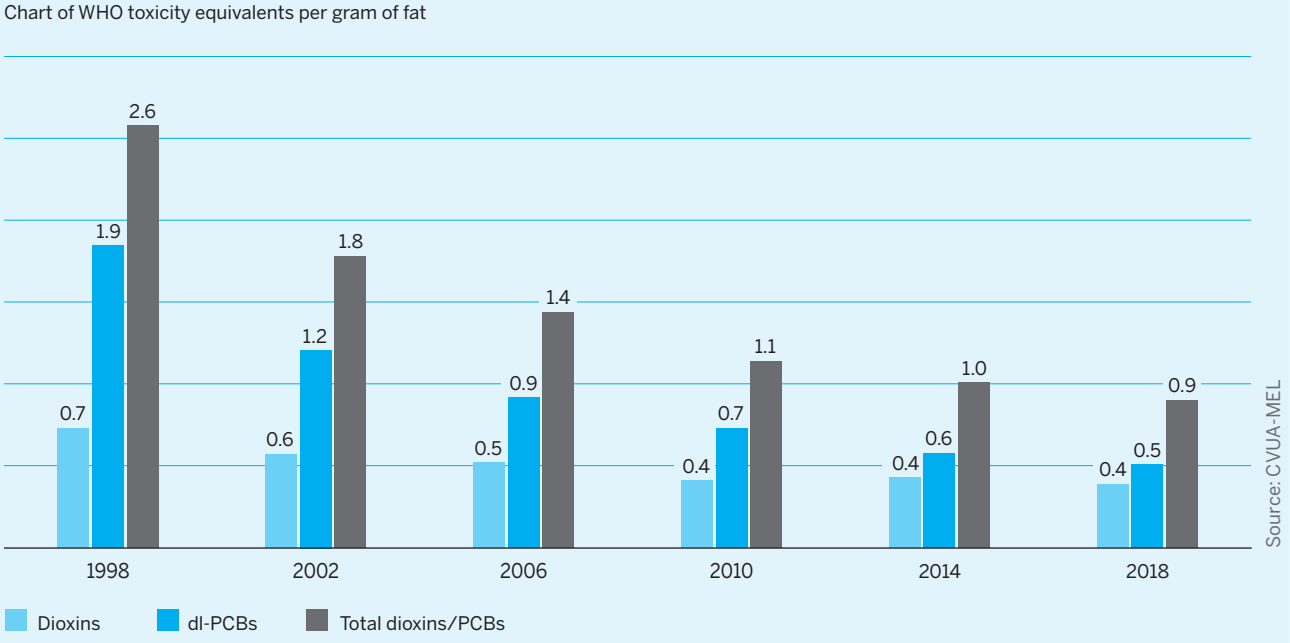
Dioxins (a catch-all term for polychlorinated dibenzo-p-dioxins and dibenzofurans) enter the environment primarily through waste incineration plants and the metal-producing and metal-processing industries. Levels of dioxins have successfully been reduced since the 1980s through mitigation. In addition, polychlorinated biphenyls (PCBs) were used in transformers, hydraulic fluids, flame retardants, plasticizers, and waterproofing up until the 1980s. Dioxins, dioxin-like PCBs (dl-PCBs), and non-dioxin-like PCBs are harmful to the environment and degrade at an extremely low rate.

Dioxins and PCBs can end up in foodstuffs, water, and the human body through the food chain. Investigations into the health impact of such materials center on the long-term effects at low concentrations. In animal testing, dioxins and PCBs were found to impair reproductive functions, the immune system, the nervous system, and the hormone balance. These substances are also classified as carcinogenic in humans by the WHO.

The state of North Rhine-Westphalia aims to minimize the amount of dioxins and PCBs absorbed by our bodies. To do so, it continuously monitors data on background levels of dioxins and PCBs in foodstuffs. For example, raw milk is analyzed every four years to determine contamination levels and act as a basis for mitigation. Maximum limits and action levels apply to dioxins and PCBs. If action levels are exceeded, the potential sources of the contamination are investigated and measures taken to mitigate or eliminate them.

In 2018, a total of 48 raw milk samples were taken from dairy plants with their own raw milk supply in North Rhine-Westphalia and analyzed for the presence of dioxins, 12 different dioxin-like PCBs, and 6 non-dioxin-like PCBs. Both measured levels of dioxins and dioxin-like PCBs and overall levels were significantly lower than the defined limits for milk and dairy products (2.5 picograms of WHO toxic equivalents per gram of fat for dioxins and 5.5 picograms WHO toxic equivalents per gram of fat for the sum of dioxin and dioxin-like PCBs in accordance with Commission Regulation [EC] No 1881/2006) |→ figure 20. As a result, levels of dioxins and dioxin-like PCBs in milk and dairy products are only one-third and half respectively of the action levels recommended by the European Commis-

Figure 20 **Dioxins and dioxin-like PCBs in raw milk from NRW**



The results of a total of 48 raw milk samples from 2018 show that the overall level of contamination with dioxin and dioxin-like PCBs has declined by some 70% since 1998. Current measurements are significantly lower than the EU's maximum limits for dioxins and dioxin-like PCBs, as well as for the sum of dioxins and dioxin-like PCBs in milk and dairy products. The stagnating dioxin and dioxin-like PCB levels over recent measurement campaigns reflect the level of background contamination in this region.

sion. At 1.5 to 6.9 nanograms per gram of fat, the sum of the 6 non-dioxin-like PCBs is also 6 to 30 times lower than the current limit of 40 nanograms per gram of fat.

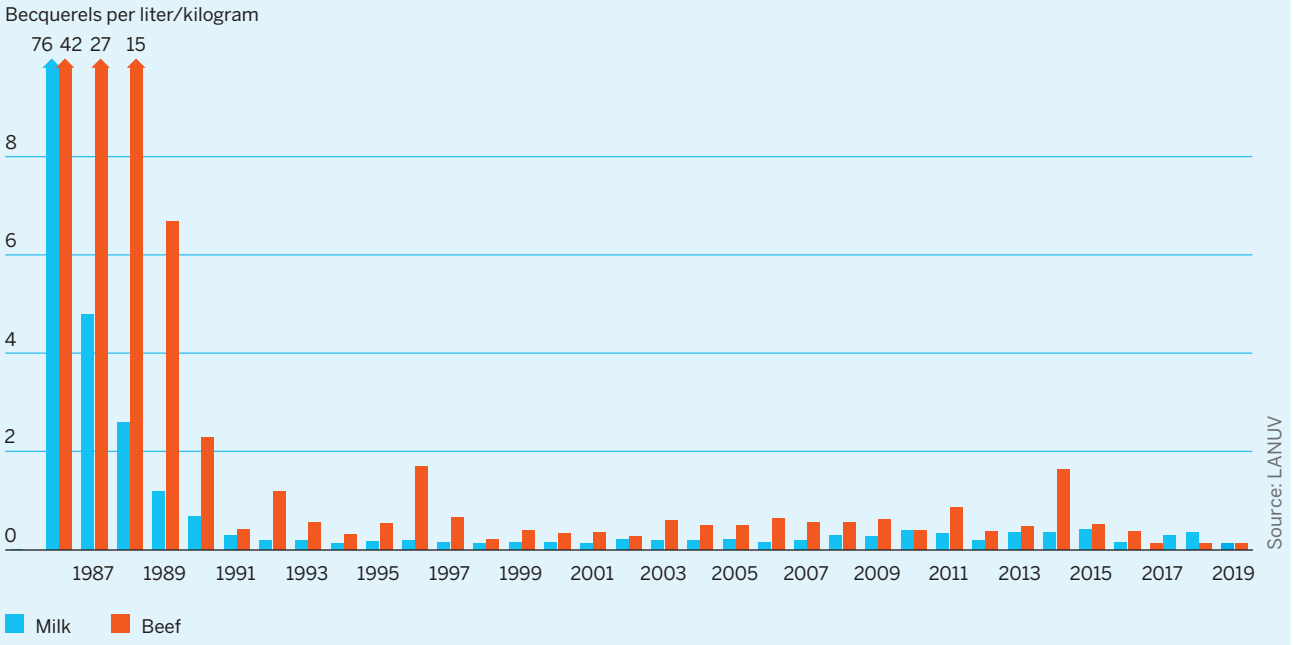
BARELY ANY RADIOACTIVITY IN FOOD AND THE ENVIRONMENT

North Rhine-Westphalia measures radioactivity concentrations in the environment on behalf of the federal government in food, feedstuffs, drinking water, groundwater, surface water, wastewater, sewage, waste, the soil, and in what are known as indicator plants. The results of this analysis are published in the annual reports of the five official measurement bodies ↗ www.umwelt2020.nrw.de/050. An analysis of 2,152 individual samples in 2019 determined only extremely low levels of artificial radioactivity in food and feedstuffs produced in or imported into North Rhine-Westphalia. Slightly higher levels of radioactive substances were found in game and samples from non-agricultural areas, including cesium-137 from the Chernobyl nuclear disaster in 1986, strontium-90 from nuclear weapons testing in the 1950s and 1960s, and iodine-131 from nuclear medicine.

In the forest, radioactive cesium originating from the fallout from the Chernobyl disaster can be found in the layers of soil on the forest floor. Wild boar eat a contaminated species of fungi known as deer truffles that form fruiting bodies and roots underground, which is why levels of radioactivity in these animals sometimes exceed the permitted limit for radiocesium of 600 becquerels per kilogram. By contrast, radioactive cesium in agricultural areas is bonded to the soil during plowing and fertilization, and is therefore practically no longer available to the roots of cultivated plants. Cesium-137 concentrations in foodstuffs such as milk or beef have therefore declined significantly since the reactor accident in Chernobyl → figure 21. The number of samples in which cesium-137 is found has also declined considerably. Some 95% of samples of plants grown in North Rhine-Westphalia, and 91% of animal samples, fell below the limit of detection for cesium-137 of 0.2 becquerels per kilogram in 2019.

The latest analysis from the federal government shows that the level of radiation emitted by Chernobyl and nuclear weapons testing, as well as from the operation of nuclear power stations, plays a minor role in terms of overall radiation in Germany. Here, the biggest contributors to

Figure 21 **Radioactive cesium-137 activity in milk and beef samples in NRW**



Radioactivity in a wide range of foodstuffs and natural substances has been routinely monitored by official bodies since the Chernobyl nuclear disaster in 1986. The level of radioactivity measured in North Rhine-Westphalia declined significantly after 1986, as shown by the mean measurements of radioactive cesium-137 detected in milk and beef. The maximum limit for cesium-137 is 370 becquerels per liter for milk and 600 becquerels per kilogram for beef.

MEASUREMENT NETWORK FOR NATURAL RADIATION AND IN THE EVENT OF AN INCIDENT

The Federal Office for Radiation Protection (Bundesamt für Strahlenschutz) operates around 1,800 local dose rate measuring stations, which are a constant source of data on natural radioactivity and for nuclear emergency planning ↗ www.umwelt2020.nrw.de/051. The network of measuring stations would detect any release of radioactive material in North Rhine-Westphalia on account of a nuclear incident, such as at one of the three nuclear power stations located near the North Rhine-Westphalia border or one of the nuclear facilities in the state ↗ www.umwelt2020.nrw.de/052.

radiation are X-ray facilities and the naturally occurring gas radon and the substances it decomposes into ↗ www.umwelt2020.nrw.de/053. The Fukushima nuclear disaster in 2011 did not result in any notable radiation contamination in Germany.

PLANT PROTECTION PRODUCTS IN FOODSTUFFS – PESTICIDE REPORT PROVIDING TRANSPARENCY

Plant protection products are all substances and materials used to combat pests and weeds. They kill off any undesired plants on arable land (herbicides); fight fungal diseases, bacteria, and viruses (fungicides, bactericides, virucides); are used as inert gases against storage pests; help to make crops more robust (growth regulators); and protect feedstuff crops and plant-based raw materials from pests (insecticides). Plant protection products are used on a widespread basis in agriculture and landscape gardening. In Germany, the Federal Office of Consumer Protection and Food Safety (Bundesamt für Verbraucherschutz und Lebensmittelsicherheit) recorded the use of some 115,000 metric tons of plant protection products in 2017 (substances including active plant protection products and auxiliary products). Of those products, 44% were herbicides, 29% fungicides, bactericides, and virucides, and 12% inert gases. In North Rhine-Westphalia, around an estimated 9,000 metric tons of these plant protection products are likely to have been used on agricultural land (substances, excluding inert gases).

Plant protection products may be used in Germany if they have been approved in an EU Community procedure and in Germany. Products undergo extensive analysis on toxicity, acute and long-term effects, effects on genetic make-up and the hormone system, carcinogenesis, and much more

in order to evaluate their impact on the health of humans and animals. Product application is also tested in the field, with residues also undergoing analysis. Maximum residue levels are set as low as possible and should be no higher than necessary for the relevant application, and no higher than is acceptable from a health-related perspective. Nevertheless, some plant protection products remain controversial, such as the herbicide glyphosate, which the International Agency for Research on Cancer has classified as a "probable human carcinogen," leading to many high-profile lawsuits in the United States.

Residues of plant protection products in foodstuffs are unavoidable in conventional agriculture. Producers, importers, and retailers all have a responsibility to ensure that the food they sell complies with legal requirements. Regulation (EC) No 396/2005 on maximum residue levels of pesticides in or on food and feed of plant and animal origin governs how much of any relevant substance is allowable and safe ↗ www.umwelt2020.nrw.de/054. Maximum levels always refer to unprocessed goods sold as purchased.

The state's official food watchdog agency analyzes around 4,000 randomly chosen food samples from Germany and abroad every year for residues of up to 600 plant protection products. The results of the analysis are published in the pesticide report, which is frequently updated ↗ www.umwelt2020.nrw.de/055. The pesticide report is split into different sections for each food group (grain, potatoes, fresh vegetables, mushrooms, fresh fruit, herbs and spices) and details how many samples were found to contain pesticides and how many exceeded maximum residue levels. It also contains comparisons by country of origin, supermarket chain, and the active ingredients detected.

PESTICIDE REPORT EXAMPLE: STRAWBERRIES

A total of 785 samples were analyzed between 2016 and 2018, 16 of which from organic farming. Pesticides were detected in 91% of all samples. Of those, 79% contained multiple residues (2 to 20 pesticides per sample), and one exceeded the maximum limit. The fungicide Cyprodinil was the most frequently detected pesticide. By contrast, only one sample of organic strawberries showed signs of pesticides, and there were no samples with multiple residues or maximum limit violations.

↗ www.umwelt2020.nrw.de/056

Waste, soil, and water in North Rhine-Westphalia

Land take

Increase in land for settlements and transport infrastructure

8.1 ha per day

Land used for settlements

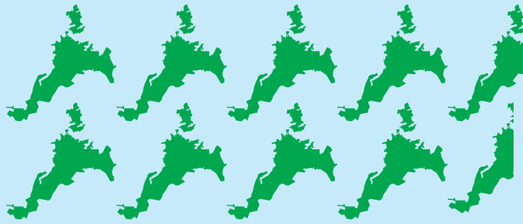
306 m² per person

Increase in settlements and transport infrastructure

from 1997 to 2019 amounts to

approx. 1,029 km²,

or 9.5 times the size of the Eifel National Park



Household waste and recycling

per capita

464 kg Trend →

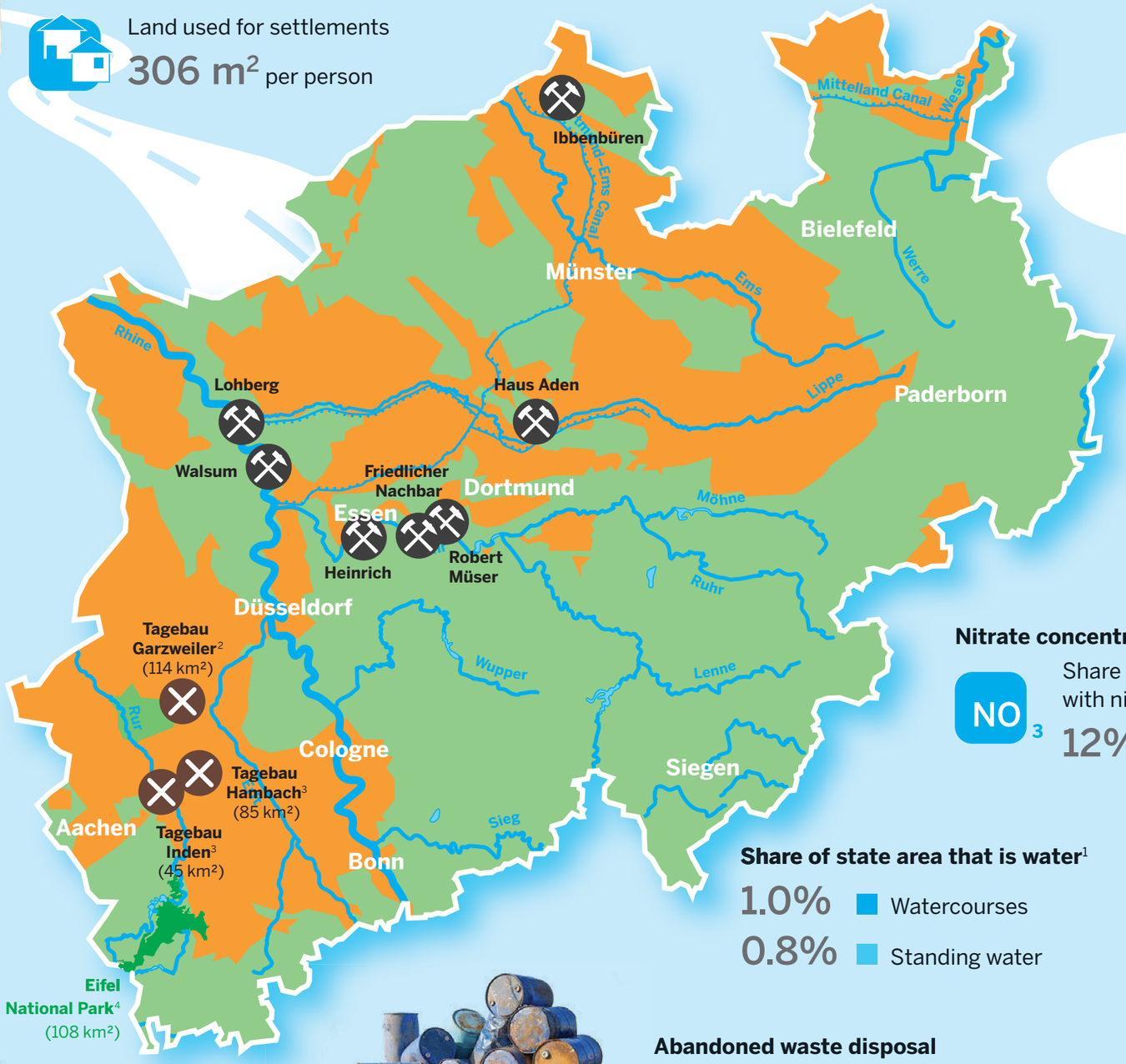
Recycling rate

50% Trend →

Total waste

more than 3.2 t

per person per year



Chemical status of groundwater

Share of state area

60% Good status

40% Poor status

Ecological status of surface waters

8.8% with a very good or good ecological status

1.6% have very good or good potential

Record water levels Rhine in Düsseldorf

High water
on January 2, 1926

1,110 cm

Low water
on October 23, 2018

23 cm

Nitrate concentration in groundwater

NO₃

Share of measuring stations with nitrate levels > 50 mg/l

12% Trend →

Share of state area that is water[1]

1.0% Watercourses

0.8% Standing water

Abandoned waste disposal and industrial sites

approx. 97,000

3

Approved lignite mining fields

Integral monitoring of rising coal mine water

7

Centralized mine water management systems

Sources: 1 IT.NRW 2019 ▪ 2 RWE 2019 ▪ 3 RWE 2017 ▪ 4 Wikipedia 2021 ▪ Map: Wikipedia 2018, LANUV, Geobasis NRW 2014

WASTE MANAGEMENT AND THE CIRCULAR ECONOMY

MORE THAN 3 METRIC TONS OF WASTE PER PERSON PER YEAR

In 2018, around 57.3 million metric tons of the waste generated in North Rhine-Westphalia was delivered to waste disposal companies based in the state (roughly equivalent to 3.2 metric tons per person) |→ figure 22. Most of the waste originated from construction or demolition work, environmental protection measures, and production processes. Municipal waste, which mainly consists of household garbage and commercial waste of a similar nature, accounted for 16% of the total. The figure of 57.3 million metric tons does not include waste that is re-used by companies or by waste-disposal companies, or that is disposed of outside of North Rhine-Westphalia.

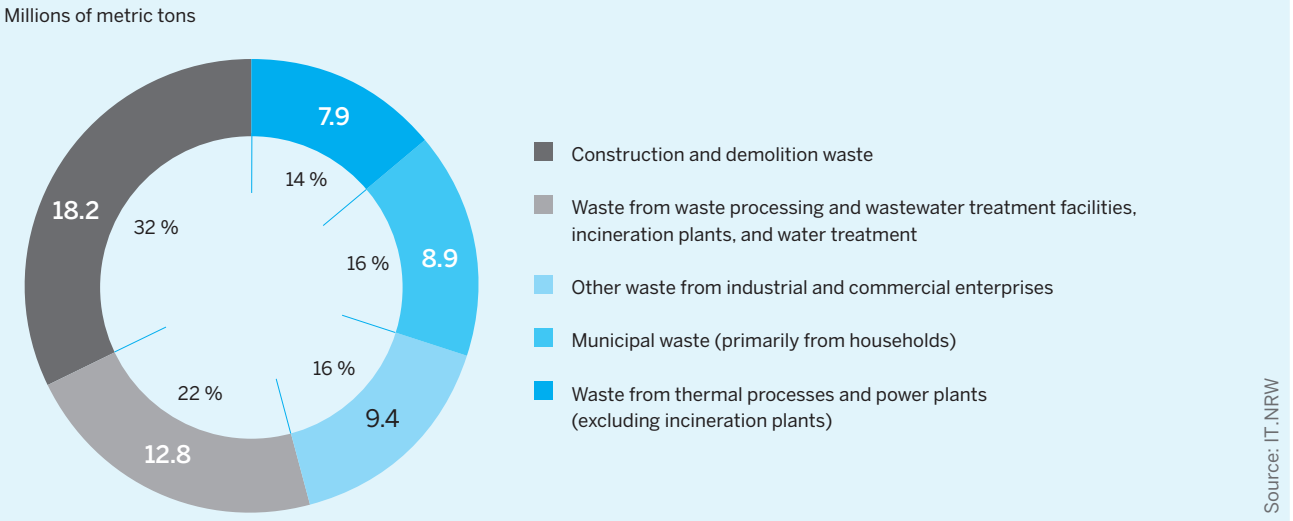
THE GOLDEN RULES OF WASTE MANAGEMENT

One of the principles of the EU's Waste Framework Directive is that waste management must not impact the environment or public health. The directive stipulates a 5-level hierarchy – prevention, preparing for re-use, recycling, recovery, and disposal – for waste management. The regulations are implemented through a variety of measures, including the German federal government's waste-prevention program and Circular Economy Act (Kreislaufwirtschaftsgesetz), as well as waste management planning and consulting.

HAZARDOUS WASTE DISPOSED OF IN NORTH RHINE-WESTPHALIA

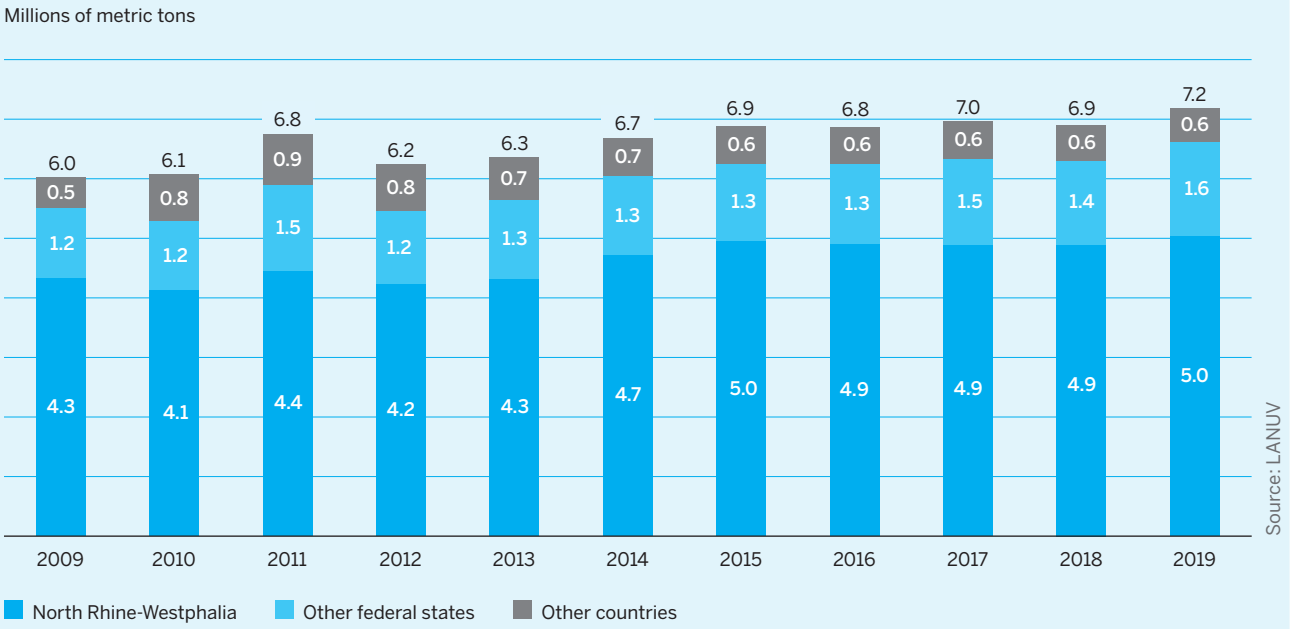
In 2019, some 6.1 million metric tons of hazardous waste was generated in North Rhine-Westphalia, 5.0 metric tons of which was disposed of in the state. At 2.4 million metric tons, waste from production processes and service provision accounted for the lion's share, with 1.9 million metric tons attributable to environmental protection measures (such as baghouse dust from incineration plants or slurry from wastewater treatment). Roughly 1.8 million metric tons originated from construction, demolition, and the remediation of contaminated sites. This, coupled with hazardous waste imported from other federal states or from abroad, resulted in 7.2 million metric tons of hazardous waste being disposed of in North Rhine-Westphalia in 2019 |→ figure 23, |↗ www.umwelt2020.nrw.de/057.

Figure 22 **Waste generated in NRW and delivered to waste-disposal plants in the state in 2018**



The waste generated in North Rhine-Westphalia in 2018 and delivered to waste disposal plants in the state totaling some 57.3 million metric tons (including hazardous waste) consisted of 18.2 million metric tons of construction and demolition waste; 12.8 million metric tons from waste processing, wastewater treatment, and incineration facilities; 9.4 million metric tons of other waste from industrial and commercial enterprises; 8.9 million metric tons of municipal waste; and 7.9 million metric tons of waste from thermal processes and power plants.

Figure 23 **Hazardous waste disposed of in NRW by region of origin**



In 2019, some 7.2 million metric tons of hazardous waste was disposed of in North Rhine-Westphalia, including bituminous coal compounds, wood containing hazardous substances, organic solvents, washing liquids, and mother liquors. Of this hazardous waste, 22% originated from other federal states (approx. 1.6 million metric tons), and 8% was imported from abroad (0.6 million metric tons). Analysis of data from the past 10 years shows that the volume of waste disposed of in North Rhine-Westphalia has increased sharply. In 2019, 85% of the hazardous waste produced in North Rhine-Westphalia was also disposed of in the state.

HOUSEHOLD WASTE LEVELS AND RECYCLING RATE STABLE

In 2019, North Rhine-Westphalia's households generated approximately 8.3 million metric tons of household garbage and packaging waste, which was picked up by garbage collectors under the dual collection system. At roughly 38%, household garbage accounted for the largest share of the waste, followed by biodegradable and garden waste (approx. 24%), paper and cardboard (approx. 14%), and bulk refuse (approx. 8%). Lightweight packaging (made from plastics, composites, aluminum, or tinplate, and collected in yellow garbage containers or bags) accounted for just under 7% of all garbage, while glass made up a 4% share and waste containing valuable resources such as wood or metal accounted for 4%. Hazardous waste collected separately, such as batteries and medication, accounted for 0.2% of total waste. Volumes of household garbage, bulk refuse, biodegradable and garden waste, and waste containing valuable resources per person per year have remained at high but stable levels over the past 10 years → figure 24.

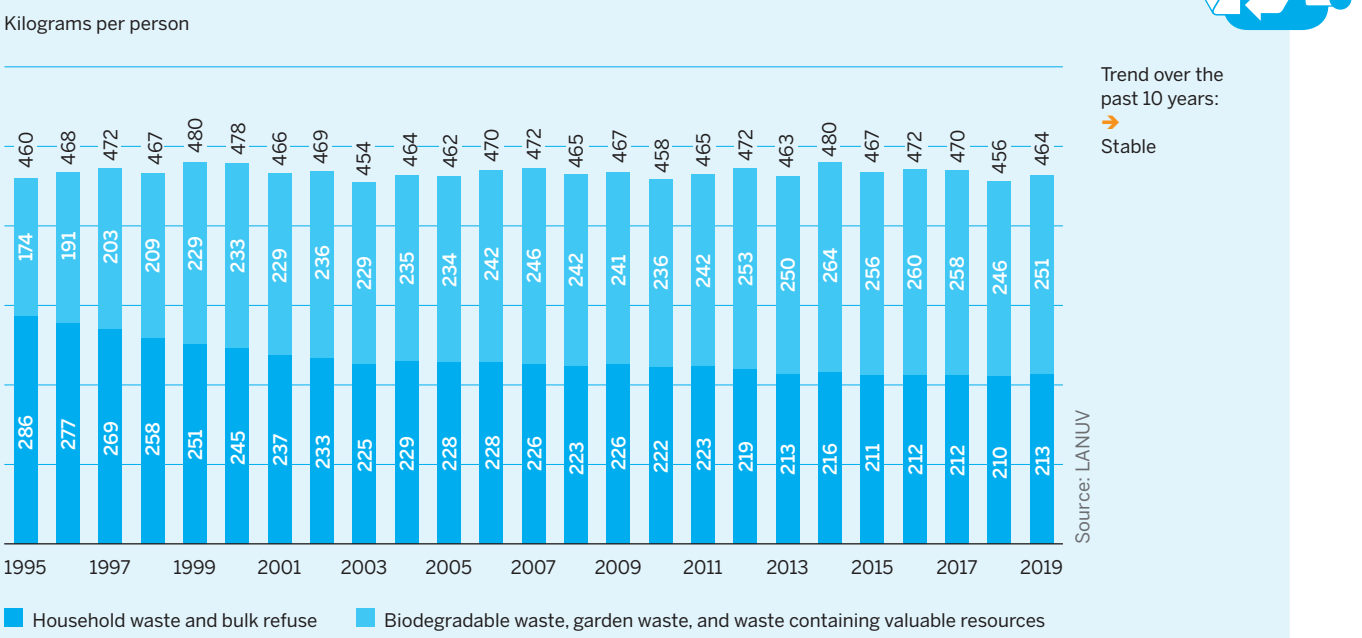
MICROPLASTICS – THE INVISIBLE POLLUTANT

Some 400 million metric tons of plastic is produced worldwide every year, using fossil fuels such as coal, oil, and gas. Plastic is omnipresent. Some of our plastic waste ends up in the ocean, where it breaks down into microplastics and accumulates in marine life. This form of pollution has put microplastics center stage in terms of research, politics, and public debate. We are now very much aware of the burden we put on the environment through the use of microplastics, and we are gaining more and more knowledge about the presence of plastics in other parts of the environment, such as soil and living organisms.

Microplastics can damage water-based habitats and lead to changes in water ecology, as it does not biodegrade very quickly – if at all. Underwater organisms can absorb microplastics through their food, meaning that traces have been found in mussels, sea snails, marine worms, sea louse, and fish. As these organisms act as food sources for other marine animals, microplastics become entrenched in the food chain. There are also indications that additives in the plastic production process, such as cadmium, flame retardants, and plasticizers, have toxic or hormone-like effects.

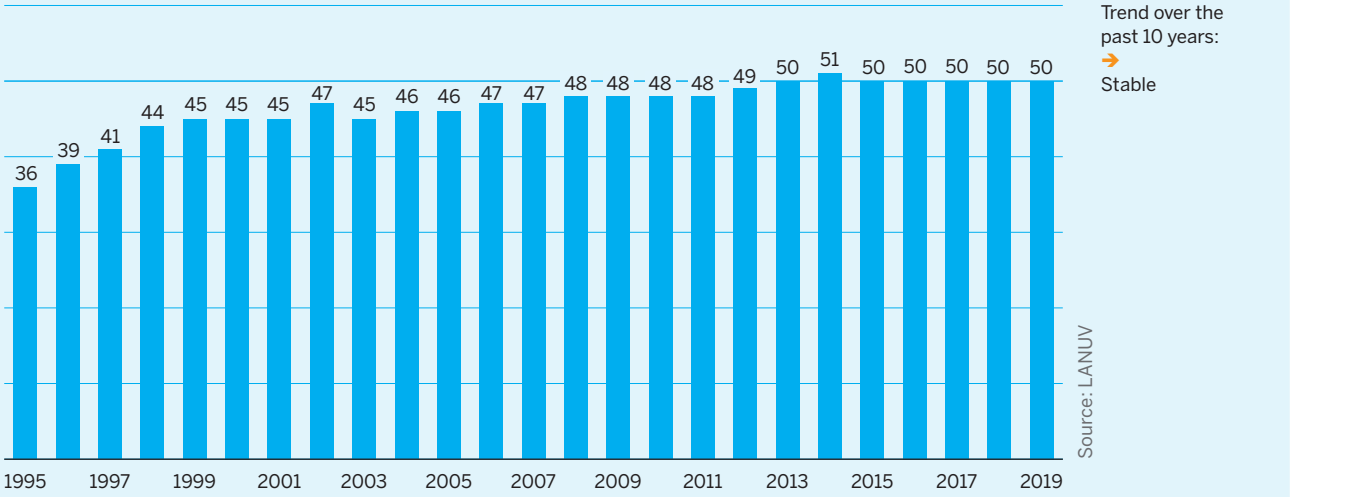
Figure 24 NRW environmental indicator: household waste and recycling

Sub-indicator: household waste and bulk refuse, biodegradable waste, garden waste, and waste containing valuable resources.



In 2019, a total of 464 kilograms of household waste was generated per person in North Rhine-Westphalia, of which 213 kilograms was household waste and bulk refuse processed in incineration plants or in biological waste facilities, and 251 kilograms was biodegradable waste, garden waste, or waste containing valuable resources. According to a statistical trend analysis, the total amount of household waste per person has remained significantly constant over the past 10 years, as has the share of biodegradable waste, garden waste, and waste containing valuable resources, which is recorded separately.

Sub-indicator: recycling rate



The recycling rate is the percentage of household waste that is supplied to plants or processes that aim to utilize these materials. The rate has stood at a stable 50% since 2015. Biodegradable and garden waste accounted for the largest share of recycled waste (48%), followed by paper and cardboard (28%), glass (9%), and lightweight packaging (6%). However, part of this household waste was either not recycled or was incapable of being recycled and instead was utilized for energy or otherwise disposed of.

www.umwelt2020.nrw.de/058

In 2018, an Austrian pilot study detected microplastics in human bodies for the first time. Researchers found 9 different types of synthetic materials, mostly polypropylene and polyethylene terephthalate (PET) ranging from 0.05 to 0.50 millimeters in diameter, in fecal samples. According to a more recent metastudy in Australia, we ingest up to 5 grams of plastic per week on average (the same weight as a credit card) simply through eating, drinking, and breathing. A Canadian metastudy drew similar conclusions, finding that the average North American ingests approximately 80,000 to 210,000 microplastic particles per year. At the moment, there is no scientific evidence to indicate whether microplastics damage the human body.

Every single one of us generates plastic waste. Plastic garbage is produced at home, in hospitals, by tradespeople and service providers, or from plastic sheeting used in farming and cultivating vegetables. The European Commission has recognized the problem and published a plastics strategy in 2018. In addition, the EU Council introduced new laws banning single-use plastic, which must be adopted through national law by 2021. These measures mark the start of Europe's mission to move plastics away from a linear economy and toward a circular economy. The ultimate aim is to ensure, for instance, that the plastic housing of an electronic device can be reused to make a product of the same value. In Germany, the circular economy is already a firm fixture for PET returnable bottles. The system allows bottles to be collected by type and used to make new beverage bottles.

In late 2018, the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (Bundesumweltministerium) adopted a 5-point plan to transform our disposable society. North Rhine-Westphalia contributes to the plan by supporting microplastics research projects ↗ www.umwelt2020.nrw.de/059 and relying on voluntary measures such as an industry commitment to banning microplastics in cosmetic products.

WHAT ARE MICROPLASTICS AND HOW ARE THEY CREATED?

Microplastics are small plastic particles with a diameter of less than 5 millimeters. A distinction is made between primary and secondary microplastics. Primary microplastics are mainly caused by washing synthetic materials, tire wear (which is said to contribute some 120,000 metric tons per year in Germany alone), and products such as cosmetics. Secondary microplastics result from the breakdown and fragmentation of larger plastic items (primarily plastic litter such as plastic bags, garden chairs, and packaging material), particularly in rivers and oceans.

SOIL AND LAND PROTECTION, CONTAMINATED SITES

SOIL – MULTIFUNCTIONAL, COMPLEX, AND SENSITIVE

Soil is the thin layer of "skin" on the earth's crust, usually no thicker than 2 meters, in which plants and trees can put down their roots. From acting as a life-support system and habitat for humans, animals, and plants to helping to maintain a natural equilibrium, soil performs many key functions in the natural world. Its water and nutrient cycles provide a means of decomposing, balancing out, and building up natural substances – for example, by protecting groundwater, acting as a carbon sink storing enormous amounts of damaging CO_2, or cooling overheated cities ↗ www.umwelt2020.nrw.de/060. Soil is the product of both natural processes and human activity, and provides a chronicle of our natural and cultural history. Not only that, soil also performs a wide range of useful functions. It acts as a store for resources and offers land for human settlements and relaxation, farming and forestry, and other economic and public purposes.

North Rhine Westphalia's natural environments are reflected in its wide variety of soils, including sandy soil, gley soil, stagnosol, and peat soil in the Münsterland region; fertile brown soil in the Lower Rhine bay and fertile plain areas; and stony clay soil in the forested uplands. Preserving their wide range of functions is essential, but land usage can put many of soil's key functions in jeopardy. Soil sealing, excavation, degradation, pollution, and compacting can only be reversed with a significant amount of time and effort, if at all. Climate change will put further strain on soil in the future, through wind and water erosion, dessication, and siltation. Only biologically active soils with a healthy humus content, a well-balanced nutrient and water cycle suited to their location, and sufficient plant coverage will be able to withstand the stresses of our changing climate.

LAND USE CHANGE AND DAILY LAND TAKE

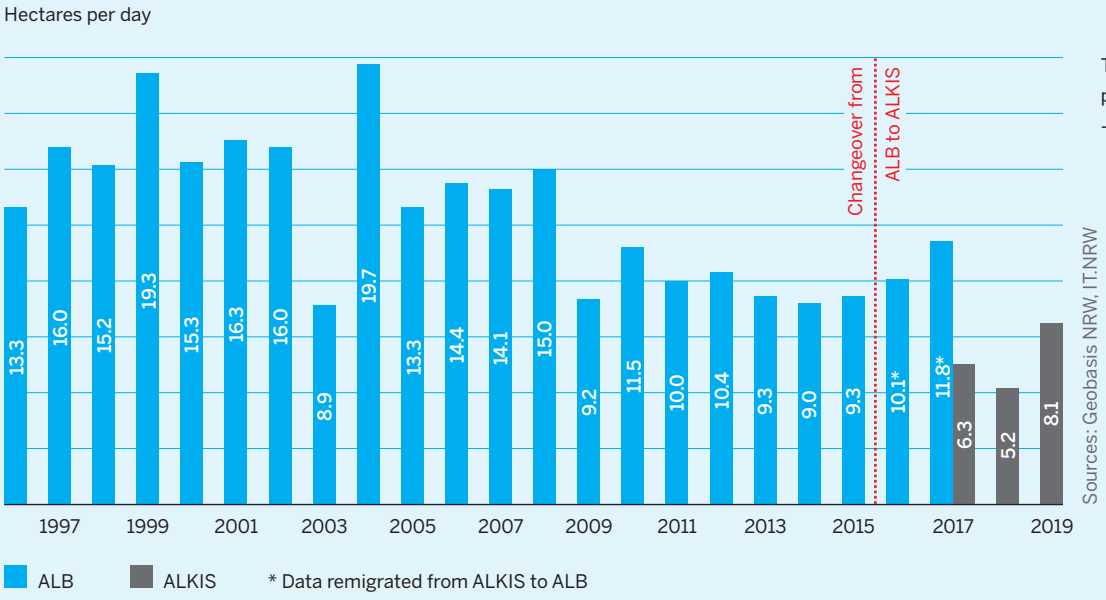
Shifts in the way we make use of land that suppress natural ecosystems in the process are key drivers of the far-reaching changes to the global climate. These shifts mainly take the form of deforestation to create arable land and pasture. However, such changes in land use have been confined to the history books in North Rhine-Westphalia. Over the past few decades, the most significant changes in the state have been the increasing sizes of human settlements and transport infrastructure, as well as higher-intensity farming → page 78:

RE-ALLOCATION AND REMNANTS DUE TO CHANGE IN CADASTRE SYSTEM

From 2015 to 2016, the land register authorities in North Rhine-Westphalia switched from the Automated Real Estate Book (Automatisiertes Liegenschaftsbuch, ALB) to the Authoritative Real Estate Cadastre Information System (Amtliche Liegenschaftskatasterinformationssystem, ALKIS). As a result, land usage for 2016 can only be stated with the help of data migrated back from ALKIS to ALB → figure 25. The changeover involved migrating land data to a new usage type catalog, as well as the reallocation of certain shoreline areas. As an example, the changeover in 2016 resulted in some 6,500 hectares of land in North Rhine-Westphalia previously attributed to land used for human settlements and transport infrastructure being reallocated to the vegetation usage type.

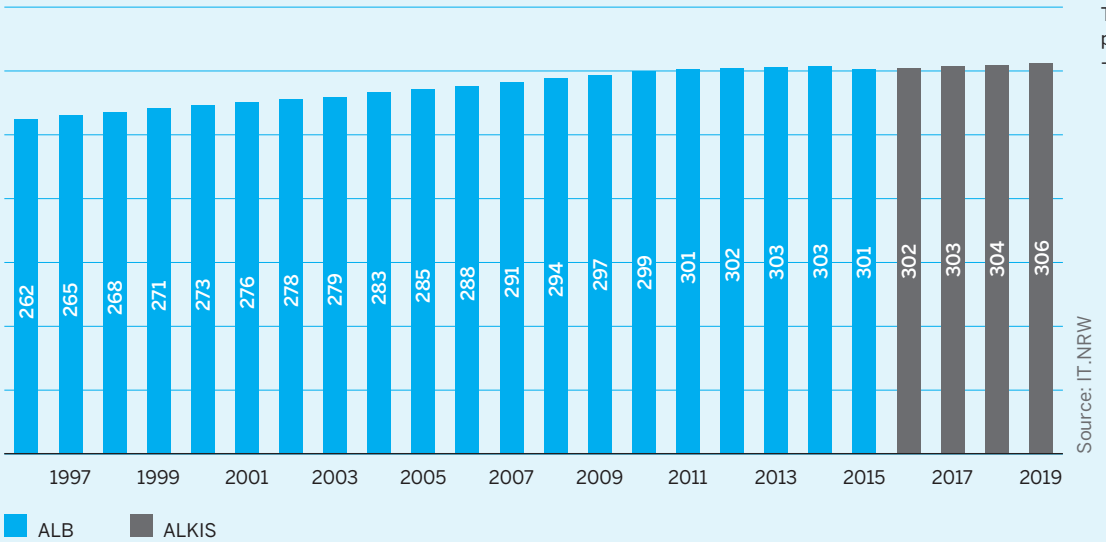
Figure 25 NRW environmental indicator: land take

Sub-indicator: increase in land take for human settlements and transport infrastructure



Between 2006 and 2015, an average of 11.2 hectares of land was taken per day for human settlements and transport infrastructure. The value for 2016 has been migrated back to ALB due to the changeover from the ALB system to ALKIS. In 2019, land take stood at 8.1hectares per day (excluding land take through underground mining, open-cast mining, and quarries). ALB and ALKIS figures are not comparable due to the reallocation. The state government aims to make an appropriate contribution toward achieving the national goal of reducing land take for human settlements and transport infrastructure to under 30 hectares per day by 2030.

Sub-indicator: land take per person for human settlements



In 2019, land take per person for human settlements stood at roughly 306 square meters. Land take for human settlements includes residential, industrial, and commercial areas, as well as sporting facilities. From 2015 to 2016, the land register authorities switched from the ALB system to ALKIS. Due to land reallocation, ALB and ALKIS data is not comparable and precludes trend analysis. Nevertheless, no decline in land take per person for human settlements is expected in the foreseeable future.

www.umwelt2020.nrw.de/061

In 2019, an average of 8.1 hectares of open countryside was taken for human settlements and transport infrastructure every single day, equivalent to around 11 soccer fields |→ figure 25, |↗ www.umwelt2020.nrw.de/062. This figure does not include land take through underground mining, open-cast mining, and quarries. Land take for human settlements and transport infrastructure has increased to approximately 1,029 square kilometers – 9.5 times the size of the Eifel National Park – since data began being recorded in 1997. The state government aims to make an appropriate contribution toward achieving the goal defined in the Germany's National Sustainability Strategy (Deutsche Nachhaltigkeitsstrategie) to reduce land take for human settlements and transport infrastructure to under 30 hectares per day by 2030.

According to the land register, the most significant types of land usage as of the end of 2019 were agriculture (47.1%), forest (24.8%, or 26.9% according to the 2014 state forest inventory), human settlements (16.7%), and transport infrastructure (7.0%). Just under half of the land in North Rhine-Westphalia used for human settlements and transport infrastructure (46%) is sealed – in other words, covered with buildings, concrete, asphalt, paving stones, or otherwise secured.

Farmland is often used for human settlements and transport infrastructure, curtailing the amount of soil available for food production, the water cycle, and climate adaptation. Farmland is also used for forest and bodies of water, as well as to compensate for settlement expansion and the construction of transport infrastructure. As a consequence, the amount of farmland shrunk by 1,187 square kilometers between 1996 and 2015 – the final 20 years of the Automated Real Estate Book (Automatisiertes Liegenschaftsbuch) system. In other words, agriculture in North Rhine-Westphalia has lost 17.1 hectares per day of fertile arable land and pasture. Following the switch to a different register system (see info box), data revealed that average farmland loss in 2017, 2018, and 2019 was 21.9 hectares per day.

The amount of land used for human settlements per capita stood at 306 square meters in 2019, up from 304 square meters in 2018 and 303 square meters in 2017 |→ figure 25. Rising standards of living and higher expectations in terms of living space are the likely causes of this trend. In addition, increased mobility and the growing number of single-person households are also factors. Even though there is a limit to the amount of land in North Rhine-Westphalia, current demands for additional housing in many large cities and structural transformation in a number of reasons mean that we are not likely to see any significant decline in land usage in the near future.

RECORDING FALLOW LAND, REMEDIATING CONTAMINATED SITES, AND RECYCLING LAND

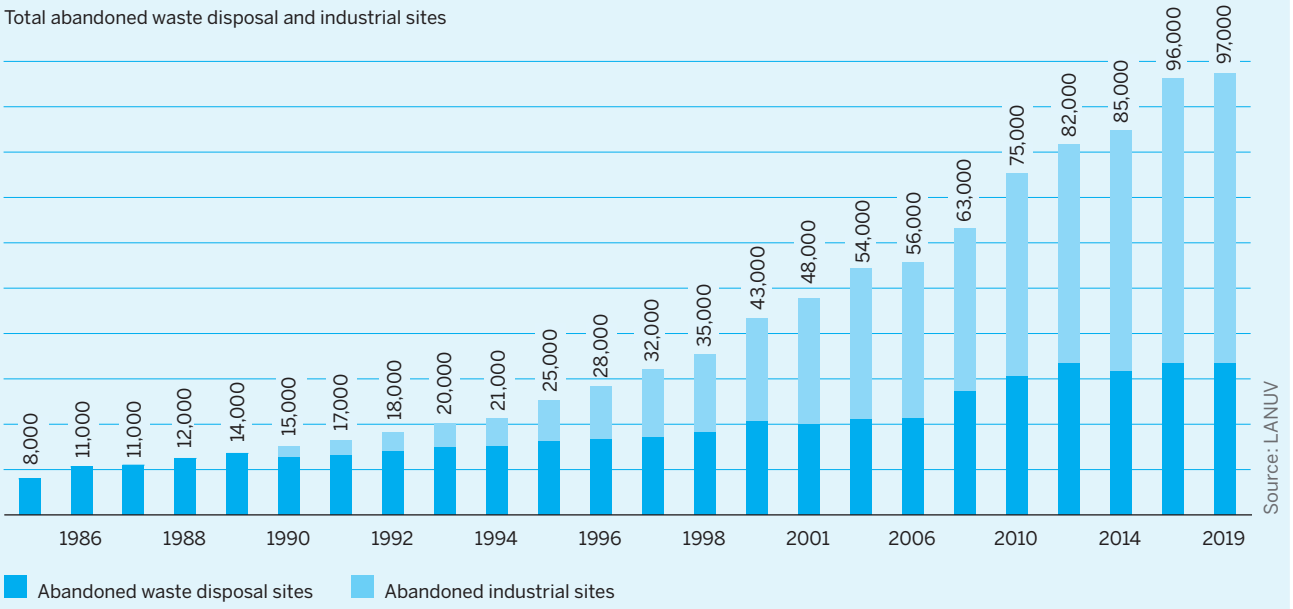
Reusing fallow land is one way of reducing the strain on land use, especially when it comes to farmland. Before any plans can be made, fallow land potential must be assessed and analyzed. The State Agency for Nature, Environment and Consumer Protection has published guidelines on the data, procedures, and identification characteristics required for documenting fallow land |↗ www.umwelt2020.nrw.de/063. Fallow land in North Rhine-Westphalia is often contaminated as a result of prior industrial use, meaning that it can only be recycled if all sources of contamination and pollution are remediated. The state has promoted and supported the recording, investigation, and remediation of contaminated sites for many years now |↗ www.umwelt2020.nrw.de/064, |↗ www.umwelt2020.nrw.de/065.

So far, some 97,000 abandoned waste disposal and industrial sites have been recorded. These sites are a reflection of North Rhine-Westphalia's history of mining, manufacturing, industry, and small trade |→ figure 26. Of these sites, some 60,000 are either suspected of contamination or at a preliminary stage of suspected contamination, while roughly 9,000 sites require no further action. Risk assessments have been completed or are ongoing for the remaining 28,000 sites, some 8,000 of which have had to be remediated to date.

CONTAMINATED SITES: ABANDONED WASTE DISPOSAL AND INDUSTRIAL SITES

Under the German Federal Soil Protection Act (Bundes-Bodenschutzgesetz), there are two types of contaminated sites: abandoned waste disposal sites and abandoned industrial sites. Abandoned waste disposal sites are decommissioned waste disposal facilities and other land on which waste has been processed, stored, or dumped in the past. Abandoned industrial sites are decommissioned facilities and other land where hazardous materials were handled, causing soil damage or other hazards for individuals or the public at large – but not including facilities decommissioned in accordance with the German Atomic Energy Act (Atomgesetz).

Figure 26 **Number of abandoned waste disposal and industrial sites recorded in NRW**



There are around 97,000 abandoned waste disposal and industrial sites on record. This figure has increased due to sites subsequently being added to the records, as well as more recent issues such as the use of poly- and perfluorinated compounds (PFCs) in fire extinguishers. Despite the state's best efforts, there is still a vast difference between the number of sites identified as requiring remediation and sites that have been remediated and removed from the suspected contamination list. The authorities face the challenge of assessing some 60% of sites with suspected contamination, finalizing the process, or, if necessary, initiating remediation and safeguarding measures.

Legislation introduced by the state government in September 2020 regarding intelligent land usage is another useful tool in reducing consumption. The measures are based on eight principles, including tradable land planning permits and fallow land registers for unclaimed plots greater than 500 square meters in size www.umwelt2020.nrw.de/066.

CADMIUM AND LEAD DEPOSITS REMAIN LOW

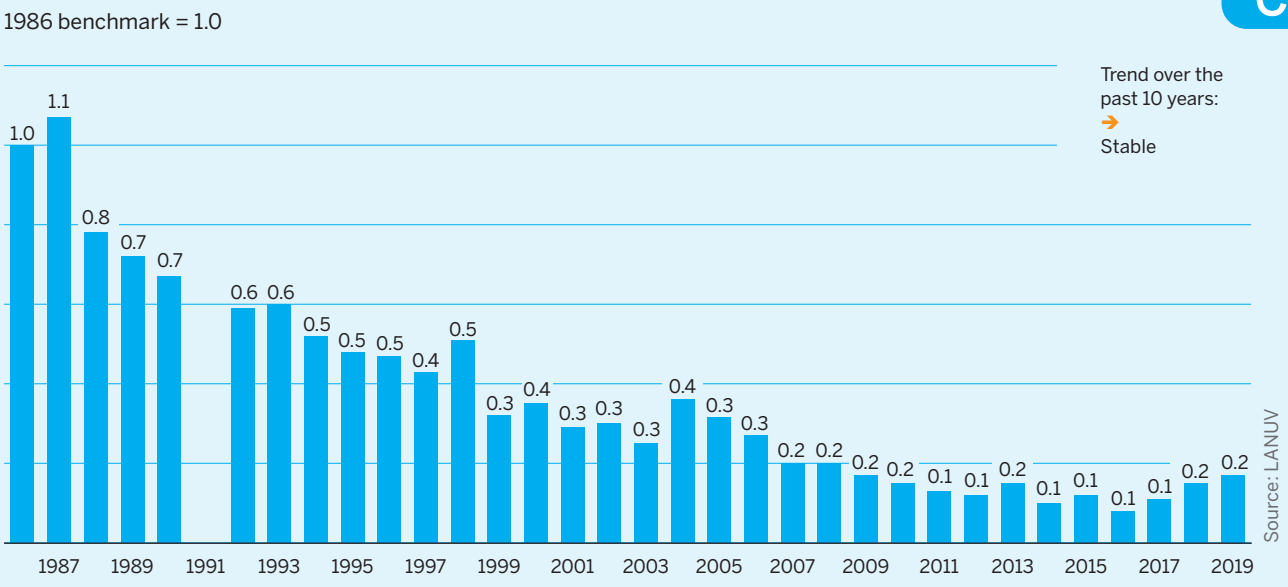
Soil is directly or indirectly exposed to deposits of a variety of pollutants. Direct pollutants include the fertilizers for arable land containing pharmaceutical residues, microplastics, or slurry contaminated with heavy metals, as well as the excessive use of plant protection products or the improper handling of hazardous materials in industry. Indirect pollutants include tire wear, nitrogen, acids, or heavy metals that are transported as aerosols.

Heavy metals such as lead and cadmium are dispersed far and wide in the production and combustion of fossil fuels. Other important sources of emissions include waste incineration plants, the cement and glass industry, and motor traffic. Heavy metals take a long time to degrade. They can be toxic at certain concentrations, impair soil function, and be absorbed by plants where they enter the food chain.

Lead and cadmium deposits measured in rain dust at state measuring stations in Velmerstot (Eggegebirge), Simmerath (Eifel), Osenberg (Bergisches Land), Hilchenbach, and Bocholt (Rothaargebirge and Münsterland, measurements from 2010 onward) are currently at one-sixth of the levels first measured → figure 25. Aside from the ban on the use of lead in fuels and brake pads, the main reasons for the decline in such deposits lie in measures to reduce dust emissions at industrial facilities – from those of a technical and organizational nature to the fitting of vacuum units and full dust-extraction systems – and the decommissioning of a number of facilities that produced high levels of dust. All told, deposits of heavy metals such as cadmium and lead in the soil have declined significantly since the mid-1980s. Heavy metal deposits have remained constant at a low level over the past 10 years.

Figure 27 **NRW environmental indicator: heavy metal deposits at rural measuring stations**

Pb Cd



Lead and cadmium deposits from rain dust measured at 5 rural measuring stations have fallen to around one-sixth of their 1986 figures. This reduction has been achieved thanks to comprehensive measures to reduce dust emission, the ban on lead in fuels and brake pads, and monitoring of the environmental impact of industrial facilities. In addition, a number of high-emission facilities have been decommissioned. The latest trend analysis confirms stable low levels of heavy metal deposits.

www.umwelt2020.nrw.de/067

WATER MANAGEMENT

WATER – THE SOURCE OF LIFE

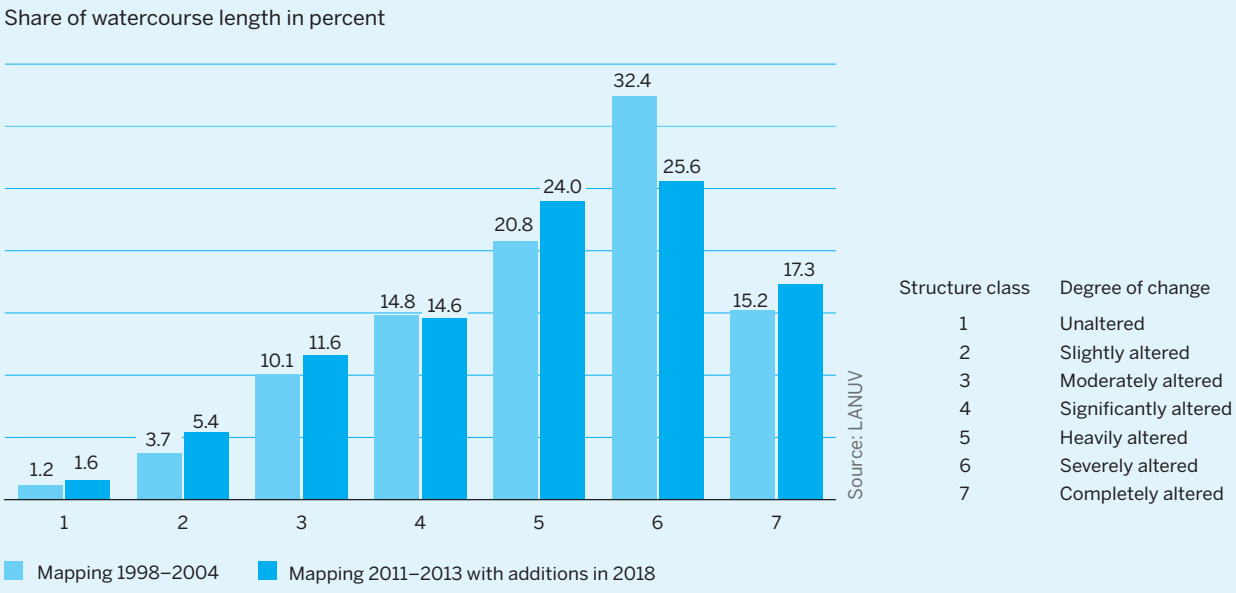
"Water is a heritage which must be protected, defended and treated as such," writes the European Commission in the first paragraph of its Water Framework Directive. In this legislation, resolved in 2000 to govern how we manage and treat water as a natural resource, the EU defines terms such as the "good status" and "good potential" of water and sets member states the target of achieving good status and good potential for all bodies of water by 2027. The aim here is to ensure that water remains available in the future in sufficient quantities and in good quality, both to bodies of water and their ecosystems and as a resource for the abstraction of drinking water.

Doing so is certainly no easy task for North Rhine-Westphalia, with its population density of 526 people per square kilometer, more than 10,000 industrial enterprises, and roughly 34,000 agricultural operations www.umwelt2020.nrw.de/068. Around 2% of North Rhine-Westphalia is covered by water, with rivers totaling some 50,000 kilometers in length. Although the state has plenty of water, North Rhine-Westphalia's rivers and lakes are under heavy strain. Most rivers are regulated, and many watercourses such as canals, reservoirs, and lakes in former open-cast mines have been artificially created. Pumping out groundwater to mine for coal has an enormous and long-lasting impact on groundwater and surface water. In addition, over 600 public sewage treatment plants discharge approximately 2.3 billion cubic meters of treated wastewater directly into surface water every year (excluding cooling water and precipitation) – with around 480 industrial enterprises discharging a further 750 million cubic meters. Private households and small businesses also consume approximately 133 liters of drinking water per day.

LOCAL SUCCESS THROUGH REWILDING

Natural watercourses meander, form islands, or branch into multiple sections. Thanks to their variations in the rate of flow and water depth, the gravel, sand, root systems, and rotting leaves in riverbeds are home to a wide variety of different species. Up to 120,000 organisms can live in a single cubic meter of water. However, many of our watercourses have lost their original function as a habitat, or have been straightened, built over, canalized, or reinforced. The reason for this human intervention lies in the function rivers have performed for hundreds of years. In the highlands of central Europe, rivers were dammed for iron ore mining and their forces used to drive machinery.

Figure 28 **Degree of change in water structure of surface waters in NRW**



The structure of watercourses with catchment areas greater than 10 square kilometers is assessed using 30 standardized national parameters (such as curvature, variation in depth, riverbed substrate, riverbank plant growth, and land usage). At the turn of the millennium, only 15% of watercourses had an unaltered, slightly altered, or moderately altered water structure (structural class 1, 2, or 3). Initial local improvements through numerous rewilding initiatives have seen this figure rise to approximately 19%.

www.umwelt2020.nrw.de/069

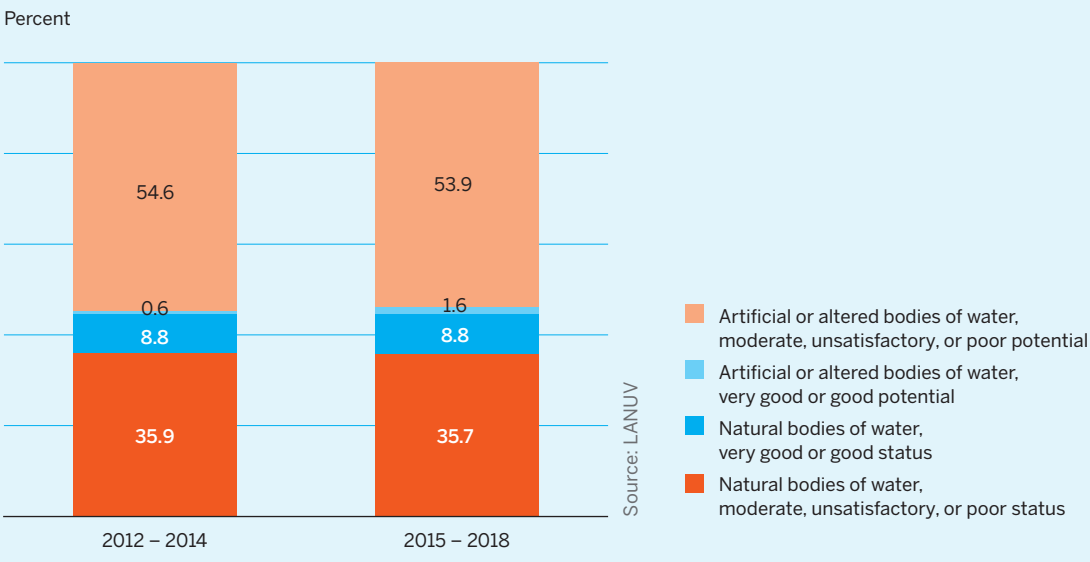
The search for farmland in lowland and riverside regions resulted in watercourses being drained and rivers and streams straightened, regulated by dams, and enlarged for shipping. The effects of bituminous coal and lignite mining on surface water and groundwater will never go away page 68 despite this form of energy generation being phased out. Bodies of water must be returned to their original dynamics, at least partly, to ensure good ecological status and good ecological potential. North Rhine-Westphalia supports ecological water management measures through its Living Water (Lebendige Gewässer) program, funding up to 80% of the cost of eligible initiatives www.umwelt2020.nrw.de/070. These measures mitigate the consequences of water usage, improve animal and plant habitats, and make ecosystems more resilient to stresses and strains such as climate change. Hundreds of rewilding measures have been implemented in the past few years. State-wide mapping for 2011 to 2012, with additional information for 2018, reflects the local improvements figure 28, www.umwelt2020.nrw.de/071, www.umwelt2020.nrw.de/072.

In spite of the progress that has been made, bodies of water continue to be impacted by pollutants and nutrients from industry, agriculture, private households, and infrastructure www.umwelt2020.nrw.de/073. The European Commission has defined binding limits for some of these substances, including hazardous materials such as polychlorinated biphenyls (PCBs) and mercury, which take a long time to degrade. Statutory limits also apply in Germany to other materials, including copper, zinc, plant protection products, and industrial chemicals pages 40, 48, and 50. However, these limits only cover a fraction of the substances that enter our bodies of water.

WATERCOURSES IMPROVING GRADUALLY

Some 44% of all rivers and streams in North Rhine-Westphalia with a catchment area larger than 10 square kilometers are natural watercourses, while 56% are classified as heavily modified and artificial watercourses. The environmental indicator on the ecological status and potential of surface waters shows how aquatic species in these bodies of water are coping. The indicator is calculated on the basis of algae species and bacteria, aquatic plants, macrozoobenthos such as crustaceans and insect larvae, certain species of fish, physical chemical criteria, and hydromorphological elements. Currently, around 20% of natural watercourses (or 8.8% of all watercourses) in North Rhine-Westphalia have a very good or good ecological status. Of the watercourses created artificially or

Figure 29 **NRW environmental indicator: ecological status and potential of surface waters**



Some 44% of all rivers and streams in North Rhine-Westphalia with a catchment area larger than 10 square kilometers are natural watercourses whose ecological status is monitored. The remaining 56% are classified as heavily modified and artificial watercourses. At the time of writing, only 8.8% of all watercourses had a good or very good ecological status. A further 1.6% had very good or good potential. The state government aims to ensure that all natural watercourses have a good ecological status, and that all heavily modified and artificial watercourses fully achieve their good ecological potential.

www.umwelt2020.nrw.de/074

heavily modified through straightening or the construction of weirs or dams, only 3% are considered to have good or very good ecological potential (1.6% of all watercourses in North Rhine-Westphalia) |→ figure 29.

Naturally, the ecological status of watercourses also has an impact on North-Rhine Westphalia's Red List. According to the list, around 35% of fish and cyclostomes are considered extinct or vulnerable in the state (correct as of 2010; the next Red List is scheduled for publication in 2021) |→ page 75. For example, the sturgeon was once abundant but has now disappeared from North Rhine-Westphalia, while the salmon and the sea lamprey are at risk of extinction in the state, as is another once-abundant species, the eel. Even the common bream, the northern pike, and the common roach are all on the warning list.

GROUNDWATER IMPROVING

Groundwater has a good chemical status if the quality standards of the German Groundwater Ordinance (Grundwasserverordnung) are complied with. Good quantitative status applies if the amount of groundwater extracted to provide drinking water or irrigation is less than the amount that is formed naturally. The third assessment of the chemical and quantitative status of the bodies of groundwater in North Rhine-Westphalia was conducted using the 1,500 Water Framework Directive measuring stations between 2013 and 2018 |↗ www.umwelt2020.nrw.de/075, |↗ www.umwelt2020.nrw.de/076. Of the 275 bodies of groundwater, 180 were found to have a good chemical status (60% of state area). A total of 95 bodies of groundwater have a poor chemical status, due mainly to excessive nitrate deposits, but also on account of high levels of ammonium and plant protection products. The poor chemical status was also due in some areas to elevated levels of heavy metals, volatile halogenated hydrocarbons, and poly- and perfluorinated compounds (PFCs), as well as the consequences of mining, site contamination, and groundwater damage. The number of bodies of groundwater with a poor status due to the presence of nitrate has declined from 88 (42% of state area) to 59 (26% of state area) compared to the second assessment 6 years ago. This fall is likely due to amendments to the German Fertilizer Ordinance (Düngeverordnung), greater fertilizer efficiency, and possibly also dry weather conditions leading to less leaching. All in all, 244 bodies of groundwater in North Rhine-Westphalia have a good quantitative status (87% of the state's area). The 31 bodies of groundwater with a poor quantitative status are located near the Rhine and Maas rivers. Their poor status is mainly due to water imbalance caused by work to reduce groundwater levels in the lignite mining regions near the Rhine.

LONG-TERM IMPACT AND INTEGRAL MONITORING – RISING COAL MINE WATER

The closure of the Prosper-Haniel coal mine in Bottrop at the end of 2018 brought centuries of German mining tradition to a close. The mine may be history, but its long-term impact continues to cost billions of euros. These burdens include clean-up costs and the effects of managing mine water, polder-related measures, and cleaning of groundwater following the mine's decommissioning. One of the main tasks is pumping water out of areas that have subsided (by up to 25 meters in the Ruhr valley) and into the floodplains (to combat the threat of flooding). The presence of PCBs in underground mining materials is a major area of concern in this regard. The phasing-out of coal mining brought about changes to mine water management, which was required to keep the pits dry. An early-warning system has been set up to detect any undesired developments resulting from future changes to the water management system and prevent or minimize the potential risks to targets.

|↗ www.umwelt2020.nrw.de/077

NITRATE CONCENTRATIONS MEASURED BY THE EUROPEAN ENVIRONMENT AGENCY MONITORING NETWORK

Germany still has a nitrate problem. In June 2018, a violation of the Nitrates Directive resulted in legal action being taken in the European Court of Justice (see also "High nitrogen surplus due to fertilizers" |→ page 91). Nitrate levels are extremely relevant to the public supply of drinking water in North Rhine-Westphalia, 50% of which originates from groundwater or springs. High concentrations of nitrate in drinking water can be converted into carcinogenic nitrosamines in the human body and impair oxygen saturation in the blood among young children.

For the "nitrate concentration in groundwater" indicator, data is taken from 115 Water Framework Directive measuring stations and reported to the European Environment Agency (EEA). In 2019, around 12% of the groundwater measuring stations dotted around North Rhine-Westphalia

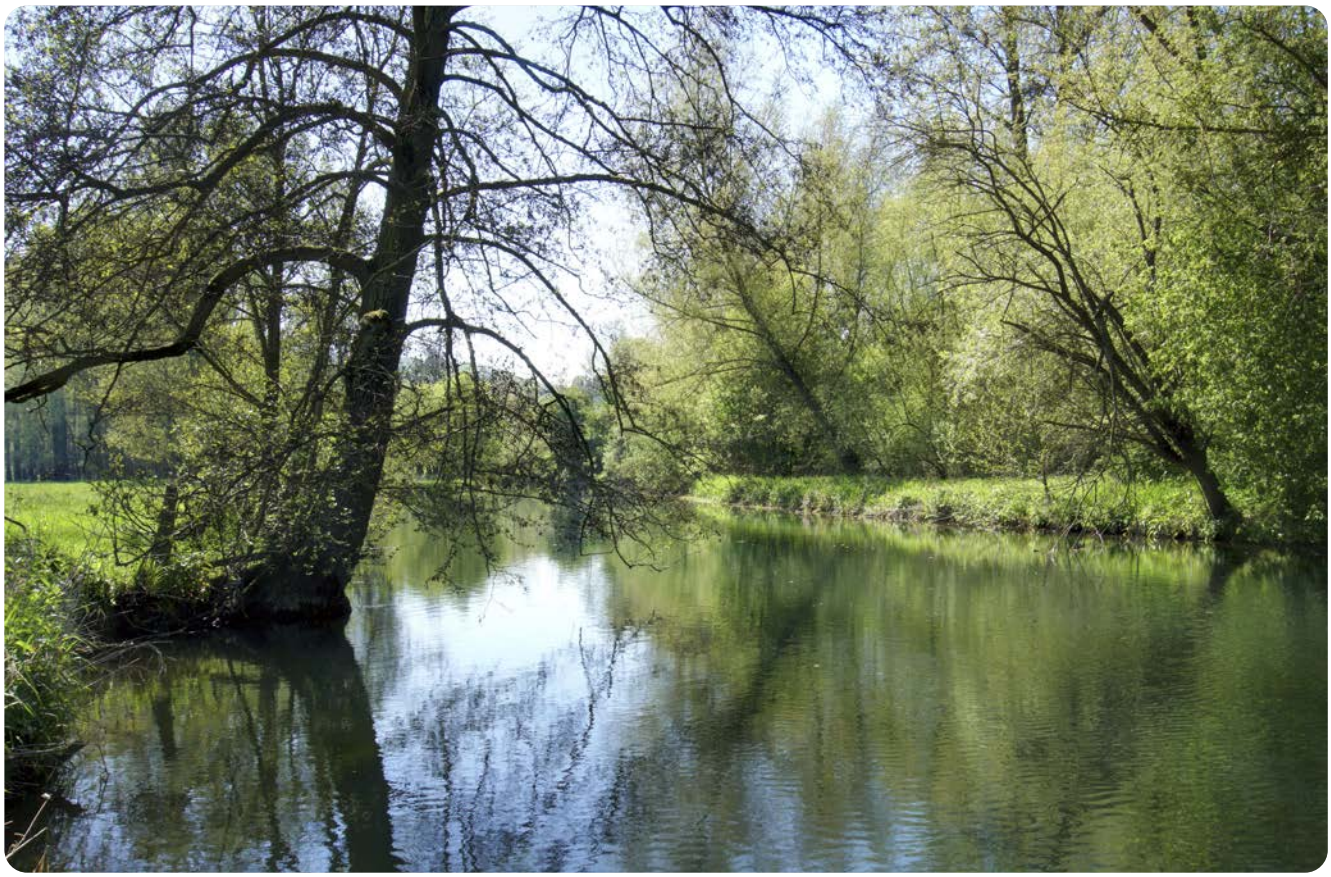
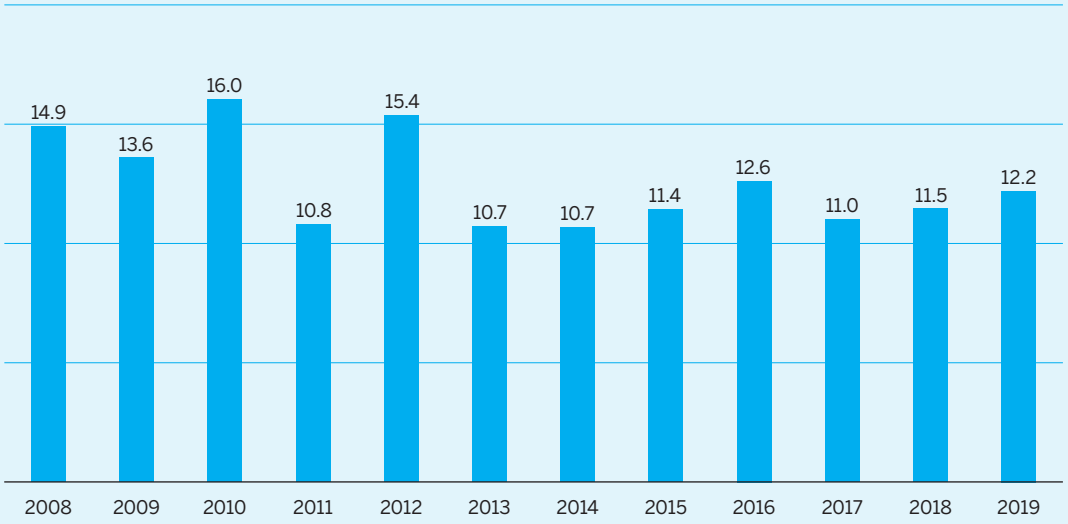


Figure 30 **NRW environmental indicator: nitrate concentration in groundwater**

NO 3

Share of measuring stations in percent with nitrate content > 50 milligrams per liter



Trend over the past 10 years:
→
Stable

Source: LANUV

Nitrate is an important indicator of groundwater quality and can have an adverse impact on the human body. The nitrate limit for drinking water (50 milligrams per liter) is the same as the threshold for "good status" under the German Groundwater Ordinance. In 2019, around 12% of the 115 groundwater measuring stations in North Rhine-Westphalia that form part of the EEA's nitrate monitoring network exceeded this limit. Analysis of the data over the past ten years reveals a stagnating trend. The state government aims to reduce the level of nitrate contamination in all bodies of groundwater to less than 50 milligrams per liter by the year 2027.

www.umwelt2020.nrw.de/078

and forming part of the EEA's nitrate monitoring network determined nitrate levels in excess of the limit for drinking water of 50 milligrams per liter as defined by the German Groundwater Ordinance |→ figure 30. If necessary, drinking water has to be blended with safe raw water. Recent reforms to federal and state fertilizer directives should satisfy the EU Nitrates Directive in the near future.

MICROPOLLUTANTS AND RESISTANCE TO ANTIBIOTICS

Micropollutants include pharmaceutical products, radiocontrast agents, cosmetic products, plant protection products, and other chemicals that are being discharged into bodies of water on an increasing basis by businesses and industrial enterprises – and primarily through wastewater in the home. Even at minute concentrations, micropollutants pose a risk to aquatic ecosystems and are particularly relevant in the densely populated, highly industrialized state of North Rhine-Westphalia, with its many "poor-quality" bodies of water.

The best way to prevent water pollution is to reduce the amount of micropollutants produced by manufacturers. Projects such as Essen Makes It Clear: Fewer Pharmaceuticals in Wastewater (Essen macht's klar. Weniger Medikamente im Abwasser) and MERK'MAL. Minimization of Discharge of X-Ray Contrast agents (Minimierung der Einträge von Röntgenkontrastmitteln) are geared toward combating this issue |↗ www.umwelt2020.nrw.de/079, |↗ www.umwelt2020.nrw.de/080. Another program, the Pure Ruhr (Reine Ruhr) initiative, has resulted in upgrades being made to 11 public sewage treatment plants to reduce micropollutants, with a further 29 improvements in the pipeline. The initiative has so far seen investment upwards of EUR 150 million, EUR 108 million of which from state subsidies.

Besides micropollutants and microplastics |→ page 58, antibiotics are another hotly debated topic in water management. Antibiotics have become essential tools in treating bacterial infections in human and veterinary medicine. However, there is increasing scientific evidence of the presence of antimicrobial-resistant bacteria in wastewater discharge from hospitals, sewage treatment plants, and slaughterhouses, as well as in surface water and the soil. The World Health Organization (WHO) recently warned of an increase in antimicrobial resistance that could even jeopardize the efficacy of drugs of last resort. A variety of approaches are being taken in the fight against antimicrobial resistance, including the One Health strategy, which fosters interdisciplinary collaboration between human, environmental, and veterinary medicine |↗ www.umwelt2020.nrw.de/081. North Rhine-Westphalia aims to gain a better understanding of how antimicrobial-resistant bacteria develop and spread and is conducting corresponding research on surface water and wastewater.

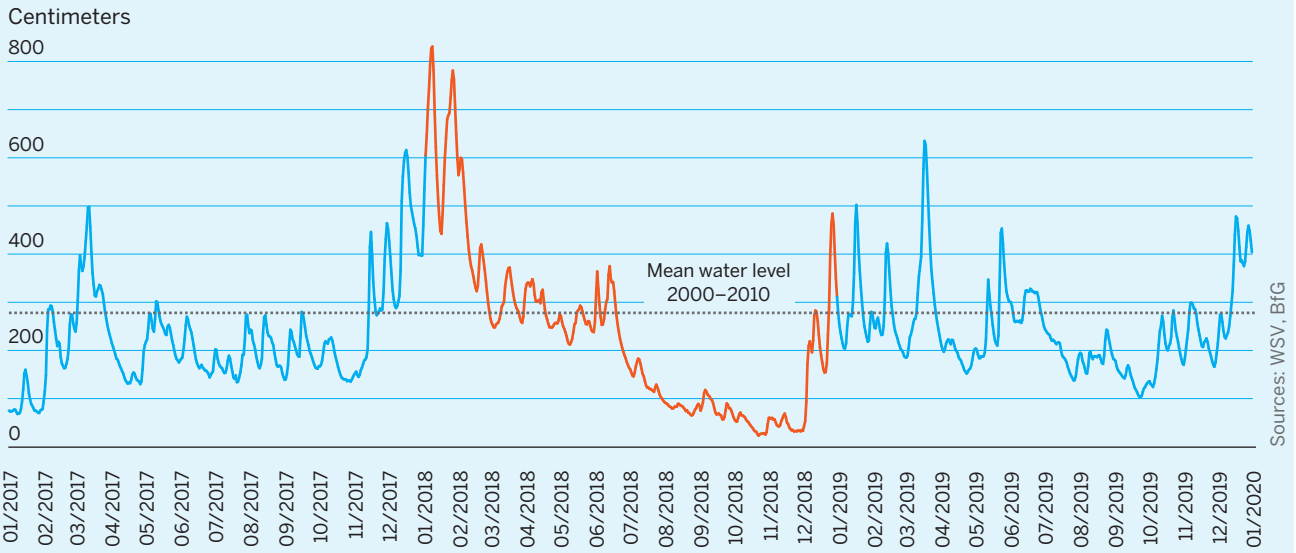
THE CHALLENGES POSED BY FLOODING AND LOW WATER LEVELS

North Rhine-Westphalia drew up a flood protection concept in early 2000 and subsequently implemented numerous flood action plans, increased and reinforced levees, improved the ability of land to retain water, and enhanced its emergency response. Not only that, the adoption of the European Commission's directive on the assessment and management of flood risks also saw a significant flood risk assessed for 438 bodies of water stretching across 5,900 kilometers of the state. Flood management plans have also been prepared for the parts of the Rhine, Weser, Ems, and Maas rivers in North Rhine-Westphalia |↗ www.umwelt2020.nrw.de/082. State authorities also provide support and guidance for heavy rainfall risk management concepts |↗ www.umwelt2020.nrw.de/083. Heavy rain events are defined as high-intensity localized rainfall with high volumes of

precipitation and poses an extremely unpredictable risk of flooding. |➔ page 19.

If flooding is at one end of the spectrum, low water levels are at the other. Climate change had a particularly significant impact in 2018 and 2019, with periods of extreme dryness causing bodies of water to dry up and some reservoir levels to fall to extreme lows. In October 2018, more than 20% of the measuring stations in North Rhine-Westphalia reported historically low water levels |➔ figure 31. The situation had severe implications for industry, shipping, power plants, agriculture, and forestry – not to mention ecosystems reliant on water. In some cases, there were even drinking water shortages and bans on watering lawns. According to the Helmholtz Centre for Environmental Research's drought monitor, soil in large swathes of North Rhine-Westphalia down to a depth of 1.8 meters has yet to recover from the lack of precipitation, even two years later in 2020 |↗ www.umwelt2020.nrw.de/084. The formation of new groundwater has generally been in decline. More dry weather and water shortages are expected in the future, making it important to take a proactive approach, manage water resources sustainably, and develop strategies for climate-resistant water usage.

Figure 31 **Rhine water level in Düsseldorf at kilometer 744.2 in 2017, 2018, and 2019**



2018 was particularly extreme, with one case of flooding and one low-water event. On January 8, the Rhine rose to 887 centimeters, just above the level at which shipping has to be suspended (880 centimeters). However, it still remained some way short of critical water levels, such as the record high-water mark of 1,110 centimeters on January 2, 1926. On October 23, 2018, a new record low-water mark of 23 centimeters was measured, with a shipping channel depth of just 176 centimeters (unrestricted shipping on the Rhine requires a minimum depth of 250 centimeters).

Nature and rural areas in North Rhine-Westphalia

The top 3 livestock species

1.4 million
cattle

6.9 million
pigs

11.8 million
chickens

Approximate share concentrated in the administrative district of Münster[1]:

The top 3 crops

156,000 ha
Summer and winter barley

251,000 ha
Summer and winter wheat

293,000 ha
Grain and silage corn

High nature value farmland

Share of agricultural land

13% Trend →

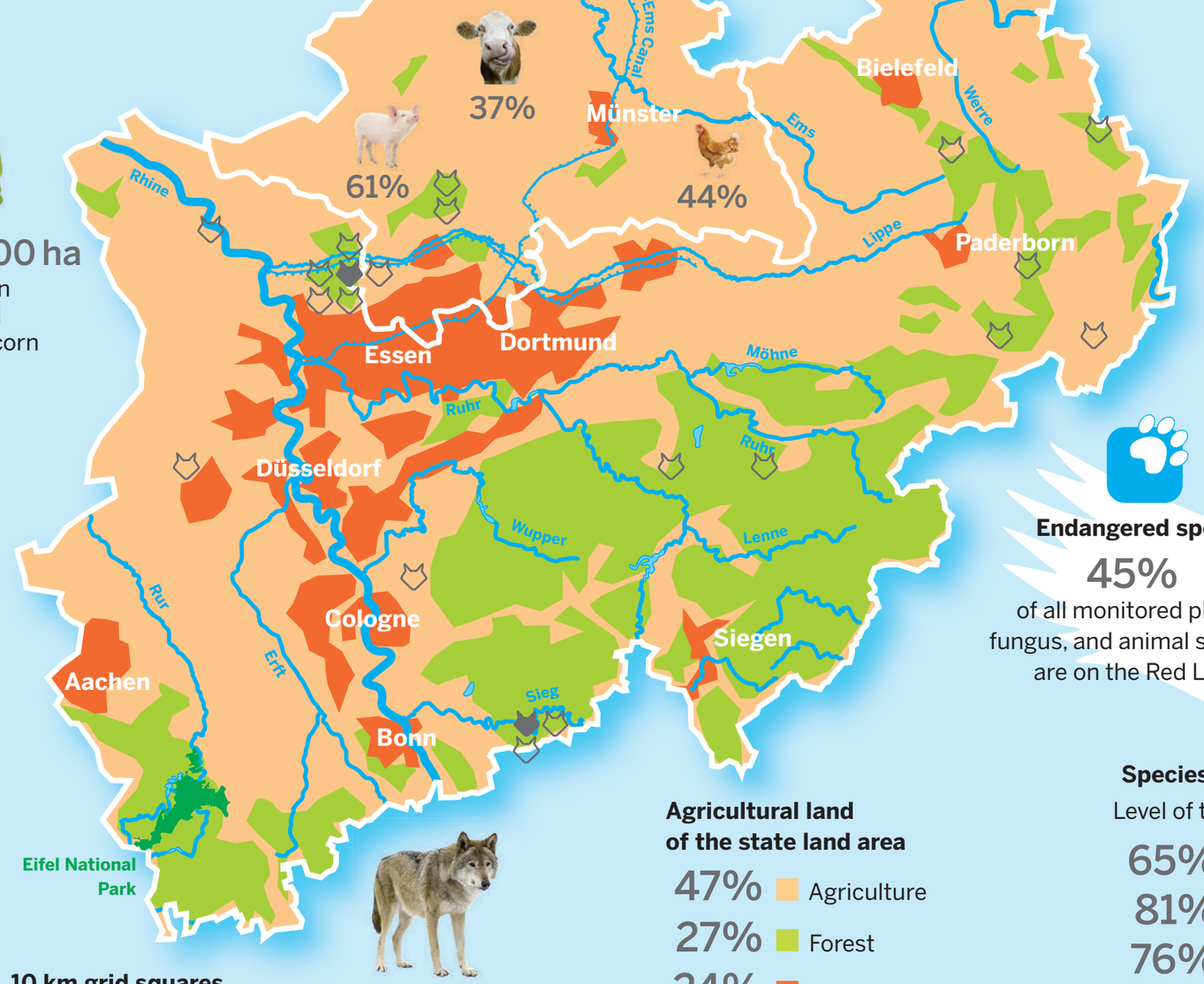
Organic farming

Share of total farmland

6% Trend ↗

Nitrogen surplus on agricultural land

116 kg/ha
Trend ↗



10 km grid squares with evidence of wolves in 2020[2]

- Free-ranging wolves
- Settled wolf pack

Agricultural land of the state land area

47%	Agriculture
27%	Forest
24%	Settlements and transport
2%	Water

Top 3 tree species in forests

30%
spruce

19%
beech

17%
oak

Proportion of deciduous and coniferous trees in forests

59% deciduous trees

41% coniferous trees

Forest condition – crown damage of all tree species

Trend →	23%	no crown damage
Trend →	33%	minor crown damage
Trend →	44%	major crown damage

Endangered species

45%
of all monitored plant, fungus, and animal species are on the Red List

Nature conservation areas

8.4%
of state land area
Rising trend ↗

Species diversity and landscape quality

Level of target achievement for habitat type

65%	Farmland	Trend ↘
81%	Forests	Trend ↗
76%	Settlements	Trend ↗
67%	Water	

Sources: 1 IT.NRW 2018, 2019 ▪ 2 LANUV 2020 ▪ Map: Wikipedia 2008, Geobasis NRW 2014

NATURAL HERITAGE AND NATURE CONSERVATION

ANIMALS AND PLANTS IN DANGER

Biodiversity is crucial to our existence as human beings and is a cornerstone of the healthy and natural development of all forms of life and ecosystems. In turn, ecosystems perform countless "ecosystem services" every single day, on which our food chain, well-being, and economic development depend. Examples of ecosystem services include the production of oxygen, the preservation of genetic diversity, and processes to provide drinking water, fuel, and much more. Ecosystems also help regulate our climate, drain surface water, and pollinate plants, plus they hold great cultural value as a place for relaxation and recovery.

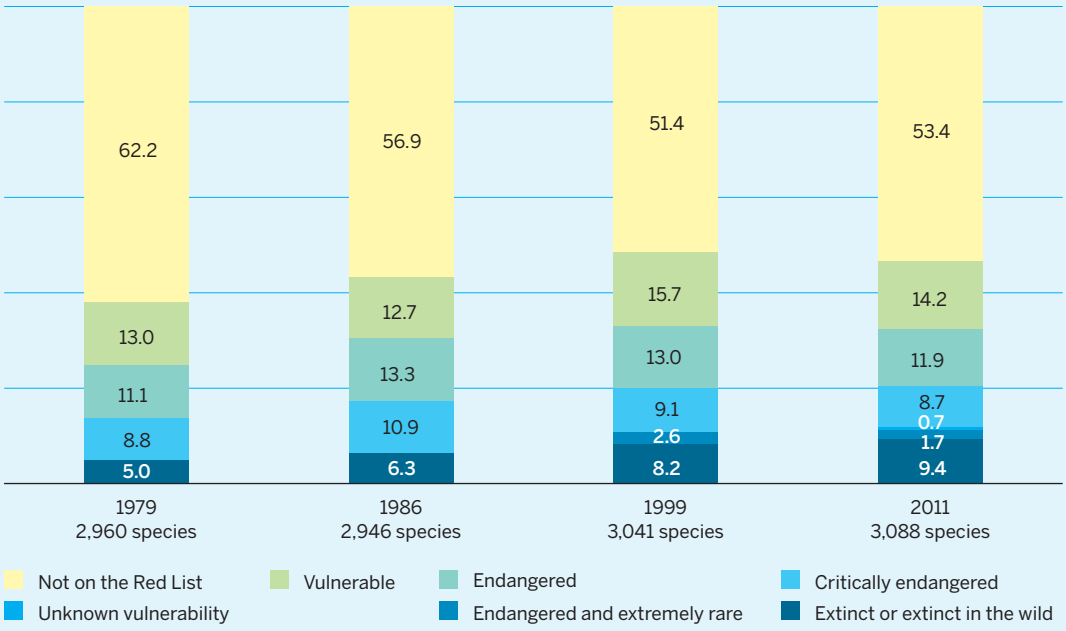
According to the Global Assessment Report on Biodiversity and Ecosystem Services published by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) in 2019, there has been a dramatic reduction in biodiversity levels ↗ www.umwelt2020.nrw.de/085. Around 1 million different species are at risk of extinction on our planet. Amphibians, coral reefs, marine mammals, and many different plant species are the most vulnerable. The current rate of extinction is at least 10 to 100 times higher than it has been on average over the past 10 million years. Only around two-thirds of the forests that existed worldwide before the Industrial Revolution survive today. Human intervention has altered 75% of the earth's surface and 66% of our oceans, and over 85% of all wetland areas have been lost in the past 300 years.

THE RED LIST IN NORTH RHINE-WESTPHALIA AND NEW SUB-LISTS

North Rhine-Westphalia is home to more than 43,000 species of animals, fungi, and plants in 70 different habitats – more than half of all species native to Germany. This level of species diversity is due to two distinct types of habitat found in North Rhine-Westphalia: the Atlantic lowlands and the continental uplands, as well as dozens of unspoiled habitats and environments that have been shaped by human intervention. Maintaining biodiversity is the core element of nature conservation. Biodiversity has been declining in Germany and worldwide for some time now.

Figure 32 **NRW environmental indicator: endangered species**

Share of endangerment categories in percent

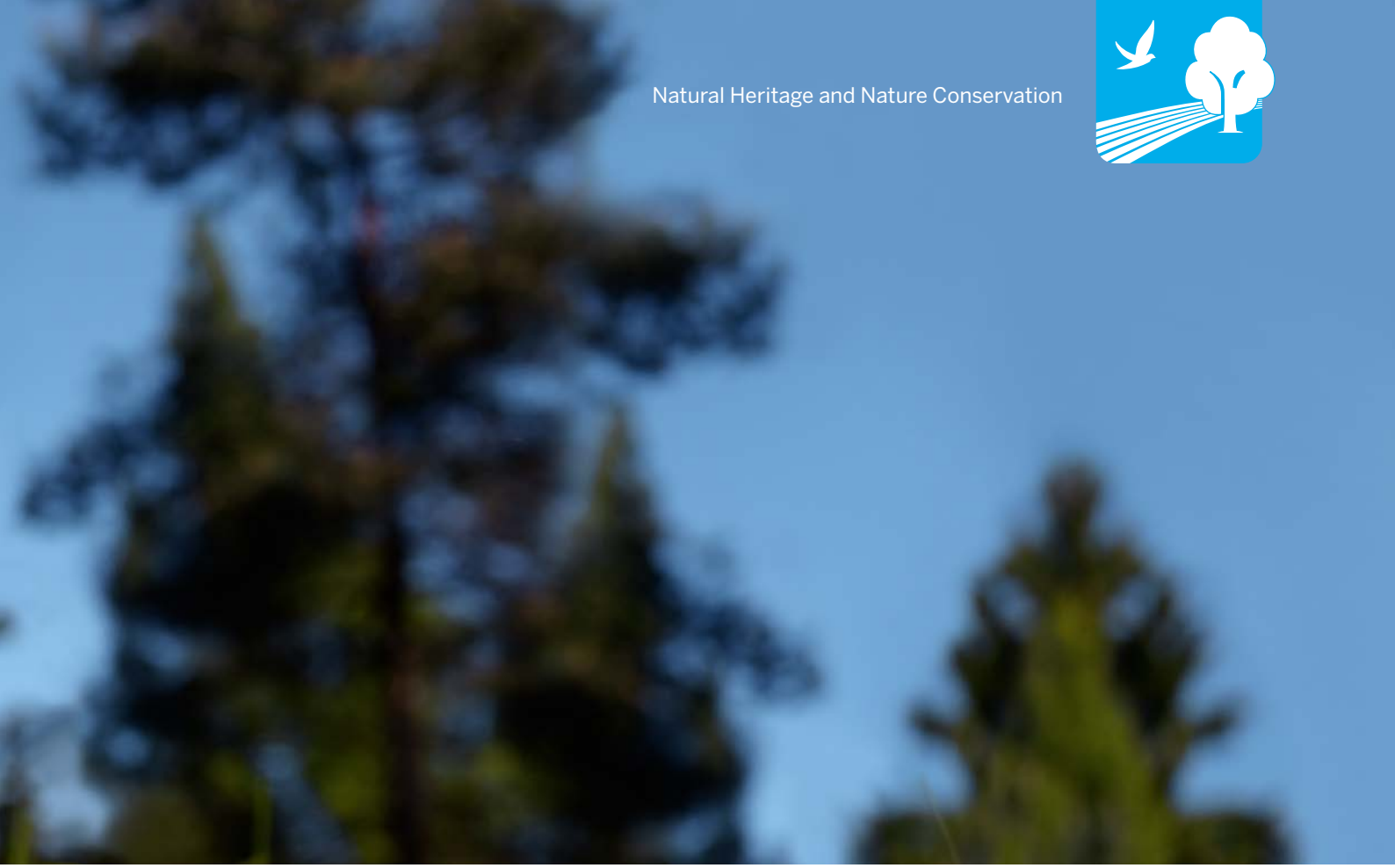


Trend over the past 10 years: –

Source: LANUV

The chart is based on the Red List of endangered plants, fungi, and animals in North Rhine-Westphalia and shows the percentage of Red List species among the total species assessed by the indicator, separated by endangerment category. It includes around 3,000 species that have been assessed in all four Red Lists, which is why the indicator does not show exactly the same percentages as the individual lists (Red Lists have been published on an increasingly comprehensive basis since 1979; the next Red List is scheduled for publication in 2021). In 2011, 46.6% of species were on the Red List. The state government aims to reduce this percentage to 40% by the year 2030.

www.umwelt2020.nrw.de/086



The endangered species environmental indicator acts as a benchmark for biodiversity in North Rhine-Westphalia. It is based on the Red List of Endangered Plants, Fungi, and Animals in North Rhine-Westphalia (Rote Liste der gefährdeten Pflanzen, Pilze und Tiere in Nordrhein-Westfalen), which was drawn up in 1979. The Red List documents the endangered status of native species and is published roughly every ten years. Over time, it has become increasingly comprehensive with a varying degree of differentiation. The most recent Red List paints a concerning picture of biodiversity in North Rhine-Westphalia. In 2011, 42% of mammal species, 71% of reptile species, 52% of wild bee and wasp species, 55% of butterfly species, and 42% of flowering plant and fern species were on the Red List. Some 45% of all monitored species are vulnerable, endangered, critically endangered, extinct, or extinct in the wild → figure 32. The next issue of the North Rhine-Westphalia Red List is due to be published in 2021. Sub-lists for nesting birds and migratory birds were last published in June 2016 www.umwelt2020.nrw.de/087.

According to the sub-list, 49% of North Rhine-Westphalia's 188 nesting bird species are considered extinct, extinct in the wild, or endangered, with a further 6% on the warning list. Nesting birds that live in non-woodland habitats featuring farmland such as arable land and grassland, as well as heathland and marshland, are particularly at risk. The ortolan bunting and the crested lark, which was once abundant in North Rhine-Westphalia, have both disappeared. Other species that used to have tens of thousands of breeding pairs in North Rhine-Westphalia have also seen sharp declines in population. The common linnet, the European serin, and the common starling are also new additions to the nesting birds section of the Red List. However, there is good news too: Thanks to targeted conservation and environmental management measures, a number of flagship species have been successfully removed from the Red List, including the Eurasian eagle-owl, the white-tailed eagle – which has recovered thanks to nesting aids – and the white stork, which has been moved to the "rare" list.

That being said, 30% of the 233 migratory birds that frequently pay visits to North Rhine-Westphalia are extinct, extinct in the wild, or vulnerable in the state, including the European roller, the carrion crow, and the Eurasian hoopoe. The migratory birds at most risk in North Rhine-Westphalia are long-migrating species and species reliant on non-woodland habitats.

GOOD AND BAD NEWS ON SPECIES DIVERSITY AND LANDSCAPE QUALITY

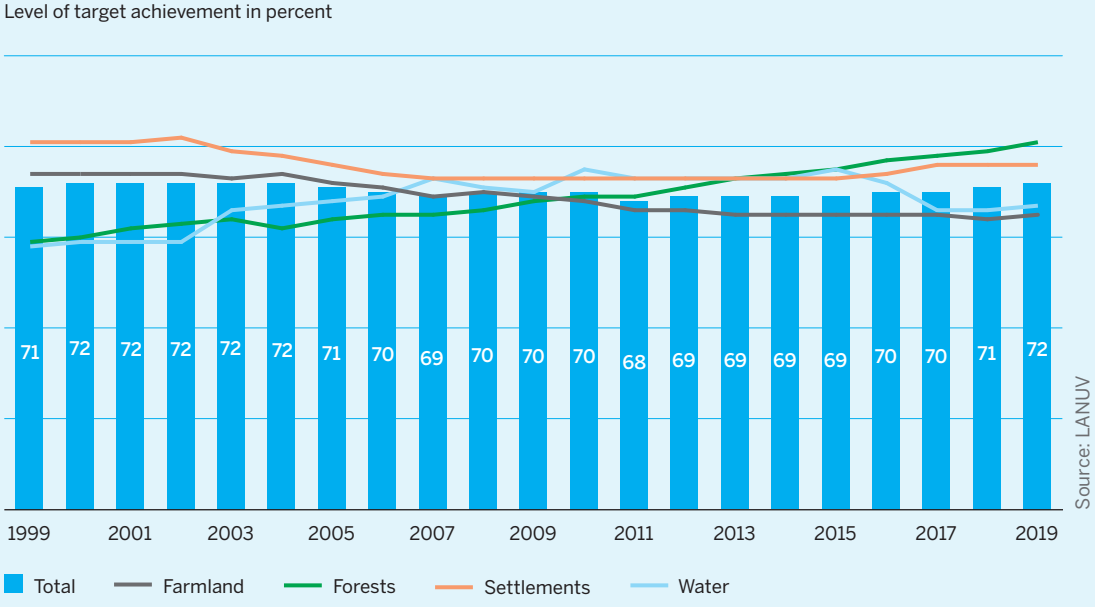
The species diversity and landscape quality environmental indicator helps to assess the quality of natural habitats and landscapes for flora and fauna in consideration of the wide variety of usages. This indicator is based on the status of around 60 nesting bird species, which provide a snapshot of the 4 landscape and habitat types North Rhine-Westphalia offers. These species include the Eurasian skylark and the northern lapwing for farmland, the common kingfisher and Eurasian reed warbler for water-based habitats, the black redstart and barn swallow for urban areas, and the black woodpecker and wood warbler for forests. At 72% target achievement, the overall indicator has some way to go to reach the target of 100%, which is derived from the maximum frequency of occurrence of the respective nesting bird species between 1997 and 2015 (a period in which these species had already seen notable declines in population). Nevertheless, conservation efforts have resulted in the overall indicator turning the corner and rising steadily over the past ten years |➔ figures 33.

No plausible explanation for the trend in urban areas can be provided at the current time. There are no indications that the Grüne Infrastruktur NRW (green infrastructure NRW) subsidy program, which aims to create a network of green and open spaces in urban areas, has had an impact |↗ www.umwelt2020.nrw.de/088. The positive trend in forests may be due to mild winters and an increase in deciduous trees and deadwood. However, the trend in farmland – which carries a strong weighting in the indicator – remains negative. "The situation is dramatic, and wide-ranging action is now crucial," wrote the German National Academy of Sciences Leopoldina in a recent joint statement entitled Biodiversity and Management of Agricultural Landscapes. The academy attributes the situation to intensive and frequent soil cultivation, the widespread use of plant protection products and fertilizers, and the relatively low percentage of extensively managed grassland and cropland |➔ page 92. Other factors include the increasing use of land, which limits the number of natural habitats, and landscape dissection |➔ page 60.

THE SPECIES-AREA RELATIONSHIP – A GOLDEN RULE OF ECOLOGY

The larger an area, the more species you will find there – and the more isolated and fragmented the habitat, the lower the biodiversity. That is why preserving what are referred to as "non-fragmented, low-traffic areas" (defined as areas not bisected by roads carrying more than 1,000 vehicles per day, railway lines, conurbations, industrial or commercial sites, airports, or canals of a certain size or above) is so important for biodiversity. North Rhine-Westphalia only has 6 non-fragmented, low-traffic areas that are larger than 100 square kilometers. The lack of such spaces, combined with continued land usage for residential and transportation purposes or for cultivation, puts native species diversity under enormous strain.

Figure 33 **NRW environmental indicator: species diversity and landscape quality in NRW**



The overall indicator based on the population status of native nesting birds has risen to 72% target achievement. Target achievement for farmland (weighted at 0.52) is at 65% and has declined significantly over the past 10 years, while target achievement for water-based habitats (weighted at 0.01) has also declined to 67%. Target achievement was 76% for urban areas (weighted at 0.18) and 81% for forests (weighted at 0.28), both of which are on upward trends. The state government aims to achieve 100% of its targets for all habitat types by the year 2030.

www.umwelt2020.nrw.de/089

THE RETURN OF THE WOLF AND THE ARRIVAL OF UNWANTED GUESTS

In Germany, wolves are highly protected by federal conservation laws and are slowly returning to the former habitats they disappeared from a century ago. There have been indications of the presence of wolves in North Rhine-Westphalia since 2009. In 2018, genetic tracing was used to identify a wolf that had established territory in North Rhine-Westphalia for the first time in 180 years. In July 2020, the first images were taken of a wolf pack in the state (in the municipality of Eitorf in the Rhein-Sieg-Kreis district). The Ministry for Environment, Agriculture, Conservation and Consumer Protection has established special wolf areas in Schermbeck (between the Lower Rhine and Münsterland regions), Senne (East Westphalia-Lippe), Eifel-Hohes Venn, and Oberbergisches Land (on the border with Rhineland Palatinate), each of which is surrounded by a buffer zone. These wolf areas, coupled with a buffer zone bordering on the Stegskopf wolf area in Rhineland Palatinate, provide a framework for the subsidies and financial assistance offered to farmers who keep grazing livestock, which covers more than one-third of the area of the state. The state of North Rhine-Westphalia offers grants and supports preventative livestock protection measures to mitigate the financial impact of damage caused by wolves. More information on this topic can be found at ↗ www.wolf.nrw.de.

In contrast to wolves, which are returning to habitats they previously inhabited for millions of years, invasive species are a real threat to biodiversity. Species are considered invasive if they occur outside of their natural habitats and pose a risk to the natural ecosystems, biotopes, or species

PROMOTING NATURAL DIVERSITY: THE NORTH RHINE-WESTPHALIA BIODIVERSITY STRATEGY

The 2015 biodiversity strategy is the starting point for all projects and measures aimed at conserving nature and species diversity in North Rhine-Westphalia. It forms part of Germany's National Strategy on Biological Diversity (Nationale Strategie zur biologischen Vielfalt) and contributes to the achievement of international biodiversity goals. Preserving diverse ecosystems is a major task for the state and is very much in the public interest. It is up to all of us to do our part to protect the world around us.

↗ www.umwelt2020.nrw.de/090

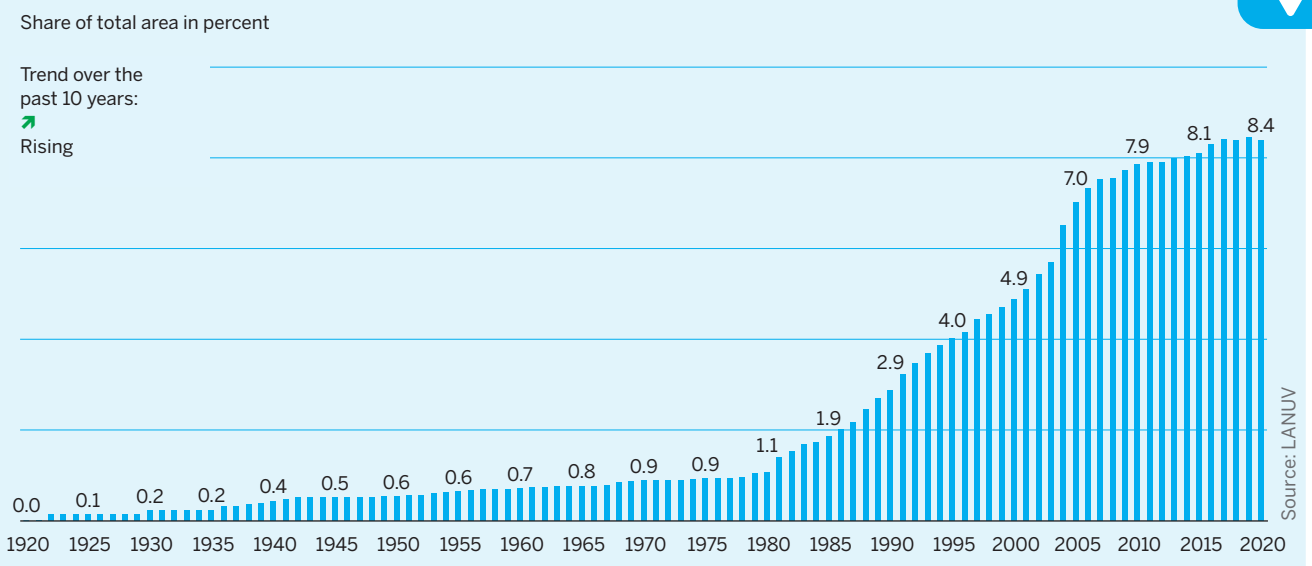
they come into contact with. Risks include supplanting native species, spreading diseases, causing economic damage, or endangering public health through population explosions. Examples of invasive species include the raccoon, a predator that spreads diseases; the coypu, which damages plants and riverbank structures; giant hogweed, which can cause a significant phototoxic reaction if it comes into contact with skin; and the common ragweed, which can act as a strong allergen.

The non-native species portal for North Rhine-Westphalia provides information on invasive species and guidance on how to prevent, control, and combat species that have established themselves in areas where they were previously not native |↗ www.umwelt2020.nrw.de/091. Examples include the rose-ringed parakeet, which has established a wild population in a range of towns and cities after pet birds escaped captivity.

PROTECTION AREAS FORM THE BACKBONE OF NATURE AND LANDSCAPE

It is vital that habitats of sufficient size and structure are preserved and developed throughout North Rhine-Westphalia so that species diversity, symbiotic relationships, and natural biotopes that are typical of the region are maintained. In many cases, populations of plant and animal species that live in isolation are not viable over the long term. A variety of species must be able to migrate to respond to changing environments, among the primary causes of which is climate change. The state-wide biotope network, which currently encompasses 11.8% of state territory, is an important instrument in this context (as of January 2021, |↗ www.umwelt2020.nrw.de/092). The network is made up of the nature conservation areas |→ figure 34, fauna-flora habitat (FFH) areas, and special protection areas for birds defined according to European law (FFH and special protection areas for birds are part of the EU-wide Natura 2000 network for the conservation and development of threatened species and their natural habitats |→ www.umwelt2020.nrw.de/093).

Figure 34 **NRW environmental indicator: nature conservation areas**



Nature conservation areas in North Rhine-Westphalia include the Eifel National Park and 3,289 other protected areas. They now make up some 8.4% of the state's total area. The increase in the number of nature conservation areas in the 2000s was primarily attributable to the implementation of the EU Habitats Directive, as many FFH areas are also natural conservation areas too. The North Rhine-Westphalia biodiversity strategy and state conservation laws are geared toward increasing the biotope network to 15% of the state's total area, which should lead to further natural conservation areas being demarcated.

|↗ www.umwelt2020.nrw.de/094

FFH REPORT ON HABITAT AND SPECIES CONDITION

EU member states are obliged to report on the status of FFH habitats and FFH species to the European Commission every six years. Federal states, such as North Rhine-Westphalia, contribute to Germany's nationwide FFH report through their own FFH reports. The North Rhine-Westphalia FFH report for 2019 draws a distinction between two major natural habitats in the state: the Atlantic lowlands (Westphalian bay, lower Rhine bay, lower Rhine lowlands) and the continental uplands (Weser and Osnabrück uplands, Rhine slate mountains). The report presents an equivocal picture of the conservation condition of habitats and species | www.umwelt2020.nrw.de/095.

Only around 18% of lowland habitats, including woodruff beech forests, dry heaths, and juniper formations on heaths, have a favorable conservation status. By contrast, 60% of upland habitats are considered to be in a favorable conservation condition, including most forest habitat types, rocky and craggy habitats, watercourses, heathlands, chalk-heath grasslands, and Nardus grasslands. In terms of species condition, the situation in the lowlands and the uplands is more equal. The percentage of species with a favorable conservation status is 42% in the lowlands and 43% in the uplands.

There are countless habitats and species that remain in an inadequate or bad condition. Around 80% of lowland habitats have an inadequate conservation status, particularly moorlands, grassland and water-based habitats, oak forests, and floodplain forests. The uplands are in much better condition in this respect, with only approximately

38% of habitats in an inadequate condition and upland grasslands and moorlands at the greatest risk. Once again, species condition is relatively even between the two habitat types, with 53% of lowland species and 52% of upland species with an inadequate conservation status. Species that are reliant on extensively managed grassland, such as butterflies, are in a particularly bad condition. In terms of specific species groups, the report shows that a particularly high percentage of mollusk and crustacean, flowing plant and fern, and moss species are in a bad condition.

Basophilic grasslands and chalk-heath grasslands in the lowlands, and regenerative hill moors in the uplands, have seen noticeable improvements compared to the 2013 FFH report. The condition of upland chalk scree, on the other hand, has deteriorated. There is better news when it comes to species: Lowland woodland species, such as the wildcat, Bechstein's bat, and the western barbastelle, have seen their conservation status improve, as have dragonflies and damselflies – such as the lilypad whiteface and the green snaketail – the Eurasian otter, and the beaver. The serotine bat, on the other hand, has seen its conservation status deteriorate.

In short, it appears that the nature conservation measures implemented over the past few years are beginning to have a positive impact on FFH habitats and FFH species.

WHAT IS THE HABITATS DIRECTIVE?

The Habitats Directive is a law introduced by the European Union to safeguard and protect wild, endemic species, their habitats, and the Europe-wide network of these habitats. The network is aimed at maintaining existing ecological relationships, and establishing and developing new ones, as well as promoting natural distribution and repopulation processes. The areas, species, and habitat types deemed to require protection are stipulated in the appendices to the Habitats Directive.

FOREST AND FORESTRY

THE FOREST IS A VITAL LINK IN THE CHAIN

North Rhine-Westphalia's forests perform a wide range of ecological, economic, and social functions and have been managed in a sustainable and environmentally friendly manner for centuries. Forestry and nature conservation laws at a federal and state level provide the framework and ensure that forests remain multifunctional, species-diverse, and unspoiled | ↗ www.umwelt2020.nrw.de/096. Privately owned forests are an important part of the forest landscape, making up 63% of total forest area.

Protected by the tree canopy, forests can generate their own climatic conditions featuring higher relative humidity, lower light intensity, and lower wind speeds. The forests of North Rhine-Westphalia are relatively young, at an average age of around 75 years. According to the most recent state forest inventory in 2014, most of the trees in North Rhine-Westphalia's forests were between 40 and 100 years old and date back to postwar reforestation.

PROTECTION, USAGE, AND RELAXATION – THE FUNCTIONS OF NORTH RHINE-WESTPHALIA'S FORESTS

The forest provides a home to some 18,000 species of plant, fungus, and animal, but also protects against plenty of harmful factors such as erosion and noise pollution. Forests in North Rhine-Westphalia release millions of metric tons of oxygen per year – withdrawing CO_2 from the atmosphere at the same time – plus they filter huge quantities of water and absorb particulate matter. Forest usage is all about its economic significance. State forests provide more than 9 million cubic meters of the renewable resource wood every year and offer means of income for some 20,000 companies generating around EUR 40 billion in annual revenue. The forest's ability to offer a place for relaxation and recovery is extremely valuable to society as a whole, as is its cultural significance, especially in and around the major conurbations along the Rhine and Ruhr.

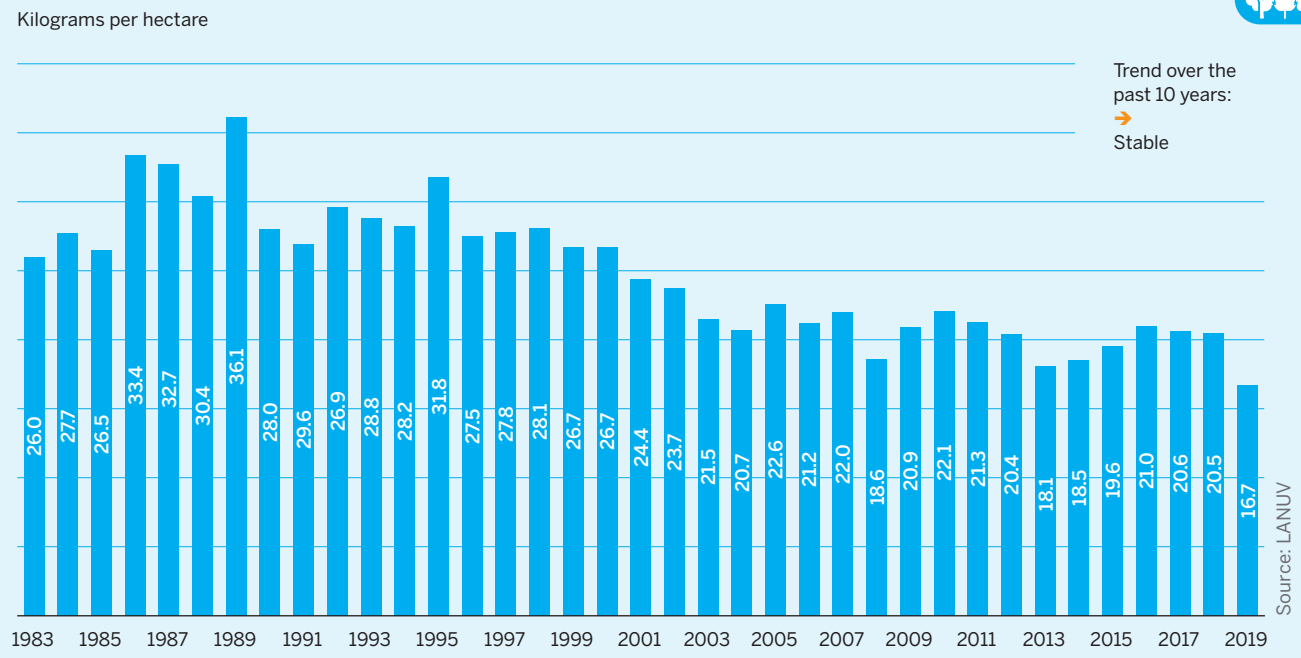
HIGH LEVELS OF DEPOSITS IN FOREST AREAS

Nitrogen and acidic compounds in the air are deposited in forest ecosystems through precipitation, and the levels of these substances are monitored by forestry authorities. Monitoring began in the 1980s following debates over forest degradation. Chronically high nitrogen and acid deposits have an adverse impact on forest ecosystems, leading to soil acidification, nutrient leaching, the release of potentially toxic aluminum, deterioration of groundwater and surface water, and a general loss of vitality and species diversity in the forest.

The deposition of nitrogen, and particularly nitrate, has been declining since the 1980s, while ammonium deposition has remained high. Acid deposits have also decreased considerably since the 1980s. Originally, acid deposits were mostly made up of sulfate, but air quality requirements have triggered a sharp decline in emissions of sulfur dioxide, which is a precursor to sulfate and a byproduct of burning fossil fuels. Nowadays, ammonium has become increasingly relevant as an acidic component. Ammonium is produced from ammonia, which originates primarily from livestock farming and from the fertilization process in high-intensity farming. Levels of nitrogen deposits and acid deposits are still too high | → figure 35, pages 38 and 91.

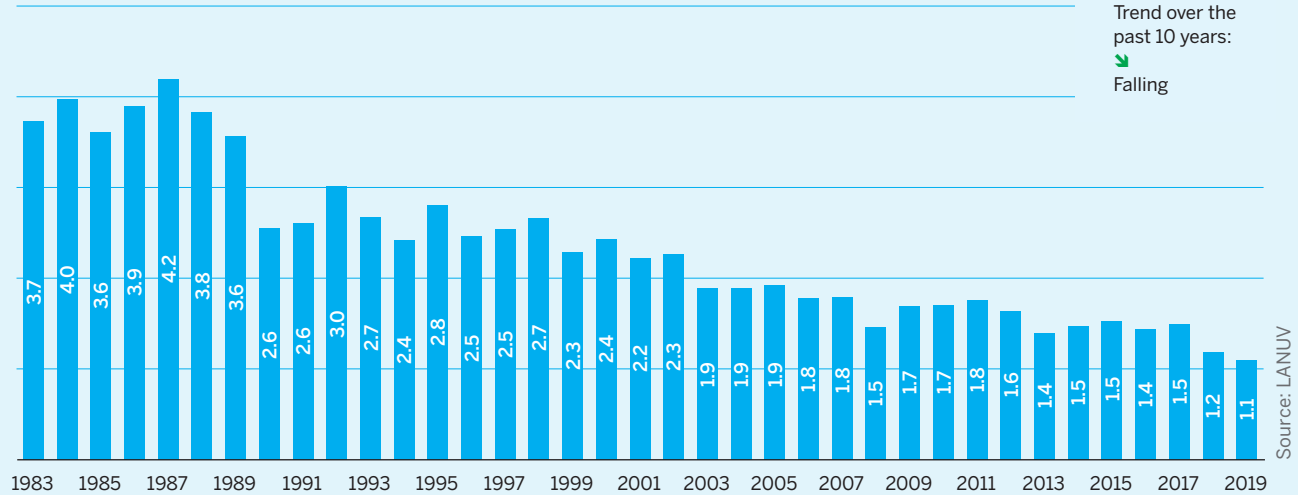
Figure 35 NRW environmental indicator: nitrogen and acid deposits

Sub-indicator: nitrogen deposits in forest areas



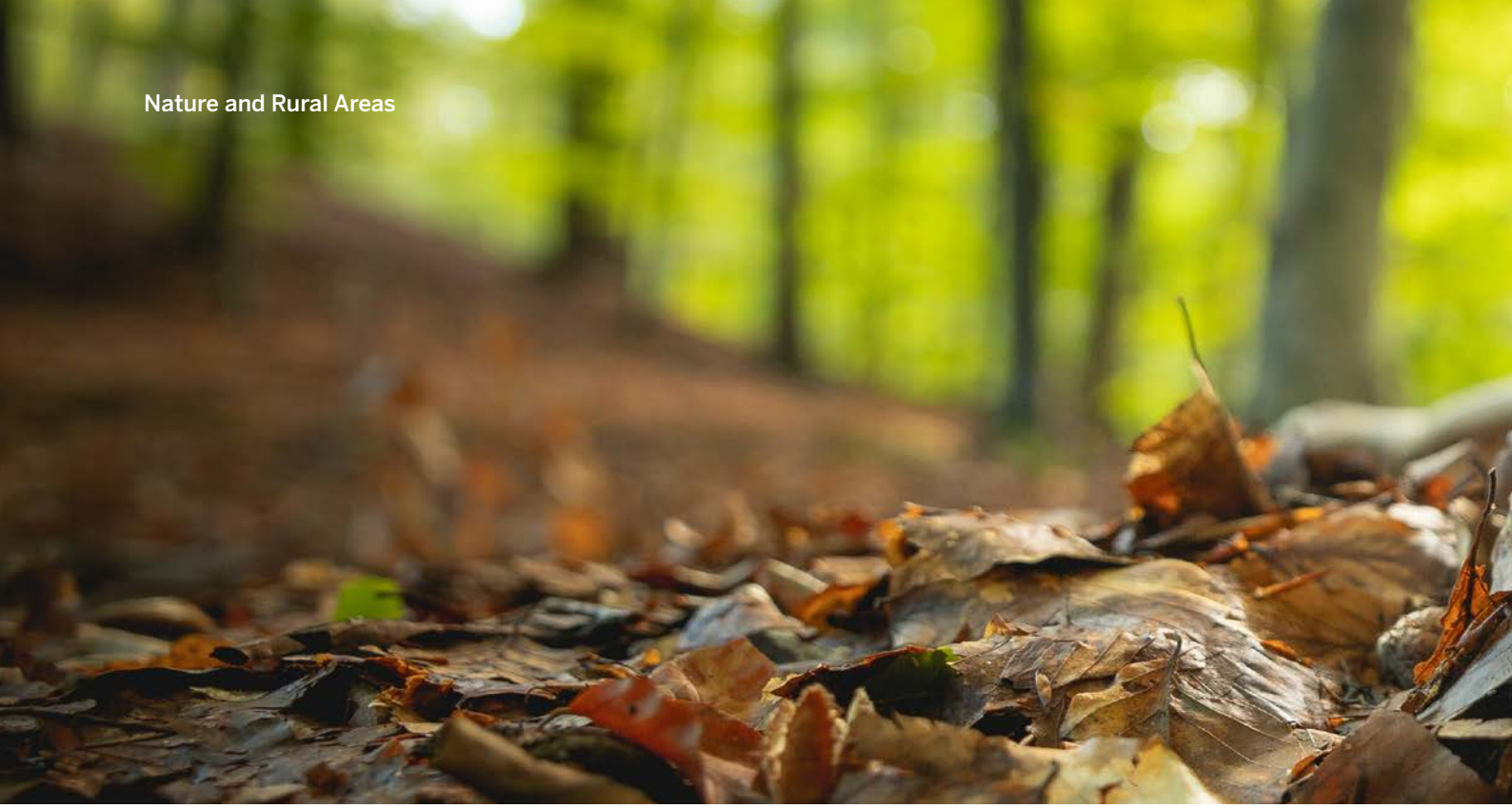
Nitrogen deposits are left in the forest floor in the form of ammonium and nitrate absorbed from rainwater. Levels have declined markedly since the 1980s, but the downward trend is currently stagnating. In 2019, the forest floor contained an average of 16.7 kilograms of nitrogen per hectare. The reason for the stagnation is high-intensity livestock farming and fertilization in the agricultural industry, as well as the burning of fossil fuels in industry and in the transport sector. The aim is to reduce nitrogen deposits in forest areas below critical levels.

Sub-indicator: acid deposits in forest areas



Amounts of ammonium and sulfate deposited in the forest floor have decreased over the past decade. There are 5 measurement stations for this indicator set up in large forest areas and at a handful of representative locations (Reichswald near Kleve, Haardt near Recklinghausen, Egge mountains, Rothaarmountains, Eifel). The stations measured an average of 1.1 kilo equivalent per hectare in 2019. The aim is to reduce acid deposits in forest areas below critical levels.

www.umwelt2020.nrw.de/097



CLIMATE STRESS – FORESTS IN WORSE CONDITION THAN EVER

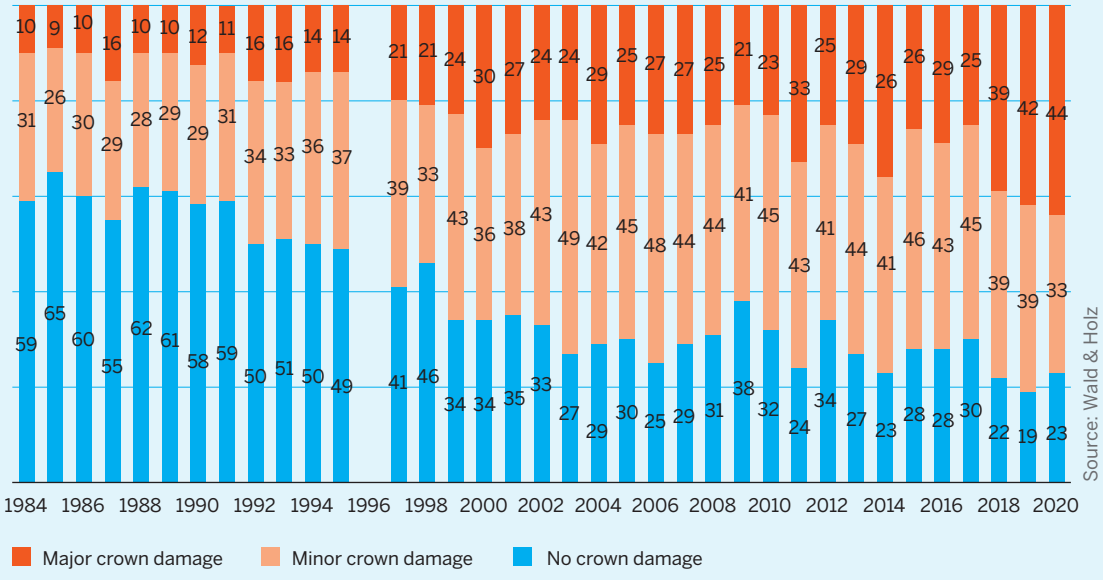
Analysis of North Rhine-Westphalia's forests in 2020 found that tree crowns were in the worst condition ever seen since records began in 1984 |↗ www.umwelt2020.nrw.de/098. The mixture of storm damage, heat, drought, and bark beetle infestation have decimated the trees over the past three years |→ page 15. High winds during Storm David and Storm Eleanor in January 2018 (known in Germany as Storm Friederike and Storm Burglind) felled countless specimens. Extreme heat and drought followed later on that year, with the months of April to August – which are important to tree growth – proving to be the warmest and driest on record since 1881. These factors triggered an explosion in bark beetle populations. Groundwater levels were partially refilled starting in late 2018, but mild temperatures allowed the bark beetles to survive the winter and feast on the now-weakened spruces. Weather records were broken once again in 2019 as North Rhine-Westphalia experienced an unusually warm, sunny, and dry summer. Following yet another mild winter and low levels of precipitation for the third year in succession, forests continue to be plagued by the disastrous bark beetle situation, low levels of groundwater, and limited access to fresh water. All in all, 44% of forest trees showed significant crown damage, 33% minor crown damage, and only 23% no crown damage at all |→ figure 36. In some areas, spruce populations have been almost completely eradicated due to bark beetle infestation. Older beech trees have also been damaged by the lack of moisture.

NORTH RHINE-WESTPHALIA OPTS FOR ENDEMIC MIXED FORESTS

According to the most recent state forest inventory, 27% of North Rhine-Westphalia is made up of forest. The most abundant tree species is spruce (30%), followed by beech (19%), oak (17%), and pine (8%). North Rhine-Westphalia's forests are also home to a significant number of larches, Douglas firs, and firs. |↗ www.umwelt2020.nrw.de/099. According to the federal and state forest inventories and the condensed carbon inventory in 2017, the share of deciduous trees in North Rhine-Westphalia's forests has risen from 48% to 59%, or 503,000 hectares, in the past 30 years |→ figure 37.

The forest climate adjustment strategy, silviculture concept, and reforestation concept for North Rhine-Westphalia all recommend endemic mixed forests, especially given the impact of climate change |↗ www.umwelt2020.nrw.de/100. |↗ www.umwelt2020.nrw.de/101, |↗ www.umwelt2020.nrw.de/102. Compared to monocultures, mixed forests are more ecologically robust, offer greater biodiversity, and pose less risk from a forest management perspective. The silviculture concept details 23 different types of forest development (typical endemic mixed forests, in other words variations of mixed oak, beech, and other mixed deciduous forests, as well as mixed coniferous forests). For existing coniferous forests, the recommended approach is to mix in deciduous species. Although the concept is focused on established native tree species, forest development methods involving mixing in selected species from other geographical regions (such as red oaks and Douglas firs) are also proposed. Useful information and digital mapping for forest management purposes and for the general public can be found at |↗ www.waldinfo.nrw.de.

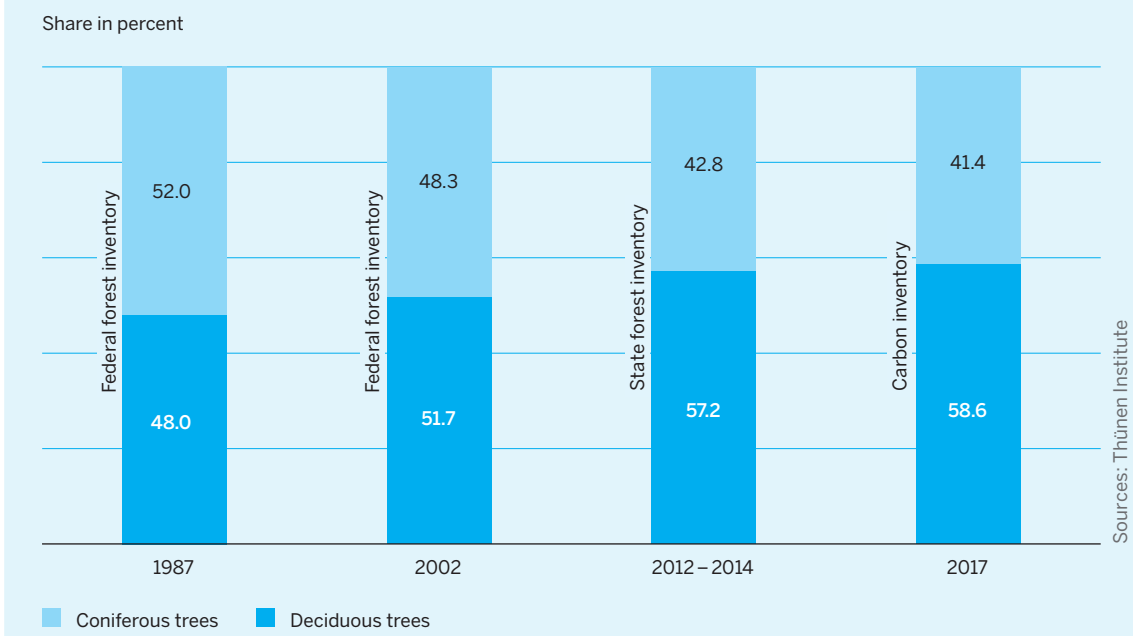
Figure 36 **NRW environmental indicator: condition of forests – crown damage for all tree species**



Crown damage is the best way of determining the health of a tree. Only a small percentage of trees have escaped the last three years, and particularly the extreme weather conditions in 2018 and 2019, unscathed. In 2019, just 19% of trees showed no crown damage, which is the lowest percentage measured since records began in 1984. In 2020, 23% of trees had no crown damage at all, while 33% had minor crown damage (11% to 25% foliage loss). The percentage of trees with major crown damage stood at 44% (trees showing moderate damage, significant damage, or no signs of life, 26 to 100% foliage loss), which was also the highest percentage determined since records began. The percentage of undamaged trees was as follows for the most significant tree species: spruce 26%, beech 17%, oak 13%, and pine 15%.

www.umwelt2020.nrw.de/103

Figure 37 **NRW environmental indicator: proportion of deciduous trees and coniferous trees**



According to the federal and state forest inventories and the condensed carbon inventory in 2017, the share of deciduous trees in North Rhine-Westphalia's forests has risen from 48% to 59%, or 503,000 hectares, in the past 30 years. By contrast, the proportion of coniferous trees has declined from 52% to 41%. This is due to the significant storm and drought events in the recent past, as well as active measures to establish more endemic and structurally diverse mixed forest areas. The data does not allow for any trend analysis, which is why no trends are presented here.

www.umwelt2020.nrw.de/104

AGRICULTURE

KEY TO THE RURAL ECONOMY

Evidence suggests humans began systematically cultivating plants at the end of the Ice Age around 12,000 years ago. Alongside forestry, hunting, fishing, and mining, agriculture is an archetypal element of human production and one of the oldest industries of them all. Agriculture is split into two main sectors: crop farming and livestock farming. Crop farming produces food for human consumption as well as feedstuffs used to feed animals. It also produces resources, such as biomass for use in renewable energy generation, and plant-based fibers such as linen, which was once important to the German textiles industry. Livestock farming gives us milk, eggs, and meat, as well as other products such as leather, wool, and manure fertilizer.

The agricultural industry is in a constant state of flux but also contributes to developments and trends. Case in point: structural transformation. In North Rhine-Westphalia more than 27,000 agricultural operations went out of business between 1991 and 2016. Case in point: land use. The agricultural industry in North Rhine-Westphalia has lost 21.9 hectares of arable land every day in the past three years alone, and is forced to rely on an ever-shrinking area of land to do business |➔ page 60. Case in point: climate change. The kind of droughts we have seen in recent years may become normal rather than just an exception in the foreseeable future, and they jeopardize the existence of countless agricultural businesses due to the resulting harvest losses |➔ page 15. Case in point: biodiversity loss. The decline in biodiversity is particularly stark in regions where land is used for high-intensity agriculture |➔ page 78.

AGRICULTURE IN NRW IN NUMBERS

According to various surveys conducted over the past few years, around 1,615,000 hectares of land, or 47% of North Rhine-Westphalia's total area, are used for agricultural purposes (according to the Integrated Administration and Control System, 1,053,000 hectares of arable land, 423,000 hectares of permanent grassland, and 13,000 of permanent crops such as fruit plantations). Roughly 34,000 businesses with approximately 117,000 employees generate produce worth some EUR 7.7 billion every year – a considerable margin of which in horticulture, which makes up one-third of German greenhouse cultivation. The three most popular crops are grain and silage corn, which account for 293,000 hectares, summer and winter wheat, with 251,000 hectares, and summer and winter barley, with 156,000 hectares. The three most popular forms of large and small livestock are hens (11.8 million), pigs (6.9 million), and cattle (1.4 million).

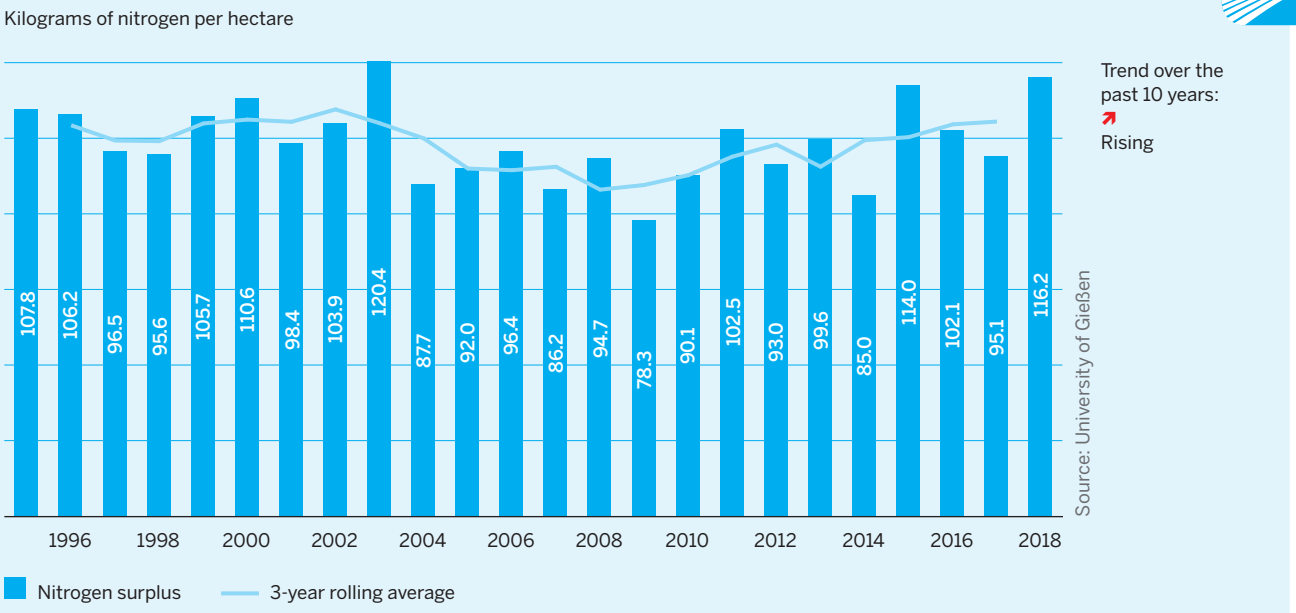
|↗ www.umwelt2020.nrw.de/105

HIGH NITROGEN SURPLUS DUE TO FERTILIZERS

Fertilizers are the basis for balanced plant nutrition in agriculture. Applying fertilizers enriches soil with nutrients such as nitrogen, phosphate, and potassium that had been removed at the last harvest. There are two different types of fertilizer: mineral fertilizer and manure fertilizer. Mineral fertiliser have been produced on a large industrial scale since the invention of the Haber-Bosch process at the beginning of the 20th century and ensured major production advances in agriculture. Manure fertilizers are organic substances produced in agriculture, such as slurry, liquid manure, dung, and fermentation residues from agricultural biogas plants. Other organic fertilizers such as compost and sewage sludge are also used. North Rhine-Westphalia has a large livestock farming industry, with roughly 22 million livestock, and one of the highest cattle densities in Germany, second only to Lower Saxony. As a result, relatively large volumes of manure are produced.

However, applying fertilizers can lead to harmful substances entering the environment, including nitrogen oxide and ammonia emissions, and the atmospheric dispersion of nitrous oxide, which is a highly potent greenhouse gas and destroys ozone in the stratosphere |➔ pages 21, 38, and 84. Fertilizer residues can also seep into groundwater, resulting in elevated nitrate concentrations, and cause the eutrophication of freshwater and coastal ecosystems through leaching |➔ page 68. Not only that, ammonia, ammonium, and nitrogen oxides can also raise the acidity of soils.

Figure 38 **NRW environmental indicator: nitrogen surplus on agricultural land (land calculation)**



By measuring the amount of nitrogen input through manure and mineral fertilizers against the volume of nutrient output through harvesting, we can see that there is a nitrogen surplus that has been steadily rising over the past 10 years. In 2018, the nitrogen surplus was calculated at 116.2 kilograms per hectare. The increase in the surplus in 2018 was primarily due to the drought-related harvest losses that year. Considerable efforts will be needed to achieve the state government's goal of reducing the nitrogen surplus on agricultural land to a maximum of 60 kilograms per hectare per year by 2030.

|↗ www.umwelt2020.nrw.de/106

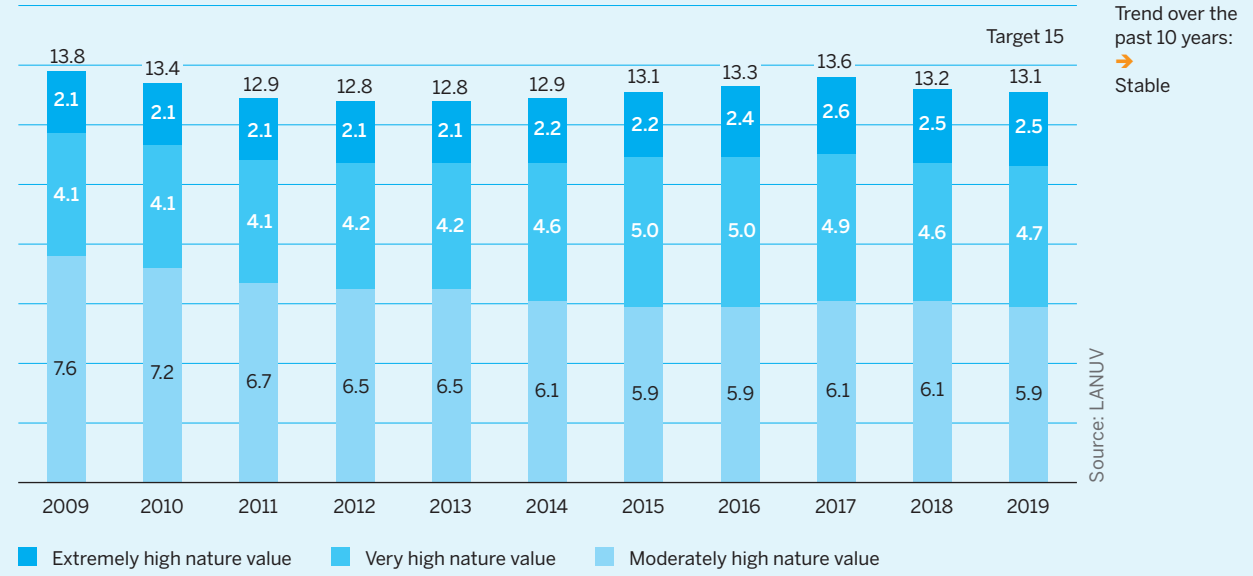
The nitrogen surplus on farmland is calculated annually as the difference between nitrogen input and nitrogen output across the whole agricultural industry. In 2018, the nitrogen surplus on North Rhine-Westphalia's farmland rose to 116 kilograms per hectare |→ figure 38, in part as a result of the drought that year. Plants suffering from drought stress reduced their photosynthetic activity, showed poorer growth, and absorbed a lower amount of nutrients than normal.

Nitrogen deposits in Germany and in North Rhine-Westphalia have been excessively high for some time now, and led the EU to take legal action in 2016 due to the inadequate implementation of the Nitrates Directive. In response, Germany revised the national fertiliser ordinance (Düngermittelverordnung) again in 2017 and 2020 and introduced stricter rules. The revised legislation and the latest state-level fertilizer ordinances curb deposits by imposing strict limitations on the application of nitrogen and phosphate fertilizers, as well as other rules |↗ www.umwelt2020.nrw.de/107. As an example, a maximum of 170 kilograms of nitrogen may be applied per hectare per year using organic fertilizers, and the set amount of fertilizer required for each parcel of land may not be exceeded. Revised maps of areas featuring high levels of nitrogen load, which are subject to additional requirements, were published in January 2021 in accordance with the Fertilizer Ordinance |↗ www.umwelt2020.nrw.de/108.

13% OF AGRICULTURAL LAND HAS A HIGH NATURE VALUE

High nature value farmland – including extensively managed grassland, arable land, orchards, edges of fields, and fallow land – is a key factor in biodiversity. Land with a high nature value also includes areas that are not actively managed, such as hedgerow, bushes, patches of woodland, and unspoiled stream habitats. In 2019, 13.1% of farmland had a high nature value, compared to around 87% with a low nature value |→ figure 39. The percentage of farmland with a high nature value stands at around 9% in the lowlands (Atlantic region), but rises to 20% in the uplands (continental region) due to the differences in natural environments and varying intensity of agricultural use. According to ecological area sampling projections, the amount of agricultural land with a high nature value has declined markedly in absolute terms. By 2018 and 2019, however, the total amount of farmland with a high nature value had risen back to the levels recorded in 2009, when the sampling began.

Figure 39 **NRW environmental indicator: high nature value farmland**



Farmland with a high nature value accounts for 13.1% of total farmland. Extensively managed grassland, arable land, edges of fields, fallow land, and linear habitats such as hedgerows, patches of woodland, and streams contribute hugely to biodiversity. Land with extremely high nature value has risen in the past 10 years, whereas high nature value land has remained constant, and the amount of land with a moderately high nature value has declined. The aim of North Rhine-Westphalia's biodiversity strategy is to increase the percentage of farmland with a high nature value to 15% by 2025.

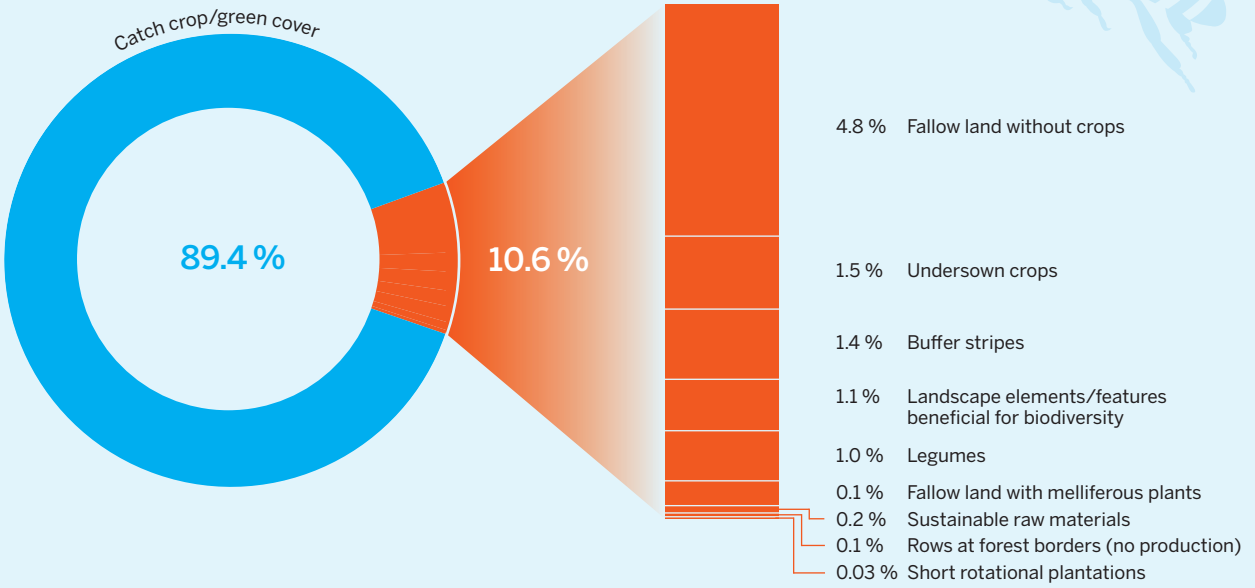
www.umwelt2020.nrw.de/109

GREEN DIRECT PAYMENTS NOT WITHOUT CONTROVERSY

Agriculture feeds the world, but it also puts strain on soil, air, water, and the animals and plants that co-habit agricultural environments, especially in areas where high-intensity farming is practiced |➔ page 78. Reforms to the common agriculture policy (CAP) introduced at the end of 2013 revised the green direct payment system to strengthen the link between EU payments and certain social responsibilities. Green direct payments, or "greening" payments, are one cornerstone of the system. Some 30% of the roughly EUR 450 million in direct payments made to agricultural businesses in North Rhine-Westphalia every year are conditional on environmental requirements being met |↗ www.umwelt2020.nrw.de/110. Greening encompasses three elements where farmers must take action: crop diversification, maintaining permanent grassland such as pasture and meadows, and identifying areas beneficial for biodiversity. Farmers may only apply for direct payments if they comply with the three mandatory practices (although small farming operations, organic farmers, and farmers focusing solely on permanent crops such as fruits are exempted from the rules). As a result, more than half of all agricultural operations in North Rhine-Westphalia set aside 5% of their arable land as areas beneficial for biodiversity |➔ figure 40. The European Commission adjusted a number of weightings in 2018 and introduced the "land lying fallow for melliferous plants" category to increase the appeal of fallow land, which is very important for biodiversity. What is more, the use of plant protection products is now also banned on areas beneficial for biodiversity (with the exception of renewable resources such as the miscanthus silvergrass in the first year of cultivation). An increasing number of penalties are also being imposed for violations of greening requirements.

Green direct payments are not without controversy though. According to a study commissioned by the German Federal Agency for Nature Conservation (Bundesamt für Naturschutz), land set aside as areas beneficial for biodiversity has not made any notable contribution to biodiversity in agricultural environments so far |➔ page 78. However, the study does note the prospect of areas beneficial for biodiversity being improved as part of the CAP from 2020 onwards and makes a number of recommendations in this regard.

Figure 40 **Composition of areas beneficial for biodiversity in NRW in 2019**



In 2019, around 157,000 hectares of land in North Rhine-Westphalia were classified as areas beneficial to biodiversity. The largest share, some 89%, was attributable to catch crops to supplement crop rotation. Fallow land, which is an important element of biodiversity, only accounted for a share of just under 5%, followed by 1.5% for undersown crop (sowing a second crop together with the seed of the primary crop to protect the topsoil from erosion). Landscape elements such as hedgerows, ponds, or patches of woodland made up 1,676 hectares, or 1.1% of areas beneficial for biodiversity.

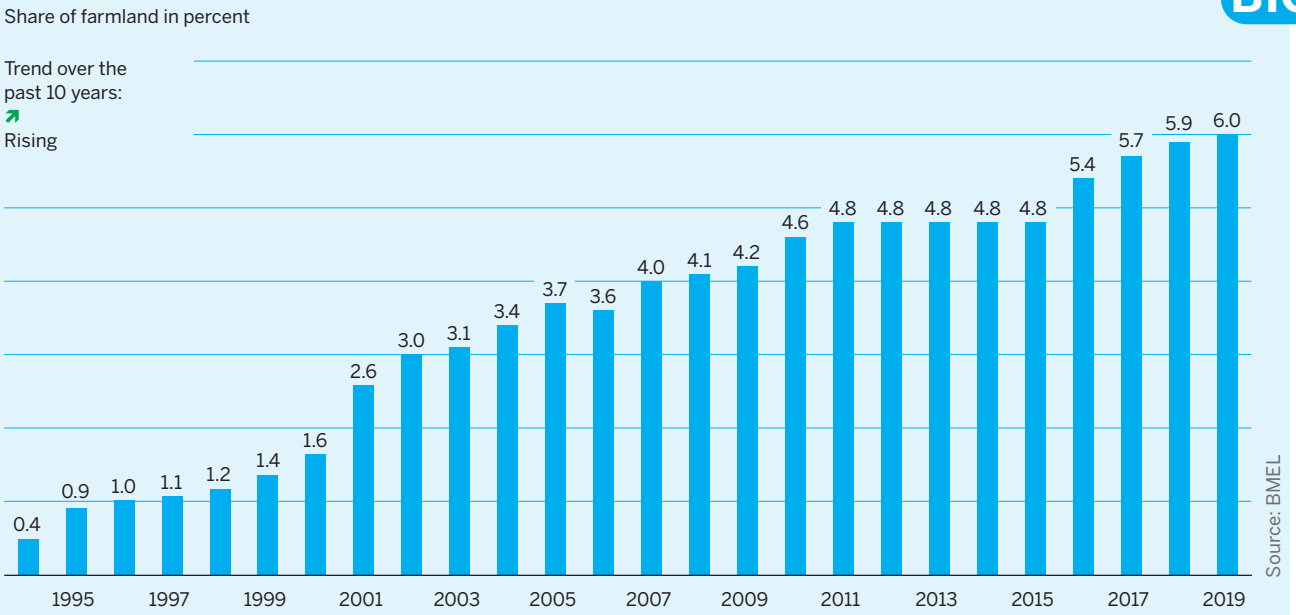
AGRI-ENVIRONMENT MEASURES AND ORGANIC FARMING

Agri-environment measures, including contract nature conservation and organic farming, are voluntary actions farmers can take. They are supported by the European Agricultural Fund for Rural Development (EAFRD) and co-financed by the federal government and state government. These schemes are predominantly focused on measures to maintain biodiversity, protect certain animal and plant species in rural habitats, protect lakes and watercourses, and prevent soil degradation and erosion – for example, by obliging farmers to put back their mowing schedule to later in the year and placing bans on the use of chemical or synthetic plant protection products. North Rhine-Westphalia has overseen and supported agri-environment measures and organic farming since 1993. The state provides environmental assistance that goes far beyond minimum statutory requirements and is fixed for a minimum of 5 years ↗ www.umwelt2020.nrw.de/111.

A total of EUR 460 million in EU, federal, and state subsidies were set aside for agri-environment measures and organic farming in the EU subsidy period from 2014 to 2020. In 2019, North Rhine-Westphalia supported 10,944 agricultural businesses implement agri-environment measures across 244,000 hectares of land. An additional 1,747 businesses received funding for organic farming under EU organic farming directives ↗ www.umwelt2020.nrw.de/112. North Rhine-Westphalia is home to a total of 2,202 organic farms across an area of 89,155 hectares → figure 41.

Figure 41 **NRW environmental indicator: organic farming**

BIO



In 2019, 89,155 hectares of land in North Rhine-Westphalia was used for organic farming by 2,202 agricultural operations. The share of total farmland used for organic farming rose to 6%. Organic farming is an environmentally friendly method of agriculture that forgoes the use of mineral nitrogen fertilizers or chemical or synthetic plant protection products, among other things, and promotes humane livestock farming. It is a vital component of maintaining biodiversity and conserving lakes and watercourses. The state government aims to increase the share of land used for organic farming to 20% by 2030.

↗ www.umwelt2020.nrw.de/113

GLOSSARY AND LIST OF ABBREVIATIONS

>	greater-than symbol
≥	greater-than-or-equal-to symbol
<	less-than symbol
%	percent
°C	degrees Celsius
µg	microgram
abiotic	relating to inanimate nature
AK UGRdL	Working Group on Environmental-Economic Accounting of the Länder (Arbeitskreis Umweltökonomische Gesamtrechnungen der Länder)
AK UGRdL	Working Group on Macroeconomic Accounting of the Länder (Arbeitskreis Volkswirtschaftliche Gesamtrechnungen der Länder)
ALB	Automated Real Estate Book (Automatisiertes Liegenschaftsbuch)
ALKIS	Authoritative Real Estate Cadastre Information System (Amtliche Liegenschaftskatasterinformationssystem)
approx.	approximately
atmosfair	climate action organization with a focus on travel
becquerel	unit of activity for a volume of a radioactive substance
BfG	German Federal Institute of Hydrology (Bundesanstalt für Gewässerkunde)
BMEL	German Federal Ministry of Food and Agriculture (Bundesministerium für Ernährung und Landwirtschaft)
bzw.	and/or (beziehungsweise, not used in the English translation)
CAP	common agricultural policy
cesium-137	radioactive substance released during the 1986 reactor disaster in Chernobyl
CHP	combined heat and power (cogeneration)
cm	centimeter
CO_2	carbon dioxide
CVUA-MEL	Chemical and Veterinary Investigations Office Münsterland-Emscher-Lippe (Chemisches und Veterinäruntersuchungsamt Münsterland-Emscher-Lippe)
dB(A)	unit of measurement for sound pressure level
decibel	one-tenth of a bel (a unit for measuring noise levels)
dl-PCB	dioxin-like polychlorinated biphenyl
DMIa	abiotic direct material input
DWD	German Meteorological Service (Deutscher Wetterdienst)
EAFRD	European Agricultural Fund for Rural Development
ECOPROFIT	Ecological Project for Integrated Environmental Protection (Ökologisches Projekt für integrierte Umwelttechnik)
EFA	Efficiency Agency NRW (Effizienz-Agentur NRW)
EC	European Community
EEA	European Environment Agency
Em.	emissions
ESRL	Earth System Research Laboratory
ETS	European Trading System
EU	European Union
Euro 6	exhaust standard for passenger vehicles
Euro 6d-TEMP	exhaust standard for passenger vehicles
FAO	Food and Agriculture Organization of the United Nations
FFH	fauna-flora habitat
GDP	gross domestic product
Geobasis NRW	Division 7 of the Regional Government of Cologne
gigajoule	1 billion joules
gigawatt	1 billion watts
ha	hectare
Hawkins	British climate researcher, known among other things for creating "warming stripes"
Hg	mercury, derived from the Ancient Greek word hydrargyros
i.e.	that is
iodine-131	radioactive material used in nuclear medicine
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
IT.NRW	State Agency Information and Technology North Rhine-Westphalia (Landesbetrieb Information und Technik Nordrhein-Westfalen)

joule	unit of energy
JRC	Joint Research Centre
KBA	German Federal Motor Transport Authority (Kraftfahrt-Bundesamt)
kg	kilogram
km	kilometer
km^2	square kilometer
l	liter
LANUV	State Agency for Nature, Environment and Consumer Protection North Rhine-Westphalia (Landesamt für Natur, Umwelt und Verbraucherschutz Nordrhein-Westfalen)
LDEN	day-evening-night noise level
LNight	night noise level
m	meter
m^2	square meter
m^3	cubic meter
megawatt	1 million watts
MERK'MAL	Minimization of Discharge of X-Ray Contrast Agents (Minimierung der Einträge von Röntgenkontrastmitteln)
mg	milligram
mod.EEM	Modular Energy Efficiency Model
MWIDE	Ministry of Economic Affairs, Innovation, Digitalization and Energy of the State of North Rhine-Westphalia (Ministerium für Wirtschaft, Innovation, Digitalisierung und Energie des Landes Nordrhein-Westfalen)
myclimate	provider of CO_2 offsetting solutions and climate change mitigation consultancy services
N	nitrogen
NASA	U.S. National Aeronautics and Space Administration
no.	number
NO_2	nitrogen dioxide
NO_x	nitrogen oxides
non-native species	species introduced through human interference to a region in which they were previously not found
NRW	North Rhine-Westphalia
O_3	ozone
PCB	polychlorinated biphenyl
PET	polyethylene terephthalate
petajoule	1 quadrillion joules
PFC	perfluorocarbons
picogram	1 trillionth of a gram
PM	particulate matter
$PM_{2.5}$	particulate matter smaller than 2.5 micrometers
PM_{10}	particulate matter smaller than 10 micrometer
PP	power plant
prelim.	preliminary
RCP	Representative Concentration Pathway
RWE	the energy supplier RWE AG (until 1990: Rheinisch-Westfälisches Elektrizitätswerk AG)
strontium-90	a radioactive material released during nuclear weapons tests in the 1950s and 1960s
SUV	sport utility vehicle
t	metric ton
terawatt	1 trillion watts
Thünen Institute	German Federal Research Institute for Rural Areas, Forestry and Fisheries
UN	United Nations
W	watt
Wald und Holz	state forestry management and maintenance agency in North Rhine-Westphalia (Landesbetrieb Wald und Holz NRW)
WHO	World Health Organization
WLAN	wireless local area network (Wi-Fi)
WSV	Federal Waterways and Shipping Agency (Wasserstraßen- und Schifffahrtsverwaltung des Bundes)

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