FEdA: Research Initiative for the Conservation of Biodiversity

A **FONA Flagship Initiative** of the BMBF to develop research-based systemic solutions for the conservation of biodiversity in Germany

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The rapid loss of biodiversity is one of the greatest challenges of our time. The FEdA research initiative aims to create the necessary scientific foundation for preserving biodiversity in Germany and securing ecosystem services that are vital to our well-being.

1. Conservation of biodiversity—an underestimated global challenge

Biological diversity[1] is one of the central foundations of human life. It is the basis for food and clean water, regulates the climate and the air quality, provides energy and medicinal products. A rich environment strongly contributes to our recreation and overall quality of life. Economists estimate the global value of ecosystem services at 125 trillion US dollars per year. Therefore, a decline in biological diversity is associated with considerable economic losses as well.

Yet, although it poses a challenge at least as large as climate change, biodiversity loss is still an underestimated threat. The drivers of climate change are largely understood due to decades of nationally and internationally coordinated research. Likewise, the public is well informed about the issue of global warming. In contrast, the reasons for biodiversity decline are much less understood, public awareness is lower, and political actions remain insufficient. Media reports often focus only on "charismatic" and well-known animals such as gorillas or rhinos when reporting species loss or the threat of extinction. Connections between the diversity of genes, species, and ecosystems mostly remain hidden.

Biological diversity has declined drastically over the past decades. More than a quarter of all species are now estimated to be threatened by extinction.

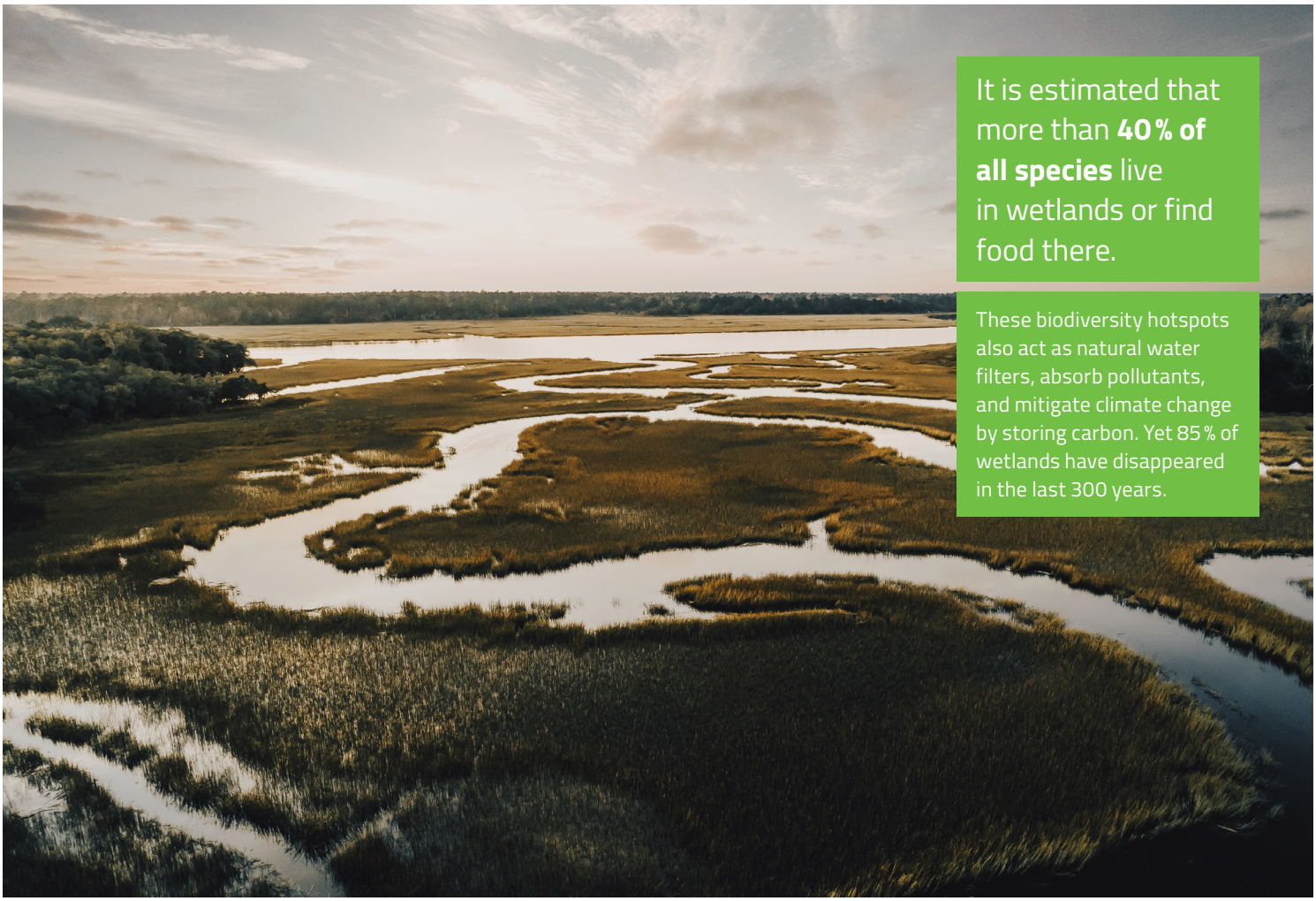
Over the past decades, biodiversity has declined drastically, both in Germany and on a global scale. Experts assume the current extinction rate of animal and plant species to be one hundred- to one thousand-fold higher on average than what is known as the "background extinction rate" in evolution. More than a quarter of all species is estimated to be threatened in their existence today.

As early as 1992, the United Nations (UN) adopted a Convention on Biological Diversity (CBD) with the aim of conserving biodiversity and ensuring its sustainable use. In 2010, the CBD parties refined their goals for global biodiversity conservation with the "Aichi Targets". They were intended to reverse the species decline by 2020. The CBD further proclaimed the years 2011–2020 as the UN Decade on Biodiversity. In addition, the UN adopted the Sustainable Development Goals (SDGs) in 2015. Two of these 17 goals directly address biodiversity, and many of the other goals are closely related to the topic.[2] The European Union (EU) also presented a biodiversity strategy to reduce key pressures on nature and ecosystem services within and outside the EU by 2020. But despite these wide-ranging efforts, species loss continues to proceed rapidly.

Reasons for the failure to stop biodiversity loss are rooted in both knowledge and action gaps that urgently need to be addressed. Therefore, the German Federal Ministry of Education and

1 The terms "biological diversity", "species diversity" and "biodiversity" are used interchangeably here to allow for easier reading. In a strict sense, species diversity only refers to the diversity of animal and plant species, while biodiversity and biological diversity encompass the diversity of species as well as genetic diversity and the diversity of ecosystems.

2 SDG 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development. SDG 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.



It is estimated that more than **40 % of all species** live in wetlands or find food there.

These biodiversity hotspots also act as natural water filters, absorb pollutants, and mitigate climate change by storing carbon. Yet 85 % of wetlands have disappeared in the last 300 years.

Wetland ecosystems, such as marshes and peatlands, are permanently or seasonally flooded with water.

Research (BMBF) has launched the Research Initiative for the Conservation of Biodiversity (Forschungsinitiative zum Erhalt der Artenvielfalt; FEdA). The initiative's research considers all levels of biodiversity, from genes to species and ecosystems, and is embedded in three overarching national programs: the Research for Sustainability (FONA) Strategy, the High-Tech Strategy 2025, and the National Biodiversity Strategy.

The goal of FEdA is to generate research-based practical knowledge that can guide decision makers, citizens, and conservation groups. The initiative comprises three fields of action: 1) To develop innovative technologies and methods to improve and boost the efficiency of biodiversity monitoring, 2) to enhance our systemic understanding of the causes, dynamics, and consequences of biodiversity changes, and 3) to generate systemic solutions and a "repertoire of measures" in cooperation with stakeholders. In order to successfully implement these goals, the BMBF will provide 200 million euros in funding to FEdA over the course of five years.

2. Knowledge gaps and the need for action

Despite decades of research, the exact extent and causes of the decline of biological diversity are difficult to determine.

While research on biodiversity and ecosystems has a long tradition, we are still lacking sufficient information on the extent and the exact causes of the decline of biological diversity. There is also a lack of reliable and effective measures to counteract this trend. More research is required for us to better understand the causes of biodiversity loss and to build the capacity to mitigate it.

Many of the overall causes of biodiversity loss are well known: Changes in land use over recent decades, habitat destruction, the use of pesticides and fertilisers, the over-exploitation of natural resources, and climate change. However, the contribution of individual drivers to the decline of species, the effects of their complex interactions as well as the role of indirect drivers—i.e., social and economic factors—remain largely unknown.

In addition, the extent of species extinction and the resulting changes in ecosystems and the services they provide to humans have been analysed inconsistently. Knowledge about the conse-

quences of extinction is mainly restricted to single species and specific habitats. Thus, targeted mitigation measures have rarely been possible.

One major reason for the existing shortcomings is the fact that biodiversity crosses the boundaries of political and economic systems, affects many different sectors within these systems (e.g., agriculture, nutrition, health), and has cross-sectoral impacts as well. Conflicts with nature conservation interests can arise during many different political, economic, and societal processes. Therefore, we need to find balanced solutions that take into account both the different political and economic requirements and the need for biodiversity protection.

"Biodiversity is declining at an unprecedented rate, and the pressures driving this decline are intensifying."

UN Global Biodiversity Outlook 5

3. Principles of FEdA

FEdA's main goal is to stimulate systemic and action-oriented research on biodiversity. Another goal is to close existing knowledge gaps regarding the causes, trends, and consequences of biodiversity loss, and to consolidate fragmented information on the status of species and landscape development. The analysis of trends will enable us to predict future developments of biological diversity. Based on this research, FEdA will create a portfolio of measures to help policymakers, industry and agriculture, society and conservation counteract the loss of biodiversity and mitigate its consequences.

The initiative's inter- and transdisciplinary research projects will consider the socio-ecological context of biodiversity loss while includung indirect and direct factors that influence changes in biodiversity and the consequences of these changes for humans.

The FEdA research initiative not only addresses universities and research institutes, but also explicitly includes stakeholders from civil society and economy such as municipalities, cities, regional associations, nature conservation organisations, companies, and agriculture. In particular, organisations and entities working in close relationships with natural systems, with a high impact on the environment or a high use of natural resources will be invited to participate, as they are most relevant for conserving biodiversity.[3] The initiative intends to build bridges between research, economic stakeholders, conservationists, the general public, and policymakers. Trans-disciplinary research contributes to this goal. FEdA workshops will bring together the different actors and facilitate finding joint solutions. Given the rapid decline in biological diversity, FEdA intends to not only provide long-term knowledge, but also to facilitate immediate action.

4. FEdA's fields of action

All FEdA projects are guided by the goal of supporting or enabling the development of systemic solutions and measures for biodiversity.

The research initiative is structured into three fields of action: Improving biodiversity monitoring; understanding the causes, dynamics, and consequences of biodiversity changes; and developing system solutions and a portfolio of measures. Research and development in the three fields of action build upon and complement each other. All research projects—including those assigned to the first and second field of action—are guided and motivated by the overarching goal of supporting or enabling the development of systemic solutions and measures for the conservation of biological diversity.

4.1 Efficiency leap in biodiversity monitoring by using innovative technologies

The extent and dynamics of biodiversity loss in Germany must be recorded and described more precisely. To this end, knowledge that is currently fragmented must be consolidated for analysis. Furthermore, the changes in biodiversity, ecosystem services, and species abundance as well as the underlying drivers must be recorded and documented in detail. This requires the development

3 Without any claim to completeness, these include: Waste/environmental management, construction industry/infrastructure, retail trade, energy industry, food industry, gardening and landscaping, gastronomy, wholesale trade (e.g., hardware stores), wood processing, beekeeping, logistics/transport, cosmetics industry, agriculture and forestry, pharmaceutical industry, urban/spatial/landscape/development planning, road construction, textile industry, tourism, water management/water and wastewater technology.

of innovative technologies that will be able to rapidly and automatically generate and provide data. It is indispensable for the development of reliable models and scenarios that data are stored in a standardised way and made available long-term.

To date, biodiversity monitoring in Germany has mainly been decentralised—i.e., spatially and temporally fragmented. For the most part, the different datasets are not linked, and often include only selected species groups. The mobilisation, synthesis, and complementation of existing data and results is a national task that needs to be solved in a joint effort of federal and state governments, academic and non-academic institutions. FEdA will substantially contribute to this process.

The aim is to achieve a comprehensive, coherent, standardised, continuous, and timely monitoring of a broad range of species (including understudied groups) as well as ecosystems. This monitoring should be based on a variety of visual, acoustic, biochemical, and genetic observation data. Modern technologies of data processing will allow analyses of biodiversity change and its underlying drivers within short periods of time. Similar to weather data today, information on biodiversity should be freely accessible for use by researchers, administrations, and the general public. First steps in this direction are taken by the AMMOD project (Automated Multisensor Stations for Monitoring of BioDiversity; www.ammod.de).

A variety of established and innovative technologies is already available and should be expanded for improving biodiversity monitoring, such as metabarcoding/metagenomics, bioacoustics, pattern recognition, remote sensing, and trace gas detection. However, there is still the need to develop appropriate technical infrastructures (e.g., for data harmonisation, access to non-centrally stored data, data analyses). This includes methodological innovations to improve, for example, database accessibility, making use of increasing digitalisation (automation of collection, data entry, transmission, and processing). In addition, the development of new types of sensors and IT-supported applications and sensor networks can contribute to monitoring improvements. Monitoring projects could also benefit from cooperation with companies experienced in the corresponding technologies.

As another important step, these technical solutions are complemented by the involvement of citizens and volunteers. Citizen science projects can foster the involvement of the public in biodiversity monitoring and increase acceptance for this kind of research and subsequent conservation measures.

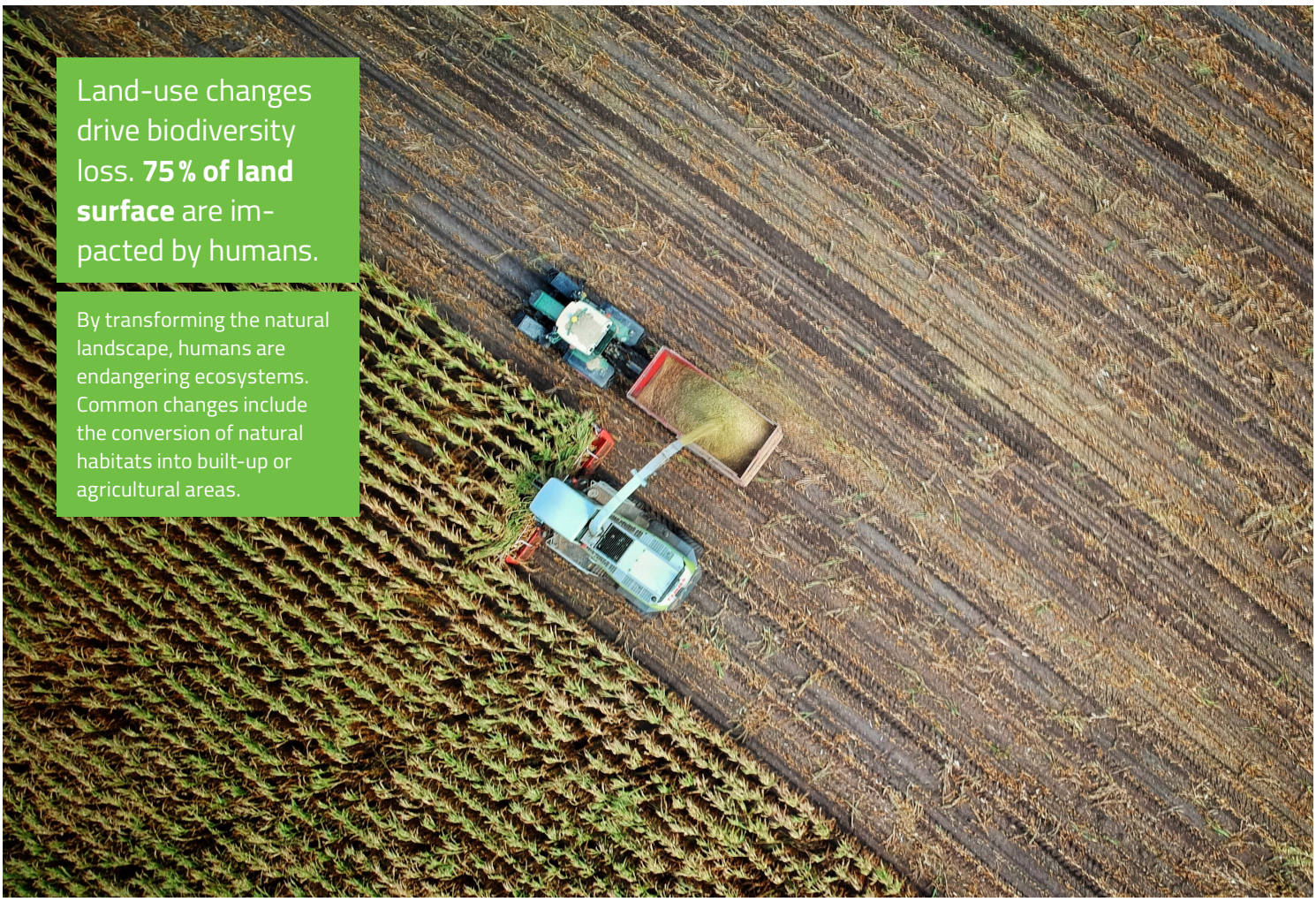
Pollinators and apex predators are essential to their ecosystems' biodiversity. Many species from these animal groups are endangered.

4.2 Causes, dynamics, and consequences of changes in biodiversity

General causes of biodiversity loss are already known, such as habitat fragmentation, the use of fertilisers and pesticides, or climate change. However, the specific causes of species loss in Germany remain widely unknown. To date, researchers have focussed on a few, well-studied groups of organisms (e.g., birds, butterflies). FEdA's second field of action aims to close these knowledge gaps. In particular, rare species and those difficult to access (e.g., soil organisms) must be investigated in further detail. In addition, other components of biodiversity should receive greater attention, such as genetic diversity, abundance, biomass, functionality, and interactions.

Furthermore, we need a better understanding of ecosystem functions and ecosystem services as well as their underlying drivers and dynamics. This requires an overview of the current and potential ecosystem services provided by protected areas as well as different ways of land used by humans. For most habitat types, the relationship between land use, biodiversity, and the provision of ecosystem services is not yet sufficiently known.

On the other hand, there is a need for a better understanding of the multiple economic, demographic, social, cultural, historical, and political factors impacting the direct drivers of biodiversity



Intensified agriculture has the capacity to feed many people, but is discussed as a major driver of insect decline.

loss. These indirect drivers also include the complex interactions of the different stress factors. Causal analyses of human practices and their impact on the degradation of ecosystems can be used to provide the necessary reliable projections of biodiversity trends. Only a holistic view allows us to understand the dynamics of biodiversity and to find appropriate, realistic measures for stopping its decline.

Apart from the causes, the consequences and risks of biodiversity and ecosystems loss must be assessed and described in greater detail. These developments affect people's lives directly and indirectly in important ways. However, these effects often begin subtly and may seem innocuous at first. Affected areas include food production, medical care, or the availability of clean water. It is estimated that many ecosystems on earth will reach a critical threshold in the next few decades due to the continuing loss of species. Reaching these so-called tipping points will lead to abrupt changes in the affected ecosystems, with mostly negative consequences (regime shifts). This poses a threat to core areas of supply, economy, and quality of life of entire countries and, ultimately, global society as a whole.

4.3 Systemic solutions and a portfolio of measures

The third field of action is dedicated to finding options and identifying decision-making and management instruments in support of biodiversity for stakeholders in politics, administration, and business. Also, economic conditions will be analysed nationally and globally, with a focus on relevant conflicts of interest, but also on possible synergies between conservation efforts and various economic sectors. The protection and sustainable use of biological diversity and the maintenance of ecosystem services are cross-sectorial tasks that need to be integrated into numerous areas of policy at various levels (local, regional, national, European, and international). For this purpose, governance structures and processes must be analysed while involving the knowledge and viewpoints of respective stakeholders.

Despite the existing spectrum of political instruments for biodiversity protection, successes have been scarce. Therefore, we need to analyse the causes for this limited effectiveness as well as obstacles in the implementation of these measures. In order to assess the suitability, the impact of and necessary conditions for the use of specific conservation instruments, we will study exemplary areas of action and representative model regions. The projects will comprise different landscape types, representing the variety of geographic diversity in Germany. Ideally, land use gradients will be included, and areas of the same landscape, but with differing land use intensity, will be compared in a pairwise fashion ("twinning" approach).

The focus on model regions makes changes in biodiversity as well as the interaction of drivers and the effects of conservation measures more visible and manageable. Solutions can thus be tailored to local needs and contexts. This will be supported by consulting and mobilising local stakeholders and decision-makers from the beginning. The focus on model regions also makes it possible to examine the consistency and transferability of different strategies. In order to maximise synergies, research in fields of action #1 and #2 should ideally also focus on these model regions.

Integrative scenarios combining ecological and social aspects can help to map synergies and trade-offs between different modes of action. In addition, we need to move on from a purely economic valuation of ecosystem services to integrative valuation approaches, taking into account ecological, social and ethical aspects.

The rapid loss of species imposes on us a high pressure to act. At the same time, there still are large gaps in our knowledge, and uncertainties remain both about the drivers of change as well as the key factors and "leverages" for mitigation. Therefore, we need more research dedicated to finding early and robust recommendations that will enable us to make the right decisions.

"We are all dependent on biodiversity. Whoever destroys natural capital should be responsible for its restoration."

Volker Mosbrugger, FEdA Spokesman

5. Infrastructure and advancement of FEdA

FEdA aims to significantly impact science while simultaneously generating societal awareness and acceptance of the results of research on biodiversity. For this purpose, the research initiative establishes a dialogue forum on biodiversity to connect the public, science, and politics.

One of the FEdA bodies is the scientific advisory board with biodiversity experts from various disciplines. In regular meetings, the advisory board evaluates project results, funding structures, and core themes of the initiative's research projects.

Another FEdA body is the initiative's central coordination office, which is based at the Senckenberg Society for Nature Research in Frankfurt/Main. The central coordination supports FEdA and the funded projects scientifically. The office also communicates scientific findings to the media, decision-makers and the general public, and establishes a database for research meta-data. The office also organises national and international scientific conferences and synthesis workshops on key topics identified by the advisory board. In addition, it conducts accompanying research such as meta-studies.

The work of these bodies is accompanied by the "Biodiversity Assessment Germany" (Faktencheck Artenvielfalt), a new joint project for assessing biodiversity conservation in Germany. It evaluates trends, direct and indirect drivers, and the effectiveness of conservation measures for the most important habitats: agricultural and open land, forests, inland waters and floodplains, coasts and coastal waters, urban areas, and soils. The project lead and eight author teams from different universities and research institutions will write a report within three years. An evidence database will allow all statements to be traced back to sources, while digital formats will facilitate access to all information and data. Special attention is paid to the analysis of grey literature (official reports, qualification papers, expert opinions), which is particularly relevant for practical application.

The "Biodiversity Assessment Germany" will evaluate trends, drivers, and conservation measures for the most important habitats in the country.

Finally, stakeholder panels consisting of representatives from politics and federal ministries, relevant economic sectors and the civil society will be established to connect research and application. The panels' goals are to check the practical and political relevance of FEdA, and to support the implementation of evidence-based recommendations in policy and economy. They will also provide stimuli for the further development of the FEdA research initiative.

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