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ANNEX

ANNEX

to the

Communication to the Commission

Approval of the content of a draft Commission Notice on the Guidance on Natura 2000 and climate change

ANNEX

Draft Commission Notice on the Guidance on Natura 2000 and climate change

Guidance on Natura 2000 and climate change

DISCLAIMER

This guidance aims to support a better understanding of how the Natura 2000 network and its management can be adapted to climate change to achieve its objectives. It provides guidance on how to design and manage Natura 2000 sites in relation to potential impacts caused by climate change, clarifying the existing flexibilities, identifying strategic planning needs and proposing practical measures to support adaptation for Natura 2000 both at network and site level, as well as in the wider landscape. This guidance is intended to support a structured, proportionate and flexible approach that helps authorities and stakeholders address climate-related pressures in a pragmatic manner.

This guidance document reflects the views of the European Commission and is not legally binding. This guidance document does not replace, add to or amend the provisions of the Birds and Habitats Directives. It rather presents clarifications to support Member States in the development of the national implementation measures most appropriate to their specific context, and it should not be considered in isolation but used in conjunction with this legislation. It does not prejudge any future position of the European Commission on the matter. Only the Court of Justice of the European Union is competent to authoritatively interpret European Union law.

This is without prejudice also to further case law by the Court of Justice of the European Union, to the outcome of the ongoing stress test of the Birds and Habitats Directives[1] and to the package of proposals for the simplification of administrative burdens tabled by the European Commission[2]. As such, it does not prejudge ongoing discussions on implementation challenges, administrative burden or policy sequencing across related EU environmental and land-use frameworks. The case studies are without prejudice to full and timely compliance with relevant obligations under the Birds and Habitats Directives.

European Commission, 2026

This document has been prepared by the European Commission with the assistance of Graham Tucker of the Institute for European Environmental Policy and Kerstin Sundseth of N2K GROUP EEIG, with contributions from Lisa Kopsieker, Giulia Costa Domingo and Evelyn Underwood of the Institute for European Environmental Policy, and Concha Olmeda of N2K GROUP EEIG, under Contract No 09.0201/2022/880820/SER/ENV.D.3 ‘Technical and scientific support in relation to the Implementation of the Habitats and Birds Directives and of the biodiversity strategy for 2030’.

[1] Communication from the Commission to the European Parliament, the Council and the Committee of the Regions, ‘Simplifying for sustainable competitiveness’, COM(2025) 980 final.

[2] Proposal for a Regulation of the European Parliament and of the Council on speeding-up environmental assessments, COM(2025) 984 final. At the time of publication of the present guidance document, this proposed regulation has yet to be adopted. In full respect of the co-legislators, who are solely competent for the adoption of EU legislation, it is beyond the scope of the present guidance to discuss this proposal.

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ACRONYMS AND ABBREVIATIONS

BD	Birds Directive
BHD	Birds and Habitats Directives
CBD	Convention on Biological Diversity
EEA	European Environment Agency
EU	European Union
CJEU	Court of Justice of the European Union
GHG	Greenhouse gases
HD	Habitats Directive
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
MPA	Marine protected area
PA	Protected area
SAC	Special area for conservation
SCI	Site of Community importance
SSCM	Site-specific conservation measures
SPA	Special protection area
SSCO	Site-specific conservation objectives
SSP	Shared socio-economic pathways
UNFCCC	United Nations Framework Convention on Climate Change
WFD	Water Framework Directive

GLOSSARY OF KEY TERMS

Adaptation	In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate and its effects (IPCC, 2023)[3].
Adaptive capacity	The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences (IPCC, online glossary)[4].
Protected habitats and species	All habitat types and species subject to the obligations under the Birds and Habitats Directives, i.e. all species of naturally occurring birds in the wild; and natural habitat types as listed in Annex I to the Habitats Directive and species of wild fauna and flora of Community interest listed in Annexes II, IV and V to the Habitats Directive.
Climate impact driver	Physical climate system conditions (e.g. means, events, extremes) that affect an element of society or ecosystems. Depending on system tolerance, climate impact drivers and their changes can be detrimental, beneficial, neutral or a mixture of each across interacting system elements and regions (IPCC, 2023).
Exposure	The presence of people; livelihoods; species or ecosystems; environmental functions, services, and resources; infrastructure; or economic, social, or cultural assets in places and settings that could be adversely affected (IPCC, 2023). Exposure is usually measured by factors external to the target, such as the rate and magnitude of changes in temperature, precipitation, sea-level rise, flood frequency and other physical factors.
Hazard	The potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources (IPCC, 2023). Climate hazards are often referred to as pressures or threats in relation to protected habitats and species.
Impacts	The consequences of realised risks on natural and human systems, where risks result from the interactions of climate-related hazards (including extreme weather/climate events), exposure and vulnerability. Impacts generally refer to effects on lives, livelihoods, health and well-being, ecosystems (habitats and species), economic, social and cultural assets, services (including ecosystem services) and infrastructure. Impacts may be referred to as consequences or outcomes and can be adverse or beneficial (IPCC, 2023).

[3] IPCC (2023), AR6 Synthesis Report. Climate Change 2023, Intergovernmental Pannel on Climate Change, Cambridge University Press, Cambridge, UK and New York, USA. https://www.ipcc.ch/report/ar6/syr/

[4] IPCC online glossary: https://apps.ipcc.ch/glossary/

Climate mitigation	A human intervention to reduce emissions or enhance the sinks of greenhouse gases (GHG) (IPCC, 2023). In the context of protected areas, it is taking direct action to reduce GHG emissions from operations and/or to enhance the capacity of the ecosystems to remove these gases from the atmosphere and store them in biomass and soils.
Natura 2000 habitats and species	Species for which Natura 2000 sites must be designated: Birds listed in Annex I to the Birds Directive, regularly occurring migratory birds, habitat types listed in Annex I to the Habitats Directive, and species listed in Annex II to the Habitats Directive.
Nature Directives	The Birds Directive and the Habitats Directive.
Nature-based Solution	Actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services, resilience and biodiversity benefits (UNEP 2022)[5].
Pressures	Factors that are detrimentally affecting habitats and species. For reporting under the Nature Directives, they refer to the pressures as reported under Article 17 of the Habitats Directive and Article 12 of the Birds Directive.
Refugia	Areas that during climatic upheaval, biological stress or major population downsizings still provide the essential elements of the species' niche for small subpopulations.
Resilience	The capacity of interconnected social, economic and ecological systems to cope with a hazardous event, trend or disturbance, responding or reorganising in ways that maintain their essential function, identity and structure. Resilience is a positive attribute when it maintains capacity for adaptation, learning and/or transformation (IPCC, 2023).
Risk	The potential for adverse consequences for human or ecological systems, recognising the diversity of values and objectives associated with such systems. In the context of climate change, risks can arise from potential impacts of climate change as well as human responses to climate change. Relevant adverse consequences include those on lives, livelihoods, health and well-being, economic, social and cultural assets and investments, infrastructure, services (including ecosystem services), ecosystems and species. In the context of climate change impacts, risks result from dynamic interactions between climate-related hazards with the exposure and vulnerability of the affected human or ecological system to the hazards. Hazards, exposure and vulnerability may each be subject to uncertainty in terms of magnitude and likelihood of occurrence, and each may change

[5] UNEP (2022), Emissions Gap Report 2022: The Closing Window — Climate crisis calls for rapid transformation of societies, United Nations Environment Programme, Nairobi. https://wedocs.unep.org/handle/20.500.11822/40874

	over time and space due to socio-economic changes and human decision making. In the context of climate change responses, risks result from the potential for such responses not achieving the intended objective(s), or from potential trade-offs with, or negative side-effects on, other societal objectives, such as the Sustainable Development Goals. Risks can arise for example from uncertainty in the implementation, effectiveness or outcomes of climate policy, climate-related investments, technology development or adoption, and system transitions (IPCC, 2023).
Scenario	A plausible description of how the future may develop based on a coherent and internally consistent set of assumptions about key driving forces (e.g. rate of technological change, prices) and relationships. Note that scenarios are neither predictions nor forecasts but are used to provide a view of the implications of developments and actions (IPCC, 2023).
Sensitivity	The degree to which a system is affected, either adversely or beneficially, by climate variability or change. The effect may be direct (e.g. a change in crop yield in response to a change in the mean, range, or variability of temperature) or indirect (e.g. damages caused by an increase in the frequency of coastal flooding due to sea-level rise) (IPCC, online glossary).
Threats	Factors that are expected to detrimentally affect habitats and species in the future.
Vulnerability	According to the IPCC (2023), vulnerability is the propensity or predisposition to be adversely affected. It encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt. Nature conservation scientists still generally consider vulnerability to be 'a function of the character, magnitude and rate of climate change to which the system is exposed, its sensitivity and its adaptive capacity' as defined by IPCC (2007)[6]. See annex 2, section 3 for further explanations.

[6] IPCC (2007), Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK. https://www.ipcc.ch/report/ar4/wg2/

Guidance on Natura 2000 and climate change

EXECUTIVE SUMMARY

Across the world, climate change is recognised as a significant risk to society, the economy and the environment. The European Climate Law[7], requires the Union institutions and the Member States to take measures to collectively achieve climate neutrality and to ensure continuous progress in enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change, in line with Article 7 of the Paris Agreement[8]. The urgency of climate mitigation and adaptation is particularly acute in Europe, where warming has occurred at about twice the global average rate, resulting in rising temperatures, more frequent heatwaves, droughts, heavy rainfall and conditions conducive to wildfires.

The biodiversity crisis is intrinsically linked to the climate crisis, with climate change acting as a major driver of biodiversity loss and ecosystem degradation in Europe, while resilient ecosystems are essential allies for climate mitigation and adaptation. Climate change is already driving shifts in ecosystems, habitats and species distributions, often towards higher latitudes and elevations with particularly detrimental impacts on endemic, rare and endangered habitats and species protected under the EU Birds[9] and Habitats[10] Directives. These impacts are expected to intensify in the coming decades.

Many ecosystems play an essential role in reducing greenhouse gas emissions and offer nature-based solutions for adapting to climate change. Conservation measures for habitats and species in Natura 2000 sites make a significant contribution here. Nature-based solutions can prevent the loss of and restore carbon-rich ecosystems and can address climate risks like riverine and coastal flooding, landslides, water shortages, erosion (including after wildfires) and soil degradation, in a cost-effective manner. Alongside restoration, a broad range of management, maintenance, risk-reduction and adaptation measures can further strengthen ecosystem resilience, depending on national circumstances and priorities.

The EU recognises the central role of biodiversity in climate adaptation. Its 2021 strategy on adaptation to climate change[11] and communication on managing climate risks[12], call for science-based ecosystem restoration and management and emphasise large-scale, long-term nature-based solutions as cost-effective, multipurpose and 'no-regret' options. More integrated and long term approaches are essential for the effective

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[7] Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law'), OJ L 243, 9.7.2021, pp. 1–17.
[8] The Paris Agreement, United Nations Framework Convention on Climate Change (UNFCCC, 2016).
[9] Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds, OJ L 20, 26.1.2010, p. 7–25.
[10] Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora, OJ L 206, 22.7.1992, p. 7–50.
[11] Forging a climate-resilient Europe - the new EU Strategy on Adaptation to Climate Change, COM/2021/82 final.
[12] Managing climate risks - protecting people and prosperity, COM/2024/91 final.

management of the Natura 2000 network and for achieving the objectives of the Birds and Habitats Directives and the Nature Restoration Regulation[13].

This guidance document aims to provide advice on how to take a structured approach to climate change adaptation for Natura 2000 sites, consistent with existing national climate adaptation strategies under the European Climate Law and the national restoration plans under the Nature Restoration Regulation. The guidance clarifies how the provisions of the Nature Directives can be applied when designating and managing Natura 2000 sites in the context of climate change impacts. It identifies strategic planning needs and practical measures to support adaptation at the level of the Natura 2000 network, individual sites and their surrounding landscapes and seas. It also promotes the use of nature-based solutions and strategic partnerships with relevant sectors, including for disaster prevention, to deliver co-benefits for biodiversity as well as climate adaptation and mitigation objectives.

The guidance provides information and advice to Member States, Natura 2000 managers and environmental authorities to help them meet their obligations while making use of the flexibilities in the Birds and Habitats Directives when adapting conservation objectives and measures to climate change. The guidance is not legally binding and presents a range of measures that Member States may choose to implement.

The Natura 2000 network, covering 18.6% of EU land and 10.5% of EU seas, will continue to host a very significant share of Europe's biodiversity as climate change intensifies. It remains the foundation of EU nature conservation policy and a cornerstone for climate adaptation, with strong potential to support Europe's overall climate response through nature-based solutions. To fulfil these roles, Natura 2000 sites must not only be managed effectively but also adapt their conservation strategies to fully integrate climate change considerations at an early stage, enabling proactive and well-adapted measures at site, landscape and network level. The adaptation of Natura 2000 to climate change should be based on vulnerability and risk assessments to identify habitats, species and sites most at risk, as well as important climate refugia, to guide action at network, site and surrounding landscape level.

Measures should focus on strengthening on-site resilience by reducing existing pressures, improving abiotic conditions, restoring degraded ecosystems and enhancing connectivity, while facilitating species movement where necessary. Where appropriate, the coherence of the Natura 2000 network should be assessed and reinforced by adding or enlarging sites or adjusting boundaries in response to range shifts. Wider landscape measures may be needed to reduce external pressures, enhance connectivity and restore habitats in line with the Nature Directives and the Nature Restoration Regulation. Emphasis should be given to win-win solutions that support climate change adaptation and mitigation as well as nature conservation objectives.

[13] Regulation (EU) 2024/1991 of the European Parliament and of the Council of 24 June 2024 on nature restoration and amending Regulation (EU) 2022/869, OJ L, 2024/1991, 29.7.2024.

1. PURPOSE OF THIS GUIDANCE

1.1 The interrelated challenges of climate change and biodiversity loss

Climate change is recognised as a significant risk to society, the economy and the environment across the world. Tackling this requires both reducing anthropogenic greenhouse gas emissions and improving the capacity of sinks to remove carbon dioxide, including sequestration (capture) in soils and vegetation, both on land and in seas. In 2015, 196 countries adopted the **Paris Agreement**[14], a legally binding international treaty on climate change at the UN Climate Change Conference (COP21).

The interplay between climate change and biodiversity loss was brought to the attention of global policymakers, notably through reports like the **Intergovernmental Panel on Climate Change (IPCC)** *Special Report on Climate Change and Land*[15]; the **Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES)** reports on *Assessment Report on Land Degradation and Restoration*[16] and the IPBES *Global Assessment Report on Biodiversity and Ecosystem Services*[17]. And in light of this scientific evidence, the **Kunming-Montreal Global Biodiversity Framework**[18] was adopted in 2022, setting clear targets on nature protection and restoration by 2030 and specific targets in relation to climate change mitigation and adaptation[19].

The Paris Agreement's overarching goal is to hold 'the increase in the global average temperature to well below 2°C above pre-industrial levels' and pursue efforts 'to limit the temperature increase to 1.5°C above pre-industrial levels.' The **European Climate Law**[20], adopted in 2021, has since set the legal framework for action to be taken by the EU and Member States to progressively reduce emissions to achieve the global targets and ultimately reach climate neutrality in the EU by 2050. The Climate Law established

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[14] Paris Agreement to the United Nations Framework Convention on Climate Change, https://unfccc.int/sites/default/files/resource/parisagreement_publication.pdf

[15] IPCC (2019): Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems.https://www.ipcc.ch/srccl/

[16] Scholes, R., et al. "The assessment report on Land degradation and restoration." Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. Bonn, Germany (2018). https://www.ipbes.net/policy-support/assessments/assessment-report-land-degradation-restoration.

[17] IPBES (2019), Global assessment report of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, Brondízio, E. S., Settele, J., Díaz, S., Ngo, H. T. (eds). IPBES secretariat, Bonn, Germany, ISBN: 978-3-947851-20-1 https://www.ipbes.net/system/files/2021-06/2020%20IPBES%20GLOBAL%20REPORT(FIRST%20PART)_V3_SINGLE.pdf.

[18] Kunming-Montreal Global biodiversity framework, 18 Dec. 2022, CBD/COP/15/L.25. https://www.cbd.int/article/cop15-final-text-kunming-montreal-gbf-221222

[19] For instance:

- TARGET 8: Minimize the impact of climate change and ocean acidification on biodiversity and increase its resilience through mitigation, adaptation, and disaster risk reduction actions, including through nature-based solution and/or ecosystem-based approaches, while minimizing negative and fostering positive impacts of climate action on biodiversity.
- TARGET 11: Restore, maintain and enhance nature's contributions to people, including ecosystem functions and services, such as regulation of air, water, and climate, soil health, pollination and reduction of disease risk, as well as protection from natural hazards and disasters, through nature-based solutions and ecosystem-based approaches for the benefit of all people and nature.

[20] Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law'), OJ L 243, 9.7.2021, p. 1–17.

the requirement to ensure continuous progress in enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change in accordance with Article 7 of the Paris Agreement.

Biodiversity loss and ecosystem degradation are increasingly recognised as challenges that require practical and cooperative responses across sectors, alongside environmental protection objectives. Climate change is a major and increasing driver of ecosystem damage and biodiversity loss, through gradual change in temperatures and rainfall, as well as increasing extreme events, such as droughts, flooding and wildfires, which in turn may have detrimental effects on both human and animal health. At the same time, well-managed and resilient ecosystems can contribute positively to climate mitigation and adaptation, for example through carbon storage, water regulation and risk reduction. This growing recognition has led to a stronger focus on nature-based and cost-effective solutions that can deliver co-benefits for biodiversity, climate objectives and local communities.

Thus, just as the crises are linked, so are the solutions. Nature-based solutions are an important and cost-effective ally in the fight against climate change. Protecting and restoring ecosystems, especially those that are carbon-rich (e.g. wetlands, peatlands and seagrasses) can substantially mitigate climate change. Healthy and well-managed ecosystems such as forests, grasslands and wetlands can also support climate adaptation by reducing the frequency and impacts of floods, droughts and wildfires while delivering co-benefits for biodiversity, local communities and economic resilience.

In 2021, the European Commission adopted an **EU Strategy on adaptation to climate change** to boost Europe's adaptive capacity, strengthen its resilience and reduce its vulnerability to climate change[21]. The Commission adopted in 2021 a new **EU Forest Strategy for 2030** and an **EU Soil Strategy for 2030**[22], as both forest and soils are crucial ecosystems both for biodiversity conservation and climate mitigation and adaptation.

To support the EU strategy on adaptation to climate change, in 2024 the European Commission produced a **communication on managing climate risks**[23] drawing on the **European Climate Risk Assessment (EUCRA)**[24]. The EUCRA identified 36 major climate risks for Europe within five broad clusters: ecosystems, food, health, infrastructure, and economy and finance. Of these, it identified ecosystems as the cluster facing the highest number of climate risks requiring urgent or more action. This is also relevant to many other policy areas because climate risks can often cascade to other societal systems, such as food production and security.

In parallel, a cost-efficient management of the Natura 2000 network and the restoration of degraded ecosystems contribute to Europe's economic resilience, prosperity and financial stability. In February 2026, the IPBES published a new assessment highlighting how continued degradation of nature poses systemic risks not only to ecosystems, but also to economic activities, business models and long-term corporate

[21] Forging a climate-resilient Europe - the new EU Strategy on Adaptation to Climate Change, COM/2021/82 final.
[22] EU Soil Strategy for 2030 - Reaping the benefits of healthy soils for people, food, nature and climate, COM/2021/699 final.
[23] Managing climate risks - protecting people and prosperity, COM/2024/91 final.
[24] European Climate Risk Assessment, EEA Report No 1/2024, (EEA 2024).

viability, as biodiversity loss, ecosystem collapse and climate pressures are increasingly intertwined with financial risk, supply-chain disruption and loss of competitiveness[25].

The **European Central Bank** experts echoed this in their work that: (i) identified that in the euro area about 72% of non-financial corporations (around three million firms, accounting for nearly 75% of corporate bank lending), are highly dependent on at least one ecosystem service; and (ii) showed that degraded ecosystems undermine productivity, disrupt supply chains and increase vulnerability to shocks, creating risks for the economy and the financial sector[26].

The EU strategy on adaptation to climate change places a **strong emphasis on the large-scale implementation of nature-based solutions to increase climate resilience**, highlighting the fact that they are often cost-effective, multipurpose, 'no-regret' solutions.

Under the EU strategy on adaptation to climate change, using nature-based solutions inland (including action to restore the sponge-like function of soils) will boost the supply of clean, fresh water and reduce the risk of flooding. In coastal and marine areas, nature-based solutions will, among other things, enhance coastal defence. Simultaneously, they will provide benefits such as carbon sequestration, tourism opportunities, biodiversity conservation and restoration.

The EU strategy on adaptation to climate change recognises the need to improve climate resilience decision support systems and technical advice, as well as the need for better policy integration and collaboration between different sectors and level of governance. This is highly relevant also to the management of the **Natura 2000 network of protected areas**. The network of over 27 000 sites, designated to protect threatened habitats and species of Community interest under the **Birds**[27] and **Habitats**[28] **Directives** (Nature Directives), currently covers 18.6% of the EU's land and 10.5% of EU waters[29]. It not only conserves Europe's most threatened habitats and species but also offers a safe haven for a huge diversity of other wildlife and ecosystems. These in turn provide a wealth of valuable ecosystem services supporting climate adaptation and mitigation.

The **Nature Restoration Regulation**[30] is an additional opportunity to build effective synergies in policy action at national, regional and local levels, as it lays down rules at EU level on ecosystem restoration to ensure the recovery of biodiverse and resilient nature across the EU, thus contributing to the EU's climate change mitigation and adaptation objectives.

The political guidelines for the European Commission for 2024–2029[31] stressed that Europe's climate is warming faster than the global average and that there is a need to step up work on climate resilience and preparedness. To address that, the Commission

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[25] Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) "Business and Biodiversity Assessment" (09 February 2026). https://www.ipbes.net/node/97532

[26] ECB Occasional Paper Series No 380 "Nature at risk: Implications for the euro area economy and financial stability" (European Central Bank, 2025). https://www.ecb.europa.eu/pub/pdf/scpops/ecb.op380.en.pdf

[27] Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds, OJ L 20, 26.1.2010, p. 7–25.

[28] Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora, OJ L 206, 22.7.1992, p. 7–50.

[29] https://www.eea.europa.eu/en/analysis/indicators/natura-2000-sites-designated-under

[30] Regulation (EU) 2024/1991 of the European Parliament and of the Council of 24 June 2024 on nature restoration and amending Regulation (EU) 2022/869, OJ L, 2024/1991, 29.7.2024.

[31] https://commission.europa.eu/about-european-commission/president-elect-ursula-von-der-leyen_en

is preparing a new European integrated framework for climate resilience, which is expected to be adopted during the second half of 2026.

Recognising the crucial role of the Natura 2000 network in climate mitigation and adaptation, and the increasing risks that climate change poses to species, habitats and ecosystem functioning, the EU strategy on adaptation to climate change and the EU communication on managing climate risks called for updated guidance for the Natura 2000 network.

1.2 Objectives, scope and structure of this guidance document

The aim of this guidance document is twofold:

- to support a better understanding of **how the Natura 2000 network and its management can be adapted to climate change** to achieve its objectives. This is done by clarifying the provisions of the Nature Directives to design and manage Natura 2000 sites in relation to potential impacts caused by climate change, clarifying the existing flexibilities, identifying strategic planning needs and proposing practical measures to support adaptation for Natura 2000 both at network and site level, as well as in the wider landscape; and
- to contribute, through an effective management of the **Natura 2000 network, to climate change mitigation and adaptation efforts**, by promoting the use of nature-based solutions, including for disaster prevention.

Member States have the flexibility to choose adaptation measures that are the most appropriate to their specific context. **This guidance document does not create new legal obligations; rather, it presents a range of measures that Member States may choose to implement in line with subsidiarity and their national priorities and needs. This guidance is therefore intended to support long-term adaptation planning and learning over time.**

This guidance document is primarily written for **Natura 2000 managers** and **environmental authorities** at national, regional and local level, as an aid to refine their conservation approaches and strategic planning in response to the increasing threats from climate change, on top of the challenges from other pressures and threats. It also aims to **inform stakeholders** (e.g. other authorities, environmental organisations, land and sea users, businesses) of the need for climate change adaptation in the Natura 2000 network, to help forge strategic partnerships, and to identify and implement measures with mutual benefits.

Its focus is on the habitats and species protected under the Birds and Habitats Directives (‘BHD habitats and species’)[32] particularly the ones for which Natura 2000 sites must be designated[33] (‘Natura 2000 habitats and species’). However, the proposed adaptation measures for these habitats and species are expected to have much wider biodiversity benefits, increasing the adaptive capacity of ecosystems and biodiversity in general and in turn their ecosystem functions.

[32] all species of naturally occurring birds in the wild and natural habitats and species of wild fauna and flora of Community interest listed in Annexes I, II, IV and V of the Habitats Directive.
[33] habitat types listed under Annex I of the Habitats Directive, species listed in Annex II of the Habitats Directive, birds listed in Annex I of the Birds Directive and regularly occurring migratory birds.

It builds on and updates the previous EU guidelines on climate change and Natura 2000[34], reflecting scientific knowledge and recent policy developments under the European Green Deal[35] on climate and biodiversity, especially the Nature Restoration Regulation. It also takes into account existing and emerging opportunities for cross-sectoral collaboration. This guidance draws on the most recent scientific studies and especially the growing practical experience and lessons from measures taken to help biodiversity to adapt to climate change – some of which are described in case studies. It summarises evidence of the broader climate change adaptation and mitigation benefits that flow from sound ecosystem management and restoration and other nature-based solutions.

This guidance is structured as follows:

- **Chapter 2** summarises the key obligations of the Nature Directives and the related provisions of the Nature Restoration Regulation of most relevance to climate change, and their implications;
- **Chapter 3** outlines how climate adaptation for the Natura 2000 network can support broader climate goals through nature-based solutions;
- **Chapter 4** proposes a climate adaptation framework to help Natura 2000 managers and competent authorities identify and select climate change adaptation measures;
- **Annex 1** summarises observed and projected climate changes in Europe;
- **Annex 2** summarises the impacts on habitats and species;
- **Annex 3** expands on the climate adaptation framework proposed in chapter 4;
- **Annex 4** provides practical guidance and recommendations on key measures at Natura 2000 network level, site level and at wider landscape and sea level;
- **Annex 5** provides further bibliographical references.

The European Commission has also produced other relevant guidance[36] covering:

- the potentially adverse impacts of projects and plans on Natura 2000 sites[37];
- the impacts related to renewable energy, in particular hydropower plants[38] and wind energy[39].
- energy transmission systems[40].

Therefore, this guidance on Natura 2000 and climate change does not cover these topics.

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[34] Guidelines on climate change and Natura 2000 dealing with the impact of climate change, on the management of the Natura 2000 network of areas of high biodiversity value, Publications Office of the European Union, 2013.
[35] The European Green Deal, COM/2019/640 final.
[36] Managing and protecting Natura 2000 sites https://ec.europa.eu/environment/nature/natura2000/management/guidance_en.htm
[37] Commission notice: 'Assessment of plans and projects in relation to Natura 2000 sites – Methodological guidance on the provisions of Article 6(3) and (4) of the Habitats Directive 92/43/EEC', 2021/C 437/01.
[38] Commission notice: 'Guidance document on the requirements for hydropower in relation to EU nature legislation', 2018/C 213/01.
[39] Commission Notice Guidance document on wind energy developments and EU nature legislation, C (2020) 7730 final.
[40] Commission notice: 'Energy transmission infrastructure and EU nature legislation', 2018/C 213/02.

2. IMPLEMENTING THE EU'S NATURE LEGISLATION IN THE FACE OF CLIMATE CHANGE

2.1 The EU's nature legislation

The Birds and Habitats Directives (Nature Directives) are the cornerstones of the EU's biodiversity policy. Together with the Nature Restoration Regulation, they are the EU's main tools for tackling the continuous decline of Europe's biodiversity and achieving the agreed European and global targets for 2030 and beyond. The Birds Directive protects all 463 wild bird species naturally occurring in the EU. The Habitats Directive protects another 1 400 rare, endangered or vulnerable species ('HD species') and their habitats and 233 habitat types of Community interest ('HD habitats').

The overall objective of the two Nature Directives is to ensure that these species and habitats are restored to, or maintained at, a *favourable conservation status* across their natural range, both inside and outside protected sites. Member States need to consider not only how to halt their decline or disappearance, but also take measures to ensure they recover sufficiently to reach a favourable conservation status.

In the marine environment, the Marine Strategy Framework Directive[41] also addresses the protection of biodiversity with the aim of achieving good environmental status. For inland, transitional and coastal surface waters and for groundwaters, the Water Framework Directive tackles water protection and, where necessary, restoration with the aim of reaching good status[42].

The Nature Restoration Regulation contains quantitative and timebound legal requirements for the restoration of all major ecosystems to ensure the recovery of biodiverse and resilient nature across the EU, including for the habitat types and species targeted by the EU's nature directives. One of its objectives is to contribute to achieving the EU's climate change mitigation and adaptation objective. To ensure that restoration measures are planned strategically, each Member State must prepare a national restoration plan, clearly identifying all possible synergies with other related EU policies and legislation, such as climate change and renewable energy policies. Until 2030, for EU-wide protected terrestrial and freshwater ecosystems, Member States may give priority to restoration measures in areas that are located in Natura 2000 sites.

2.2 State of nature in the EU

Thanks to the Nature Directives, much has been achieved over the years to tackle the decline of Europe's biodiversity, not least through the creation of an EU-wide Natura 2000 network[43]. However, despite best efforts and notable success stories, many protected habitat types and species have not yet reached a favourable conservation status.

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[41] Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive), OJ L 164, 25.6.2008, p. 19–40.
[42] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, OJ L 327, 22.12.2000, p. 1–73.
[43] Sites can be visualised on the online Natura 2000 map viewer: http://natura2000.eea.europa.eu

The EEA's latest 'State of Nature in the EU' report for 2013-2018[44] (published in 2020) concluded that the population status for almost half of the wild bird species in the EU is good, but the conservation status for the majority (63%) of the species protected under the Habitats Directive is still poor or bad. The conservation status is favourable for only 15% of the 230 protected habitat types[45].

The 'State of Nature' report for 2013-2018 notes that it takes time before species and habitats show signs of recovery, even after all the necessary conservation measures have been put in place. And yet it concludes that existing pressures and expected future threats that these habitats and species face are still too significant to allow them to recover and move towards a favourable conservation status.

Climate change is likely to have an increasingly important impact on the conservation status of many of Europe's most vulnerable and valuable habitats and species, which are already in a poor conservation status and are under significant pressure. For many habitats and species, even relatively small additional climate-related impacts (as summarised in annex 2) can lead to further declines and eventually push the species or habitats beyond a threshold where their survival or recovery is no longer possible. It is therefore important that conservation strategies and actions for these species and habitats take account of the increasing impacts from climate change, in a proportionate manner and in line with national circumstances.

2.3 Designating and managing Natura 2000 sites in the context of climate change

Box 2-1 Selected examples of flexible management of Natura 2000 sites in the context of climate change, including emergency situations (e.g. natural disasters) and unavoidable deterioration due to climate change

Member States can **act flexibly in emergency situations like wildfires or floods**, despite the Habitats Directive lacking explicit emergency provisions. Quick responses are vital to save lives and property and protect biodiversity in these areas. During such emergencies, **Member States can bypass certain administrative procedures** to address immediate threats to the site and public safety. Actions should, where possible, **minimise environmental impact**, choosing alternatives that least harm habitats and species protected by Natura 2000. To ensure clarity and **legal certainty**, it is beneficial to outline conditions for emergency actions within a legal framework, including evaluating the impact of these actions and implementing restoration measures when necessary. For further details, see section 2.3.5.

Member States also enjoy **flexibility regarding the obligation to prevent habitat deterioration and significant disturbance of species** protected in Natura 2000 sites when faced with **unavoidable climate-driven changes** backed by robust scientific evidence. This includes **unpredictable natural disasters** and **climate change-induced events**, like habitat transformations. In these cases, the **non-deterioration obligation doesn't apply**, allowing adaptation of site-specific conservation objectives and measures. For instance, natural transitions, such as alpine heath being gradually replaced by forest or spruce forest shifting to

[44] EEA (2020), State of Nature in the EU: Results from reporting under the nature directives 2013-2018, EEA Report No 10/2020, European Environment Agency, Copenhagen. https://www.eea.europa.eu/en/analysis/publications/state-of-nature-in-the-eu-2020

[45] The conservation status and trends of protected habitats and species can be consulted on https://nature-art17.eionet.europa.eu/article17/. For birds they can be consulted on https://nature-art12.eionet.europa.eu/article12/. A new State of Nature in the EU report will be published by the Commission in 2026, covering the period 2019-2024.

beech or mixed deciduous forests at higher altitudes, should not be seen as deterioration. For further details, see section 2.3.4.

This flexibility streamlines implementation, **reducing administrative burdens and costs** for management authorities while enhancing prioritisation of conservation measures and improving legal certainty.

To understand how Natura 2000 sites can best adapt to climate change, it is first important to recall the legal framework governing site selection, classification or designation, protection and management, as well as flexibilities which can be used in the climate change context. This is briefly summarised below. Further details can be found in a series of published Commission notes and guidance (Box 2-2).

Box 2-2 European Commission guidance on managing Natura 2000 sites

- Commission notice on provisions of Article 6 of the Habitats Directive 92/43/EEC[46]

- Commission notice on assessment of plans and projects in relation to Natura 2000 sites[47][37]

- Commission note on setting conservation objectives for Natura 2000[48]

- Commission note on establishing conservation measures for Natura 2000[49]

- Commission note on de-designation of sites or parts of sites[50]

- Commission note on removal of habitats and species from the subject of protection in Natura 2000[51]

Article 4 of the Habitats Directive governs the procedure for adopting sites of Community importance (SCIs) which must then be designated as special areas of conservation (SACs) by Member States. Article 4 of the Birds Directive provides for the classification of special protection areas (SPAs). Under the Habitats Directive, sites are designated in order to protect core areas for HD habitats (i.e. habitat types listed in Annex I) and HD species (i.e. animals and plants listed in Annex II). Under the Birds Directive, sites are classified to protect bird species listed in Annex I and regularly occurring migratory birds, with a special focus on the protection of wetlands of international importance. The site selection process is carried out on purely scientific grounds to ensure that the best sites are selected for the Natura 2000 network.

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[46] Commission Notice Managing Natura 2000 sites — The provisions of Article 6 of the Habitats Directive 92/43/EEC, OJ C 33, 25.1.2019, p. 1–62.
[47] Commission Notice Assessment of plans and projects in relation to Natura 2000 sites – Methodological guidance on the provisions of Article 6(3) and (4) of the Habitats Directive 92/43/EEC 2021/C 437/01, OJ C, C/437, 28.10.2021, p. 1-107.
[48] https://circabc.europa.eu/ui/group/3f466d71-92a7-49eb-9c63-6cb0fadf29dc/library/4f06f774-df20-4269-9e49-1a79a95fa040/details.
[49] https://circabc.europa.eu/ui/group/3f466d71-92a7-49eb-9c63-6cb0fadf29dc/library/da138066-6136-4dec-9f98-07ed00e64231/details.
[50] https://circabc.europa.eu/ui/group/fcb355ee-7434-4448-a53d-5dc5d1dac678/library/8555aa28-9fb6-411f-8228-f8c99b296564/details.
[51] https://circabc.europa.eu/ui/group/fcb355ee-7434-4448-a53d-5dc5d1dac678/library/fc6b5435-6d07-41b6-bf28-c43edcbf72fd/details.

Once a Natura 2000 site has been designated, its protection and management is governed by Article 6 of the Habitats Directive and Article 4 of the Birds Directive.

Article 6 has three main categories of measures for site protection:

- Article 6(1): provides for establishing the necessary **conservation measures**, involving if needed management plans and statutory, administrative or contractual measures, which correspond to the ecological requirements of the HD habitat types and the HD species that are present on the site.
- Article 6(2): focuses on **preventive measures**, requiring Member States to take appropriate steps to **avoid the deterioration** of natural habitats and the habitats of species as well as a significant disturbance of the species for which the areas have been designated.
- Article 6(3) and (4) set out a series of **procedural and substantive safeguards (including compensatory measures**) when approving **plans and projects** likely to have a significant effect on a Natura 2000 site in view of the site's conservation objectives.

While Article 6(1) applies only to SACs designated under the Habitats Directive[52], an equivalent regime laying down 'special conservation measures' applies for the SPAs classified under the Birds Directive (Article 4(1) and 4(2))[53]. Moreover, Article 7 of the Habitats Directive makes the provisions of Article 6(2), (3) and (4) applicable to SPAs.

2.3.1 Setting site-specific conservation objectives (SSCOs) in the context of climate change

2.3.1.1 How to establish site-specific conservation objectives (SSCOs)?

Under the Nature Directives, a conservation regime is required for every Natura 2000 site, and for all HD habitat types and HD Annex II species and all BD Annex I bird species as well as regularly occurring migratory birds (i.e. Natura 2000 habitats and species) that are significantly present in the site (as listed in the Standard Data Form[54]). Site-level conservation objectives should therefore be set for both SCIs/SACs and SPAs.

According to the Commission's guidance[55], the site-specific conservation objectives (SSCO) must be clear and correspond to the ecological requirements of the Natura 2000 species and habitats in that particular site. This needs to be defined on a case-by-case basis as the ecological requirements of a particular species or habitat can vary from one site to another depending on local circumstances.

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[52] Member States have at most 6 years from the time a site is selected as a SCI to designate it as a special area of conservation (SAC) and establish the necessary conservation measures under Article 6(1).

[53] see Case C-66/23 (Elliniki Ornithologiki Etaireia and Others), paragraphs 40 and 59.

[54] SDFs are available for every Natura 2000 site on http://natura2000.eea.europa.eu

[55] See Commission note on setting conservation objectives for Natura 2000. https://circabc.europa.eu/ui/group/3f466d71-92a7-49eb-9c63-6cb0fadf29dc/library/4f06f774-df20-4269-9e49-1a79a95fa040/details

The SSCOs should specify the level of conservation condition to achieve for these species and habitats on the site in a clear and precise way by using specific attributes[56] and targets. In general, the conservation objectives should clearly specify whether the aim is to maintain or improve their condition[57]. In this way, each site in the network can contribute in the best way possible to the overall goal of achieving favourable conservation status for the listed habitat types and species at national, biogeographical and European level.

When establishing conservation objectives, Member States can set priorities in view of the sites' importance in maintaining or restoring species or habitats at a favourable conservation status at national biogeographical level and for the coherence of the Natura 2000 network. For instance, they could prioritise the conservation of a particular species in a site if that site hosts a major share of that species' national/EU/ regional population, over a species for which the site hosts only a few individuals at the edge of its range.

2.3.1.2 If certain habitats or species cannot reach good condition in the future or their condition is deteriorated due to unavoidable impacts of climate change, how can this be reflected in the SSCOs?

In some cases, negative impacts from climate change on species and habitats in a given site may be unavoidable, despite all necessary conservation measures being in place (see Box 2-3). Such situations should ideally be dealt with by reviewing the conservation objectives, both at the level of the site and at the level of the network. For example, if saltmarshes in a given site are unavoidably contracting due to sea level rise without reasonable conservation measures available to enable their inland expansion (e.g. due to existing infrastructure), their expected reduced area coverage can be addressed by reviewing the site-specific area target for that habitat. However, whenever possible, efforts should be made to offset this loss by expanding or creating saltmarshes elsewhere ensure that a coherent ecological network of saltmarshes is maintained (see case study 5). In another example, if a change of climatic conditions would make a site inhospitable for certain migratory birds, the conservation objectives and measures for these species should be deprioritised in this site. This would allow resources to be reallocated towards other species for which the site remains or has become important or other sites that may have become more important for these migratory birds.

Considering the inherent uncertainties of future climate scenarios, SSCOs should be lowered when there is robust scientific evidence showing that protected features are already affected or that they will unavoidably be further deteriorating or disappearing from the site due to climate change (see also Box 2-4). Examples could concern alpine heath being replaced by forests that move into higher altitudes. Likewise, it would be inappropriate to already lower SSCOs for a migratory bird on the presumption that the site may become inhospitable for them in the future. It should be evident that the site no longer responds to the species ecological requirements even if conservation measures, including measures to support climate adaptation have been taken in the management of the site.

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[56] Attributes are specific characteristics that define the conservation condition of the habitat or the species based on their ecological requirements.

[57] See conservation objectives in Commission Implementing Decision (EU) 2023/2806 of 15 December 2023 concerning a site information format for Natura 2000 sites, OJ L, 2023/2806, 18.12.2023.

Conversely, new species may become increasingly present and eventually establish themselves (or at least, use the site as part of their migratory routes) once suitable climatic and habitat conditions become available. This may justify including new species within the site's protection regime and defining appropriate SSCOs and site-specific conservation measures (SSCMs) in order to take account of the changes to the species' distribution caused by climate change.

2.3.2 Setting site-specific conservation measures (SSCMs) in the context of climate change

2.3.2.1 How should the site-specific conservation measures (SSCMs) be set?

Conservation measures (see Box 2-3) are the actual mechanisms and actions that need to be implemented in a Natura 2000 site in order to achieve its site-specific conservation objectives. Such measures may need to be implemented within and/or outside site boundaries or even across multiple sites (e.g. to tackle diffuse pollution).

Conservation objectives should be reasonably stable over time, but the site-specific conservation measures (SSCMs) may need to be adjusted at regular intervals to reflect any changes in threats and pressures, including those brought about by climate change, and any changes in the conservation status of the species and habitats on the site. Site conditions may be affected by changes to existing threats or the arrival of new pressures. Such changes are not always easy to predict and anticipate. Climate change may also impact on Natura 2000 species or habitats in many other ways (e.g. changes in phenology, predator-prey interactions, habitat structure and function).

Box 2-3 Requirements for site-specific conservation measures

Site-specific conservation measures should, as per the note on conservation measures for Natura 2000:

- be related to the site's conservation objectives for each of the species and habitats present;
- reflect the threats and pressures to which the habitats and species on the site are exposed;
- be based on solid scientific data about the site, species and habitats present, as well as their condition of conservation, conservation needs, the impacts of existing threats and land uses and stakeholder interests;
- be sufficiently specific, detailed and time-bound (who does what, where and when) to facilitate their implementation;
- be quantified in terms of the resources needed for their implementation;
- include a regular monitoring and review mechanism.

Regular monitoring of the conservation measures and their impacts on targeted habitats and species is therefore essential as it will indicate if the conservation measures are having the desired effect, or whether they need to be adjusted to ensure that they achieve the conservation objectives set for that site. This regular review should form an integral part of any protected area's management strategy and is especially relevant when addressing emerging pressures, such as climate change.

2.3.2.2 How can SSCMs be set to support adaptation of the Natura 2000 network to climate change?

To set appropriate SSCMs that support adaptation to climate change, a climate change risk and vulnerability assessment for the Natura 2000 network and its sites and protected habitats and species that are at risk from climate change should take place. A climate change adaptation framework with specific steps to support this process is proposed in chapter 4 and elaborated in annex 3. Further details on recommended measures that can be taken at network, site and wider landscape level are presented in annex 4. SSCMs can be adapted flexibly as climate change impacts evolve in order to achieve the conservation objectives set for the site and its protected habitats and species. Member States may choose the most proportionate and cost-effective measures, while fostering synergies with other climate change adaptation actions, such as flood management and wildfire risk reduction.

2.3.2.3 When can SSCMs for protected habitats and species negatively affected by climate change be altered or terminated?

SSCMs for protected habitats and species can be altered or terminated in response to the adjustment or termination of the SSCOs in cases of unavoidable deterioration due to climate change, provided that there is scientific evidence that these measures can no longer contribute to the conservation or restoration of the protected habitats and species (see section 2.3.1 and box 2-3).

2.3.3 Management plans for Natura 2000 sites

Although not strictly legally required, Natura 2000 management plans are often used at national level as a tool for setting SSCOs and SSCMs in an open and transparent manner. They are useful for a number of reasons. They can raise awareness of the threats and conservation needs of the site and so help build consensus on long-term management solutions among stakeholders and interest groups. This can in turn create a sense of shared ownership and responsibility for the final outcome. They can also be an important tool for estimating the site’s funding needs and identifying potential funding sources. Equally, management plans can help to better integrate Natura 2000 requirements into other land-use policies and plans.

Management plans also provide a structured mechanism for monitoring and adapting SSCMs in light of changing pressures and threats, or the changing state of conservation of the species and habitats present in the site. This also makes them especially useful tools for adjusting to climate change and for integrating any new climate adaptation measures as required (see annex 4).

2.3.4 Non-deterioration in the context of climate change

2.3.4.1 How can the non-deterioration provision of the Habitats Directive be understood in the context of climate change?

In the context of climate change, Member States' responsibilities under the Nature Directives relate to the application of appropriate and proportionate measures, rather than to the prevention of unavoidable climate-driven ecological transformation.

Article 6(2) of the Habitats Directive requires Member States to take appropriate steps to avoid deterioration of natural habitat types and habitats of species and significant disturbance of species for which the site has been designated[58]. This requirement covers both **human-caused deterioration** and **predictable natural deterioration** that **can be avoided or, where not possible, mitigated** (i.e. decrease the risk of occurrence and magnitude of natural events). Member States are therefore free to determine the most appropriate and proportionate measures in a specific context, as long as the measures are effective in preventing deterioration. This issue is clarified in the Commission notice on the provisions of Article 6 of the Habitats Directive[59].

2.3.4.2 Can deterioration caused by climate change amount to a breach of the Birds and Habitats Directives?

As the above question explains, Member States are required to take measures to **address the predictable and avoidable impacts of climate change** on the conservation of species and habitats in Natura 2000 sites. The measures must be sufficient to avoid, or where avoidance is not possible, mitigate the climate change-related impacts. **But they will not be held accountable for any deterioration caused by unpredictable (e.g. natural disasters) and/or unavoidable events** (see Box 2-4).

In such cases, where deterioration or transformation is unavoidable and occurs despite reasonable conservation and adaptation efforts, this should not be interpreted as a failure to comply with the Nature Directives. This nevertheless requires that climate change risks and potential impacts on the Natura 2000 network are assessed and duly taken into account in the management of the network and its sites.

Box 2-4 Potential cases of unavoidable deterioration due to climate change

As described in annex 2, although there is much that can be done to increase the adaptive capacity of habitats and species, it is inevitable that for some Natura 2000 sites, habitats and species, practical measures to avoid the impacts of climate change may be limited, especially over the long-term. For example, species that are critically dependent on snow cover, particular hydrological conditions, or particular sea temperatures, would be expected to deteriorate or disappear from areas where the conditions they need no longer occur.

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[58] See Case C-66/23, Elliniki Ornithologiki Etaireia, paragraphs 36-43. There the Court confirmed that conservation objectives must be set for all species occurring in the site, and that the level of protection provided for in Article 6(2) of the Habitats Directive must be determined by reference to those conservation objectives.

[59] Commission Notice Managing Natura 2000 sites — The provisions of Article 6 of the Habitats Directive 92/43/EEC, OJ C 33, 25.1.2019, p. 1–62.

Scientists have a high level of confidence that the climate will continue to change in the coming decades, and uncertainty is not a valid excuse for inaction. As the future losses of such habitats and species cannot be reliably predicted (e.g. due to uncertainties over future greenhouse gas (GHG) emissions, climatic conditions and species adaptation), appropriate efforts and adaptation measures should be made to increase the resilience of habitats and species protected in Natura 2000 sites.

Measures to increase resilience of habitats and species should continue for as long as there is a reasonable prospect of maintaining them, according to robust monitoring data and scientific evidence. In case of uncertainty, the precautionary principle should prevail and conservation and restoration measures should continue with the aim of maintaining a viable habitat area or species population within a site. If it becomes clear, based on scientific evidence that, as a result of climate change, species and habitats in a certain site cannot be maintained, their conservation objectives and measures in the site may be deprioritised to allow resources to be reallocated elsewhere. To ensure a coherent ecological network, efforts may then need to be directed towards new sites that in the meantime may have become suitable or important for these habitats or species. Whenever possible, Member States should take a strategic approach to this issue at Natura 2000 network level.

2.3.4.3 What if deterioration cannot be avoided?

As explained in sections 2.3.1 and 2.3.2, in cases of unavoidable deterioration due to climate change according to robust scientific evidence, SSCOs and SSCMs can be adapted or even removed.

2.3.4.4 How can we address climate change impacts and the provision of non-deterioration on Annex I HD forest habitat types in Natura 2000 sites?

Box 2-5 Managing Annex I HD forest habitat types in the context of unavoidable climate change impacts

In several European regions, warming temperatures, altered precipitation regimes, and increased disturbance frequencies (e.g. stronger or more frequent droughts, storms, bark beetle outbreaks) undermine forest resilience and change environmental conditions leading to **shifts in the natural distribution of tree species**.

For example, European spruce (*Picea abies*) forests - an Annex I HD habitat in high elevation areas and boreal regions - may decline and be gradually replaced by beech (*Fagus sylvatica*) or mixed deciduous forests. Beech forests themselves may transition toward xeric oak forests (e.g. *Quercus pubescens*, *Q. cerris*) particularly in south-eastern and central Europe. These transitions may be accompanied by changes in canopy density, microclimate, hydrology and soil conditions.

As a general principle, the replacement of one Annex I forest habitat type by another, when resulting from natural processes driven by climate change, should be accepted provided that the transition is demonstrably climate-induced and not the result of avoidable human pressure. In these situations, management interventions (e.g. sustainable forest management[60] or assisted migration) should support ecosystem resilience rather than attempting to maintain the original habitat type.

Climate-driven disturbances may often give rise to temporary successional or transitional phases dominated by native pioneer species. These phases should not be interpreted as habitat deterioration when they result from unavoidable climatic impacts and contribute to soil protection, microclimatic buffering and the re-establishment of forest structures compatible with the site's conservation objectives.

This approach is justified for various reasons:

- Attempting to preserve climate-sensitive habitat types in areas that can no longer support them may lead to a degradation of ecosystem functions, increased disturbance risks (e.g. pest outbreaks, storm damage, fire), and long-term impacts on biodiversity.

- Natural dynamics make part of forest conservation: forest habitat types will usually adapt naturally to changing climatic conditions. Where such changes happen very fast, active management (e.g. by assisted migrations or the use of genetic tree material of non-local provenance) might be a way forward to ensure continued resilience and productivity of forests while preserving their value for biodiversity. The voluntary Commission guidelines on biodiversity-friendly afforestation, reforestation and tree planting discuss climate adaptation in further detail[61].

- Long-term conservation value: allowing natural transitions preserves the ecological integrity of the site and supports the emergence of habitat types better adapted to future conditions.

- Legal robustness: the non-deterioration principle does not require Member States to counteract unavoidable global drivers. What must be prevented is avoidable deterioration caused by local anthropogenic pressures or deliberate inaction. Natural and climate change-induced transitions fall outside this scope when properly documented.

<u>Decision-making approaches in forest management</u>

Acknowledge and manage uncertainty

Models predicting future climatic conditions remain uncertain, particularly regarding temperature extremes, precipitation variability, disturbance regimes and ecological outcomes. Therefore:

- management should avoid over-reliance on projections with a single trajectory;

- decision-making should embrace active and adaptive management, allowing adjustments as new information becomes available;

[60] See definition of sustainable forest management: *'Sustainable forest management means the stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfil, now and in the future, relevant ecological, economic and social functions, at local, national, and global levels, and that does not cause damage to other ecosystems.'* https://foresteurope.org/sustainable-forest-management/

[61] Guidelines on biodiversity-friendly afforestation, reforestation and tree planting, Publications Office of the European Union, 2023. https://data.europa.eu/doi/10.2779/731.

- management should avoid relying on single tree species; there is no "miracle tree species" capable of ensuring resilience under all conditions.

While a range of national and international studies and guidelines on the topic exist, the voluntary Commission guidelines on closer to nature forest management[62] (dedicated to forests with a commercial use for timber and non-timber forest products) discuss several principles and measures that can be translated into benefits for forest resilience in a changing climate also in protected forests. In adiditon, the concept of sustainable forest management defined by Forest Europe continuously moderates the various claims on forests and forest resources balancing the three pillars of sustainability—ecological, social, and economic. If managed sustainably, forests play an indispensable role in climate and biodiversity protection. They protect soils and water resources, provide livelihoods, and contribute to the wellbeing of rural and urban communities[63].

Promote diversity and complexity

When planting or supporting the recovery of habitats within Natura 2000 sites, managers should:

- **aim to restore native species and develop native natural forest habitat types**, where feasible while facilitating climate change adaptation, in line with the broader objective of EU nature legislation;
- **promote mixed-species stands**, where feasible, which are generally more resilient and productive under variable climates;
- **promote structural diversity**, both vertical and horizontal, including uneven-aged and mixed-canopy approaches.

Species choice and forest structure should also consider soil type and hydrological effects, such as water infiltration, soil moisture retention and evapotranspiration regulation, which are increasingly important under changing climatic conditions.

Avoid tree cover loss

Large canopy openings (for example made by clear-cutting Annex I habitat types), should not be made in areas that would conflict with site-specific conservation objectives or habitat integrity. This is because they could:

- lead to soil degradation, including carbon loss, nutrient leaching and hydro-physical damage;
- reduce microclimatic buffering provided by canopy cover, increasing heat and drought stress;
- increase vulnerability to erosion, invasive species, fire risk and regeneration failures;
- prevent the accumulation of structures, such as standing and lying deadwood, that benefit biodiversity and soil regeneration.

Small-scale canopy openings can be made where necessary for example to facilitate natural regeneration or increasing species diversity.

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[62] Guidelines on closer-to-nature forest management - Publications Office of the European Union, 2023. https://op.europa.eu/en/publication-detail/-/publication/2d1a6e8f-8cda-11ee-8aa6-01aa75ed71a1.
[63] https://foresteurope.org/sustainable-forest-management/

Strengthen natural regeneration

Natural regeneration:

- favours locally adapted genotypes already proven to cope with site conditions;
- supports more complex and resilient forest structures;
- reduces planting and maintenance costs and limits soil disturbance from heavy machinery.

Pioneer species such as birch (*Betula spp.*), rowan (*Sorbus aucuparia*), or aspen (*Populus tremula*) should be welcomed as resilience indicators, facilitating microclimatic protection and soil development, even if they are not the final target species.

Recommendations specific to Natura 2000 implementation

- Ensure that any intervention aligns with the site's **conservation objectives**, which may need periodic updates to reflect ecological and climatic realities.

- **Document, justify and, where possible, monitor** the natural drivers of any transitions between habitat types occur, associated disturbances and their unavoidability.

- Favor **native habitat trajectories and diversified forest structures**; avoid introducing non-native species except in well justified exceptional cases and without compromising conservation values.

- Apply the **precautionary principle** by maintaining genetic diversity.

- Soil protection measures should address not only physical disturbance but also the **preservation of soil biological functions**, including organic matter, microbial activity and carbon stocks, which underpin nutrient cycling, water retention and regeneration capacity essential for the long-term stability of Annex I forest habitats.

- Adopt active and **adaptive management**, including regular monitoring of forest condition and disturbances (e.g. tree mortality, pest outbreaks, fire impacts), evaluation of outcomes and the ability to adjust strategies accordingly.

- Establish **systematic monitoring** of forest dynamics. This is a core element of adaptive management and supports legal robustness by demonstrating that observed habitat changes are linked to unavoidable climate-driven processes rather than preventable anthropogenic pressures, in line with the non-deterioration principle.

- Provide **information, education and training for forest owners and managers** to facilitate the uptake of climate-adapted, conservation-compatible forestry practices.

Conclusion

The growing pressure from climate change on forests may require **dynamic conservation approaches** in Natura 2000 sites. Accepting natural transitions, strengthening microclimatic buffering, protecting soils and hydrological functions, diversifying species and structures, and managing uncertainty through adaptive management will help ensure that, despite changing conditions, the network of Natura 2000 sites will continue to enable the natural habitat types and the species' habitats concerned to be maintained or, where appropriate, restored at a favourable conservation status in their natural range.

Effective implementation of the non-deterioration principle must consider what is within the control of Member States while supporting ecological processes that sustain long-term forest health.

2.3.5 Precautionary measures to decrease the risk of natural disasters related to climate change such as catastrophic wildfires and floods

2.3.5.1 Are wildfire protection infrastructures and plans in or near Natura 2000 sites subject to an appropriate assessment under Article 6 of the Habitats Directive?

Traditional wildfire protection infrastructures, such as linear firebreaks, forest road networks, and the mechanical removal of vegetation or topsoil, are indispensable in some situations, but can have significant impacts on Natura 2000 sites by fragmenting habitats and disrupting wildlife movement[64]. Long-term fire suppression can also lead to dense underbrush, increasing the risk of wildfires.

The Court of Justice of the European Union (CJEU) has determined that the creation and maintenance of wildfire protection infrastructure is considered a ‘project’ within the meaning of the first sentence of Article 6(3) of the Habitats Directive, meaning it can be subject to an appropriate assessment. However, these measures do not have to be subject to such an assessment if they are part of the site’s established conservation measures under Article 6(1) (Case C-434/22, paragraph 50)[65]. Member States can make a proactive use of this flexibility where the conservation of the protected features in the site may benefit from wildfire prevention, for example by integrating relevant preventive elements such as firebreaks as part of conservation measures for habitats or species at risk from wildfires. Fire protection measures which do not fulfil that condition and are likely to undermine the site’s conservation objectives must be subject to an appropriate assessment of the implications for the site (Case C-434/22, paragraph 51)[66].

Furthermore, Commission guidance[67] has clarified that sectoral plans, including forest management and wildfire protection plans, fall under the scope of Article 6(3) if they are likely to significantly affect a Natura 2000 site. Such plans must also be subjected to an appropriate assessment to evaluate their implications for the site.

2.3.5.2 In the face of climate-related natural disasters, such as wildfires or floods, emergency operations in Natura 2000 sites must sometimes be carried out without

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[64] Fernández, P., Rodríguez, A., Gutiérrez, D. et al. (2019), Firebreaks as a barrier to movement: the case of a butterfly in a Mediterranean landscape, Journal of Insect Conservation, 23, pp. 843–856

[65] Judgement of the Court of Justice in Case C-434/22 (Latvijas valsts meži).

[66] Judgement of the Court of Justice in Case C-434/22 (Latvijas valsts meži).

[67] Commission Notice [Managing Natura 2000 sites — The provisions of Article 6 of the Habitats Directive 92/43/EEC,] OJ C 33, 25.1.2019, p. 1–62..

the possibility for a prior appropriate assessment. Are such urgent interventions in line with the requirements of Article 6(3) of the Habitats Directive?

The Habitats Directive does not contain any explicit provisions covering emergency measures. However, it is common sense that emergencies such as harmful wildfires or floods might require immediate, on-the-spot decisions to address urgent risks which would jeopardise the achievement of the objectives of the Habitats Directive, or pose an imminent threat to public safety. In such urgent situations, conducting an appropriate assessment may not be feasible.

The CJEU has identified two relevant circumstances in which it may not be necessary to conduct an appropriate assessment:

- When assessing the need to conduct an appropriate assessment for activities to maintain forest fires safety infrastructure, **an appropriate assessment will not be required if that activity is already included in the conservation measures for the site** (Case C-434/22, paragraph 68)[68]. Therefore, measures (including emergency measures), do not need to be assessed under Article 6(3) of the Habitats Directive if they are provided for in the conservation measures of a site.
- **Emergency measures** for the protection of a site can take place in or near Natura 2000 sites **without a prior appropriate assessment if a current or imminent risk detrimental to the preservation of that site requires their immediate implementation** (Case C-434/22, paragraph 69 and 71)[69][66]. This allows for rapid responses, such as creating firebreaks, to avert potential disasters.

The exception for emergency measures, however, should be only applied to responses to current or imminent risks. The duration and scope of any measures that need to be taken should be limited to the minimum response necessary to neutralise the risk. To the extent possible, the chosen actions should minimise environmental impact, favouring the least damaging alternatives for the habitats and species protected by the Natura 2000 site.

It is highly advisable that the conditions for carrying out emergency actions in Natura 2000 sites be explicitly detailed beforehand in a legal text to ensure clarity and objectivity and prevent misuse. This legal framework should include aspects such as the scope of what is considered an ‘emergency’, the governance for decision-taking, temporal limitations, the conditions for terminating the state of emergency, and obligations related to posterior assessments (see case study 1).

Following the resolution of an emergency, a comprehensive *ex post* evaluation of the impact of the emergency works on the site is crucial. Ideally, this evaluation should take place within a legally established period. This assessment helps quantify any damage and informs restoration measures in case they are needed. Obligations under Article 6(2) of the Habitats Directive become particularly relevant after this *ex post* evaluation.

While the ruling in the case C-434/22 is limited in scope to emergency actions to prevent damage from forest fires to the sites, a similar approach can be taken for preventing threats to human health and public safety, provided all the necessary

[68] Judgement of the Court of Justice in Case C-434/22 (Latvijas valsts meži).
[69] Judgement of the Court of Justice in Case C-434/22 (Latvijas valsts meži).

measures are taken thereafter to remedy any significant damage to the site from these emergency measures.

In essence, while **emergency measures** can be taken in and near Natura 2000 sites to avert further damage, these must be **justified and limited in time and must be followed by thorough evaluations**.

Case study 1: Slovenia's legislative amendments to define conditions for human safety-related emergency exemptions in Natura 2000 sites

Background

The European Commission, through an infringement procedure, found Slovenia to be non-compliant with the Habitats Directive due to broad exemptions in its national legislation. Those exemptions allowed emergency measures without proper environmental evaluations, including for emergency actions in Natura 2000 sites, which could bypass the necessary appropriate assessment. The Slovenian government responded by amending its legislation to address these concerns.

Legislative amendments

Slovenia amended Article 10 of its Nature Conservation Act to explicitly define strict conditions under which exemptions to the general regime of nature conservation may apply. These changes include:

- Scope of exemptions: the Act now clearly states that its provisions do not apply during emergency interventions due to natural or other disasters (as defined by disaster protection regulations) or water-related threats (according to water regulations).
- Time-limited exemptions: the legislation specifies that exemptions for natural disasters and water-related threats are only applicable from the onset of a disaster until the competent authority declares the intervention concluded, in accordance with relevant protocols.
- Post-event impact assessment: the national nature authority is mandated to assess the impact of emergency measures on biodiversity and natural values within 60 days post-intervention.
- Consideration of conservation needs: the act emphasizes that the conservation of nature should be taken into account as much as possible even during emergencies.

Outcome and compliance

These amendments addressed the European Commission's concerns by providing a clear legal framework for when and how emergency actions can be conducted without prior appropriate assessment in Natura 2000 sites.

2.3.6 Ensuring a coherent ecological network and favourable conservation status (FCS)

2.3.6.1 How can a coherent ecological network be achieved in the context of climate change?

In addition to site-level actions taken in response to impacts on protected features, it may be necessary to consider adjusting the network as a whole (and in each biogeographical region) for such features to ensure the network continues to achieve its objectives despite the new and growing threats from climate change.

Article 3(1) of the Habitats Directive states that Natura 2000 (including SACs and SPAs) is a '*coherent European ecological network of special areas of conservation'* that must enable *'the natural habitat types and the species' habitats concerned to be maintained or, where appropriate, restored at a favourable conservation status in their natural range'*. This means the Natura 2000 network focuses on two goals: (i) **targeted site protection** for Natura 2000 species and habitats in terms of quantity and quality; and (ii) ensuring **sufficient geographical distribution** in relation to their range. The meaning of the term 'coherent' is not defined in the Directive, but a European Commission study recommended that it should entail the network's adequacy, representativity, resilience and connectivity (see Box 2-6).

Article 3(3) also stipulates that '*where they consider it necessary, Member States shall endeavour to improve the ecological coherence of Natura 2000 by maintaining, and where appropriate developing, features of the landscape which are of major importance for wild fauna and flora, as referred to in Article 10*.' According to Article 10, such features *are 'those which, by virtue of their linear and continuous structure (such as rivers with their banks...) or their function as stepping stones (such as ponds or small woods), are essential for the migration, dispersal and genetic exchange of wild species.'*

It is therefore important to ensure that for any habitat type or species protected by the Nature Directives that go locally extinct in one or more sites for unavoidable reasons such as climate change, adequate measures are taken elsewhere in the network as needed to maintain the Natura 2000 network's coherence to achieve its objectives. Annex 4 describes options for assessing and achieving network coherence.

Box 2-6 Properties of a coherent Natura 2000 network

In 2010, a study for the European Commission[70] recommended that to be coherent, the Natura 2000 network should meet the criteria for the following four key properties:

- **Adequacy**: the individual components of the network are of sufficient size and shape, with an appropriate distribution to ensure the ecological viability and integrity (i.e. favourable conservation status) of its habitats and species.
- **Representativity**: the components provide for all of the requirements of all protected habitat and species over their annual cycle (e.g. breeding, roosting, feeding and migrating).
- **Resilience**: the network is able to undergo, absorb and respond to change and disturbance while maintaining its functions and controls.
- **Connectivity**: the network is sufficiently connected to enable necessary movements of propagules (e.g. larvae and seeds) and individuals for breeding and dispersal, foraging, migration, climate change adaptation, and to maintain ecological processes and linkages.

[70] Arcadis and IEEP (2010), Dealing with conflicts in the Implementation and Management of the Natura 2000 Network - Strategic Planning (lot 2), guidance document, Report to the European Commission, Arcadis, Antwerp, Belgium.

2.3.6.2 What if favourable conservation status (FCS) cannot be achieved due to unavoidable impacts of climate change?

The Natura 2000 network is contributing to FCS but it might not be sufficient to achieve it on its own (e.g. if a big part of the area of a habitat type is outside the network). Therefore, this question would be relevant for the network in a certain biogeographical region of a Member State but also to occurrences of habitat types and species beyond the network.

As explained above, in cases of unavoidable deterioration due to climate change according to robust scientific evidence where FCS can no longer be achieved at network level even though all reasonable conservation and restoration measures have been taken, there might be a need to review both SSCOs and SSCMs in the relevant sites. In such a case, an assessment of the measures that could be taken for the affected feature(s) in the relevant biogeographic region in a changed climatic situation would be needed. This assessment may include, among others, a review of the sufficiency of the network for the affected feature to determine if new or other sites could play a role in restoring its conservation status in the future, as well as a review of SSCOs and related SSCMs.

If there is robust scientific evidence that a certain feature in a certain region can no longer achieve the previously set favourable reference values (FRVs), then this situation needs to be acknowledged. Depending on the specific circumstances (a range shift, a change of distribution pattern, a total disappearance, etc.) measures beyond the level of the national biogeographic region(s) may need to be analysed. For example, if the range of a habitat type shifts northwards and it thereby expands its range in Member State (MS) A but at the same time loses parts or all of its range in MS B, the way MS A and B define and contribute to the favourable conservation status of this habitat type should be re-evaluated. This could mean that the FRV for area and range in MS B might have to be reduced or even become zero, while in MS A the FRVs will have to be raised. It is important to ensure that the best possible information is available, and an open expert debate is held to find the best possible solutions.

2.3.7 Changing the legal status or scope of protection of a Natura 2000 site

2.3.7.1 When can site boundary or protected features be changed in a site due to climate change impacts?

In certain cases, it may be that in spite of all measures taken to prevent it, the impacts of climate change on a Natura 2000 site could be such that one or more of the species or habitat types present on the site disappear without reasonable prospects for re-occurring and without restoration possibilities. Moreover, a site or parts of a site, in spite of measures taken, may no longer be able to contribute to the overall objectives of the EU Nature Directives. Such cases, supported by robust scientific evidence, may justify changes to the boundaries of a site, or removing habitats and species from the site's protection regime, or even entirely de-classifying a site, as explained in the Commission's notes on the designation of sites or parts of sites and on the removal of habitats and species from the subject of protection.

If irreversible developments linked to climate change occur that can justify removing habitats and species from a site's protection regime, or changing the boundaries or de-designating an entire site, it should be assessed how far the impact of such losses could be balanced or compensated by proposing new or enlarging existing site(s) in order to protect new areas for the 'lost' habitats and species (see also annex 4).

Conversely, EU protected species or habitats may establish themselves in areas where they were previously absent. This would justify expanding existing sites, changing their boundaries (e.g. to the north or landwards) as explained above, designating new Natura 2000 sites, or including new species and habitats in the protection regime of existing sites to ensure a coherent ecological network (see section 2.3.6 and annex 4 for adaptation measures at network and site level). Member States can prioritise their conservation measures and resources based on their specific needs and conservation objectives.

2.3.7.2 Under which circumstances can sites or parts of sites be de-designated, or features be removed from protection?

The disappearance of a species or habitat from a site may be the result of a slow progressive shift in a species or habitat's distribution and range due to climate change. For example, this may take the form of irreversible habitat loss due to sea-level rise or due to an unpredictable natural disaster that may irreversibly affect the site.

As clarified by the CJEU:

- Article 9 of the Habitats Directive allows for the **declassification of sites** (and arguably parts of sites) '*where this is* ***warranted by natural developments*** *noted as a result of the surveillance provided for in Article 11*'. The CJEU confirmed this in paragraph 25 of its judgement *in Case C 301/12*[71]. In paragraph 30, the court went on to explain however '*that* ***a mere allegation of environmental degradation*** *of an SCI […]**cannot suffice** of itself to bring about such an adaptation of the list of SCIs'*.
- '*The failure of a Member State to fulfil that obligation of protecting a particular site does not necessarily justify the declassification of that site[…]. On the contrary, it is for that State to take the measures necessary to safeguard that sit*e' (paragraph 32). '*Member States are required to propose to the Commission the declassification of a site on the list of SCIs […] provided that that request is based on the fact that,* ***despite compliance with the provisions of Article 6(2) to (4) of that Directive, that site can definitively no longer contribute to the conservation*** *of natural habitats and of the wild fauna and flora or the setting up of the Natura 2000 network*' (paragraph 36).
- In Case C-281/16, paragraph 36[72], the CJEU noted that '*a proposal by a Member State to reduce the size of a site placed on that list requires* ***proof that the areas in question do not have a substantial interest in achieving that objective*** **[of conserving natural habitats and wild fauna and flora]** ***at national level****. In addition, the Commission may accept and implement the proposal only if it concludes that those areas are also not necessary from the perspective of the entire European Union'*.

[71] Judgment of the Court of Justice in Case C-301/12 (Cascina Tre Pini).
[72] Judgment of the Court of Justice in Case C-281/16 (Leenheerenpolder).

Therefore, a site or a part of the site may be de-designated or declassified, or a species or habitat removed from the conservation regime of the site due to natural developments caused by climate change, provided that:

- It is **duly justified on a case-by-case basis** and backed up by **conclusive scientific evidence proving that all efforts were made** to anticipate or prevent the species or habitats irreversible disappearance as a result of changing climatic conditions or other factors.
- It is shown that the deterioration occurred in spite of **full compliance with the requirements of Article 6(2), (3) and (4) of the Habitats Directive** (for compliance with Article 6(2) see section 2.3.4).
- It is assessed that the site, or parts of it, **have no other values or functions to support the objectives of the Nature Directives**, including its potential to be colonised by other Natura 2000 habitats and species due to its new characteristics. Solely the fact that a site or part of a site no longer serves the purpose for which it was initially designated (i.e. has a significant presence) does not suffice to justify its de-designation. In general, as Natura 2000 sites are designated for the protection of several species and habitats, it would be expected that not all are subject to climate change impacts in the same way. By contrast, deterioration caused by human-caused activities or the lack of appropriate management and conservation measures, including those necessary to tackle emerging climate risks and its potential impacts on Natura 2000 (e.g. measures that increase resilience to climate change), cannot be used as a justification for (even partially) declassifying sites or for removing species or habitats from the site's conservation regime.

2.3.7.3 What are the steps to be followed when a change of legal status or scope of protection of a Natura 2000 site is needed?

The Commission's notes on the designation of sites or parts of sites and on the removal of habitats and species from the subject of protection explain the necessary justifications needed and the steps to be followed by Member States, including in cases of changes induced by climate change.

If new species and/or habitats are recorded in the site (for instance as a result of distribution shift due to climate change or of reintroductions as a conservation measure), these should be recorded in an update of the site standard data form and in the national official act or instrument that legally designates the site. The site's SSCOs and SSCMs should also be adjusted to reflect their ecological requirements.

3. HOW THE NATURA 2000 NETWORK CAN CONTRIBUTE TO THE EU'S CLIMATE CHANGE ADAPTATION AND MITIGATION TARGETS

3.1 Win-win solutions to help meet climate change adaptation and mitigation targets

The Natura 2000 network provides and safeguards a wide range of ecosystem services including food, fuel, timber, healthy soil, clean air and water, carbon sequestration and storage and protection from natural disasters, such as floods, landslides, droughts and catastrophic wildfires. Such services are of considerable socio-economic value, collectively estimated to be worth around EUR 200–300 billion per year[73].

As a result of the observed and expected climate changes in Europe (annex 1, section 2), many of the ecosystem services provided by the Natura 2000 network have an increasingly essential role in reducing greenhouse gas emissions and adapting to climate change, through nature-based solutions (including ecosystem-based solutions). Moreover, as shown in later examples, the investment in adaptation really pays dividends: ecosystem restoration and other nature-based solutions can significantly reduce the financial and economic risks associated with climate change.

Many of the practical activities that are required to increase the capacity of habitats and species to adapt to climate change, such as reducing other pressures on them and enhancing and restoring their ecosystems, can also contribute to broader climate adaptation and/or mitigation goals. This provides mutual benefits, i.e. win-win opportunities. In some cases, such actions may even be synergistic and result in benefits that are greater than if the actions were taken separately.

However, it is also important to recognise that some climate mitigation or adaptation actions have the potential to conflict with Natura 2000 objectives and management needs. Such conflicts can arise from inappropriately used nature-based solutions, such as tree planting on non-forested habitats of high biodiversity value[74]. Potential conflicts should be identified as early as possible and avoided through consultations with relevant authorities and other stakeholders. This can be facilitated by developing a climate adaptation framework, as described in chapter 4 and annex 3. If potential mitigation and adaptation conflicts concern projects and plans, as defined under the Habitats Directive, they must be handled in accordance with the legal requirements of Article 6(3) and 6(4) of the Directive.

There are many ways that ecosystem conservation and restoration in the Natura 2000 network can contribute to climate mitigation and broad adaptation benefits. The main ways are summarised in Table 1 and described in section 3.2 and section 3.3.

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[73] Ten Brink, P., Bassi, S., Badura, T. et al. (2013), The Economic Benefits of the Natura 2000 Network-Synthesis Report, European Commission, Luxembourg.
[74] Seddon, N., Smith, A., Smith, P., et al. (2021), Getting the message right on nature-based solutions to climate change, Global change biology, 27(8), pp. 1518-1546.

Table 1 Potential climate mitigation and adaptation benefits of ecosystem restoration

Broad habitat	Measure / action	Climate mitigation potential	Adaptation potential	Comments
Marine & coastal [1]	Restoring & recreating carbon-rich HD habitats (e.g. sea-grasses & saltmarshes)	High	Improved coastal flood protection	Potential conflicts [2]
	Sand dune restoration	Low	Improved coastal flood protection	
	Reducing pressures: pollution, invasive alien species (IAS), habitat disturbance etc.	Low-High	Reduced toxic algal blooms, IAS impacts	Climate mitigation potential depends on the habitat, e.g. high for seagrass
Lakes & rivers	Restoring & recreating HD lake habitats	Variable/ High	Increase in freshwater storage	
	Restoring river watercourses & connections to floodplains & other wetlands	Variable/ High [3]	Reduced flood impacts, increased groundwater recharge & drought resilience	Depends on situation [4]
	Reducing pressure: water abstraction, pollution, IAS	Low	Maintenance of flows, reduced eutrophication	
Bogs, mires, fens & marshes	Habitat restoration: rewetting, tree removal & restoring vegetation where necessary	Very high	Improved water quality, enhanced water retention reduces flood, drought & fire risks	
	Reducing other pressures: grazing & prescribed burning	High		
Heath & scrub	Habitat restoration: tree removal & restoring vegetation where necessary	Variable / negative	Reduced potential fire impacts due to lower fuel loads	

Broad habitat	**Measure / action**	**Climate mitigation potential**	**Adaptation potential**	**Comments**
	Fire management (e.g. prescribed burning, grazing, fire breaks)	Variable	Reduced fire risk/ impacts[5]	
	Reducing other pressures: atmospheric pollution, inadequate grazing, IAS	Variable	Grazing can reduce vegetation fuel load & fire impacts	
Forests	Recreating HD habitats	High	Slope stabilisation, reduced run-off, reducing pollution & flooding	
	Forest restoration e.g. from monospecific age-class stands with clearcutting to mixed stands with a selective removal system, continuous canopy cover & natural regeneration	Variable/ High	Increased forest resilience (e.g. to drought, heat, storms, disease) & reduced fire risk/ impacts [5]	
	Afforestation to buffer / connect	High	Increased resilience of fragmented forests e.g. resilience to heat, storms	
	Replanting with admixtures of European species (or genotypes) more resilient to climate change, with a focus on native species or species from adjacent biogeographical areas	High	Increased resilience as above	
	Reducing other pressures: atmospheric pollution, IAS		Increased resilience as above	
Grasslands & cropland	Recreating / restoring HD grasslands: reducing management intensity	Very high	Reduced water pollution, run-off & erosion	

Broad habitat	Measure / action	Climate mitigation potential	Adaptation potential	Comments
	Maintaining / restoring HD grasslands: grazing & haymaking etc. (avoiding / reversing abandonment)	High	Maintenance of agricultural production and cultural landscapes, reduced erosion risk & fire impacts	
	Grassland protection from ploughing & re-seeding of grassland	Medium	Reduced water pollution, run-off & erosion	
	Restorative management of arable land (e.g. low-tillage, use of rotations and fallow)	Medium		
	Fire management (e.g. grazing, prescribed burning)	Low - variable		

Notes:

1. *Marine and coastal includes marshes and dunes.*
2. *Can result in the loss of some desired habitats (e.g. if unique freshwater marshes are replaced by salt marshes).*
3. *Although freshwater ecosystems have relatively low sequestration rates and stocks, associated peat soils which are common in riparian areas and floodplains can significantly contribute to climate mitigation.*
4. *Can lead to too frequent or otherwise damaging flooding if flood banks are removed or lowered in some situations.*
5. *Fire is a natural phenomenon in ecosystems with fire-dependent species. The fire risk/impact reduction here refers to the risks and impacts of destructive wildfires.*

Sources: Climate mitigation potential based on Hendriks et al. (2020)[75], see Table 2 below. Adaptation potential based on Keesstra et al. (2018)[76], Harrison et al. (2016)[77], Cooper (2020)[78], European

[75] Hendriks, K., Gubbay, S., Arets, E. et al. (2020), Carbon storage in European ecosystems: A quick scan for terrestrial and marine EUNIS habitat types, internal report for EEA by Wageningen Environmental Research and Susan Gubbay, Wageningen.

[76] Keesstra, S., Nunes, J., Novara, A. et al. (2018), The superior effect of nature based solutions in land management for enhancing ecosystem services, Science of The Total Environment, 610–611, pp. 997–100.

[77] Harrison, I.J., Green, P.A., Farrell, T.A. et al. (2016), Protected areas and freshwater provisioning: a global assessment of freshwater provision, threats and management strategies to support human water security, Aquatic Conservation: Marine and Freshwater Ecosystems, No 26 (S1), pp. 103-120.

[78] Cooper, R. (2020), Nature-based solutions and water security, GSDRC, University of Birmingham.

Commission (2021)[79], Seddon et al. (2020)[80], EEA (2021)[81], Penning et al. (2023)[82], Valor et al. (2023)[83] and other references listed in the nature-based solutions bibliography.

3.2 How the Natura 2000 network can contribute to climate mitigation through carbon sequestration and storage

The Natura 2000 network's ecosystems have an important role to play in contributing to the EU's climate mitigation targets through carbon sequestration in soil, sediments and vegetation, which helps offset unavoidable GHG emissions from other sectors. The EU's climate neutrality and GHG reduction target is a "net" target, meaning increases in the carbon sink are included in the target. The 2023 amendment of the land-use, land-use change and forestry (LULUCF) Regulation[84] sets an overall EU-level objective of 310 Mt CO_2e of net removals in the LULUCF sector by 2030.

Member States are responsible for managing and expanding their carbon sinks to meet this EU target. The amended Regulation maintains the 'no debit rule' that emissions (debits) from LULUCF sectors should not exceed removals (credits) until 2025. If emissions do exceed removals, the Member State is obliged to increase sink capacity or by making use of flexibility mechanisms (e.g. trading emission credits). In 2026, removals should start exceeding emissions. Each Member State has a binding national target for 2030 and a commitment to achieve a sum of net GHG emissions and removals for the whole period 2026-2029.

The main ways to manage and expand carbon sinks are to protect, restore and recreate HD habitats (i.e. those listed in Annex I to the Habitats Directive), especially carbon-rich habitats, to reduce land-use-related GHG emissions, and/or increase natural carbon sinks. There may be opportunities where:

- existing carbon stores that are declining or at risk, are protected from loss or degradation;
- carbon sequestration rates are increased through ecosystem restoration or enhancement;

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[79] Land-based wildfire prevention Principles and experiences on managing landscapes, forests and woodlands for safety and resilience in Europe. Publications Office of the European Union, 2021. https://op.europa.eu/en/publication-detail/-/publication/4e6cc1f1-8b8a-11eb-b85c-01aa75ed71a1/language-en

[80] Seddon, N., Chausson, A., Berry, P., et al. (2020), Understanding the value and limits of nature-based solutions to climate change and other global challenges, Philosophical Transactions of the Royal Society B, 375, 20190120.

[81] EEA (2021), Nature-based solutions in Europe: Policy, knowledge and practice for climate change adaptation and disaster risk reduction, EEA Report No 1/2021, European Environment Agency, Luxembourg: Publications Office of the European Union.

[82] Penning E., Peñailillo Burgos R., Mens M., *et al.* (2023), Nature-based solutions for floods and droughts and biodiversity: Do we have sufficient proof of their functioning? Cambridge Prisms: Water, 1, e11, pp. 1–17.

[83] Valor, T., Coll, L., Pique, M., et al. (2023), FIRE-RES Ecological factors driving resistant and resilient landscapes to high intensity and extreme wildfire events, Deliverable D1.11 FIRE-RES project. DOI: 10.5281/zenodo.7785271.

[84] Regulation (EU) 2023/839 of the European Parliament and of the Council of 19 April 2023 amending Regulation (EU) 2018/841 as regards the scope, simplifying the reporting and compliance rules, and setting out the targets of the Member States for 2030, and Regulation (EU) 2018/1999 as regards improvement in monitoring, reporting, tracking of progress and review, OJ L 107, 21.4.2023, p. 1-28.

- previously lost carbon-rich habitats are re-created.

Table 2 summarises the natural ability of different ecosystem types to sequester and store carbon. The ranges vary greatly within habitat types, largely due to their broad classification. The estimates are also from different parts of the EU-27 subject to different climatic conditions and management systems. They should therefore be regarded as indicative for the aims of this guidance. Bulkeley (2020)[85] provides an analysis of EU-funded projects on nature-based solutions for climate mitigation.

Table 2 Carbon stock and sequestration estimates for ecosystem types and selected marine habitats

a. Land ecosystems

	Carbon storage(t C ha^{-1})				**Carbon sequestration (t C ha^{-1} yr^{-1})**			
Ecosystem	**mean**	**median**	**min**	**max**	**mean**	**median**	**min[2]**	**max**
Wetland [1]	261.8	247.2	0.9	827.1	1.0	0.3	-0.5	6.5
Forest	133.0	115.5	5.0	500.0	3.2	3.0	0.02	9.3
Heathland	110.3	88.0	2.0	548.6	0.02	0.02	0.02	0.02
Agricultural	107.7	99.0	7.0	266.7	1.2	0.9	-0.8	4.3
Tundra	101.2	23.2	1.5	711.0	0.6	0.3	0.10	1.4
Sparsely vegetated	69.7	24.0	20.6	164.5	0.02	0.02	0.00	0.04
Grassland	61.3	5.0	0.5	438.0	0.2	0.2	0.2	0.2
Coastal	48.0	48.0	48.0	48.0	0.7	0.7	0.6	0.7
Shrub	33.5	12.0	6.9	190.1	0.1	-0.02	-0.7	1.3
All land ecosystems	**145.7**	**96.0**	**0.5**	**827.1**	**1.8**	**1.0**	**-0.8**	**9.3**

b. Selected marine habitats

Habitat type	**Carbon storage(t C ha^{-1})**	**Carbon sequestration (t C ha^{-1} yr^{-1})**
Maerl beds	620 C_{inorg}	1.0
Lophelia reefs	100 C_{inorg}	0.3
Seagrass beds	20 – 50 C_{org}	0.8
Intertidal sediments	5 – 20 (top 10cm)	0.1 – 0.4

[85] Bulkeley, H. (2020) Nature based solutions for climate mitigation - an analysis of EU-funded projects, European Commission, Brussels.

Kelps	5 – 9 C_{org}	Contribution largely in depositional areas
Intertidal macroalgae	5 C_{org}	Contribution largely in depositional areas
Sub-tidal sediments	<1 (top 10 cm)	0.003 - 0.009

Note: Ecosystem types are based on the 2019 EUNIS marine habitat classification and the 2017 EUNIS habitat classification for terrestrial ecosystems[86]. 1. Wetlands include peatlands, fresh-water reed marshes, intertidal marshes, salt marshes, riparian ecosystems. Mean, median, min and max estimates are not provided for the marine habitats because they are not included in the source reference. 2. Negative rates can occur due to high rates of decomposition of soil organic matter, for instance in drained or dehydrated peat soils.

Source. Adapted from Hendriks et al. (2020)[87]. Units adapted from Mg C ha^{-1} for land and g m^{-2} for marine. C_{org} = organic carbon. C_{inorg} = inorganic carbon.

Of all land ecosystems, wetlands have the highest average carbon stocks, especially peatlands (with thick peat layers) and salt marshes. Other habitat types may also have high carbon stores when on peat soils. Forests also generally have high carbon stocks, above and below ground, although they vary greatly depending on their location, species, age of the stand and management. Forests are estimated to achieve the highest rates of sequestration, although the range is quite wide.

There are currently insufficient data on marine carbon stores and sequestration rates to provide ranges and averages. However, the estimates provided in Table 2 indicate that marine habitats in Europe vary greatly, with maerl beds having much higher stores and sequestration than all other marine habitats, and most land habitats. Sequestration rates are also relatively high in sea grass beds. Although the carbon stores and sequestration rates are much lower in kelp, intertidal and sub-tidal habitats, they capture and lock up a considerable amount of carbon overall due to their great extent.

In many situations, the protection, management and restoration (‘climate-proofing’) of habitats in Natura 2000, and the wider environment (landscape level), can reduce and reverse actual or potential carbon losses and increase sequestration rates. A common and important example is in drained peatlands (i.e. bogs, fens and mires), which can become a source of carbon dioxide rather than a sink. However, rewetting these areas can greatly reduce or eliminate carbon losses by preventing the oxidation of the peat[88] [89]. Further restoration measures, such as regaining the dominance of peat-forming plant species (i.e. primarily *Sphagnum* species), may then be necessary to achieve or increase peat formation and carbon sequestration.

There are many examples of peatland restoration being successfully carried out, with substantial climate mitigation benefits (and adaptation – see below) although these are difficult to quantify. Two case studies of peatland restoration, in Estonia[90] and Ireland[91],

[86] https://www.eea.europa.eu/data-and-maps/data/eunis-habitat-classification-1/folder_contents.
[87] Hendriks, K., Gubbay, S., Arets, E. et al. (2020), Carbon storage in European ecosystems: A quick scan for terrestrial and marine EUNIS habitat types, internal report for EEA by Wageningen Environmental Research and Susan Gubbay, Wageningen.
[88] Günther, A., Barthelmes, A., Huth, V., et al. (2020), Prompt rewetting of drained peatlands reduces climate warming despite methane emissions, Nature Communications, 11 (1), 1644.
[89] Renou-Wilson, F., Moser, G., Fallon, D., et al. (2019), Rewetting degraded peatlands for climate and biodiversity benefits: Results from two raised bogs, Ecological Engineering No 127, pp. 547-560.
[90] https://soo.elfond.ee/en/projektist/miks/
[91] https://www.raisedbogs.ie/

are summarised in case study 2 and case study 3. Other examples of carbon-rich HD Annex I habitats that have been restored with documented carbon sequestration and storage benefits include seagrass (described in case study 4 in Italy[92]), and saltmarsh in the UK (case study 5). The Horizon 2020 project WaterLANDS[93] running from 2021 to 2026 aims to synthesise existing knowledge on the successful restoration of wetlands and enable an upscaling of restoration of sites across Europe.

Case study 2: climate mitigation and adaptation benefits of measures to restore peatland sites, LIFE Mires (Estonia)

The aim of the LIFE Mires Estonia project (2015-2020), coordinated by the Estonian Fund for Nature non-governmental organisation, was to restore the good condition of mire habitats on selected sites. Restoration actions were undertaken on six Natura 2000 sites, including restoring the hydrological regime by removing the drainage system, revegetating abandoned peat mining areas, and clearing trees from afforested bogs. The project achieved 7 900 ha of restored mires and significant increases in the targeted species' populations (e.g. Moor Frog, dragonfly species) were expected.

Alongside these biodiversity benefits, the project is expected to deliver climate mitigation benefits as the targeted mire habitats have significant carbon sequestration and storage capacities. However, in Estonia, degraded peatlands emit around 8 $MtCO_2$/yr. Restoring these habitats can therefore contribute to climate mitigation objectives by reducing these carbon emissions. Moreover, action to restore mires also has the potential to contribute to climate change adaptation. In Estonia, extreme weather frequently triggers flooding and fire incidents are also on the rise. Extended wetlands can buffer both flooding and fire events, while providing other enhanced ecosystem services, including giving a boost to local tourism.

The project tackled conservation dilemmas inherent in priorities and the trade-offs between habitats and species, as well as habitat and species monitoring and adaptive management practices. It achieved an increase in social acceptance and important awareness-raising successes about restoration and wetlands. A manual documents the best practice techniques followed in the project[94].

Source: LIFE Mires Estonia[95]

Case study 3: restoring active raised bog in Ireland's network of special areas of conservation

Raised bogs are invaluable wetland habitats that have suffered significant declines as a result of human activities. Approximately 9 100 ha of raised bog habitat is included in Ireland's protected network of SACs and Natural Heritage Areas. Restoring the protected raised bog

[92] https://webgate.ec.europa.eu/life/publicWebsite/project/LIFE12-NAT-IT-000331/habitat-1150-coastal-lagoon-recovery-by-seagrass-restoration-a-new-strategic-approach-to-meet-hd-wfd-objectives
[93] https://waterlands.eu/
[94] Salm, J.-O., Remm, .L., Haljasorg, M. et al. (2021), Restoration of Mire Habitats: Experiences from the Project 'Conservation and Restoration of Mire Habitats'. Estonian mires, Tartu. https://soo.elfond.ee/en/projektist/aruanded/
[95] https://soo.elfond.ee/en/projektist/ and https://webgate.ec.europa.eu/life/publicWebsite/project/LIFE14-NAT-EE-000126/conservation-and-restoration-of-mire-habitats.

network is important to increase the biodiversity value of Ireland's peatbogs and contribute to climate change mitigation.

The LIFE project Irish Raised Bogs (2016-2022) is the largest single peatland restoration project undertaken in Ireland to date. It focuses on restoring and recreating the hydrological and ecological conditions of active raised bog in Ireland's SAC Network. The aim was to restore 752 ha over 2 649 ha of raised bog through various rewetting measures, and carry out monitoring to demonstrate the positive impacts of restoration. Modelling based on initial results predicts that the project will achieve over 95% of the targets. Although the project does not deduce the impacts from restoration action on GHG emissions, it is possible to estimate the expected effect of rewetting actions based on previous studies. Evidence shows the potential of rewetting measures for transforming drained peatlands from a carbon source to a carbon sink (e.g. from 1.37 tC/ha/yr on drained, domestic cutover to -0.49 tC/ha/yr following rewetting) in a cost-effective manner.

The project has resulted in large socioeconomic benefits and public acceptance of restoration activities across the project sites and beyond. A socioeconomic study has already shown that the economic spin-off from the project is estimated to have been over EUR 3 million in the midlands region (for example through ecotourism). A key success factor was the preparation phase, which included in-depth stakeholder mapping and understanding of the history of peat use. In addition, the project involved best practice sharing and engagement with restoration projects in the UK. To support future restoration action, the project produced a review of best practice measures[96].

Source: LIFE projects The living bog[97] and Irish Raised Bogs[98].

Case study 4: restoring seagrass in the Venice lagoon

Coastal lagoons are ecosystems of high ecological importance that provide essential habitats for a wide variety of plant and animal species and support the delivery of key ecosystem services of socio-economic importance including climate regulation, fisheries productivity, and coastal protection. A key indicator of lagoon ecosystem health is the extent and status of their aquatic seagrass meadows. These 'ecological engineers' support multiple biological communities and climate change mitigation as they capture and store significant quantities of carbon dioxide. As seagrass meadows have declined considerably, protecting and restoring the seagrass provides a nature-based solution to simultaneously achieve carbon mitigation and biodiversity conservation.

The main objective of the LIFE-SeResto project (2014-2018) was to restore and consolidate about 36 km^2 of coastal lagoon habitat by transplanting submerged seagrasses, mainly *Zostera marina* and *Zostera noltei*, in sites within the northern Venice lagoon. To achieve this objective, a range of measures were implemented in collaboration with local stakeholders. They include preparatory work to identify transplantation sites, direct seagrass transplantation and meadow development support, monitoring to assess the success and benefits of the project, and dissemination work to share lessons and best practice from the project.

[96] Cushnan, H. (2022), LIFE Technical Manual - review of best practice measures, RPS Group Ltd., https://www.raisedbogs.ie/wp-content/uploads/2022/09/Appendix-23-E10-LIFE-Projects-Technique-Manual-D01.docx.pdf.
[97] https://www.raisedbogs.ie/.
[98] https://webgate.ec.europa.eu/life/publicWebsite/project/LIFE14-NAT-IE-000032/restoring-active-raised-bog-in-irelands-sac-network-2016-2020.

As a result of the restoration measures (with seagrass in an area over 10 km^2), the sites support a higher degree of biodiversity and function as refuge, feeding and nursery areas for various benthic and fish species, as well as for birds. In addition, restoration has contributed to water quality improvements and, in the last two years of the project, to the sequestration of around 1 500 t CO_2.

Key lessons can be drawn from several of the factors that contributed to the success of this project. These include technical aspects of the methodology including the decision to use several small sites in a large area using small sods and single rhizomes, whose collection has no significant impacts on donor sites, and to use manual work, requiring no machinery. Another crucial factor was the close involvement of local operators (fishermen, hunters, rowers, naturalists) who have an intimate knowledge of the lagoon.

Source: LIFE-SeResto[99]

Clearly there is potential to contribute to climate mitigation by restoring, recreating, or managing many other HD Annex I habitats, or other habitats of importance for Natura 2000 species. Potential solutions include:

- recreating and restoring suitable climate-resilient forest habitats and other carbon-rich habitats, which in addition to expanding the habitat can increase connectivity by creating corridors and joining up fragmented patches of habitats;
- planting native species in appropriate sites to buffer habitats, or recreating semi-natural grasslands and shrublands on former arable land;
- reverting intensively used arable land to grassland[100] alone, even if not to a semi-natural quality, may benefit numerous species (e.g. certain farmland birds) while increasing carbon stocks and reversing carbon losses associated with arable land management (e.g. leaving bare ground, soil disturbance and ploughing) and increasing numerous wider adaptation benefits;
- the sustainable management of arable, forest and urban soils to avoid soil degradation and increase their water retention capacity.

Similarly, the biodiversity protection and enhanced resilience associated with climate adaptation measures within Natura 2000 sites can contribute to climate change mitigation by ensuring that important existing carbon stocks are not lost due to the impacts of climate change. Management actions in Natura 2000 sites can also enhance habitat carbon storage and sequestration. For example, on saltmarshes, appropriate grazing regimes can enhance carbon stocks by up to 10 tC/ha, particularly on old marshes with fine-grained soils[101]. The simple act of preventing the ploughing and re-seeding of grasslands alone can prevent significant carbon losses from soil disturbance,

[99] https://webgate.ec.europa.eu/life/publicWebsite/project/LIFE12-NAT-IT-000331/habitat-1150-coastal-lagoon-recovery-by-seagrass-restoration-a-new-strategic-approach-to-meet-hd-wfd-objectives and https://www.isprambiente.gov.it/en/projects/inland-waters-and-marine-waters/seresto-project.

[100] Reverting arable land to grassland may require in some cases significant changes to the farming system and entail economic risks for farmers; these aspects should be considered when assessing such management measures.

[101] IUCN (2021), Manual for the creation of Blue Carbon projects in Europe and the Mediterranean, International Union for Conservation of Nature and Natural Resources. https://iucn.org/resources/file/manual-creation-blue-carbon-projects-europe-and-mediterranean

increasing carbon stocks by around 8 kgC/ha/yr according to one study in Germany[102]. Where permanent grasslands have been converted to arable land, action to restore the grasslands has the highest potential to increase carbon storage of all agricultural management practices[103].

Another significant contribution to maintaining or increasing carbon stocks in Natura 2000 sites, and the wider environment, can be through the creation or restoration of landscape features, such as hedgerows, woodlots and scattered trees. For example, such small woody landscape features in agricultural landscapes in Germany were estimated to store around 111 Mt of carbon over 900 000 ha (123 tC/ha)[104].

3.3 How Natura 2000 can help reduce and mitigate the impacts of extreme events – some examples

3.3.1 Wildfires

Wildfires, defined here as 'any uncontrolled vegetation fire that involves a decision, or action, regarding suppression'[105] have been increasing in severity in some countries, although not overall across the EU in terms of numbers or total area burnt (European Forest Fire Information System - EFFIS)[106]. The reasons for this are complex. They include an observed increase in the hot and dry conditions that are conducive to triggering and sustaining fires, so-called 'fire weather', as a result of climate change (annex 1, section 2.4). Other contributory factors include land-management changes, social patterns such as rural abandonment and urban expansion, under-management of agricultural land and forests, changing cultural traditions and leisure behaviours, and sub-optimal fire management policies such as overreliance on fire suppression and insufficient prevention measures.

EFFIS reports[107] show that the temporal and spatial patterns of wildfires in Europe are changing. The wildfire season now lasts longer than it used to. Extreme fire danger conditions in central Europe and the Mediterranean region make it easier for large fires to start and spread, with several critical fires covering an area greater than 10 000 ha. Most of the area burnt has been in the inherently fire-prone regions of southern Europe (in Portugal, Spain, France, Italy and Greece). However, wildfires have also occurred in areas that have so far been considered at low risk, such as in parts of north-western and central Europe. The EFFIS 'current situation viewer'[108] includes a 'Protected Areas Layer' enabling users to assess fire danger and monitor the extent of wildfires in protected areas.

[102] Reinsch, T., Loges, R., Kluß, C. et al. (2018), Effect of grassland ploughing and reseeding on CO_2 emissions and soil carbon stocks, Agriculture, Ecosystems & Environment, 265, pp. 374-383.
[103] Lugato, E., Bampa, F., Panagos, P., et al. (2014), Potential carbon sequestration of European arable soils estimated by modelling a comprehensive set of management practices, Global Change Biology, 20 (11), pp. 3557-3567.
[104] Golicz, K., Ghazaryan, G., Niether, W., C., et al. (2021), The role of small woody landscape features and agroforestry systems for national carbon budgeting in Germany, Land, 10 (10), 1028.
[105] European glossary for wildfires and forest fires (2012). https://www.ctif.org/sites/default/files/2018-01/European%20glossary%20for%20wildfires%20and%20forest%20fires.pdf
[106] https://forest-fire.emergency.copernicus.eu/
[107] https://forest-fire.emergency.copernicus.eu/reports-and-publications/annual-fire-reports
[108] https://forest-fire.emergency.copernicus.eu/apps/effis_current_situation/

Although fire is an important natural event in many ecosystems, such as some boreal forests, Atlantic heathlands and Mediterranean forests and scrublands, wildfires are also damaging Natura 2000 habitats and species – especially when severe, frequent or large-scale. Large-scale severe fires are particularly damaging, as extreme temperatures cause the destruction of all above-ground woody vegetation (including tree crowns), as well as damage to the soil, plant tubers and seed bank. The exposed soil is then prone to erosion, which is being exacerbated by climate-change-related increases in extreme rainfall events.

Such changes in soil conditions can prevent the recovery of the original plant communities and associated animal species. In turn, this can lead to the loss of HD habitat types and replacement by low biodiversity-value vegetation. Large-scale fires also reduce the structural diversity of the landscape, as large blocks of habitat become of the same age and dominated by similar vegetation at the same stage of succession. Although some plants and habitats can withstand occasional moderate fires, and may even depend on them, they may die out if fires are too frequent, even if of low intensity. There is evidence that homogeneous landscapes covered by fire-prone shrublands are expanding in Europe as a result of increasing extreme wildfire events and more frequent fires[109].

An additional concern is that some areas and ecosystems that did not normally burn due to their damp soils and vegetation are becoming vulnerable to fire due to prolonged drought conditions. Fires in such habitats can be extremely damaging, especially as an absence of fire previously means that there are large volumes of fuel build up that can then result in particularly severe fires.

The protection and conservation management of forests, shrublands and other high-risk habitats in Natura 2000 also provides benefits for fire prevention as many of the requirements are the same or similar. In forest management, measures that are often taken in Natura 2000 sites to achieve conservation objectives can boost resilience to climate change and directly and indirectly help to reduce the scale, intensity and impact of fires. Such measures include:

- protecting old-growth and primary forests where their micro-climate and high moisture content of large pieces of decaying wood reduce wildfire risk;

- maintaining habitat mosaics, for example by using agroforestry, permanent crops and vineyards as buffers;

- grazing by different livestock species, to maintain specific use of grassland management and/or transhumance with resistant breeds better adapted to the surrounding environment;

- using prescribed burning which can restore protected grasslands while providing benefit for the bioeconomy in remote area (e.g. grazing opportunities);

[109] Moreira, F., Viedma, O., Arianoutsou, M., et al. (2011), Landscape–wildfire interactions in southern Europe: implications for landscape management, Journal of environmental management, 92(10), pp. 2389-2402.

- using a mix of silvicultural systems to create diverse woodland and agroforestry structures;
- maintaining species and age diversity;
- introducing practices to maintain moist cool forest conditions (e.g. such as maintaining canopy cover, avoiding large-clear cuts);
- retaining or planting less flammable native species (fire resistance);
- controlling the spread of pyroendemic invasive alien species;
- appropriate management of deadwood in high risk areas (such as after severe bark beetle infestations[110] or windfalls) to avoid vertical and horizontal fuel continuity.

Concerns have been raised over the requirement to maintain high levels of deadwood in forests for biodiversity (and the use of deadwood as a biodiversity indicator), as this can add to fuel load. This has therefore been investigated in detail by a European Commission study that concluded that 'it is likely that in most conditions deadwood is not significantly contributing to fire risk'[111]. In Mediterranean-type forests, this study considered that deadwood (understood as woody material that is not part of living plants and exceeds a diameter threshold of 10 cm) cannot be considered a significant driving fire risk in comparison to other characteristics: i.e., high horizontal and vertical (ladder fuel) continuity of forests because of the decrease in forest management and rural depopulation. However, there could be exceptions immediately following other disturbances (e.g. drought, pest outbreaks, windstorms) due to the presence of fine woody fuels attached to deadwood.

Although it can represent a large portion of the fuel load, coarse deadwood with a diameter larger than 10 cm, commonly associated with biodiversity benefits, tends to contain higher amounts of moisture and has a lower surface-to-volume ratio and therefore burns slowly and contributes little to fire intensity. On the other hand, as explained in the above mentioned study, accumulation of fine woody debris with a diameter from 1 to 10 cm on the forest floor can increase the fire risk tremendously if the climatic conditions preclude their rapid decomposition. Deadwood management is therefore context-dependent and must factor in local climate conditions and size of target deadwood.

More information on recommended management actions can be found in annex 4 part 2.4.1.

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[110] See case study in Horizon Project FIREURISK which concluded that deadstands remain highly combustible after a bark beetle attack. https://fireurisk.eu/wp-content/uploads/2025/04/D4.6Report-on-cascading-effectsGMVv1.0.pdf

[111] Larjavaara, M., Brotons, L., Corticeiro, S., et al. (2023), Deadwood and Fire Risk in Europe, JRC134562, Publications Office of the European Union, Luxembourg.

3.3.2 Riverine and coastal flooding

Another important and widespread benefit from natural and semi-natural habitats and related ecosystem processes is their ability to retain water in the landscape. This helps not only mitigate the impact of prolonged droughts but also reduces flooding and its impacts (see bibliography in annex 5 for reference sources). The EU recognises that these nature-based solutions to flooding, and the role of Natura 2000 in maintaining and restoring them, already contribute to water and flood management in the EU, including in relation to the objectives of the Floods Directive[112], and Water Framework Directive (WFD)[113] [114]. Pluvial flooding (i.e. from direct rainfall), fluvial/riverine flooding and coastal flooding are all increasing in large parts of Europe as a result of climate change (more rainfall, more intensive rainfall and/or sea-level rise), and these trends are expected to continue under all likely scenarios. Nature-based solutions are therefore likely to have an increasing role in adapting to climate change and flood management.

Ecosystems, including many HD habitats, can reduce flooding and its impacts in a variety of ways and circumstances, as summarised in Table 3. Further references and case examples are provided in the bibliography. In general, flooding can be reduced in three ways: in catchments, on floodplains and along coasts; as outlined below. However, a case-by-case assessment is always needed to determine how much flood risk can be reduced, especially for extreme events.

Table 3 Broad habitat types and their potential to contribute to flood management

Habitat types	Contribution to flood prevention and management	Case studies
Bogs and mires	Can function as sponges, which slows run-off and can reduce peak flow downstream. As any sponge, if saturated, these habitats will lose their buffering capacity.	UK[115]
Riverbank and bed vegetation	Can slow flows, which can reduce flood risk downstream (attenuating high flows) or increase risk upstream (by increased roughness / blockage).	Arga River, Spain[116]
Floodplain grasslands and wetlands	Store flood water (washlands) reducing flood risk downstream. Level of flood risk reduction varies depending on area of natural flood plain (storage volume), connection to the river and distribution throughout a catchment.	River Elbe, Germany[117]

[112] Directive 2007/60/EC of the European Parliament and of the Council of 23 October 2007 on the assessment and management of flood risks, OJ L 288, 6.11.2007, p. 27–34.
[113] Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, OJ L 327, 22.12.2000, p. 1–73.
[114] The interaction between the Floods Directive and the Nature Directives, scoping document, CIS Working Group on Floods under the Floods and Water Framework Directives. European Commission, 2020. https://circabc.europa.eu/d/a/workspace/SpacesStore/448abaa4-66c0-43ce-851d-ca395bdb03f9/Report_Floods_Nature_Directives_final_clean.pdf
[115] Gao, J., Holden, J. and Kirkby, M. (2016), The impact of land-cover change on flood peaks in peatland basins, Water Resources Research, 52 (5), pp. 3477-3492.
[116] https://www.nwrm.eu/case-study/fluvial-and-ecosystem-restoration-arga-aragon-rivers-spain
[117] https://www.ddni.ro/manager/editor/UserFiles/File/Scientific%20annals/volume/19/11.pdf

Floodplain, riverine woodland	Store flood water and can slow the flow, which can reduce flood risk downstream (attenuating high flows). Compared with floodplain grasslands and wetlands, riverine woodland can increase risk upstream (by increased roughness / blockage).	
Coastal dune grassland	Help to stabilise dunes and protect adjacent coastal areas, with some potential to stop waves overtopping.	The Sand Motor, the Netherlands[118]
Coastal dune woodland	Help to stabilise dune areas – as above.	
Coastal salt marshes and meadows	Reduce wave height and energy and thereby the risk of coastal erosion and flooding.	Case study 5
Shingle and stony beaches	Reduce wave height and energy and thereby the risk of coastal erosion and flooding.	
Sub-tidal habitats	Reefs, kelp and seagrass beds retain sediment and reduce wave height and energy, and thereby reduce coastal erosion and flooding.	

Source: *adapted from European Commission (2020)[119], and EEA (2015)[120] for sub-tidal habitats*

Protecting and restoring HD habitats, including soils as well as vegetation, will help increase water retention and thereby reduce river flows and flood peaks. Blanket bogs are particularly effective at retaining water as Sphagnum mosses, which are the dominant plants in healthy bogs and have a huge capacity to absorb water. Restoring degraded bogs by drain blocking in upland catchments can therefore reduce run-off rates and downstream flood risk, as well improving water quality and helping to maintain flows during dry periods.

Other measures such as tree and shrub planting, maintaining forest cover in headwater areas, and reverting arable land to grasslands[121], can also increase water infiltration, reduce run-off rates and downstream flood risk, and increase soil and vegetation carbon stores. Also restoring natural streams, including reconnections to adjacent wetlands in river valleys, will help reduce river flows during intensive rainfall events.

Floodplains can play an important role in storing water, especially along the middle and lower reaches of rivers, and thereby buffering the effects of heavy rainfall. Consequently, creating areas to store water during high river levels, known as 'washlands', has been a practice for centuries. As the regular flooding precludes crop production, washlands have been traditionally managed as wet pastures and meadows.

[118] https://dezandmotor.nl/en/

[119] European Commission (2020), The interaction between the Floods Directive and the Nature Directives. Scoping document, CIS Working Group on Floods under the Floods and Water Framework Directives.

[120] EEA (2015), Water-retention potential of Europe's forests. A European overview to support natural water-retention measures, EEA Report No 13/2015, European Environment Agency, Luxembourg.

[121] Reverting arable land to grassland may require significant changes to the farming system and entail economic risks for farmers; these aspects should be considered when assessing such management measures.

They are of considerable nature conservation value, including for their HD habitats and often breeding and wintering waterbird populations. As result, a large proportion of lowland floodplain grasslands that are still connected to their river and flood seasonally are within Natura 2000 sites.

Despite their important flood alleviation functions, up to 90% of floodplains have been lost in Europe[122]. Consequently, protecting and restoring floodplain ecosystems and HD habitats in Natura 2000 sites helps provide nature-based solutions that alleviate flooding, as well as other biodiversity and ecosystem service benefits. Ecosystem restoration on floodplains can often improve flood alleviation where it increases their capacity for flood storage. This can be achieved by removing or lowering flood banks, or by installing sluices that can let water onto the flood plain in a managed way.

There are many examples all over Europe where floodplain restoration has been used to cost-effectively aid flood management. One is in the Dyle floodplain (Belgium), where a nature-based solution provided required flood alleviation at lower costs and with more ecosystem services benefits, including achieving Natura 2000 site objectives, than an alternative constructed technical solution[123]. Similarly, as part of the Sigma Plan II for the Scheldt estuary in Belgium, nature-based flood prevention measures to protect Antwerp were found to have a lower cost than constructing a storm surge barrier[124]. Furthermore, the value of the flood protection, recreational and ecosystem service benefits for 2010–2100 were higher than the scheme's costs.

Coastal flooding, including due to storm surges, sometimes in combination with pluvial and fluvial flooding, is a threat for many low-lying parts of Europe. Climate change is increasing the risk of coastal flooding as the rising sea-level, and increasing frequency and intensity of storms, increases coastal erosion, saltwater incursion and the inundation of coastal areas (annex 1, section 2.2). Natural habitats of low-lying coasts such as shingle beaches, sand dunes and saltmarsh often provide cost-effective and resilient barriers to the sea, as they are able to absorb the energy of the waves and recover afterwards. Action to restore such coastal habitats can therefore re-establish their capacity for coastal protection. In many cases, coastal restoration can simultaneously achieve nature conservation, climate adaptation to floods and climate mitigation co-benefits, as described in the case study in the UK (see case study 5).

Case study 5: managed coastal realignment and habitat creation in the UK

Many intertidal coastal habitats and Natura 2000 sites in Europe are becoming increasingly affected by erosion, which is being exacerbated by sea-level rise and increasing severe storms resulting from climate change and hard flood defences that constrain natural processes and landward movements of habitat. In the UK, strategic coastal nature conservation and flood defence planning (including through LIFE projects[125]), and the realignment of coastal flood defences has helped reduce habitat loss by enabling the creation of new intertidal habitat.

[122] Tockner, K., Uehlinger, U. and Robinson, C.T. (eds), (2009), Rivers of Europe, 1. ed, Academic Press, Amsterdam.
[123] Turkelboom, F., Demeyer, R., Vranken, L., et al. (2021), How does a nature-based solution for flood control compare to a technical solution? Case study evidence from Belgium, Ambio, 50 (8), 1431-1445.
[124] https://www.sigmaplan.be/en
[125] Initially, Living with the Sea https://webgate.ec.europa.eu/life/publicWebsite/project/LIFE99-NAT-UK-006081/living-with-the-sea-managing-natura-2000-sites-on-dynamic-coastlines.

The new habitat also acts as a natural flood barrier, generally at lower costs than built flood defences. Habitat creation has also increased carbon storage (albeit at slow rates) and produced other ecosystem services, further contributing to the economic benefits of managed realignment.

The coastal erosion and some managed realignment schemes have led to, or are expected to lead to, the loss of some areas of freshwater habitat. Some of these are reedbeds that are key breeding areas for the Eurasian Bittern (*Botaurus stellaris*), which has a depleted and fragmented population in the UK. To address this, a LIFE-funded strategic programme of research and planning was carried out to identify habitat restoration and creation needs and the locations needed to compensate for the expected habitat losses at coastal sites, and to increase the range and connectivity of the species population over the UK. Several hundred hectares of reedbed habitat has been created, including at new sites, mainly through LIFE projects, and some post-mineral extraction planning requirements. This has contributed to a substantial increase in the Bittern population (from 11 booming males in 1997, to 191 in 2017).

The key success factors were evidence-based strategic and integrated planning of nature conservation and flood defence requirements with all stakeholders, adoption in planning policy and use of the flood defence budget. This enabled habitat compensation to take place before the expected losses at Natura 2000 sites materialised, in compliance with requirements under the Habitats Directive.

Source: LIFE UK marine SACS[126]; LIFE Living with the sea[127]; LIFE Bittern[128].

[126] https://webgate.ec.europa.eu/life/publicWebsite/project/LIFE96-NAT-UK-003055/to-develop-and-promote-the-necessary-conservation-measures-for-uk-marine-sacs.
[127] https://webgate.ec.europa.eu/life/publicWebsite/project/LIFE99-NAT-UK-006081/living-with-the-sea-managing-natura-2000-sites-on-dynamic-coastlines.
[128] https://webgate.ec.europa.eu/life/publicWebsite/project/LIFE02-NAT-UK-008527/developing-a-strategic-network-of-spa-reedbeds-for-botaurus-stellaris.

4. A CLIMATE ADAPTATION FRAMEWORK FOR NATURA 2000

4.1 Key steps in creating an adaptation framework for the Natura 2000 network

An adaptation framework for the Natura 2000 network could be integrated within the national adaptation planning cycles, allowing for synergies with related policy actions, flexible timing, data use and prioritisation. This would be relevant in particular for the national restoration plans under the Nature Restoration Regulation and the National Energy and Climate Plans (NECPs).

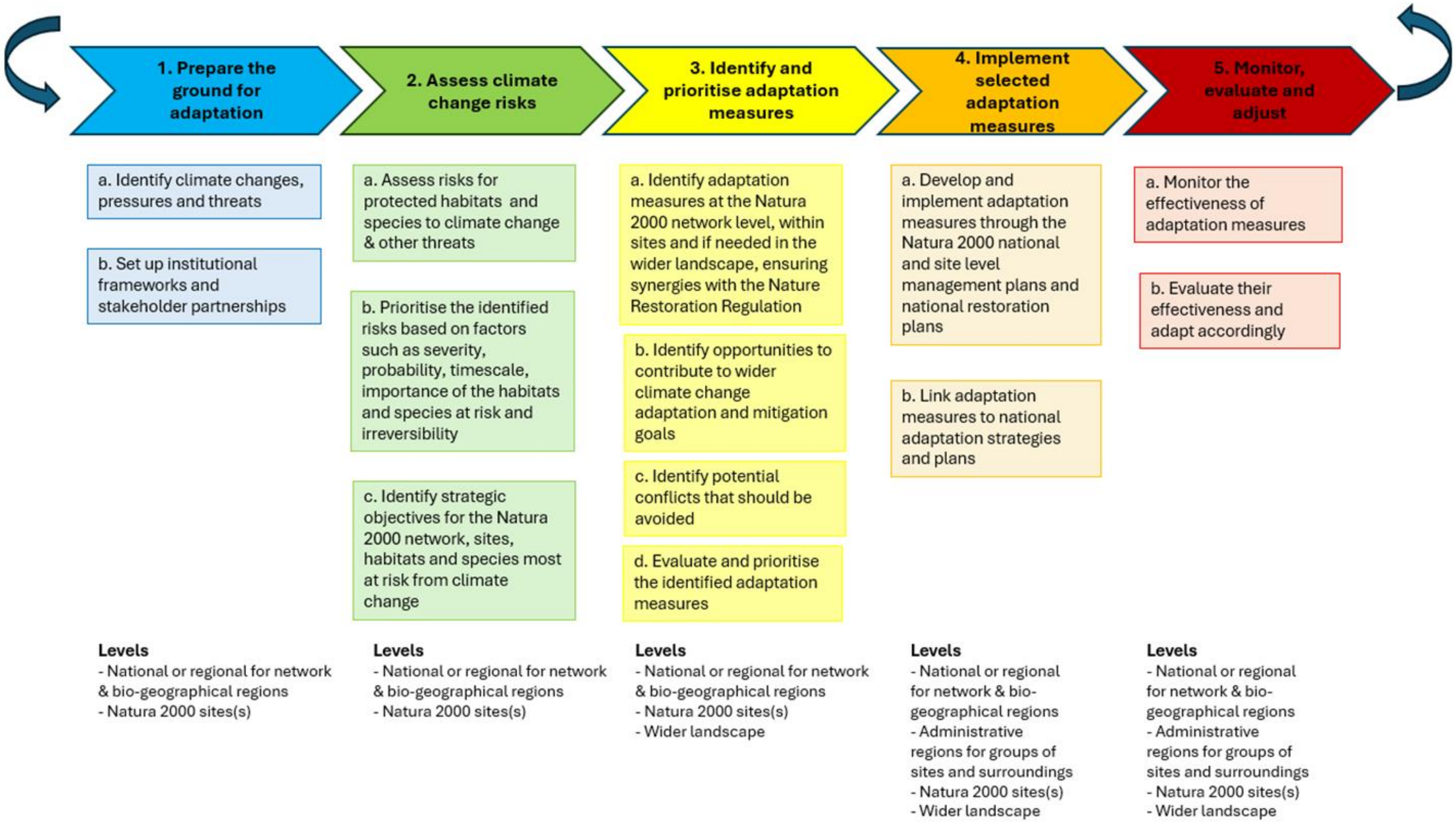
If applied to Natura 2000, existing climate adaptation frameworks would typically include the following steps:

1. **assess climate change risks** for ecosystems, habitats and species;
2. develop strategies and practical measures that **increase the resilience** of ecosystems, habitats and their associated species populations to climate change, thereby improving their *on-site* adaptive capacity;
3. develop strategies and practical measures that **accommodate changes** by **facilitating the movemen**t of species and habitats to new areas with suitable climatic conditions.

The decision framework outlined in this guidance (Figure 1) builds on these key steps, taking into account important developments in adaptation planning, including the IUCN guidance on climate change adaptation for protected area managers and planners[129]. The decision framework closely follows the European Commission Guidelines on Member State's adaptation strategies and plans[130] and the Adaptation Support Tool[131], with some adjustments to reflect the specific needs and terminology for the Natura 2000 network.

[129] Gross, J. E., Woodley, S., Welling, L. A., *et al.* (2016), *Adapting to Climate Change: Guidance for protected area managers and planners*, Best Practice Protected Area Guidelines Series No. 24, IUCN, Gland, Switzerland.
[130] Commission Notice Guidelines on Member States' adaptation strategies and plans 2023/C 264/01, OJ C 264, 27.7.2023, p. 1–31.
[131] https://climate-adapt.eea.europa.eu/en/knowledge/tools/adaptation-support-tool

Figure 1 Proposed climate adaptation framework for Natura 2000.



The framework may be applied to:

1. the Natura 2000 network at national or biogeographical level and the marine regions; and
2. the Natura 2000 sites at risk.

The framework may be applied to the Natura 2000 network and sites for which climate pressures and threats to Natura 2000 habitats and species have been identified, considering their wider landscape if necessary. The initial assessment of climate changes and potential pressures and threats could be carried out at a network or regional level, with information shared with relevant sites. In the interest of efficiency, it may be useful to apply the framework to groups of sites (e.g. wetlands) by sharing information and resources. This might involve nature authorities at national, regional, local or site level, and collaboration between them.

Adaptation measures for Natura 2000 sites may involve external action in surrounding landscapes and/or areas of sea. This is likely to involve collaboration with a range of authorities and stakeholders, at various levels in order to plan and implement such external adaptation measures.

Potential adaptation measures that may be taken at network level, at site and at wider landscape level are covered in more detail in annex 4.

The steps of the proposed adaptation framework are summarised below and further elaborated in annex 3.

Step 1: Prepare the ground for adaptation

Step 1 of the framework is designed to help:

- gain an initial general understanding of the expected climate changes, pressures and threats across the country / regions and the Natura 2000 network;
- identify stakeholders and build institutional capacity and strategic partnerships to support planning and implementation.

Step 2: Assess climate change risks for the Natura 2000 network and sites

Step 2 of the framework will help to:

- quantify the risks from climate change threats to protected habitats and species, for the Natura 2000 network and for sites;
- prioritise climate-related risks, taking into account other threats;
- set climate change adaptation objectives for the Natura 2000 network and sites most at risk from climate change threats.

Step 3: Identify and prioritise adaptation measures

Step 3 of the framework will:

- identify measures to increase the resilience of Natura 2000 habitats and species and their ability to relocate in response to climate change;
- identify measures for adaptation at the Natura 2000 network level (national, subnational and biogeographical), within sites and their surrounding landscape;
- identify opportunities for adaptation measures to fulfil the obligations under the Nature Restoration Regulation, implemented through national restoration plans;
- identify win-win opportunities where adaptation measures for Natura 2000 may support, or be supported by, wider climate adaptation and mitigation objectives;
- prioritise Natura 2000 adaptation measures.

Step 4: Implement the selected adaptation measures

Step 4 of the framework is designed to:

- turn adaptation options into measures with a timetable;
- integrate the selected adaptation measures with the Natura 2000 national and site management planning;
- implement adaptation measures including through the national restoration plan;
- identify synergies and link the adaptation measures to national and regional adaptation planning and the national adaptation strategy and plan.

Step 5: Monitor and evaluate the effectiveness of the adaptation measures

Step 5 of the framework is designed to:

- ensure the identified adaptation measures are implemented;
- the effects of adaptation measures and their impacts on the ecosystem and specific targeted protected habitats and species are reliably evaluated;
- adaptation measures are adjusted in accordance with the monitoring results to optimise their effectiveness and efficiency.

ANNEX 1

OBSERVED AND PROJECTED CLIMATE CHANGES

1. Climate change worldwide and future scenarios

As clearly stated in the AR6 IPCC global climate change assessment, it is unequivocal that human influence has led to widespread and rapid warming in the atmosphere, land, ocean and cryosphere[132]. This warming is primarily due to rapid increases in GHGs in the global atmosphere since pre-industrial times (i.e. 1850-1900), including carbon dioxide, methane and nitrous oxide. As a result, global mean near-surface temperatures and heat waves have steadily risen, both on land and in seas[133].Globally, the past 11 years have been the 11 warmest on record, and the 2023–2025 period marked the first time a three-year term that has exceeded the 1.5°C limit set in the Paris Agreement. Global temperature in 2025 was only marginally (0.01°C) cooler than 2023, and 0.13°C cooler than 2024, which remains the warmest year on record[134].

As climate change is mainly driven by global-scale GHG emissions, it is necessary to briefly consider the global outlook for future emissions, before examining potential further changes in the EU. Projections for future global GHG emissions have been produced based on scenarios of potential climate futures[135]. The current IPCC framework consists of possible shared socioeconomic pathways (SSPs) to 2100 based on key socio-economic drivers of change. In accordance with EUCRA, climate projections in this guidance use a low-emissions scenario based on SSP1-2.6, and a high-emissions scenario based on SSP3-7.0. As the SSPs are relatively recent, most of the scientific modelling studies of projected biodiversity impacts, as discussed in annex 2, have used previous IPCC scenarios[136] [137].

The low-emissions scenario is in line with the UNFCCC 2015 Paris Agreement goal of limiting global warming to well below 2° C above pre-industrial levels, and pursuing efforts to limit the increase to 1.5° C. Despite initiatives at subsequent UNFCCC

[132] IPCC (2021) Summary for Policymakers in: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK and New York, USA.
[133] See for example Copernicus Marine Service Ocean State Report 9 (2025): Karina von Schuckmann (Mercator Ocean International, France), Lorena Moreira (Nologin, Spain), Álvaro de Pascual Collar (Nologin, Spain), Marilaure Grégoire (University of Liège, Belgium), Pierre Brasseur (CNRS, France), Gilles Garric (Mercator Ocean International, France), Johannes Karstensen (GEOMAR Helmholtz Centre for Ocean Research Kiel, Germany), Piero Lionello (University of Salento, Italy), Marta Marcos (University of the Balearic Islands, Spain), Pierre-Marie Poulain (Istituto Nazionale di Oceanografia e di Geofisica Sperimentale (OGS), Italy), and Joanna Staneva (Helmholtz-Zentrum Hereon, Germany) (Eds.): 9th edition of the Copernicus Ocean State Report (OSR9), Copernicus Publications, State Planet, 6-osr9, https://doi.org/10.5194/sp-6-osr9.
[134] Copernicus 2025 Global climate highlights https://climate.copernicus.eu/global-climate-highlights-2025
[135] 'A plausible description of how the future may develop based on a coherent and internally consistent set of assumptions about key driving forces ... and relationships' (IPCC, 2022a).
[136] IPCC (2014), Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, et al (eds.)], Cambridge University Press, Cambridge, UK and New York, USA.
[137] Colin, A., Vailles, C. and Hubert, R. (2019), Understanding transition scenarios, Eight steps for reading and understanding these scenarios, Institute for Climate Economics.

Conferences of Parties to keep the 1.5° C target alive, UNEP concluded that 'there is no credible pathway' to achieving the 1.5° C target[138].

Given the current state of the climate, it is firstly essential for countries to increase their efforts to contribute to limiting global warming to as much below the 2.0°C target as now feasible. Secondly, due to the further inevitable climate changes and the faster rate of warming in Europe, it is prudent to plan adaptation measures for higher levels of warming. The European Scientific Advisory Board on Climate Change recommends preparing for climate risks arising from 2.8-3.3 °C of global warming by 2100, and to use more adverse pathways for stress-testing to assess the robustness of adaptation options under higher-risk futures[139].

2. Climate change in Europe

Unless otherwise indicated, the climate change trends and statistics in this section are drawn from EEA (2017)[140], EUCRA[141] and IPCC AR6[142]. Additional sources of information on observed and projected climate changes are provided in the bibliography.

2.1 Temperatures

In Europe, temperatures have been rising at about twice the global rate. Over 2018-2022, the average temperature for Europe was around 2.2°C warmer than the pre-industrial level (1850-1990), while the average global temperature was 1.2°C above the pre-industrial level. Some European regions have shown faster rates of warming, including in the Alps, Pyrenees and other mountains in Spain, and especially in the Scandinavian mountains and Iceland.

The main trends in temperature-related climate change impact drivers on land in Europe include:

- milder winters, especially in the north, with fewer cold nights, cold spells and frost days;
- warmer summers;

[138] UNEP (2022) Emissions Gap Report 2022: The Closing Window — Climate crisis calls for rapid transformation of societies, United Nations Environment Programme, Nairobi.
[139] European Scientific Advisory Board on Climate Change (2026), Strengthening resilience to climate change - Recommendations for an effective EU adaptation policy framework. https://climate-advisory-board.europa.eu/reports-and-publications/strengthening-resilience-to-climate-change-recommendations-for-an-effective-eu-adaptation-policy-framework
[140] EEA (2017) Climate change, impacts and vulnerability in Europe 2016: An indicator-based report, EEA Report No 1/2017, European Environment Agency, Copenhagen.
[141] European Climate Risk Assessment, EEA Report No 1/2024, (EEA 2024). https://www.eea.europa.eu/en/analysis/publications/european-climate-risk-assessment
[142] IPCC (2023) *AR6 Synthesis Report. Climate Change 2023*, Intergovernmental Pannel on Climate Change, Cambridge University Press, Cambridge, UK and New York, USA.

- shifts in the timing of seasons, with summers in western Europe beginning around 10 days earlier in the 2000s compared to the 1960s[143];
- heat waves, including in the seas, have become more frequent and extreme.

Sea surface temperatures have also risen since records began in 1850. Over 2018-2022, the sea surface temperature increase since 1980 was around 0.5°C globally and around 1.1°C in Europe. As on land, temperature extremes have led to heatwaves in the marine environment in Europe in recent years. The increase in atmospheric carbon dioxide concentrations is also leading to increased ocean acidification. The increases in sea temperature and changes in freshwater inflows and sea ice are also having other knock-on effects on marine chemistry and biodiversity.

According to the EUCRA, under a low-emissions scenario (SSP1-2.6 scenario), near-surface temperatures in Europe are projected to increase by nearly 2.5°C by 2050 and stay at about the same level to 2100. However, as noted in the section above, this scenario no longer seems feasible. **The EUCRA projections under scenario SSP2-4.5 are for temperatures to rise by nearly 3°C by 2050 and about 4°C by 2100.** Under the EUCRA high-emissions scenario (SSP3-7.0), the projected increase would be to about 3°C by 2050 and then to about 5.5°C by 2100.

In general, temperatures on land are expected to rise the most in the southern European region, primarily in the summer, under both low and high-emission scenarios. The frequency and intensity of extreme hot weather events are also predicted to continue increasing in all regions. Sea surface temperatures are expected to continue to rise the most in the Baltic Sea and Black Sea, less so in the Mediterranean Sea, and least in the north-east Atlantic.

2.2 Changes to precipitation (rainfall and snow)

Europe has also seen significant changes in precipitation volumes and patterns, which are consistent with global and regional climate models, However, while overall precipitation has increased, there are marked regional variations. Northern Europe is becoming wetter overall, but drier in summer. Southern Europe is becoming drier, especially in winter. Under low and high-emission scenarios, overall precipitation is projected to continue increasing in northern Europe, decrease in southern Europe, and change little elsewhere. However, winter precipitation is expected to continue to increase in most of Europe.

The frequency of extreme rainfall events has increased in northern, western and central-eastern Europe. This, together with some land-use changes, has led to an observed increase in river and pluvial (i.e. direct rainfall) flooding in western, central Europe and northern Europe. Mountain regions are especially prone to such events, with cascading effects leading to floods, landslides and lake outbursts. In lowland coastal areas, compound flooding has occurred as a result of high river levels coinciding with sea storm surges.

Extreme events are expected to become more frequent under the low and high-emission scenarios for most areas, excluding the Mediterranean. Overall, heavy daily

[143] Cassou, C. and Cattiaux, J. (2016), Disruption of the European climate seasonal clock in a warming world, Nature Climate Change, 6 (6), pp. 589-594.

precipitation in winter is likely to increase by up to 35% by the end of the century. Summer heavy rain is also projected to increase in most of Europe, although some regions in the south are predicted to experience reductions[144]. In northern and eastern Europe, increases in pluvial flooding are expected in scenarios with global warming over 2°C while river flooding will decrease. In western and central Europe, both pluvial and river flooding are expected to increase with global warming above 2°C.

Despite the overall increase in rainfall, as a result of increased evaporation, there has been a general drying trend, especially in southern and central-eastern Europe. The absence of precipitation during prolonged droughts has led to low river levels and the depletion of groundwater aquifers. By 2050, droughts are expected to increase in frequency in eastern, central and southern Europe, particularly in the Mediterranean, under all climate scenarios.

The amount and number of days with snowfall continues to decrease. Together with warming, this has led to shorter periods with snow cover, increased glacier retreat and thinning, and reduced meltwater. These trends are expected to continue under all emissions scenarios.

2.3 Changes to wind patterns

Over recent decades, wind speeds have shown considerable anomalies compared with average conditions, including periods of frequent and very severe storms, contrasting with some near-record low windspeeds. Although no clear trend is apparent so far, the IPCC AR6 report projects likely **increases in severe windstorms** in Northern Europe and possibly Central Europe, and likley decreases in Southern Europe.

2.4 Fire-weather conditions

High temperatures and dry conditions have led to an increase in the weather conditions conducive to triggering and sustaining wildfires, called fire-weather (or fire-danger) conditions. Such conditions have been observed more widely over Europe, both earlier and later in the year. Climate projections indicate that this pattern is expected to continue.

At 2°C of global warming, the number of additional days per year with high to extreme fire danger, compared to 1981-2010, is predicted to increase by over 10 in parts of Italy, much of France and the Balkan peninsula; and by over 20 in most of Portugal and Spain[145].

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[144] Detailed maps on the projected changes in summer and winter temperatures and total precipitation across Europe under a 1.5°C, 2°C and 4°C warming scenario (relative to 1995-2014) are available on the IPCC WG1 Interactive atlas: IPCC Regional Assessment Report: Europe, Working Group 1, (2021) https://www.ipcc.ch/report/ar6/wg1/downloads/factsheets/IPCC_AR6_WGI_Regional_Fact_Sheet_Europe.pdf.

[145] EEA (2020), State of Nature in the EU: Results from reporting under the nature directives 2013-2018, EEA Report No 10/2020, European Environment Agency, Copenhagen.

2.5 Sea-level rise

Sea levels have risen over most coastal regions in Europe since 1900, except for the northern Baltic coast due to the continuing post-glacial rebound from the ice age. This is expected to continue at a rate similar to or faster than the global average. In Europe for 2081-2100, relative sea-level rise is expected to range from 0.4-0.5 m under the SSP1-2.6 scenario to 0.7-0.8 m under the SSP5-8.5 scenario[146].

The combination of the projected increases in severe windstorm in Northern Europe with sea-level rise increases the risk of coastal erosion, flooding, salt water intrusion and impact on coastal and marine biodiversity. This, in turn, may lead to severe disruption to the affected coastal ecosystems and damage to their particularly important and vulnerable Natura 2000 sites.

[146] Climate Change 2021 – The Physical Science Basis .
Working Group I Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, pp. 1767 – 1926.

ANNEX 2

POTENTIAL IMPACTS OF CLIMATE CHANGE ON BIODIVERSITY

1. How climate change impacts species and ecosystems

According to the IPCC terminology, changes in physical climate system conditions (e.g. means, events and extremes) that affect ecosystems or society are known as climate impact drivers. Climate impact drivers can have a wide range of interacting impacts on species and ecosystems via several mechanisms, which also interact with other influential factors. The outcomes of these impacts may include changes in the distribution, size and condition of protected habitats and species populations. The full range of biodiversity impacts are described in Scheffers et al. (2016)[147], and the main impacts in Europe are summarised below, with some specific examples based on IPBES[148], Foden et al. (2019)[149], the IPCC AR6 report on ocean and coastal ecosystems[150] , terrestrial and freshwater ecosystems[151], EUCRA[152] and other key European studies listed in the bibliography.

While the impacts of climate change can be described in various ways, it is useful to describe them in terms of their underlying mechanisms as this can help identify the best forms of adaptation action. In summary, the following main types of interacting mechanisms can result in impacts on species (from the individual organism to population level), on ecosystems and on HD habitat types.

Climate change impacts on species may firstly arise as a result of the direct effects of abiotic changes in climate impact drivers, such as changes to temperatures and precipitation. Some of the most frequent and widely documented climate change impacts are in the timing of events (phenology). Many studies have revealed that spring events are happening earlier and the growing seasons in temperate regions are lengthening. In the marine environment, fish migrate to cooler or deeper waters, and invasive species spread if they are better adapted to the new conditions.

The direct physiological effects of climate changes can be more significant for sensitive species, such as leading to lower reproduction rates and higher mortality rates. Physiological stress can also increase susceptibility to disease and pests. For example,

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[147] Scheffers, B R, De Meester, L, Bridge, T C et al. (2016) The broad footprint of climate change from genes to biomes to people. Science, 354(6313), aaf7671.
[148] IPBES (2018), The IPBES regional assessment report on biodiversity and ecosystem services for Europe and Central Asia, Zenodo.
[149] Foden, W. B., Young, B. E., Akçakaya, H. R., et al. (2019), Climate change vulnerability assessment of species, WIREs Climate Change No 10 (1), e551.
[150] Cooley, S., Schoeman, D., Bopp, L., et al. (2022), Oceans and Coastal Ecosystems and Their Services, in: Climate Change 2022: Impacts, Adaptation and Vulnerability, Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, et al. (eds.)], Cambridge University Press, Cambridge, UK and New York.
[151] Parmesan, C., Morecroft, M.D., Trisurat, Y., et al. (2022), Terrestrial and Freshwater Ecosystems and Their Services in: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor. et al. (eds.). IPBES-IPCC co-sponsored workshop report on biodiversity and climate change, Cambridge University Press, Cambridge, UK and New York, USA.
[152] European Climate Risk Assessment, EEA Report No 1/2024, (EEA 2024).

pan-European forest monitoring has revealed that warm summers and high seasonal variability in precipitation have increased the likelihood of tree death, with tree mortality hot spots in southern and northern Europe[153].

Species are also widely and substantially impacted by changes in the abiotic condition of their habitats as a result of climate change, such as changes to snow and ice levels, soil moisture, water levels and water chemistry. Particularly influential habitat-related pressures resulting from the combination of higher temperatures and lower summer rainfall have reduced ground and river water levels and increased the areas subject to regular fires. Sea-level rise combined with more extreme storms is also leading to increased coastal flooding and erosion.

The most significant observed climate change pressures generally result from complex biotic interactions between species. The pressures may arise where the timing of key events for species are no longer in synch, for example peak predator food requirements when breeding and the availability of prey, or plant flowering and the emergence of their pollinators. Other, often more significant pressures result from changes in species that another depends on (such as prey, pollinators and dispersers) or are detrimental (e.g. competitors, predators, parasites, pathogens). Changes in each species may then have cascade effects on others, potentially leading to complex profound ecosystem changes such as changes in HD habitat type.

While there is strong evidence that species and ecosystem impacts have resulted from gradual changes in the climate, such as average temperature and overall rainfall, the impacts of increased variability are less certain. There are growing indications that large-scale simultaneous disturbance events (such as flooding or extreme drought) increase population fluctuations and the risk of local extinctions, especially of small populations and short-lived species. For example, droughts have been found to be more of a threat to the Lesser Kestrel (*Falco nuamanni*) in southern Europe than gradual climate change[154]. **As some Natura 2000 habitats and species are highly localised, the impact of an extreme event affecting them could be significant.**

The IPCC AR6 also highlights that global evidence indicates with high confidence that the combination of internal variability and longer-term climate trends is pushing ecosystems to tipping points, beyond which abrupt and possibly irreversible changes are occurring. Such impacts have been observed in the European marine environment, where very high water temperatures have caused shifts in the distribution of species (e.g. kelp and other seaweeds, as well as fish), driven regime shifts and caused local extinctions. Southern Eurasian boreal forests may also reach an abrupt tipping point over the next two to three decades under a high-emissions scenario[155].

Climate events and trends that are likely to be damaging are referred to as 'hazards' according to IPCC terminology (see glossary). However, amongst nature conservation scientists and authority staff, including when reporting under the Nature Directives, hazards are normally referred to as pressures or threats (when expected in the future).

[153] Neumann, M., Mues, V., Moreno, A., et al. (2017), Climate variability drives recent tree mortality in Europe, Global change biology, 23(11), pp. 4788-4797.
[154] Marcelino, J., Silva, J., Gameiro, J., *et al.* (2020), Extreme events are more likely to affect the breeding success of lesser kestrels than average climate change, Scientific Reports, 10 (1), pp. 1-11.
[155] Rao, M.P., Davi, N.K., Magney, T.S., et al. (2023), Approaching a thermal tipping point in the Eurasian boreal forest at its southern margin, Communications Earth & Environment, 4(1), 247.

Given that this guidance is written primarily for conservation managers and authorities, the terms ‘pressure’ and ‘threats’ are mainly used here, except in direct quotes.

Whether a climate impact driver is a pressure or threat depends on the habitat and species involved and its context (e.g. the conservation objectives for a Natura 2000 site). For example, an increase in temperature might be detrimental for some habitats and species and beneficial for others in some sites, and the reverse in other sites. The relationship between climate impact drivers, habitats and species may also be nonlinear: beneficial up to a point before becoming detrimental, and/or complex due to interactions with other climate components or environmental changes.

The impacts of climate change interact with other existing pressures on habitats and species, such as land-use change including due to intensive agriculture practices, habitat management, invasive alien species, pollution and infrastructure development. For many Natura 2000 habitats and species, climate change-related pressures have been so far relatively low compared to others[156]. Nevertheless, **even relatively small additional pressures can lead to population declines that push the species beyond a threshold** where the survival or reproductive rates fall below the level needed to maintain the population. Indeed, **as many Natura 2000 habitats and species already have an unfavourable conservation status**[157]**, they may have limited capacity to absorb additional pressures.**

It is particularly concerning that some non-climate change pressures are increasing as a result of climate change. For example, the effects of climate warming on food web structure and stability favour the success of invading species[158]. Disease and pest outbreaks are also expected to increase and spread, as shown by the expansion of the small spruce bark beetle (*Ips amitinus*) into northern Europe[159].

2. Climate change impacts on species populations and habitats

For some species, the overall outcome of the combined impacts of climate change impact drivers are changes in population size (as result of changes in mortality and reproduction) and distribution. The changes may be positive, negative or variable depending on the species, habitat type and local circumstances. The impacts of climate are expected to vary over each habitat’s or species’ range, depending on whether the climate changes make the situation more or less favourable.

This means that range expansions are expected along what is known as the ‘leading edge’ of a species’ or habitat’s distribution in relation to climate, which is where the

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[156] https://tableau-public.discomap.eea.europa.eu/views/sonpressuresandthreats/Pressuresandthreats?%3Adisplay_count=n&%3Aembed=y&%3AisGuestRedirectFromVizportal=y&%3Aorigin=viz_share_link&%3AshowAppBanner=false&%3AshowVizHome=n

[157] EEA (2020) State of Nature in the EU: Results from reporting under the nature directives 2013-2018, EEA Report No 10/2020, European Environment Agency, Copenhagen.

[158] Sentis, A., Montoya, J.M. and Lurgi, M. (2021), Warming indirectly increases invasion success in food webs, Proceedings of the Royal Society B: Biological Sciences, 288(1947), 20202622.

[159] Økland, B., Flø, D., Schroeder, M., et al. (2019) Range expansion of the small spruce bark beetle Ips amitinus: a newcomer in northern Europe, Agricultural and Forest Entomology, 21(3), pp. 286-298.

direction and gradient of warming is creating more suitable conditions[160]. Local extinctions are expected along the 'trailing edge' of distribution, where conditions are becoming unsuitable, for example too warm. In Europe, the resulting range expansions from climate change tends to be towards the north, higher altitudes and in deeper water. Conversely, range contractions are generally anticipated in the south, at lower altitudes and at shallower depths.

There is now clear wide-ranging documented evidence of the expected impacts of climate changes in Europe at the leading edge of species' distributions, with the species range shifting predominantly northward. This has been documented across a broad range of plant and animal groups in Europe, including butterflies, dragonflies and birds , and marine zooplankton, benthic invertebrates and fish[161]. **Terrestrial species are also moving to higher altitudes in land ecosystems.** For example, over a century, mountain plants in the Alps have shown a consistent upward shift of at least 100 elevational meters, with 49 out of the 125 investigated species now at higher altitudes in the region than previously recorded[162]. **In marine ecosystems, as well as moving northward, some species are moving to deeper water**. This has been observed in the well-studied North Sea, amongst benthic invertebrates[163] and demersal fish[164]. There is less evidence of species' range contractions at their trailing edge, which may be due in part to time lags and difficulties in distinguishing declines from climate change and other factors. However, amongst Arctic-Alpine plants, the Glacier Buttercup (*Ranunculus glacialis*), is experiencing habitat loss due to rising temperatures[165].

According to Huntley (2007)[166] the observed movements of species generally appeared to be approximately equal to the rate of movement needed to track climate changes. More recent analyses have indicated that movements and range shifts in some species lag behind the changes expected based on their underlying physiology or general climatic limits giving rise to 'climate debt'. For example, whilst many benthic invertebrates in the North Sea have shown north-westerly range shifts (on their leading and trailing edges), changes have been slower than shifts in sea temperatures, resulting in many species experiencing increasing temperatures[167].

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[160] Huntley, B. (2007). Climatic change and the conservation of European biodiversity: Towards the development of adaptation strategies, Convention on the Conservation of European Wildlife and Natural Habitats, Standing Committee 27th meeting, Strasbourg, 26-29 November 2007, Council of Europe, Strasbourg.

[161] Poloczanska, E.S., Burrows, M.T., Brown, C.J. et al. (2016), Responses of marine organisms to climate change across oceans. Frontiers in Marine Science, 3, p.62.

[162] Frei, E., Bodin, J. and Walther, G-R. (2010), Plant species' range shifts in mountainous areas–all uphill from here? Botanica Helvetica, 120 (2), pp. 117-128.

[163] Hiddink, J.G., Burrows, M.T., and García Molinos, J. (2015), Temperature tracking by North Sea benthic invertebrates in response to climate change. Global Change Biology. 21, pp. 117–129.

[164] Perry, A.L., Low, P.J., Ellis, J.R. et al. (2005), Climate change and distribution shifts in marine fishes. Science 308, pp. 1912–1915.

[165] Guisan, A., Broennimann, O., Buri, A., et al (2019), Climate change impacts on mountain biodiversity. Biodiversity and climate change, pp. 221-233.

[166] Huntley, B. (2007). Climatic change and the conservation of European biodiversity: Towards the development of adaptation strategies, Convention on the Conservation of European Wildlife and Natural Habitats, Standing Committee 27th meeting, Strasbourg, 26-29 November 2007, Council of Europe, Strasbourg.

[167] Hiddink, J.G., Burrows, M.T., and García Molinos, J. (2015), Temperature tracking by North Sea benthic invertebrates in response to climate change. Global Change Biology. 21, pp. 117–129.

As in the case of lowland forest herbaceous plants in France[168] climate debt may, at least in part, be due to species being able to tolerate suboptimal climate conditions. However, there is also evidence that some species are hampered in adapting to climate change through movements and range expansion due to:

- intrinsic biological constraints on dispersal and colonisation (see annex 2, section 3);
- restricted ranges and small population sizes;
- populations / habitats already being in poor condition and declining;
- bounded distributions (e.g. islands, mountain tops, high latitudes);
- blocked dispersal routes (e.g. by mountains, fragmented habitat);
- dependence on specific habitats or prey that are more vulnerable than the species to climate change.

Habitat types are also shifting in response to climate change pressures, as observed with the replacement of areas of alpine heath with forest habitats. However, shifts in the distribution of habitats tend to be slow, in part due to the long-generation time of their keystone species, such as trees. At the same time, the community composition of many habitats is unlikely to remain intact or be replicated as they form in new areas, because climate change will impact the constituent species to varying degrees. Indeed, there is already a general pattern of increasing relative abundance of heat-loving or heat-tolerant species in species communities. These in turn change the ecosystem structure and other ecosystem characteristics and functions. Hence, as climate change progresses, new types of habitat are forming, and some current habitats (including HD habitats) may change sufficiently to become no longer recognisable. Such changes may be accompanied by local losses of some specialist species (e.g. HD species) that are highly dependent on the habitat.

Whether the potential distribution of habitats and species expands or contracts is largely dependent on whether the area with a suitable climate (the climate space or climate envelope) for them increases or decreases[169]. The eventual actual distribution of habitats and species will also depend on interactions with other species and factors, such as land use, which can also be altered due to climate change.

The **climate space ratio** is the area where, at a certain time, there are expected suitable climate conditions that make up a proportion of the habitats' or species' current or recent range. It is an important metric that indicates potential overall climate impacts. For example, a ratio of 25% by 2030 would suggest that by that time, the species' range will reach a quarter of its current area. A ratio over 100% indicates the potential for the species' distribution to expand, depending on other conditions, especially the presence of suitable habitat.

Increases in the potential range and area of a habitat depend on the suitable climate space coinciding with areas that are suitable for them in all other critical ways (e.g. soil type, hydrology, altitude, aspect). The redistribution of habitats may also

[168] Bertrand, R., Lenoir, J., Piedallu, C., et al. (2011), Changes in plant community composition lag behind climate warming in lowland forests, Nature, 479(7374), pp. 517-520.
[169] Watling, J.I., Brandt, L.A., Mazzotti, F.J., & Romañach, S.S. (2013), Use and interpretation of climate envelope models: a practical guide, University of Florida.

be constrained by natural barriers, such a high-altitude areas separating plains, and the converse. Artificial barriers, such as urban areas and intensively managed farmland and forests may also constrain habitat redistribution. Human interventions may therefore be needed to help establish habitats in new areas of suitable climate space.

Similarly, increases in species distribution can only occur if there is suitable habitat for them within the new climate space, or if there is the potential for suitable habitat to develop. It is important to bear in mind that a species' current climate envelope may primarily reflect its habitat, location and conditions as it is now. Under future conditions, the distribution of species will primarily depend on its habitat distribution, which may not be closely linked to climatic factors. It may also take a long time for habitats to develop (perhaps decades) in new areas with a suitable climate, causing a lag effect.

Increases in a species' distribution will also depend on its ability to disperse and reach new areas with suitable climate and habitats. As mentioned above, whilst there is evidence that species can move in response to climate change, many may be limited by dispersal and colonisation constraints (e.g. limited dispersal abilities, physical barriers to movement, low levels of breeding productivity, or lack of suitable habitat).

Given these constraints on the ability of habitats and species to move to, colonise and remain exist in new areas with suitable climates, another important metric is the **projected degree of overlap between a species' or habitat's current and projected climate space**. A low overlap between current and future modelled climate space suggests that the species will need to move to new areas with a suitable climate to maintain the total area of their range. Low levels of overlap may therefore result in substantial range and population impacts on some species.

Observed impacts on species and ecosystems provide clear and strong evidence that a comprehensive, well-managed and well-connected Natura 2000 network, together with other protected areas, will be of fundamental importance for the future of Natura 2000 habitats and species. For species and habitats with high degrees of overlap between existing and projected climate space, Natura 2000 sites can be expected to continue to hold a high proportion of their biogeographical population or habitat area.

Even where the amount of suitable climate space and coinciding suitable habitat is projected to decrease substantially within the network, it is likely that Natura 2000 sites will be more resilient and provide more suitable conditions than areas outside[170]. The network should provide the principal means of maintaining or achieving favourable conservation status.

For species and habitats with low levels of overlap between existing and projected climate space, for example, fish and molluscs in European river catchments[171], protected areas will provide high-quality habitat ('space for nature'), that can facilitate the colonisation and range expansion of species as they respond to climate change. However, **it is important to ensure that protected areas respond to the implications**

[170] Regos, A., D'Amen, M., Titeux, N., et al. (2016), Predicting the future effectiveness of protected areas for bird conservation in Mediterranean ecosystems under climate change and novel fire regime scenarios. Diversity and Distributions, 22(1), pp. 83–96.

[171] Markovic, D., Carrizo, S., Freyhof, J. et al. (2014), Europe's freshwater biodiversity under climate change: Distribution shifts and conservation needs, Diversity and Distributions, 20(9), pp. 1097-1107.

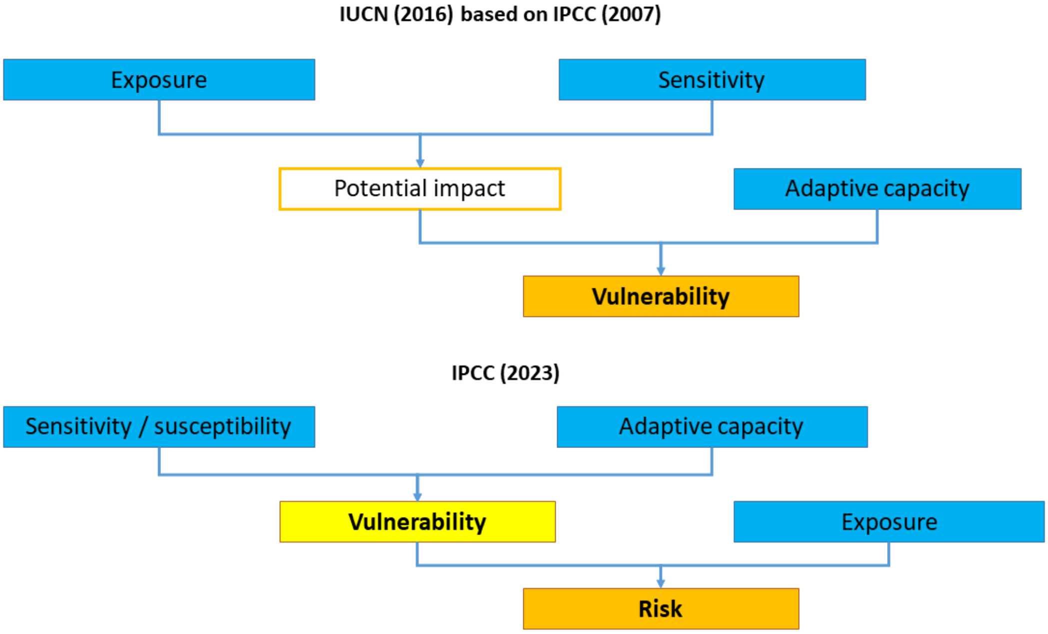
of climate change. This means identifying and addressing current and future gaps in coverage, such as through new site designations and/or expansions, and/or boundary modifications (see chapter 2, section 2.3.6 and annex 4, section 2.2).

3. Factors that affect climate change risks for habitats and species

The IUCN and most conservation scientists consider that the potential impacts of climate change are dependent on two key factors: exposure and sensitivity. **Exposure** is the degree to which an ecosystem, habitat or species is exposed to significant climate impacts drivers (e.g. average temperature increases or extreme events). **Sensitivity** is the degree to which an ecosystem, habitat or species is affected, either adversely or beneficially, by the climate change impact drivers.

It does not matter how sensitive a habitat or species is to a particular climate change impact driver, if it is not exposed to the drivers, and vice versa. **To be potentially impacted, a habitat or species must be both sensitive to and exposed to the same climate change impact drivers.**

Annex 2 – Figure 1 Climate change risk factors for habitats and species



Sources: Gross et al., (IUCN) (2016)[172] and interpretation of IPCC (2023)[173] definitions of vulnerability and risk.

[172] Gross, J. E., Woodley, S., Welling, L. A., et al. (2016), Adapting to Climate Change: Guidance for protected area managers and planners, Best Practice Protected Area Guidelines Series No. 24, IUCN, Gland, Switzerland.
[173] IPCC (2023) AR6 Synthesis Report. Climate Change 2023, Intergovernmental Pannel on Climate Change, Cambridge University Press, Cambridge, UK and New York, USA. https://www.ipcc.ch/report/ar6/syr/.

According to Foden et al. (2019)[174], the factors that contribute to a species' sensitivity to climate change impact drivers typically include:

- dependency on a specialised habitat and/or microhabitat;
- environmental tolerances or thresholds that are likely to be exceeded due to climate change;
- dependence on environmental triggers that are likely to be disrupted by climate change;
- dependence on interspecific interactions that are likely to be disrupted by climate change;
- rarity;
- sensitive life history (e.g. long generation length and slow growth rates);
- high exposure to other pressures (such as from invasive species, or land abandonment).

Fundamentally, the potential impacts of a species' exposure to climate change impact drivers may be mediated to some extent by its ability to adapt to climate change.

In general, a species' potential adaptation responses to climate change follow one or more of the following responses, which this guidance aims to enhance:

- Stay and adapt (*in situ*) through:
  - withstanding declines in survival and productivity;
  - behavioural change (e.g. switching to new prey types);
  - natural selection of existing genotypes (i.e. of individuals in a population that are better suited to the new conditions);
  - macro-evolution (i.e. creating new genetic forms that are better adapted to the new conditions), but this process is normally slow and may only aid adaptation in species with short generations).
- Move to new locations with suitable climatic conditions, through:
  - small-scale movements, e.g. in existing Natura 2000 sites (altitude, depth, aspect);
  - dispersal and colonisation of new sites.

Consequently, according to the IUCN, overall vulnerability to climate change (i.e. risk of actual impacts) 'is a function of the character, magnitude and rate of climate change to which the system is exposed, its sensitivity and its adaptive capacity' based on the IPCC (2007). Although alternative definitions have been presented since the IPCC AR5, these have not been widely adopted within the conservation community[175] [176].

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[174] Foden, W. B., Young, B. E., Akçakaya, H. R., et al. (2019), Climate change vulnerability assessment of species, WIREs Climate Change No 10 (1), e551.
[175] Foden, W. B., Young, B. E., Akçakaya, H. R., et al. (2019), Climate change vulnerability assessment of species, WIREs Climate Change No 10 (1), e551.
[176] Duffield, S. J., Morecroft, M. D., Pearce-Higgins, J. W., et al. (2024), Species- or habitat-based assessments of vulnerability to climate change? Informing climate change adaptation in Special Protection Areas for birds in England, Biological Conservation, 291, 110460.

According to the current IPCC AR6[177], vulnerability is 'the propensity or predisposition to be adversely affected' which 'encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt'. Annex 2 - Figure 1 includes a schematic interpretation of the IPCC definition to illustrate how it differs from that recommended by IUCN, as still used in most climate change vulnerability assessments of habitats and species.

As a result of the substantial differences in its definition and assessment, this guidance avoids the use of the term 'vulnerability' where this is appropriate. Instead, it uses the more generic term of 'risk', as defined in the IPCC AR6 as 'the potential for adverse consequences for human or ecological systems, recognising the diversity of values and objectives associated with such systems' (see Glossary for further explanation). EUCRA[178] uses the same risk concept and definition of the IPCC AR6. As indicated in annex 2 - Figure 1, in practice, similar components are considered in the assessment of vulnerability as recommend by the IUCN and risk under the IPCC system. Where the results of vulnerability assessments are referred to later in this guidance, unless otherwise indicated, they use the IUCN terminology and approach shown in annex 2 - Figure 1.

Factors that affect a species' capacity to adapt to climate change include intrinsic attributes, such as its ability to change morphology, physiology or behaviour in response to environmental change. These attributes affect a species' ability to stay and withstand climate change. They depend on the species' phenotypic plasticity (i.e. variation within a genotype) and evolvability (i.e. genetic change). Another adaptive response may be move to and colonise new suitable locations, depending on the species' ability to disperse. Extrinsic factors may constrain a species' adaptive capacity, such as habitat fragmentation, reducing the capacity of a species to disperse.

Therefore, as discussed further in annex 3, section 1 on adaptation principles, adaptation measures usually first aim to support autonomous adaptation to climate change by increasing resilience and then, where necessary, to reduce extrinsic constraints on movements.

[177] IPCC (2023) *AR6 Synthesis Report. Climate Change 2023*, Intergovernmental Pannel on Climate Change, Cambridge University Press, Cambridge, UK and New York, USA.
[178] European Climate Risk Assessment, EEA Report No 1/2024, (EEA 2024).

ANNEX 3

A CLIMATE ADAPTATION FRAMEWORK FOR NATURA 2000

1. Key steps in creating an adaptation framework for the Natura 2000 network

An adaptation framework for the Natura 2000 network could be integrated within the national adaptation planning cycles, allowing for synergies with related policy actions, flexible timing, data use and prioritisation. This would be relevant in particular for the national restoration plans under the Nature Restoration Regulation and the National Energy and Climate Plans (NECPs).

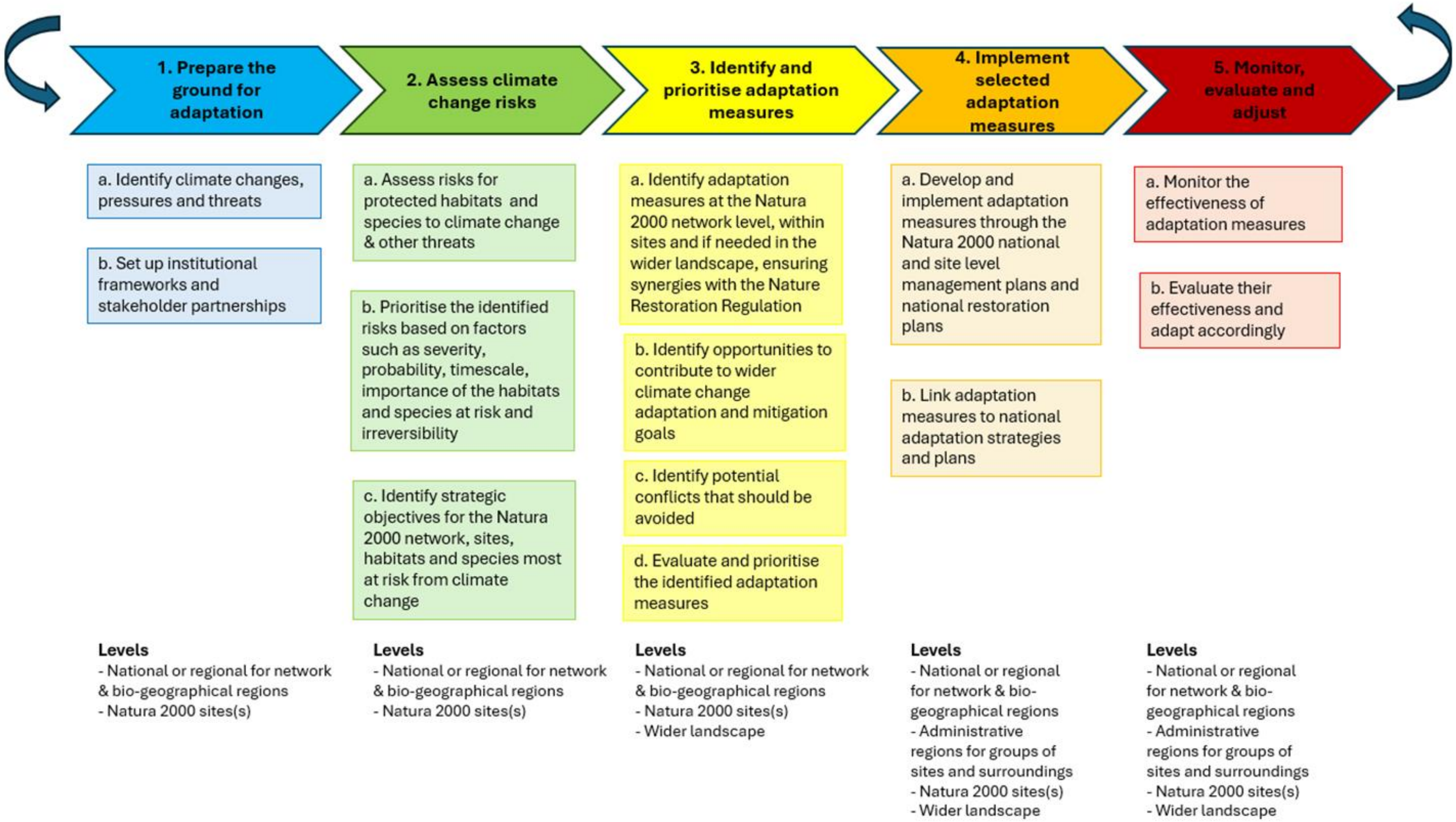
If applied to Natura 2000, existing climate adaptation frameworks would typically include the following steps:

- **assess climate change risks** for ecosystems, habitats and species;
- develop strategies and practical measures that **increase the resilience** of ecosystems, habitats and their associated species populations to climate change, thereby improving their *on-site* adaptive capacity;
- develop strategies and practical measures that **accommodate changes** by **facilitating the movemen**t of species and habitats to new areas with suitable climatic conditions.

The decision framework outlined in this guidance (Annex 3 - Figure 1) builds on these key steps, taking into account important developments in adaptation planning, including the IUCN guidance on climate change adaptation for protected area managers and planners[179]. The decision framework closely follows the European Commission Guidelines on Member State's adaptation strategies and plans[180] and the Adaptation Support Tool[181], with some adjustments to reflect the specific needs and terminology for the Natura 2000 network.

[179] Gross, J. E., Woodley, S., Welling, L. A., *et al.* (2016), *Adapting to Climate Change: Guidance for protected area managers and planners*, Best Practice Protected Area Guidelines Series No. 24, IUCN, Gland, Switzerland.
[180] Commission Notice Guidelines on Member States' adaptation strategies and plans 2023/C 264/01, OJ C 264, 27.7.2023, p. 1–31.
[181] https://climate-adapt.eea.europa.eu/en/knowledge/tools/adaptation-support-tool

Annex 3 – Figure 1 Proposed climate adaptation framework for Natura 2000.



The framework may be applied to:

- the Natura 2000 network at national or biogeographical level and the marine regions; and
- the Natura 2000 sites at risk.

The framework may be applied to the Natura 2000 network and sites for which climate pressures and threats to Natura 2000 habitats and species have been identified, considering their wider landscape if necessary. The initial assessment of climate changes and potential pressures and threats could be carried out at a network or regional level, with information shared with relevant sites. In the interest of efficiency, it may be useful to apply the framework to groups of sites (e.g. wetlands) by sharing information and resources. This might involve nature authorities at national, regional, local or site level, and collaboration between them.

Adaptation measures for Natura 2000 sites may involve external action in surrounding landscapes and/or areas of sea. This is likely to involve collaboration with a range of authorities and stakeholders, at various levels in order to plan and implement such external adaptation measures.

Potential adaptation measures that may be taken at network level, at site and at wider landscape level are covered in more detail in annex 4.

1.1 Step 1: Prepare the ground for adaptation

Step 1 of the framework is designed to help:

- gain an initial general understanding of the expected climate changes, pressures and threats across the country / regions and the Natura 2000 network;
- identify stakeholders and build institutional capacity and strategic partnerships to support planning and implementation.

Step 1a: Review expected climate changes and identify pressures and threats

The first step is to get an initial general understanding of the observed and expected changes in climate across the country/regions and Natura 2000 network and the resulting likely climate impact drivers. This information can then be used to identify sites that are already affected to some extent (climate change is a pressure) or are expected to be most affected and are likely to face significant impacts on Natura 2000 habitats and species (climate change is a threat). The collated climate information can then feed into similar initial assessments at Natura 2000 site level and the work to identify site-specific climate pressures and threats to Natura 2000 habitats and species. Based on the pressures and threats identified, an initial prioritisation of sites, habitats and species can be made for adaptation planning and detailed climate risk assessments.

The work to identify potential climate change threats should be based on the most up-to-date and robust climate data, and the likely range of climate change scenarios as discussed in annex 1.

Step 1b: Set up institutional frameworks and stakeholder partnerships

Another key adaptation requirement is **the engagement of a diverse range of stakeholders to support integrated and transdisciplinary approaches to climate change adaptation in protected areas**[182]. This is because, for it to be successful, the approach must embrace multiple issues such as conservation objectives, potential climate impacts, other interacting threats, institutional settings, policies, legislation and civil society. This is especially the case for Natura 2000 as the vast majority of sites are subject to important economic and social uses in rural areas, such as agriculture, forestry, fisheries, recreation and tourism. Well-designed, interdisciplinary planning (especially large-scale) and implementation of the adaptation measures in close cooperation with a range of stakeholders are also ways to minimise the risk of maladaptation.

Therefore, it is essential to secure **the active and early involvement of all relevant sectors and stakeholders in drawing up and implementing management and conservation policies**. This is crucial to reduce conflicts and maximise synergies between climate change adaptation for biodiversity and opportunities for nature-based adaptation and mitigation (as described in chapter 3). To achieve this, an important preparatory step is to secure the necessary institutional capacity (see Guidelines on Member State's adaptation strategies and plans[183]). As climate change threats cover wide areas and affect many transboundary Natura 2000 sites, dialogue and planning should also take place between neighbouring Member State authorities, especially for sites that are part of large international ecosystems (e.g. rivers and coasts).

To facilitate the interdisciplinary and cross-sectoral approach to climate adaptation planning and measures, **creating strategic long-term partnerships with all key stakeholders is recommended, at national (and transnational if needed), regional and site levels.** These should involve representatives from all relevant institutions, landowners and sectors affecting Natura 2000, including water, agriculture, forestry, fisheries, energy, civil protection, flood control and tourism/recreation. The partnerships should share knowledge to establish who may be affected by climate change and how, and to identify adaptation and mitigation options (including nature-based solutions), potential conflicts and win-win situations, and opportunities for collaboration and funding sources. A key aim is to obtain wide stakeholder ownership of, and commitment to, agreed adaptation plans and measures.

An example of how partnerships can support climate change has been shown in the LIFE Natur'Adapt project carried out by Reserves Naturelles de France (see case study 6).

Case study 6: LIFE NATUR'ADAPT

The objective of the LIFE Natur'Adapt project was to mainstream climate change considerations into the management of natural protected areas. More specifically, it developed a methodology for site managers on how to adapt to climate change. It also created a community of experts and practitioners to share knowledge and experience in carrying out

[182] Rannow, S., Macgregor, N.A., et al. (2014a), Managing protected areas under climate change: challenges and priorities. Environmental Management No 54 (4), pp. 732-743.
[183] Commission Notice Guidelines on Member States' adaptation strategies and plans 2023/C 264/01, OJ C 264, 27.7.2023, p. 1–31.

climate adaptation measures in protected areas. Over the coming 10 years, the goal is to achieve the integration of climate change into the management planning and practices of 80% of French nature reserves.

The LIFE project was coordinated by *Réserves Naturelles de France* working in close partnership with protected area managers, the National Natural History Museum, and two NGOs: Tela Botanica and the EUROPARC Federation. Financial support for the EUR 4.5 million project was provided by the European Commission via the LIFE Climate Action programme, the French Ministry of Ecology and the French Agency for Biodiversity.

Over 5 years (2018-2023) the project worked on the following three issues:

- **developing tools and operational methods** for site managers to embark on an approach to adapt to climate change (development of a vulnerability diagnosis and an adaptation plan);
- **building a community of experts** around the adaptation of the management of natural areas to climate change, in particular via the Natur'Adapt platform;
- **activating all levers** (institutional, financial, awareness-raising, etc.) needed for the practical implementation of adaptation work.

The different tools and methods were first tested on six project partner reserves. These test sites were selected to be representative of the country's wider environment covering different ecosystems (coastal, wetlands, forests, agri-pastoral and rocky habitats) within the four biogeographical regions of mainland France. They also included a wide range of land uses, activities and administrative structures. The methodology was then reviewed and tested on a further 15 sites before being written up and widely disseminated at national level and across the EU.

The final methodological guide provides practical advice on carrying out a vulnerability and opportunities assessment. On the basis of this guide, users can draw up a climate change adaptation plan for the protected area[184]. It is available in French and English and, although developed and tested on French sites, will be of interest to site managers across Europe, and beyond.

The guide further supported by a series of practical tools and training modules for managers. The online collaborative platform remains active after the end of the project and continues to actively exchange knowledge and best practice (including over 700 members). It is open to all those who are interested to join and share their experiences.

Source: LIFE Naturadapt[185]

[184] Coudurier C., Petit L., Tissot, A. et al. (2023), Natur'Adapt climate change adaptation process – A methodological guide to developing a vulnerability and opportunities assessment and an adaptation plan for a protected area (adapted version for European distribution), LIFE Natur'Adapt – Réserves Naturelles de France, https://naturadapt.com/groups/communaute/documents/776/get.

[185] https://naturadapt.com/ and https://webgate.ec.europa.eu/life/publicWebsite/project/LIFE17-CCA-FR-000089/adapting-nature-protection-to-the-challenges-of-climate-change-in-europe-basis-of-dynamic-collective-learning.

1.2 Step 2: Assess climate change risks for the Natura 2000 network and sites

Step 2 of the framework will help to:

- quantify the risks from climate change threats to protected habitats and species, for the Natura 2000 network and for sites;
- prioritise climate-related risks, taking into account other threats;
- set climate change adaptation objectives for the Natura 2000 network and sites most at risk from climate change threats.

Step 2a: Assess the vulnerability for Natura 2000 habitats and species to climate change and other threats

A climate risk assessment is the foundation for identifying the main concerns and adaptation objectives to reduce the climate risk and thus the adverse impacts of climate change. It determines the nature, extent and likelihood of climate change events and trends and, in turn, their ecological effects and potential impacts on ecosystems, habitats and species (and affected communities), from national / biogeographical to site level. Climate risk assessments should apply to specific time periods, such as short-term (e.g. 2030s), mid-term (e.g. 2050s) and long-term (e.g. 2100s). They should use the best available data, including results from Article 17 HD and Article 12 BD reporting, to quantify the risks and factors affecting them as much as feasible, while also clearly indicating areas of uncertainty and knowledge gaps. Risk assessments should be updated where necessary, including when climate change projections or other scientific data change or improve significantly.

A key component of overall climate change risks to ecosystems, habitats and species is their vulnerability as explained in annex 2, section 3.

Vulnerability assessments apply to climate changes within defined areas, and can therefore be used from national down to site level.

Vulnerability assessments and other forms of climate risk assessments involve analyses of observed (historical) and projected (future) climate, land use, demography, and other important climate and non-climate factors. Different approaches may be taken to data gathering and analysis, depending on its perceived importance, the availability of data and the resources available. At its simplest initial level, it may use expert knowledge, workshops and general risk criteria to produce assessments of relative vulnerability. These may draw on general observed or expected climate change trends for the region, and knowledge of how habitats and species may be affected. For an example of a simple assessment, see Sârbu et al. (2014[186], Figure 17.2) on the potential impacts on alpine vegetation communities from possible site-level climate changes.

Another common vulnerability assessment approach is to draw on expected or observed associations between biological traits and climate change impacts, and to use biological and life history information to score or rank species' sensitivity and adaptive capacity

[186] Sârbu, A., Anastasiu, P. and Smarandache, D. (2014), Potential Impact of Climate Change on Alpine Habitats from Bucegi Natural Park, Romania, in Rannow, S., Neubert, M. (eds), Managing Protected Areas in Central and Eastern Europe Under Climate Change, pp. 259-266, Advances in Global Research, Springer.

(e.g. as used by Sajwaj et al., 2011[187]). Such information can then be combined with assessments of exposure to produce semi-quantitative assessments of vulnerability. More complex vulnerability assessments utilise correlative approaches, or complex mechanistic models, or a combination, to produce quantitative and spatially explicate estimates. Specific guidance on vulnerability assessments is beyond the scope of this document and therefore not explored in detail (for further guidance, see the sources listed in bibliography).

Practical approaches for applying vulnerability assessments to identify Natura 2000 habitats, species and sites most at risk, including the identification of climate refugia and spatial analyses of suitable climate space, are further elaborated in annex 4.

Step 2b: Prioritise the identified risks

The projected climate risks may be prioritised by taking into account their:

- **severity** / magnitude of the impact, as estimated by the overlap or ratio of suitable climate space for a habitat or species;
- **probability;**
- **timescale** (i.e. when significant impacts are expected);
- **importance of the Natura 2000 habitats and species at risk**, giving a high weighting to species that are endemic or near endemic to the EU or an area in the EU, threatened globally, threatened in the EU (i.e. on a Red Data List and/or with a unfavourable-bad conservation status), with a high proportion of the habitat or species population with the network (or site); and species that are of high importance for ecosystem functioning and resilience;
- **irreversibility**, for example in relation to habitats that cannot be feasibly restored, or species populations that are threatened with extinction (global or regional) and would not be able to recolonise (or be translocated from wild populations).

When prioritising climate risks for Natura 2000 network and its habitats and species, it is essential to assess the risks in relation to all other significant pressures and threats. For the majority of habitats and species the most widespread, immediate and severe reported threats relate to habitat change, habitat fragmentation and pollution[188]. It is also important to consider potential interactions between existing threats and climate changes. For example, droughts may lead to increased water abstraction, which lowers water tables and river levels, with detrimental impacts on wetlands.

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[187] Sajwaj, T., Tucker, G.M., Harley, M., et al. (2011), Impacts of climate change and selected renewable energy infrastructures on EU biodiversity and the Natura 2000 network: An assessment framework for climate change vulnerability - methodology and results. Task 2a report to the European Commission under Contract ENV.B.2/SER/2007/0076 Natura 2000 Preparatory Actions – Lot 5: Climate Change and Biodiversity in relation to the Natura 2000 Network, AEA, Axiom, IUCN, IEEP, UNEP & WCMC, Brussels.

[188] EEA (2020) State of Nature in the EU: Results from reporting under the nature directives 2013-2018, EEA Report No 10/2020, European Environment Agency, Copenhagen.

Step 2c: Identify strategic objectives for the Natura 2000 network, sites, habitats and species most at risk from climate change

Based on the climate change vulnerability and risk assessments and consideration of other pressures and threats, strategic objectives for the Natura 2000 network should be drawn up for the short, mid and long-term with the view to optimise adaptation to climate change. The objectives should be drawn up first at the Natura 2000 national network level (and biogeographical regions within) to facilitate coherence and efficiency. The objectives could aim, for example, to increase the coverage of certain habitats and species in the network, improve ecological connectivity between sites, or designate or classify new sites.

Network-level adaptation objectives should inform and where relevant be incorporated into the site-specific conservation objectives that are already required for all species and habitats present on Natura 2000 sites (chapter 2, section 2.3.1). These might, for instance, include recreating lost habitats or increasing the population of certain species that are already present. Other objectives might be to manage the site to encourage colonisation by certain target species that are at a higher risk from climate threats in other parts of the network.

1.3 Step 3: Identify and prioritise adaptation measures

The purpose of the adaptation framework is to support identification and prioritisation and sequencing of actions, recognising that not all measures can or should be implemented everywhere, and that choices must reflect ecological effectiveness, feasibility and socio-economic context.

Step 3 of the framework will:

- identify measures to increase the resilience of Natura 2000 habitats and species and their ability to relocate in response to climate change;
- identify measures for adaptation at the Natura 2000 network level (national, subnational and biogeographical), within sites and their surrounding landscape;
- identify opportunities for adaptation measures to fulfil the obligations under the Nature Restoration Regulation, implemented through national restoration plans;
- identify win-win opportunities where adaptation measures for Natura 2000 may support, or be supported by, wider climate adaptation and mitigation objectives;
- prioritise Natura 2000 adaptation measures.

Step 3a: Identify adaptation measures to tackle climate change risks

Key principles

Based on the climate change strategic objectives for the Natura 2000 network, sites, habitats and species most at risk as identified in the previous step, specific adaptation measures should be identified and implemented, at network, site and if needed wider landscape, taking into account competing land uses, other public interest objectives and socio-economic constraints. The primary aim of such measures is to increase the **adaptive capacity** of ecosystems, habitats and species by:

- **firstly increasing their *in situ* resilience** to climate threats, to enable them to stay and survive, and
- **secondly, where necessary, helping species accommodate climate change** by moving to more suitable locations (either within sites or over longer distances).

Increasing resilience is particularly important because ecosystems and habitats that are in good ecological condition, and species that have thriving populations, are more likely to be able to withstand climate threats (e.g. Natura 2000 habitats and species with a favourable conservation status). As a result, some may be able to persist and adapt to new climatic conditions in their current locations even though they may appear less suitable or even unsuitable in the climate envelope modelling.

As discussed in annex 2, section 2, ‘climate lags’ where some species appear to be shifting range more slowly than anticipated provides evidence that to some extent, this is already happening. Resilience is expected to be higher in healthy ecosystems with intact functions and structures, keystone species, and in diverse native species communities with high genetic diversity, because they are more stable and able to withstand or recover from pressures.

Therefore, for many Natura 2000 habitats and species, **the principal way to increase resilience is to reduce existing pressures and threats on them that in many cases are non-climatic**. Measures should focus on reducing the most significant pressures and threats influencing the Natura 2000 habitats and species, such as from habitat deterioration (e.g. large scale clear-cutting of forests, eutrophication due to intensive agriculture, damage of sensitive marine habitats and species from bottom fishing, habitat fragmentation, pollution), overexploitation, disturbance and invasive alien species. These actions are often referred to as **‘no-regrets measures’** as they should normally be taken anyway for general nature conservation and restoration purposes under current climate conditions.

If action to reduce existing pressures is insufficient, additional more targeted measures might be required to improve habitat condition and bolster species populations, especially for those that are currently not in favourable conservation status. Restoration measures in this respect could include hydrological interventions to restore wetlands, re-establishing diverse river beds and allowing more natural dynamics, active improvement of management regimes by re-introducing extensive grazing or mowing regimes that were abandoned that aim to restore optimal conditions for the habitat’s structure and function, including typical species. Such measures can increase the condition of individuals, productivity and population size, thereby strengthening source populations and increasing the likelihood that individuals disperse successfully and colonise other suitable areas if conditions deteriorate locally.

Restoration or re-establishment of habitats may also help reverse fragmentation and improve ecological connectivity, thereby strengthening populations while also facilitating dispersal between sites. Further actions might include the restoration or re-establishment of additional habitats such as breeding or foraging sites, removing barriers to dispersal (e.g. obsolete dams or other infrastructure that interrupts ecological connectivity) or reintroductions or assisted migration of individuals to increase genetic diversity. Evidence indicates that such interventions can be beneficial, with targeted interventions maximising the persistence of the most vulnerable populations, while expanding habitat management and site protection can benefit the largest number of species and ecosystems[189].

Annex 3 – Table 1 outlines suitable measures for species according to the main types of adaptation constraint. Most importantly, obtaining time to enable new areas of habitat to develop for moving species to colonise will probably be a common need as many species will be able to shift and move faster than their habitats can establish. Indeed, this may be the only option for some species that rely on specific habitat types that take a long time to develop, even with proactive habitat creation interventions.

Annex 3 – Table 1 Suitable adaptation measures for different types of adaptation constraint

Adaptation constraint	**Response**
Temporary gaps in suitable climate space	Boost the resilience of existing populations to gain time
Inability to move to new areas of suitable climate and habitat	Increase dispersal capabilities (or translocate/ assist migration)
Absence of suitable habitat in new areas of suitable climate	Boost the resilience of existing populations (to gain time) and aid habitat restoration or re-establishment
Permanent loss of areas with suitable climate space that coincide with potential habitat	Boost the resilience of existing populations to see if populations can persist, or invest resources elsewhere

Source: Adapted from Tucker and de Soye (2009)[190].

There is scientific consensus that while adaptation measures can prevent or at least slow some detrimental climate impacts, in the long run there will be an increasing need to balance concerted active interventions for specific HD Annex I habitat types (as recognised now) and species within their current sites, with strategies that pursue longer-term broader goals. Recognising that some change is inevitable, long-term adaptation goals should specify what is acceptable in terms of change, as well as being flexible and adaptable as knowledge improves. One reason for this is that because species vary in their response to climate change, some current HD habitat types are likely to diverge in composition. Similarly, some mobile species populations may show marked changes in distribution, as already indicated by shorter migrations by some waterbirds. However, this may not necessarily be detrimental in terms of their flyway population size.

[189] Bowgen, K M., Kettel, E F., Butchart, S H M., et al. (2022), Conservation interventions can benefit species impacted by climate change, Biological Conservation, 269, 109524.
[190] Tucker, G.M., and de Soye, Y. (2009), Impacts of climate change on EU biodiversity policy, and recommendations for policies and measures to maintain and restore biodiversity in the EU in the face of climate change. Tasks 2b & 3b, report to the European Commission under Contract.ENV.B.2/SER/2007/0076 Natura 2000 Preparatory Actions – Lot 5: Climate Change and Biodiversity in relation to the Natura 2000 network, AEA, Axiom, IUCN, IEEP, UNEP & WCMC, Brussels.

The IUCN climate change adaptation guidelines for protected areas[191] recognises that some substantial long-term ecosystem changes are inevitable. Therefore, it is necessary to factor in appropriate levels of intervention in adaptation strategies. Similarly, the 2012 International Conference on Managing Protected Areas under Climate Change (IMPACT)[192] recommended that the Natura 2000 network will need to become more of a functional and dynamic system, supplemented with other areas to improve its coherence[182].

The work to identify measures to increase the adaptive capacity of Natura 2000 habitats and species should include targeted and habitat- and species-specific measures where required to achieve favourable conservation status. This should include action to implement the national restoration plans drawn up under the Nature Restoration Regulation.

Measures to enhance the adaptive capacity of Natura 2000 at network, site and wider landscape level are elaborated in annex 4.

Step 3b: Identify opportunities to contribute to wider climate change adaptation and mitigation goals

After identifying adaptation measures, it is important to look at the impacts of climate change on wider climate change adaptation and mitigation objectives, land/sea users and other stakeholders. As is the case with other elements in the framework, this should be carried out at strategic level (e.g. involving discussions between nature conservation and other sectoral authorities and stakeholder representatives) and then at site level too.

This work can identify broad areas with potentially overlapping co-benefits, such as where habitat restoration could contribute to flood alleviation, erosion reduction, securing water supplies, reducing pollution and increasing carbon storage and sinks. Any such mutual benefits may then be supported through joint action and partnerships (e.g. native forest expansion between nature and forest authorities). This may enable funding to be sought from outside the nature sector, for example in relation to forestry, flood defence and fire risk reduction. This is a critical step in the integration of climate change adaptation requirements for Natura 2000 and wider climate change mitigation and adaptation objectives. Hence the importance given to the establishment of a partnership (see annex 3, section 1.1) involving Natura 2000 authorities, landowners, land/sea users, key businesses, local communities, civil protection and other stakeholders.

Step 3c. Identify potential conflicts that should be avoided

While there may be potential mutual benefits for Natura 2000 from climate mitigation initiatives and adaptation measures from other sectors, there may also be potential conflicts. For example, a flood defence project may negatively affect a Natura 2000 site. If possible, these conflicts should be identified at an early stage through strategic

[191] Gross, J. E., Woodley, S., Welling, L. A., et al. (2016), Adapting to Climate Change: Guidance for protected area managers and planners, Best Practice Protected Area Guidelines Series No. 24, IUCN, Gland, Switzerland.

[192] Under the EU INTERREG project HABIT-CHANGE. http://habit-change.eu/service/home.htm

planning and discussions with stakeholders in order to select the most appropriate measures. This may include considering alternative solutions, such as nature-based approaches that work with natural processes and maintain ecological connectivity. If formal proposals are made for projects or plans that could have a negative impact on a Natura 2000 site, they must be subject to an appropriate assessment in accordance with Habitats Directive Article 6(3).

Step 3d: Evaluate and prioritise adaptation measures

As the assessment of climate change risks and adaptation measures is likely to produce a long list of possible options, it is essential that objective evidence-based prioritisation is made, covering the network, sites and the wider landscape.

Certain considerations can be used to prioritise the adaptation measures, such as:

- ability to tackle the highest priority climate change risks for Natura 2000 habitats and species as identified in step 2b (annex 3, section 2);
- address first the sites where the climate change risks on Natura 2000 habitats and species are expected to be the highest;
- effectiveness and reliability in reducing (mitigating) the projected detrimental climate change impacts on Natura 2000 habitats and species;
- flexibility, prioritising measures that can be easily adjusted at a low cost in response to their results, changes in expected climate risks and other new information;
- contribution to the objectives of the Nature Restoration Regulation;
- potential to contribute to climate mitigation objectives, such as increasing carbon storage and sequestration by restoring carbon-rich habitats (chapter 3, section 3.2);
- potential to reduce other projected detrimental climate change impacts (e.g. nature-based solutions reducing the risks of flooding and other disasters, or providing more reliable water resources), prioritising win-win options and those with multiple benefits (chapter 3, section 3.1);
- cost-effectiveness.

The measures maybe prioritised according to the abovementioned consideration. In particular, **priority should be given to measures that are most likely to support the achievement and maintenance of favourable conservation status for Natura 2000 habitats and species of high conservation importance and highly vulnerable to climate change.**

The selection of adaptation measures should be based on ecological principles and take into account their degree of reliability, according to the best available evidence. Untested measures with an uncertain degree of reliability, risks of maladaptation and high costs (e.g. large-scale corridors) require robust and comprehensive assessments of the likely impacts (including non-environmental impacts) and cost-effectiveness.

While the situation will vary for specific Natura 2000 habitats and species and Natura 2000 sites, **a high priority should be given to measures that increase the *in situ* resilience of ecosystems for both habitats and species by reducing significant threats, and reversing their past impacts. In practice this often means re-enforcing**

and speeding up existing conservation action, such as protecting the most important sites, reducing pollution, controlling invasive alien species, regulating exploitation, managing and restoring semi-natural habitats and species populations.

In some areas, the most important actions will be to increase the resilience of sites to extreme climate events (e.g. fires, floods, storms) as these events are already increasing in frequency and severity (annex 4, section 2.4). Such events, can result in the complete loss or near destruction of habitats and species populations in a site (or e.g. within a river valley) from which they cannot easily recover.

At network level, **increasing the coverage of protected areas is widely recommended as one of the most effective means of meeting the climate adaptation needs** described above[193] [194]. This is based on numerous studies that have shown that protected area networks play a key role in maintaining good-quality habitats ('space for nature') that are resilient to climate change and can be colonised by species as they move in response to climate change[195] [196] [197] [198] [199] [200] [201] [202] [203]. It is also clear that when the protected areas are large and connected through linkages and stepping stones embedded in a permeable matrix, this further promotes population persistence and range expansion[204].

An assessment of the evidence of the benefits of measures to strengthen protected area networks has resulted in **a general order of priorities: the highest priority being to improve site quality, followed by enlarging sites, then adding more sites, then better connecting sites using stepping stones and a more permeable habitat**

[193] Hannah, L., Midgley, G., Andelman, S., et al. (2007), Protected area needs in a changing climate, Frontiers in Ecology and the Environment, 5 (3), pp. 131-138.
[194] Pörtner, H.O., Scholes, R.J., Agard, J. et al. (2021), Scientific outcome of the IPBES-IPCC co-sponsored workshop on biodiversity and climate change, IPBES secretariat, Bonn, Germany, DOI:10.5281/zenodo.4659158.
[195] Gaget, E., Pavón-Jordán, D., Johnston, A., et al. (2021), Benefits of protected areas for nonbreeding waterbirds adjusting their distributions under climate warming, Conservation Biology, 35 (3), pp. 834-845.
[196] Gillingham, P. K., Alison, J., Roy, D. B., et al. (2015), High Abundances of Species in Protected Areas in Parts of their Geographic Distributions Colonized during a Recent Period of Climatic Change, Conservation Letters, 8 (2), pp. 97-106.
[197] Gillingham, P. K., Bradbury, R. B., Roy, D. B., et al. (2015), The effectiveness of protected areas in the conservation of species with changing geographical ranges, Biological Journal of the Linnean Society, 115 (3), pp. 707-717.
[198] Gillingham, P. K., Britton, J. R., Jones, G., et al. (2024), Climate change adaptation for biodiversity in protected areas: An overview of actions, Biological Conservation, 289, 110375.
[199] Hiley, J.R., Bradbury, R.B., Holling, M. et al. (2013), Protected areas act as establishment centres for species colonizing the UK, Proceedings of the Royal Society B Biological Sciences No 280 (1760), pp. 2012-2310.
[200] Johnston, A., Ausden, M., Dodd, A.M., et al. (2013), Observed and predicted effects of climate change on species abundance in protected areas, Nature Climate Change, 3 (12), pp. 1055-1061.
[201] Lawson, C.R., Bennie, J.J., Thomas, C.D., et al. (2014), Active Management of Protected Areas Enhances Metapopulation Expansion Under Climate Change, Conservation Letters, 7 (2), 111-118.
[202] Thomas, C.D., Gillingham, P.K., Bradbury, R.B., et al. (2012), Protected areas facilitate species' range expansions, Proceedings of the National Academy of Sciences of the USA, 109 (35), 14063-14068.
[203] Virkkala, R., Pöyry, J., Heikkinen, R.K., et al. (2014), Protected areas alleviate climate change effects on northern bird species of conservation concern, Ecology and Evolution, 4 (15), 2991-3003.
[204] Keeley, A.T., Ackerly, D.D., Cameron, D.R. et al. (2018), New concepts, models, and assessments of climate-wise connectivity, Environmental Research Letters, 13(7), 073002.

matrix[205] **and finally creating corridors**[206]. These are further described in annex 3 - Table 2.

Further recommendations on the criteria for evaluating climate change adaptation strategies and measures are included in the *Habitat Change Management Handbook*[207].

Annex 3 – Table 2 Typical priorities for designing protected areas and wider ecological (nature) networks

Note. Figures are indicative only and should be used with due regard to local circumstances. Sites do not necessarily refer to a designated site (protected area) but an area of contiguous wildlife habitat.

Better site quality >	**Bigger sites >**	**More sites >**	**Stepping stones and permeable matrix >**	**Corridors**
• Encourage natural processes • Encourage habitat mosaics • Create more niche and welcome ecological disturbances for more species – use 'ecosystem engineers' • Increase messiness (variation of physical structure within sites) • Restore missing biodiversity by increasing niche or by reintroduction • Maintain rare species • Encourage climate colonists (except IAS) • Reduce edge effects by	• Big enough to encourage natural processes – sufficient to ensure functioning ecosystems • Provide space for ecosystem dynamism, supporting mosaics • Reduce edge effects by decreasing the edge: area ratio • Restore fragmented habitats; • Restore degraded habitats surrounding the site • Enlarge sites to > 40 ha (or > 100 ha for wide-ranging species)	• Create larger sites in preference to many smaller sites • Target areas of unprotected irreplaceable habitat or with a long ecological continuity of low-intensity land management • Target areas with complex or additional topography & geomorphology and with a potential to be climate change refugia • Target areas of important habitat potential in the surrounding area • Target degraded areas with potential for high ecosystem service delivery • Ensure connectivity for new sites	• For poorly dispersing species, sites should be < 1 km from each other and < 200 m apart for highly specialised species within a habitat • Expand sites towards existing habitat to reduce space between patches • Increase the cover of semi-natural habitat in landscape • Reduce the intensity and decrease the diversity of land-use in the surrounding countryside • Stepping stones should provide appropriate resources to avoid becoming	• Prefer natural corridors over human-designed corridors • Use linear landscape features • Ensure corridor habitat matches the habitat in core sites • Minimum width of corridors equals 100 m, preferably wider

[205] I.e. improving the ability for species to move through the intervening landscape between patches of habitat.

[206] Crick, H., Crosher, I., Mainstone, C., et al. (2020), Nature networks evidence handbook, Research report NERR081, Natural England, York, UK.

[207] Wilke, C., Rannow, S. and Bilz, M. (2013) HABIT-CHANGE Management Handbook - A guideline to adapt protected areas management to climate change. HABIT-CHANGE Report 5.3.2, Leibniz Institute of Ecological and Regional Development (IOER) and partners, Germany.

buffering sites and encouraging graded eco-tones[208] to 'soften the edge' • Buffer sites with at least a 50 – 100 m buffer strip, possibly up to 500 m wide • Maintain ecological continuity of sustainable management to protect soils		ecological traps (i.e. attract species to poor quality habitats)

Source: Crick et al., (2020)[209][206] with minor adaptations.

1.4 Step 4: Implement the selected adaptation measures

Step 4 of the framework is designed to:

- turn adaptation options into measures with a timetable;
- integrate the selected adaptation measures with the Natura 2000 national and site management planning;
- implement adaptation measures including through the national restoration plan;
- identify synergies and link the adaptation measures to national and regional adaptation planning and the national adaptation strategy and plan.

Once all the climate change adaptation measures have been identified, prioritised and selected, the measures should be integrated into the Natura 2000 national and site-level management plan. The Natura 2000 adaptation measures should be developed in synergy with the national restoration plan required under the Nature Restoration Regulation, as certain adaptation measures can be implemented under the national restoration plan. The adaptation measures should also be linked to the **national adaptation strategy and plan** (required by the European Climate Law).

Key aims of this step should be to scale-up and coordinate action, seek synergies with other sectors, policies and strategies and obtain funding. As discussed earlier (step 1) it is particularly important to **involve a wide range of partners** to help identify and access a wide range of funding sources. As a result of the numerous potential co-benefits between climate change adaptation measures for Natura 2000 sites and wider climate change adaptation and mitigation objectives, **a wide range of funding opportunities[210] should be sought**, including measures that would not be available to fund nature conservation objectives alone.

[208] Transition zones between two different habitats or ecosystems.

[209] Crick, H., Crosher, I., Mainstone, C., et al. (2020), Nature networks evidence handbook, Research report NERR081, Natural England, York, UK.

[210] Public funding may be subject to State aid rules. Should a measure constitute aid, it would need to be assessed under the relevant State aid framework.

An important part of the planning should be to consider the necessary timetable for action and identify urgent action, especially as adaptation measures should already be underway to tackle some risks. It may therefore often be appropriate to focus on immediate impacts over the short-term, especially where they have already been observed and are therefore likely to continue. However, the planning of measures for the climate threats that are expected to have longer-term impacts on the Natura 2000 network and sites may be needed. This is because some measures will take a long time to plan, and implement, and most habitats respond slowly to management and restoration measures. Early adaptation can help to reduce financial losses and preparedness can avoid expenditure on expensive emergency measures later[211].

1.5 Step 5: Monitor and evaluate the effectiveness of the adaptation measures

Step 5 of the framework is designed to:

- ensure the identified adaptation measures are implemented;
- the effects of adaptation measures and their impacts on the ecosystem and specific targeted protected habitats and species are reliably evaluated;
- adaptation measures are adjusted in accordance with the monitoring results to optimise their effectiveness and efficiency.

To ensure that the adaptation measures are implemented and achieve their expected outcomes, **it is essential to regularly monitor and evaluate their effectiveness**. The measures should be evaluated against the overarching goals of the Nature Directives, and the contribution of the Natura 2000 network, to achieve and maintain the favourable conservation status of habitats and species, and the more specific adaptation goals formulated in the early steps of the adaptation framework. The measures should be monitored and evaluated to track progress and inform decision-making by indicating which measures need adjustment (*see below*).

Monitoring work should avoid unnecessary duplication of effort, and therefore be designed to use where possible existing monitoring schemes and data of Member States, in particular the schemes set up under Article 12 of the Birds Directive and Article 17 of the Habitats Directive as well as under the Nature Restoration Regulation that requires the monitoring of the effectiveness of restoration measures.

Based on the monitoring and evaluation work, the adaptation goals and evolving climatic conditions and risks, the measures should be revised and adjusted where necessary. Given the high levels of uncertainty over required actions and their effectiveness, they should be implemented using **adaptive management**[212]. Adaptive management is a key strategy that supports decision-making in face of uncertainty and changing conditions. It is a structured, iterative process of optimal management decision-making, based on system monitoring.

As the impacts of climate change become better known and predictable over time, adaptive management is seen as an essential, practical tool to integrate climate

[211] Rannow, S., Wilke, C., Gies, M. et al. (2014b), Conclusions and Recommendations for Adapting Conservation Management in the Face of Climate Change, in Rannow, S, Neubert, M (eds), Managing Protected Areas in Central and Eastern Europe Under Climate Change, pp. 291-303. Advances in Global Research, Springer.

Also known as ‘adaptive resource management’ or other terms for similar management approaches.

adaptation measures in management of and planning for all protected areas, including Natura 2000 sites. By monitoring to assess the effectiveness of management actions and progress towards achieving the set conservation goals, it can help to identify whether other measures are needed at different management levels, and the site management level in particular.

Adaptive management can also help ensure that adaptation measures generate the intended results by revising and improving the measures planned and implemented. This can help prevent adverse outcomes which increase or shift risks instead of reducing them (maladaptation).

Approaches to management planning and adaptive management to climate change adaptation in Natura 2000 sites have been developed in the Natur'Adapt case study (case study 6). For marine protected areas, approaches have been developed in the Interreg V-B Mediterranean Operational Programme MPA-Adapt case study[213], summarised below in case study 7.

To support effective adaptive management, there is a need to increase and improve monitoring of climate change effects in Natura 2000 sites and of the impacts on protected habitats and species (e.g. on the structure and function, composition, population, and area and range). Similarly, monitoring the wider environment should also be strengthened, especially for landscapes that closely interact with the Natura 2000 network. To increase and improve biodiversity monitoring in relation to Natura 2000 sites and climate change, the following actions are recommended:

- build on and refine the monitoring carried out in relation to Article 12 of the Birds Directive and Article 17 of the Habitats Directive, to enable a robust analysis of the condition of habitats and species in the Natura 2000 network, the impacts of pressures and threats including climate change and the measures taken to address them;
- ensure there is adequate monitoring, including on climate change impacts in the wider environment, especially in areas that closely interact with the Natura 2000 network;
- develop protocols for conservation managers to monitor change and engage in citizen science approaches to enhance data collection and increase the sense of ownership local communities have for conservation areas;
- increase monitoring and dissemination of related ecosystem evaluation (mapping and assessment of ecosystem service benefits e.g. carbon storage, flood relief) provided from actions such as ecosystem re-establishment / restoration, and other biodiversity adaptation measures that provide wider climate adaptation and mitigation benefits, especially from within Natura 2000 sites;
- increase and improve the monitoring of measures that aim to increase the network's coherence, such as increasing protected area coverage, habitat stepping stones, corridors, wildlife passages and wider environmental measures.

[213] https://ec.europa.eu/regional_policy/en/projects/Spain/mpa-adapt-preparing-the-mediterranean-region-for-the-impacts-of-climate-change

Case study 7: MPA-Adapt

The Mediterranean Sea climate will undergo rapid changes over the next decades. Direct evidence of climate change is already being observed at the Mediterranean coast, including in marine protected areas (MPAs) and Natura 2000 sites. The need to build resilience in both social and ecological aspects of MPAs through adaptive management is becoming essential to mitigate and adjust to the rapid changes to maintain and protect healthy ecosystems. However, climate change is not explicitly incorporated in most management plans and information to assist MPA decision-making is both limited and fragmented.

The goals of the Interreg MPA-Adapt project were to develop collaborative and site-specific adaptation plans for MPAs that boost resilience to climate change impacts. This was achieved by building capacity for effective management, assessing risks and exploring potential action and priorities to achieve adaptability and to boost the resilience of biodiversity in the sites and in the local communities. It also provided guidance to MPA managers and local stakeholders to implement and test climate change approaches.

Five MPAs were selected to carry out this initiative. These five sites are designated as Natura 2000 sites but they also have other forms of protection. All contain Natura 2000 habitats and species.

The five MPAs applied a common process and methodology to draw up action plans for adaptation to climate change. A series of measures were proposed to be incorporated in the management plans of the MPAs, including monitoring, regulation and adaptation of activities to support the resilience of marine species and habitats to climate change, communication and awareness-raising campaigns and strategies to integrate climate change adaptation in the management plans of each MPA. MPA-Adapt supported MPA managers by focusing on common vulnerabilities, and at the same time, provided an adaptable conceptual framework to tackle the site-specific problems in each MPA.

This project is a first of its kind for the marine and coastal Mediterranean environment. It will also foster networks by improving dialogue and coordination between MPA managers and scientists in order to create the first line of Mediterranean MPA sentinel sites. The MPA-Adapt project is now continued by the project named MPA-Engage, which aims to apply the methodologies developed in the former project and extend the process of preparing climate change adaptation plans to more MPAs in the Mediterranean.

Source: MPA-ADAPT[214]

[214] https://mpa-adapt.interreg-med.eu/ and https://ec.europa.eu/regional_policy/en/projects/Croatia/mpa-adapt-preparing-the-mediterranean-region-for-the-impacts-of-climate-change

ANNEX 4

POTENTIAL ADAPTATION MEASURES

1. Requirements of habitats and species at risk from climate change

Member States have the flexibility to choose adaptation measures that are appropriate to their ecological conditions and funding frameworks. This chapter presents a range of practical measures that Member States may choose to implement in line with their national priorities and needs, without creating new legal obligations.

1.1 Network level

Network measures should aim to maintain or increase the future resilience and effectiveness of the Natura 2000 network as a whole, taking into account likely climate change impacts, including local extinctions and the potential colonisation of new areas. In particular, measures should **improve network coherence where necessary** to help achieve the favourable conservation status of its Natura 2000 habitats and species. As discussed in Section 2.3.6, Box 2-6, **to be coherent the network needs to be adequate, representative, resilient and connected**. Given the expected impacts of climate change and potential changes in the distribution of some habitats and species, network coherence may need to be re-assessed and if necessary adjusted in terms of the number, location and size of sites.

The adequacy of the network is particularly important. Numerous studies and recommendations for climate change adaptation (e.g. IUCN guidance and others in the bibliography) have stressed the need to increase the size of protected high-quality habitats. **Protected area networks play a key role in maintaining good-quality habitats ('space for nature') that are resilient to climate change and can be colonised by species as they move in response to climate change**. Larger sites are also more resilient, as they tend to be more resistant to pressure (e.g. pollution and disturbance), more heterogenous and hold larger species populations, which are more resilient because they are less prone to extinction from chance events.

When habitats and species decline or are going to be lost from sites, it will be essential to ensure that their overall presence in the network remains sufficient, taking into account changes in their distribution. For species, this may depend on their habitat being sufficiently distributed and the species' ability to move and colonise new sites. For the habitats and species at most risk from climate change and other threats, it may be necessary to increase their representativity in the network to minimise the risk of losses, such as those resulting from climate change.

The sites within the network must also be adequately connected to enable species to move from current to future suitable climate zones. **For species that might need to move in response to climate change, it is vital that their Natura 2000 sites are sufficiently functionally connected** to other areas within or outside Natura 2000 sites, in particular with areas expected to remain or become suitable in the face of climate change. **Facilitating range shifts will require a sufficient degree of connectivity** over large distances for some species because their suitable climate zones may be predicted to move several hundreds of kilometres over the long term. Cross-border cooperation might be required to protect the best routes and increase the scope to run cross-border measures.

However, certain strategies to facilitate connectivity may also have disadvantages that should be considered when drawing up the strategies at network level (e.g. may provide inadequate space for species to move or facilitate the spread of invasive alien species[215]). As illustrated in chapter 3, annex 3 – Table 2, evidence indicates that the priority order of actions to enhance ecological networks is usually to first improve the quality of existing sites, increase their size, increase the number of sites, and then increase connectivity through stepping stones, a more permeable matrix and corridors. In some circumstances, improving the quality and size of sites alone may provide adequate functional connectivity by increasing reproductive success and emigration rates.

1.2 Site level

When developing Natura 2000 site-level climate change adaptation measures, it is advisable to ensure that site-specific conservation objectives (SSCOs) have been set, as described in Section 2.3.1. These should cover all Natura 2000 habitats and species. Although not a legal requirement, it is also recommended that species at risk from climate change across the network that could be potential new colonists, due to suitable habitats and climate conditions, should be identified and taken into account.

The conservation objectives should aim to support the resilience of the habitats and species in Natura 2000 sites. Species populations and habitats that are in a good ecological condition are better able to adapt to climate change. Healthy populations are more capable of recovery after extreme events and produce more young that can disperse to new suitable areas. On-site resilience measures should firstly aim to **reduce existing pressures** that are detrimental to the condition of habitats and species, and secondly **improve their condition** by taking restoration measures for the habitats and species that are currently not in good condition. **Precautionary measures** may also be needed **to prevent detrimental impacts from increasing climate-related threats**, such as fires, storms, floods and other extreme events.

For many habitats and species, increasing their resilience by reducing existing pressures will not be enough to adapt to climate change, especially for those that are not in good condition. For such habitats and species, more proactive measures will be needed to restore them and increase their resilience to climate change. To this end, restoring natural ecosystem processes and properties may often be the most appropriate and cost-effective first step. Examples include enabling natural landscape-forming processes, such as sedimentation, marshland development and meandering. This will help maintain ecosystem integrity, even when species' communities and structures are changing.

However, habitats and species that are particularly vulnerable to climate change may require further **enhanced ecological conditions**, (e.g. optimal and consistent seasonal water levels). More proactive targeted measures may therefore be required, for

[215] Hilty, J., Worboys, G.L., Keeley, A., et al. (2020), Guidelines for conserving connectivity through ecological networks and corridors, Best Practice Protected Area Guidelines Series No 30, IUCN International Union for the Conservation of Nature, Gland, Switzerland.

example, retaining more water in wetland sites to alleviate drought impacts. Sites with **heterogeneous landscapes** also tend to be more resilient, as they offer a greater range of resources and microclimates, which have, for example, been found to buffer butterfly populations against climatic variation and generate more stable population dynamics[216] [217]. Increasing habitat diversity and micro-habitats can also create new biophysical conditions that may allow species to avoid climate changes such as by moving to a more shaded area, or damper location, or into deeper water. However, care needs to be taken to ensure that increasing the variety of habitats and the species diversity does not result in declines in other habitats and species populations that reduces their viability.

Where necessary, the size of the Natura 2000 site should also be considered, as some may be too small for their Natura 2000 habitats and species to ever achieve good condition, even without growing climate-related threats. Where feasible, increasing the size of a site can substantially increase its resilience because larger sites:

- can hold larger populations of species, which are more resilient to shocks (e.g. extreme events, and disease outbreaks) and the chance of extinction;
- are more resilient as they are more likely to have their full complement of key species, and more diverse species communities, due to the well-known species-area relationship;
- provide more habitat and structural diversity, and therefore heterogeneity;
- are less affected by external pressures such as pollution and disturbance, as outer areas may form a buffer.

1.3 Wider landscape level

Climate change adaptation measures for Natura 2000 should prioritise increasing the area and quality of habitats within the network and other protected areas. But it may be necessary and cost-effective to complement such measures with action in the surrounding landscape. The landscape is defined as the contiguous area adjoining a Natura 2000 site that has significant influences on the habitats and species within it. The landscape may be a large area, conceivably at river-basin scale or wider catchment scale for some sites. Measures at this scale may have the greatest potential for strategic practical network improvements and substantial co-benefits.

Landscape measures should usually aim to tackle one or more of three potentially interacting requirements for habitats and species that are at risk from climate change:

- **reducing external pressures and threats** on Natura 2000 habitats and species within Natura 2000 sites;
- **enhancing connectivity** to:
  - strengthen Natura 2000 species metapopulations that include components within Natura 2000 sites; and/or

[216] Oliver, T.H., Roy, D.B., Hill, J.K., et al. (2010), Heterogeneous landscapes promote population stability, Ecology Letters, 13 (4), pp. 473-484.
[217] Oliver, T. H., Marshall, H. H., Morecroft, M. D., Brereton, T., Prudhomme, C., & Huntingford, C. (2015). Interacting effects of climate change and habitat fragmentation on drought-sensitive butterflies. Nature Climate Change, 5(10), 941-945.

- facilitate dispersal to new sites in response to climate changes (i.e. aiding accommodation to climate change).

Priority should normally be given to reducing existing external pressures on Natura 2000 sites, primarily to increase the resilience of the habitats and species in the sites. However, it is important to note that reducing pressures and taking all other action to increase the resilience of the population within the site can also increase functional connectivity between Natura 2000 sites and the wider landscape. This is because larger and healthier populations of species have higher levels of reproductive productivity which lead to higher levels of emigration. In other words, the sites become the main sources of colonisation in the wider landscape. In some situations, small populations of species in fragmented small patches of habitat are sink populations (i.e. not able to sustain themselves) and are dependent on recolonisation (the rescue effect) from larger source populations such as in good-quality, large protected areas. Hence, the rule of thumb priority of focusing nature conservation measures on improving the quality and size of protected areas and increasing their number (see annex 3 – Table 2).

Despite the critical importance and quality of protected areas, additional actions are often required to increase connectivity across the landscape, especially to increase the resilience of small and fragmented populations (i.e. by strengthening metapopulations). The sections below describe several measures that can be taken around Natura 2000 sites to reduce external pressures, and to increase connectivity. The measures include reducing barriers, maintaining and enhancing corridors and stepping stone patches of habitat0, and improving the general ecological quality of the wider landscape.

A common challenge with landscape-level adaptation measures is to integrate the management of protected areas in ways that are directly related to and meaningful for other stakeholders in their surroundings. It is therefore especially important to develop a strategic partnership (discussed in annex 3, section 1.1) between those responsible for managing protected areas and those responsible for managing the surrounding areas. This will involve developing collaboration with multiple stakeholders on and around sites, as well as sharing information and experience with site managers on sites elsewhere in the Natura 2000 network.

2. Measures that can contribute to Natura 2000 adaptation to climate change

2.1 Identify habitats, species and Natura 2000 sites at risk from climate change, and refugia

An essential early step in the process of developing strategies for adaptation to climate change is to assess which habitats and species are most at risk (step 2 under the climate adaptation framework). **In this context, it is appropriate to assess their vulnerability,** as described in annex 2, section 2.3. According to the IUCN definition, vulnerability is based on exposure, sensitivity and adaptive capacity (annex 2 - Figure 1). It is recommended that **vulnerability assessments are carried out, firstly to assess the vulnerability of habitats and species across the Natura 2000 network** (e.g. country or biogeographical region), before assessing the adequacy of Natura 2000 coverage and Natura 2000 sites at most risk. If such information is not already available, then an initial assessment should be carried out using relatively simple and efficient methods such as a trait-based approach. This can then produce a list of Natura 2000 habitats and species scored according to their biological and life-history traits that make them relatively vulnerable to climate change.

As even simple vulnerability assessment approaches require a considerable amount of information to be collated and analysed, it may be necessary to initially assess groups of similar habitats and species. Another option is to initially screen out species that are very unlikely to be at risk from climate change using sensitivity assessments carried out in nearby countries that are likely to be appropriate. Alternatively, species could be screened out based on exposure to climate change, as a species or habitat needs to be both sensitive and exposed to climate change impacts to be at risk.

To provide a comprehensive vulnerabilityassessment and solid foundation for adaptation planning, it is recommended that secondary climate threats (e.g. the construction of flood banks, drains and reservoirs) **and all other interacting non-climatic threats** (e.g. intensive agriculture, forestry and fisheries) **are also taken into account.**

The second aim of the assessment is to **estimate the changes in suitable climate space for Natura 2000 habitats and species** according to an appropriate range of climate change projections, and to quantify them in term of their ratios and overlaps compared to the current situation (see annex 2, section 2).

The final overall aim of the assessment is to **identify Natura 2000 sites (or regions) that are likely to be particularly important to the Natura 2000 habitats and species identified as being most at risk from climate change within the country**. Importantly, the assessment should identify Natura 2000 sites with contrasting expected impacts from climate change: those that are most at risk, and those that appear to have more stable climates and may provide climate refugia. The aim of **identifying the high-risk sites** is to target climate change adaptation measures to them, and the surrounding landscape if necessary, where they are likely to be feasible and cost-effective. The aim of **identifying refugia** is to ensure that they are adequately protected and managed so that their habitats and species are not threatened by other non-climate-related pressures. Future climate refugia maybe identified outside the Natura 2000 network, or other protected areas, and if necessary should be considered for classification as Natura 2000 sites or other protected areas.

The estimation of future suitable climate space ratios and overlaps, and to identification of particularly **vulnerable sites and refugia** involves spatial data to provide maps of areas expected to have suitable climates for the habitat or species according to various climate change scenarios and projections. As recommended by Foden et al. (2019)[218][149] modelling approaches based on correlative analysis of current habitats and species distributions and climates are typically the most useful first step. Hlásny et al. (2021)[219] provide an example of such an approach, applied at a European continental scale, that identifies areas with significantly high and low climate stability over the 21st century.

These assessments can then be further refined using more sophisticated mechanistic models, or combined approaches, if necessary, to confirm which habitats, species and sites are at most risk. More detailed maps indicating the vulnerability of habitats and

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[218] Foden, W. B., Young, B. E., Akçakaya, H. R., et al. (2019), Climate change vulnerability assessment of species, WIREs Climate Change No 10 (1), e551.
[219] Hlásny, T, Mokroš, M, Dobor, L, et al. (2021) Fine-scale variation in projected climate change presents opportunities for biodiversity conservation in Europe. Scientific Reports, 11(1), 17242.

species may also be produced to feed into more local landscape and site-related vulnerability assessments and adaptation measures.

Although vulnerability assessments provide essential information for planning climate change adaptation, they must be carried out and interpreted very carefully[220]. For example, Hlásny et al. (2021)[221] state that interpreting the pattern of regional zones of stability is fraught with difficulty as very many contributing variables play a role, including the different representations of atmospheric processes in climate models and the complex procedures used to identify them. Assessments should therefore follow good practices as given in the more detailed guidance sources listed in the bibliography.

In marine and coastal ecosystems, guidance was devised under the 2022-2025 EU Horizon project MSP4BIO[222], which worked on integrated socio-ecological management of marine ecosystems. It includes a framework for marine protected area (MPA) managers and modellers to assess the vulnerability of marine species and ecosystems to climate stressors. The project MPAEurope (2023-2026 Horizon Europe project)[223] mapped the optimal locations for MPAs with the aim of establishing an ecologically coherent network of representative biodiversity areas across Europe's seas. Findings show that that the marine species' projected distributions under the most extreme climate changes scenario by 2100 were encompassed in the representative biodiversity areas. Thus, the representative biodiversity areas were predicted to be a climate change resilient network. Further EU projects can be found in CORDIS[224].

2.2 Assess the coherence of the Natura 2000 network in relation to expected climate change

The Natura 2000 network currently covers 18.6% of the EU's land and 10.5% of its sea (chapter 1, section 1.1). However, studies of landscape- and seascape-level resilience suggest that a figure of 30% or 50% or even higher may be required to ensure a fully resilient landscape[225] [226]. Expanding the Natura 2000 network would also contribute to the EU target of increasing protected area coverage on both land and sea to 30% by 2030, of which 10% should be strictly protected, in accordance with the *EU biodiversity strategy for 2030* and Target 3 of the and the Kumming-Montreal Global Biodiversity Framework of the Convention on Biological Diversity[227].

Site designations in the Natura 2000 network should not be a static process, but should periodically re-assess the network's coherence in terms of its adequacy, representativity, resilience and connectivity. When doing so, assessments should

[220] Santini, L., Benítez-López, A., Maiorano, L., et al. (2021), Assessing the reliability of species distribution projections in climate change research. Diversity and Distributions, 27(6), pp. 1035-1050.
[221] Hlásny, T, Mokroš, M, Dobor, L, et al. (2021) Fine-scale variation in projected climate change presents opportunities for biodiversity conservation in Europe. Scientific Reports, 11(1), 17242.
[222] MSP4BIO project: Improved Science-Based Maritime Spatial Planning to Safeguard and Restore Biodiversity https://msp4bio.eu/about/
[223] https://mpa-europe.eu
[224] https://cordis.europa.eu/search?q=%27MSP%27%20AND%20%27MPAs%27&p=1&num=10&srt=Relevance:decreasing
[225] IPCC (2023) AR6 Synthesis Report. Climate Change 2023, Intergovernmental Pannel on Climate Change, Cambridge University Press, Cambridge, UK and New York, USA.
[226] Wilson, K.L., Tittensor, D.P., Worm, B. et al. (2020) Incorporating climate change adaptation into marine protected area planning, Global Change Biology, 26 (6), pp. 3251-3267.
[227] Kunming-Montreal Global biodiversity framework, 18 Dec. 2022, CBD/COP/15/L.25

consider the extent to which nationally designated protected areas and other effective area-based conservation measures (OECMs) may provide a sufficiently coherent network for each Natura 2000 habitat and species in relation to expected climate changes (i.e. with the objective of achieving and maintaining their favourable conservation status).

Drawing on risk and vulnerability assessments and other scientific evidence, consideration should be given to the need for **new and/or larger Natura 2000 sites** for the following reasons:

1. To compensate in advance for expected losses of Natura 2000 habitats and species that are highly at risk from climate change. This should focus first on sites that hold a high proportion of the national / biogeographical habitat area or species population and are at significant current risk of loss, or severe damage, from extreme events such as droughts, flooding or coastal erosion.
2. To protect critical climate refugia, especially for Natura 2000 habitats and species that may be highly concentrated in such sites and have a more favourable conservation condition than elsewhere.
3. To increase connectivity and the resilience of individual sites and network, and to support accommodation to climate change to ensure sites are sufficiently close and appropriately located to allow for movement, thereby supporting metapopulations and their ability to move to and colonise sites.
4. To protect areas of newly restored or re-created habitats, or habitats of species in areas that are expected to become more suitable for such habitats and species as a result of climate change, securing space for ecosystem restoration and sites for translocations (see section 2.8 of this annex).

Although the impacts of climate change have been relatively modest so far for Natura 2000 habitats and species, some studies and initiatives have assessed the need for new and/or larger Natura 2000 sites to address expected climate change threats. See for example, in relation to the expected loss of coastal wetlands of key importance for the Bittern (described in ccase study 5), and the need for additional protected areas for the priority habitat '*Tetraclinis articulata* forests' (case study 8).

Case study 8: reviewing the need for new protected areas

The HD Annex I priority habitat '*Tetraclinis articulata* forests' (HD 9570*) is restricted to south-eastern Spain and Malta.

A study in Spain reviewed the possible impacts of climate change on this forest type by analysing the change in distribution of this forest type under two scenarios (A2 and B2).

Under scenario B2, the existing network of reserves will most likely be sufficient to protect the species. Under this scenario, the potential area for the forest type will expand and current and future potential habitats partially overlap. Most of the reserves are sufficiently close to allow the species to migrate by means of short-distance dispersal.

Under scenario A2, a loss of the current coastal habitat would occur. Although two existing reserves in the interior would be suitable, the probability of natural colonisation is low because *Tertaclinis articulata* has a low dispersal capability and the current and future potential distribution areas do not overlap.

Source: Adapted from Esteve-Selma et al. (2012)[228] cited in European Commission (2013)[229].

A number of studies have used modelling approaches to examine the resilience of protected area networks to various climate-change scenarios[230] [231] [232].

Currently, the available evidence suggests that, with the notable exception of sites at risk from increasing extreme events (e.g. for the Bittern case study 5), over the short-term there is unlikely to be a pressing need to designate or expand many Natura 2000 sites as a result of direct climate change threats. In the mid- to longer-term, more radical changes to the Natura 2000 network may be necessary, depending on the severity and pace of further climate change. These will need to be planned for in a coherent and systematic way.

Separate to the benefits of expansion, Natura 2000 site boundaries may need to be adjusted to accommodate the impacts of climate change. Such adjustments may be needed in case of major structural changes, such as unavoidable coastal erosion or conversion of freshwater habitats into brackish ecosystems. Less profound and smaller-scale adjustments may also be increasingly required to maintain the protection of specific Natura 2000 habitats and species where they move substantially beyond existing boundaries. However, most Natura 2000 sites have boundaries that are broadly set for multiple habitats and species. Furthermore, as existing Natura 2000 habitats and species move (or die-out), they may be replaced by others. Therefore, the need for boundary adjustments in relation to specific Natura 2000 habitats and species may not frequently arise in practice.

2.3 Address key pressures and threats and restore ecosystems

The reporting under Article 17 of the Habitats Directive and Article 12 of the Birds Directive indicates that a substantial proportion of Natura 2000 habitats and species have an unfavourable conservation status and are subject to a wide range of frequent and high-level pressures. Thus, for most habitats and species, and a large proportion of sites, there is scope for ‘no-regret measures’ that can contribute to more robust ecosystems.

To put these adaptation measures into practice, pressures and threats affecting habitats and species at risk from climate change, inside and outside the network, should be

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[228] Esteve-Selma, M.A., Martínez-Fernández, J., Hernández-García, I., et al. (2012), Potential effects of climatic change on the distribution of Tetraclinis articulata, an endemic tree from arid Mediterranean ecosystems, Climatic Change, 113 (3), pp. 663-678.

[229] European Commission (2013) Guidelines on climate change and Natura 2000. Dealing with the impact of climate change on the management of the Natura 2000 Network of areas of high biodiversity value, Office of Publications of the European Union, Luxembourg.

[230] Araújo, M B, Alagador, D A., Cabeza, M., et al. (2011), Climate change threatens European conservation areas, Ecology Letters, 14 (5), pp. 484-492.

[231] Araújo, M B., Lobo, J. M. and Moreno, J C., (2007), The effectiveness of Iberian protected areas in conserving terrestrial biodiversity, Conservation Biology, 21 (6), pp. 1423-1432.

[232] Hannah, L., Midgley, G., Andelman, S., et al. (2007), Protected area needs in a changing climate, Frontiers in Ecology and the Environment, 5 (3), pp. 131-138.

comprehensively assessed, and appropriate measures identified to reduce them to insignificant levels where feasible. Ideally this should be part of a comprehensive management planning exercise, through participatory approaches involving all key stakeholders (see annex 3, section 1.2).

While all pressures and threats should be assessed, attention should be given to those that are likely to increase as a result of climate change impact drivers:

- **High summer temperatures**
  - agricultural abandonment;
  - increase in human-caused fires (accidental and intentional);
  - forest die-back and higher rates of disease.
- **Low summer rainfall, and more frequent and severe droughts**
  - agricultural abandonment;
  - water abstraction (rivers and groundwater);
  - irrigation of crops and associated intensive practices;
  - canalisation of rivers and construction of water control structures (dams).
- **High winter rainfall and extreme rainfall events**
  - construction of hard flood defences;
  - soil compaction and sealing;
  - increase in drainage.
- **Sea-level rise and increased coastal storm surges**
  - construction of hard flood defences;
  - structures inhibiting sediment supply and movements.

In addition to these climate-related pressures, there are often other anthropogenic pressures that need to be dealt with at landscape scale, including:

- atmospheric pollution (e.g. eutrophication from nitrogen deposition);
- upstream or marine water pollution (e.g. eutrophication from point-source industrial and urban sources, aquaculture and nutrient rich run-off from farmland);
- hydromorphological pressures (straightening of rivers and impoundments) and disturbance and fragmentation impacts from infrastructure developments.

To maximise the resilience of habitats and species to additional climate change pressures, it is essential to tackle these pressures through cooperation with the relevant authorities, including on measures under the Water Framework Directive, the Marine Strategy Framework Directive[233] and the Floods Directive.

[233] Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive).

One approach to dealing with external pressures often recommended in climate change adaptation guidance is to create buffer zones[234]. One of their advantages is that they can increase the area subject to necessary protection measures, without the higher administrative complexity and burdens of designation as a Natura 2000 site, or other form of protected area. But they may still require some form of new governance and legal basis, as for example in the Austrian federal state of Vorarlberg, which designated a buffer zone around one Natura 2000 site by issuing a local ordinance that specifies rules for buffer zone I and buffer zone II[235].

Buffer zones can be selective in terms of the land uses and activities that are regulated in the buffer zone (e.g. prohibiting highly disturbing activities), which may increase their acceptability to stakeholders. The role of the buffer zone is to prevent habitat loss or even stimulate restoration, such as by preventing the ploughing of grasslands to help maintain habitat area. Buffer zones can also contribute to increasing connectivity, although this should not be their primary aim – as specifically designed measures should be used for such purposes.

Therefore, where climate adaptation is needed, the potential benefits of buffer zones should be considered but weighed against the greater potential protection and management afforded by protected area designation.

Increasing the resilience and adaptive capacity of the network by restoring the favourable conservation status of its habitats and species is a key step. **The Nature Restoration Regulation provides the framework to implement further restoration measures for the ecosystems within and outside the Natura 2000 network.** National restoration plans to be drawn up under the Nature Restoration Regulation are an opportunity for Member States to use a science-based, coherent and integrated approach to identify the restoration measures needed to achieve the restoration targets and fulfil the obligations set out in Articles 4, 5 and 8 to 13 of the Regulation and to contribute to the EU’s biodiversity and climate objectives enshrined in EU nature and climate laws.

Restoration measures may support adaptation to climate change by improving the condition, representativity and connectivity (incl. through re-establishment) of habitats and habitats of species throughout the network and, if needed, outside. **The climate adaptation needs of the Natura 2000 network should therefore be thoroughly taken into consideration when drawing up or revising the national restoration plans.**

2.4 Manage climate change related extreme events

Although many ecosystems are adapted to periodic disturbances, extreme events such as droughts, floods, storms and severe wildfires can be particularly damaging for some Natura 2000 habitats and species. Some Natura 2000 sites may also be especially prone to such events. As discussed in annex 1, section 2, extreme weather and wildfires are

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[234] Huntley, B. (2007). Climatic change and the conservation of European biodiversity: Towards the development of adaptation strategies, Convention on the Conservation of European Wildlife and Natural Habitats, Standing Committee 27th meeting, Strasbourg, 26-29 November 2007, Council of Europe, Strasbourg.

[235] The ordinance specifies a prohibition on construction and activities. Landesrecht konsolidiert Vorarlberg: Gesamte Rechtsvorschrift für Pufferzonen zum Schutz von Gebietsteilen außerhalb des Natura 2000 Gebietes, Fassung vom 17.10.2023. https://www.ris.bka.gv.at/GeltendeFassung.wxe?Abfrage=LrVbg&Gesetzesnummer=20000509

becoming more frequent and severe as a result of climate change, and this trend is expected to continue under all likely scenarios.

It is, therefore, already **necessary to plan how to manage extreme events in Natura 2000 sites**, and in the **wider landscape** where this can influence the site (e.g. within river catchments). This should aim to reduce the frequency of such events where this is possible, and to manage and reduce their impacts when they do occur. As these extreme events are often associated with socio-economic impacts, threatening the livelihoods and even lives of local people, it is essential that planning considers these related issues. In fact, in many cases, sound management of Natura 2000 sites provides opportunities for nature-based solutions to mitigate the impacts of extreme events, such as coastal flooding (case study 5) or river flooding (case study 11).

Where Natura 2000 sites are at particularly high risk of extreme events and hold a high proportion of a Natura 2000 habitat or species population, consideration should be given to complementary measures in other sites or areas that can reduce the risk to the most threatened Natura 2000 habitats and species. This could, for example, include increasing protection by designating other Natura 2000 sites, facilitating the movement of species to other sites and, if necessary, translocation (as discussed in section 2.8 of this annnex).

2.4.1 Fire management

Climate change is contributing to an increase in the number, area and severity of wildfires (chapter 3, section 3.3.1 and annex 1, section 2.4). While recognizing this growing threat, wildfire risk management in Natura 2000 sites should ensure compatibility with the conservation objectives of the sites, and with the preservation of biodiversity, ecosystems, and landscapes (see chapter 2, section 2.3.5).

To effectively manage risks in Natura 2000 sites without compromising conservation objectives (or even enhancing ecosystem processes), wildfire preparedness that relies on traditional protection infrastructures and interventions within **integrated wildfire risk management** needs to be complemented by **landscape and ecosystem-based prevention**. Depending on the local context, this may include landscape management and planning, ecosystem restoration, appropriate fuel (biomass) management through thinning, prescribed burning and grazing, reforestation focusing on more diverse forest species and on their adaptation capacity to disturbances, managing forest in a closer-to-nature manner[236], as well as promoting integrated wildfire prevention governance.

One of the most effective strategic ways of limiting the potential risks and impacts of wildfires is by **landscape planning** that maintains or restore multifunctional resilient mosaic landscapes. Wildfire prevention should be a priority in landscape planning[79], seeking the reduction of risk through targeted management of the amount and connectivity of fuels to reduce fire growth rate, increase the potential for fire suppression, and mitigate fire damage[237]. Practices such as maintenance of permanent crops and agro-forestry systems are important tools in the creation of these resilient landscapes.

[236] In line with the voluntary Commission guidelines on closer to nature forest management. https://environment.ec.europa.eu/publications/guidelines-closer-nature-forest-management_en
[237] Moreira, F., Ascoli, D., Safford, H, et al. (2020), Wildfire management in Mediterranean-type regions: Paradigm change needed, Environmental Research Letters, 15(1), 11001.

Ecosystem-based fuel management techniques include thinning, prescribed burning and extensive grazing. **Thinning** involves selectively removing trees to decrease forest density and create a more resilient structure, for example by creating a fuel gap between the understory and the canopy. For wildfire protection purposes, thinning has been demonstrated to be more efficient when combined with prescribed burning, at least in temperate conifer forests[238].

Well-planned **prescribed burning** is a cost-effective tool that can mimic natural fire regimes, improving forest health and biodiversity. At the same time, it reduces the likelihood of high-severity fire in ecosystems adapted to low- or mixed-severity fire, such as some grasslands, Mediterranean forests and shrublands, temperate heathlands, and boreal forests (taiga). An EU good practice involving prescribed burning is the LIFE Taiga project[239], in which the technique has been used to restore boreal forests that have become too dominated by spruce or pine and lack dead wood. Prescribed burning in certain especially fragile or valuable habitat types, such as primary and old-growth forests, may be considered a permissible activity, only if an assessment proves the suitability of such measure for the conservation objectives. Whilst in some Member States the potential of prescribed burning has remained unexplored (among other causes due to liability issues and risk-averse policies that prioritise fire suppression and perpetuate the 'firefighting trap'), a paradigm shift is needed, especially in the Mediterranean region[240].

Many HD habitats (e.g. types of semi-natural grasslands, heathlands and sclerophyllous scrub) depend on **grazing by livestock** as part of traditional low intensity High Nature Value (HNV) farming systems[241], including traditional silvopastoralism. This includes extensive grazing by different livestock species, grassland management, and/or transhumance with resistant breeds better adapted to the surrounding environment. Socio-economic difficulties and disadvantages related to natural or other specific constraints have caused widespread abandonment of HNV farming especially in remote and mountainous areas, affecting many Natura 2000 sites, with 11% of the agricultural land in the EU and UK under high risk of abandonment[242]. Without grazing, abandoned land naturally turns into shrubland and eventually forest. Abandoned farmland is also targeted for forest plantations, often of highly combustible species, contributing to an increase in fuel loads and fire hazard[243]). Although lack of human activity can sometimes have biodiversity benefits, it has been mostly detrimental[244] especially for semi-natural non-forest HD habitats and many associated species. For such reasons, the

[238] Davis K. T., Peeler J., Fargione J., et al (2024), Tamm review: A meta-analysis of thinning, prescribed fire, and wildfire effects on subsequent wildfire severity in conifer dominated forests of the Western US, Forest Ecology and Management Vol. 561.
[239] https://lifetaiga.se/controlled-burning-in-woodlands/.
[240] Moreira, F., Ascoli, D., Safford, H, et al. (2020), Wildfire management in Mediterranean-type regions: Paradigm change needed, Environmental Research Letters, 15(1), 11001.
[241] Oppermann, R., Beaufoy, G. and Jones, G. eds. (2012) High Nature Value Farming in Europe, Ubstadt-Wieher, Germany: Verlag regionalkultur.
[242] Castillo, C P., Jacobs-Crisioni, C., Diogo, V., et al. (2021), Modelling agricultural land abandonment in a fine spatial resolution multi-level land-use model: An application for the EU, Environmental Modelling & Software, 136, 104946.
[243] Moreira, F., Viedma, O., Arianoutsou, M., et al. (2011), Landscape–wildfire interactions in southern Europe: implications for landscape management, Journal of environmental management, 92(10), pp. 2389-2402.
[244] Queiroz, C., Beilin, R., Folke, C., et al. (2014), Farmland abandonment: threat or opportunity for biodiversity conservation? A global review, Frontiers in Ecology and the Environment, 12 (5), pp. 288–296.

focus of many management measures within Natura 2000 sites on semi-natural habitats is on maintaining traditional HNV livestock farming practices, often through the support of common agricultural policy (CAP) measures[245]. This in turn provides considerable benefits in terms of reducing fire risks, especially in relation to large and severe fires. The cost-effectiveness of using livestock to reduce wildfire risk has been shown in a number of studies[246] [247] [248] and projects, such as the LIFE LANDSCAPE FIRE project and the GrazeLIFE (case study 9).

Case study 9: GrazeLIFE recommendations concerning grazing and wildfire prevention

The EU LIFE Programme project *GrazeLIFE: Grazing for wildfire prevention, ecosystem services, biodiversity and landscape management* was carried over 2019-2021 and led by Rewilding Europe. It assessed how land use models that are based on grazing systems by livestock and semi-wild herbivores can offer (cost-) effective solutions to environmental challenges, including climate change, biodiversity loss, soil degradation and increased frequency and severity of wildfires.

Outcome from the project in relation to fire risks:

Results (based on literature and studies in Velebit in Croatia, Coa Valley in Portugal, and Galicia in Spain)

Field studies in the Mediterranean and southern Atlantic areas show that extensively grazed areas suffer less from large-scale wildfires than surrounding areas which are abandoned (shrub encroachment) or afforested with monocultures of pine or *Eucalyptus*. Extensive grazing limits the coverage of tall grasses, gorse and shrubs, thus leading to vertical discontinuity of vegetation and reducing fire risk. Mixed guilds of grazers and browsers are especially effective in creating natural fire breaks.

However, in practice, management policies and subsidies are mainly oriented toward fire-suppression or – in case of prevention policies– focused on mechanical cutting instead of considering grazing. At the same time, there is even growing evidence that policies favouring full fire suppression (i.e. preventing all fires) lead to long-term accumulation of fuel and, consequently, larger and more intense fires in the future.

Implications

Using herbivores to reduce fuel loads is a promising management strategy to avoid fuel build-up and mitigate wildfires in a relatively low-cost and more sustainable way. Fire policies should therefore adopt an approach that supports using herbivores as a cost-effective way to reduce fuel loads, in combination with prescribed fires or other mechanical management measures.

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[245] European Commission, 2026. Grassland and livestock dynamics How grazing management sustains and shapesEuropean grasslands, Analytical Brief N°13. https://agriculture.ec.europa.eu/document/download/b397715c-d526-4dd7-af26-adbdfe43af6d_en?filename=analytical-brief-13-grassland_en.pdf

[246] Lecina-Diaz, J., Chas-Amil, M.L., Aquilué, N., et al. (2023), Incorporating fire-smartness into agricultural policies reduces suppression costs and ecosystem services damages from wildfires. Journal of Environmental Management, 337, 117707.

[247] Pais, S., Aquilu´e, N., Campos, J., et al. (2020) Mountain farmland protection and fire-smart management jointly reduce fire hazard and enhance biodiversity and carbon sequestration, Ecosystem Services, 44, 101143.

[248] Rouet-Leduc, J., Pe'er, G, Moreira, F., et al. (2021), Effects of large herbivores on fire regimes and wildfire mitigation, Journal of Applied Ecology, 58 (12), pp. 2690-2702.

Source: GrazeLIFE[249]. For further information see Rouet-Leduc et al. (2021)[250].

Once a wildfire occurs, management decisions have to be taken, usually within a short timeframe (see chapter 2.3.5). Ideally, contingency plans to aid on these decisions should be prepared beforehand, and they can be integrated in Natura 2000 management plans. In many ecosystems, fires occur from time to time as part of their natural dynamics, and several species (animals and plants) depend on or benefit from them. In such cases, subject to a case-by-case analysis, no post-fire intervention (this is, allowing the ecosystem to recover naturally) could be considered a management option. In this context, low or moderate intensity wildfires in those ecosystems which are adapted to them should not be interpreted as deterioration[251].

Post-fire **salvage logging** (felling and removing burnt tree trunks) can in some cases hamper forest regeneration. It can increase soil erosion and compaction, reduce nutrient availability, damage seedlings and reduce biodiversity. Less aggressive post-fire treatments may be recommended in Natura 2000 sites. Partial cut plus lopping (i.e. felling most of the trees, cutting the main branches, and leaving all or part of the biomass in situ) has proven successful in Mediterranean forests. Anti-erosion and flood control works such as log/stem barriers, wooden dams and mulching has also proved to be successful in certain situations for reducing post-fire runoff and erosion[252].

In some cases, the only viable solution for achieving an acceptable level of biodiversity may imply restoration through **reforestation**. Reforestation in Natura 2000 sites should favour the use of native species (and, even more critically, local and/or climate-adapted genotypes) to create resilient and biodiverse landscapes, and be in line with the sites' conservation objectives. Preference for broadleaved species in place of coniferous species should also be considered, given their lower fire vulnerability[253]. Moreover, exploring the use of other species that may have potential to enhance the ecosystem's resilience to climate change (e.g. the use of *Tetraclinis articulata* in xeric infra- and thermo-Mediterranean ecosystems) could be justifiable in some cases. The Commission has provided specific guidance on biodiversity-friendly reforestation[254] and forest management.

Case study 10 is an example of integrated landscape and forest management measures taken to reduce wildfire impacts in Mediterranean forests. Further examples from LIFE projects and guidance are provided in the bibliography.

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[249] https://grazelife.com
[250] Rouet-Leduc, J., Pe'er, G., Moreira, F., et al. (2021), Effects of large herbivores on fire regimes and wildfire mitigation, Journal of Applied Ecology, 58 (12), pp. 2690-2702.
[251] Natura 2000 and forests, Part I-II. Publications Office of the European Union,, 2015.
[252] Guidelines on closer-to-nature forest management, Publications Office of the European Union, 2023. https://op.europa.eu/en/publication-detail/-/publication/2d1a6e8f-8cda-11ee-8aa6-01aa75ed71a1
[253] Zhao J., Yue C., Wang J., et al. (2024), Forest fire size amplifies postfire land surface warming, Nature, 633, pp. 828-834.
[254] Guidelines on Biodiversity-Friendly Afforestation, Reforestation and Tree Planting, SWD(2023)61.

Case study 10: Adapting Mediterranean forests to climate change – LIFE NORTENATUR (Portugal)

Climate change has considerable impacts on Mediterranean forests and on associated ecosystem services. Therefore, adaptation measures are needed, in particular, to reduce the threats from forest fires. Currently, many southern European countries take adaptation measures including:

- changing forest management: actions to increase species diversity; plant trees that are better adapted to the predicted climate changes; change silvicultural practices; change soil management practices to enhance water storage capacity and soil carbon storage.

- landscape-level measures: actions to plan for 'fire-smart' landscapes; diversify habitat types, forest types and land uses; maintain/restore connectivity; protect 'refugial' areas in heterogeneous landscapes.

An example of such a plan was developed in the LIFE-funded project NORTENATUR. In 2003, a devastating fire destroyed vast areas of *Quercus* forests in Alentejo in Portugal, impacting the São Mamede and Nisa - Lage da Prata Natura 2000 sites. The lack of management of these forest areas was identified as the main cause of the fire propagation.

The NorteNatur project aimed to pilot sustainable management practices for these Natura 2000 sites. By fostering collaboration among national authorities, universities, and local forest producers, the project sought to create a comprehensive management plan integrating *Quercus* montados and associated habitats into existing legal planning instruments. Specific goals included developing protection strategies against forest fires, implementing sustainable land use practices, and restoring damaged ecosystems.

Key pilot actions included constructing barriers to combat erosion, planting riparian vegetation, fencing sensitive areas, controlling cattle density, restoring riparian habitats, and eliminating invasive species. The project also implemented surveillance measures to protect *Juniperus* bushland and initiated awareness-raising activities for the local community.

The project successfully developed management tools and demonstrative practices to guide future conservation efforts. Habitat and GIS mapping led to a draft Management Plan and a Priority Habitats Protection Plan Against Forestry Fires. The involvement of landowners, local authorities, and stakeholders enhanced long-term sustainable management and protection of these habitats.

Source: NORTENATUR[255]

2.4.2 Disturbance management – storms

This type of measure is particularly relevant to two very different ecosystems: forests and coastal habitats. Typical adaptation measures in forests that help prevent large-scale damage, while also maintaining ecosystem resilience and biodiversity, include measures to ensure forest diversity in tree maturity and in species composition.

On coastlines, storm protection has traditionally involved the construction of sea walls, groynes (structures that constrain longshore drift and build up sediment on the shore) and supplementation of sand, shingle or rocks as a shoreline barrier. These measures can be costly and cause ecosystem damage, such as by constraining the landward

[255] https://webgate.ec.europa.eu/life/publicWebsite/project/LIFE04-NAT-P-000214/management-and-conservation-of-the-sites-of-s-mamede-and-nisa-laje-de-prata

movement of habitats (known as 'coastal squeeze'). This can exacerbate the loss of intertidal habitats as a result of sea-level rise and erosion. Given these high costs, there is increasing recognition that some habitats such as saltmarsh (HD Annex I types 1310, 1320 and 1330) can reduce erosion and provide effective barriers to storm surges as a nature-based solution[256]. As a result, programmes of coastal realignment have provided the opportunity to recreate intertidal habitats in Natura 2000 sites (e.g. see case study 5).

It is, therefore, recommended that Natura 2000 site managers consider the options for coastal realignment or similar initiatives that can both help protect the site from flooding and contribute to habitat restoration and recreation – as well as providing flood protection benefits for habitat areas and farmland. However, it is also important to consider the possible losses of some habitat types that may result from realignment and increased saltwater intrusion.

2.4.3 Flood management

As discussed in chapter 3, section 3.3.2, a number of measures can be taken in Natura 2000 sites, or higher in the catchment, to reduce the impacts of undesirable changes in flooding frequency, depth and seasonality as a result of climate change. These can include a number of nature-based solutions that can provide additional co-benefits for habitats and species, and at the same time cost-effective flood mitigation for residents and landowners at risk of increasing flood impacts[257] [258].

Nature-based solutions can include:

- action to reduce run-off, such as by blocking ditches (e.g. on mires), replanting and regeneration of woodland or other vegetation and soil management;
- the use of natural barriers to slow flows;
- action to re-engineer canalised rivers and other water courses to recreate meanders and also slow the rate of flow to flood prone areas downstream;
- within floodplains, action to remove, lower or set back flood banks in appropriate locations to restore habitats while providing flood alleviation benefits.

Such measures must be carefully designed and in line with the ecological requirements of the Natura 2000 habitats and species within sites.

While such natural flood management measures can reduce climate change impacts on Natura 2000 habitats and species and provide wider multiple benefits, they need to be carefully considered and designed with technical experts and in consultation with all stakeholders. Poorly designed or inappropriate flood measures can be damaging for some Natura 2000 habitats and species. For example, lowering flood banks on flood

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[256] See further examples of nature-based solutions in the coastal area here: https://climate-adapt.eea.europa.eu/en/mission/solutions/mission-stories-inactive/nature-based-coastal-restoration-story23

[257] EEA (2016), Flood risks and environmental vulnerability. Exploring the synergies between floodplain restoration, water policies and thematic policies, EEA Technical report No 1/2016, European Environment Agency, Copenhagen.

[258] Environment Agency (2010), Working with natural processes to manage flood and coastal erosion risk, A Guidance Document, Environment Agency, Bristol, UK.

plains can lead to excessive or too frequent flooding, which can lead to detrimental changes in habitat types, such as from HD Annex I wet grasslands (e.g. lowland hay meadows HD 6510) to wetland vegetation that may be of lower nature conservation value.

An example of how flood management and wetland habitat restoration can provide mutual benefits is provided in the Danube corridor case study, as summarised below in case study 11.

Case study 11: Lower Danube Green Corridor

The floodplains of the lower Danube have experienced historic transformations due to the construction of dykes for agriculture and other development purposes. These significant landscape alterations have exacerbated major floods which have caused devastating impacts on local populations and millions of euro in damage. These extreme weather events are expected to become more frequent due to climate change.

To safeguard the Danube's environment and mitigate flooding, Bulgaria, Moldova, Romania and Ukraine signed the Lower Danube Green Corridor Agreement. The agreement aims to connect, preserve and restore wetlands along the river by protecting 995 000 ha and restoring 224 000 ha of floodplains, including numerous Natura 2000 sites. Alongside reducing the risk and socio-economic impact of flooding, the agreement supports sustainable development by strengthening the local economy (e.g. through sustainable fisheries and tourism). The resulting floodplain protection and restoration efforts – carried out by several LIFE projects - have generated a range of positive outcomes including enhanced climate adaptation and mitigation, enriched biodiversity and ecosystem services, increased water retention and flood mitigation capacity, and diversified nature-based incomes.

The following lessons can be drawn from key factors which contributed to the success of the project: the need to carefully consider the complexity of the ecosystem types, dimensions and natural processes involved, testing different restoration techniques, applying adaptive management options and monitoring impacts first at the local scale, facilitating champions in the form of NGOs, providing targeted policy and legal support along with strategic thinking, addressing property rights, and involving local actors.

Source: GREENDANUBE[259] ; GREEN BORDERS[260]; LIFE Riparian Forests[261]; Riparian Habitats in BG[262]

2.5 Enhance abiotic conditions for particularly vulnerable habitats and species

For the most vulnerable Natura 2000 habitats and species additional measures to increase their resilience may be necessary as climate change is expected to change the conditions of Natura 2000 sites, particularly their hydrology. Maintaining the hydrological integrity of a site is often key to delivering species and habitat objectives,

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259 https://webgate.ec.europa.eu/life/publicWebsite/project/LIFE06-NAT-RO-000177/conservation-and-integrated-management-of-danube-islands-romania

260 https://webgate.ec.europa.eu/life/publicWebsite/project/LIFE07-NAT-RO-000681/cross-border-conservation-of-phalacrocorax-pygmeus-and-aythya-nyroca-at-key-sites-in-romania-and-bulgaria.

261 https://webgate.ec.europa.eu/life/publicWebsite/project/LIFE13-NAT-BG-000801/restoration-and-conservation-of-riparian-forests-of-habitat-type-910-in-natura-2000-sites-and-model-areas-in-bulgaria.

and this will become increasingly difficult in many sites as droughts and floods increase in frequency and severity.

Other changes to the condition of sites are expected due to higher temperatures and higher atmospheric carbon dioxide concentrations. The expected changes include higher vegetation growth rates and a longer growing season in many parts of Europe (except where constrained by very high temperatures and low rainfall), resulting in an increase in biomass and nutrient build-up. On grasslands, climate change is leading to earlier mowing dates and an increase in the number of cuts.

Site managers should therefore identify the main climate change threats within their site (drawing on the risk/vulnerability assessments as described in annex 3, section 1.2 and annex 4, section 2.1) that are likely to affect the key abiotic characteristic of the site related to its Natura 2000 habitats and species. Measures that can counteract the expected effects and their impacts on the habitats and species should then be identified and prioritised, ideally by integrating the measures in existing site management plans.

There are many measures that can be taken to maintain or manage if necessary, the conditions in a site that are expected to change due to climate change. Measures may include **general ecosystem restoration actions as well as more targeted habitat and species-specific management interventions**. Examples of such enhancement measures include:

- increasing water retention within the site by, for example, adapting the existing drainage system, creating ponds or lakes (case study 12), seasonal flooding, restoring meanders or streams and reforestation to slow flows;
- ensuring sufficient water supplies in times of drought by developing water retention basins (e.g. for marshland waterbirds, fens and lakes);
- ensuring sufficient water drainage from the site during excessive periods of rainfall (e.g. to protect dry grasslands and heathlands);
- increasing shade from vegetation on water courses (case study 13), or other temperature sensitive habitats;
- increased grazing and/or periodic mowing of vegetation to counteract increased vegetation growth rates (e.g. for grasslands and fens);
- removing vegetation by cutting, and/or turf removal, to counteract nutrient enrichment (e.g. for heathlands).

Case study 12: ponds for biodiversity conservation and climate change adaptation

Ponds and “pondscapes” (networks of ponds) are largely neglected and generally undervalued, but remarkably important for biodiversity conservation to increase the resilience of ecosystems to climate change. The Horizon 2020 project PONDERFUL investigates how ponds can be used as nature-based solutions for climate change adaptation by assessing pondscape management in four EU countries (Belgium, Denmark, Germany and Spain) as well as Switzerland, Turkey, UK and Uruguay. The aim is to develop better methods for maximising the use of ponds and pondscapes in climate change adaptation and mitigation, biodiversity conservation and the delivery of other ecosystem services.

Source: POND Ecosystems for Resilient Future Landscapes in a changing climate[263]

Case study 13: increasing shade along streams (Spain)

The time required for "thermal recovery" depends on stream characteristics, local topography and factors that affect the composition of riparian species and their rates of growth. Re-vegetation also restores allochthonous food sources to the stream ecosystem. Tree roots stabilise banks and offer long-term protection against erosion. In general, recovery of stream shade (and therefore temperature) is expected to take decades and is accelerated by deliberate planting. It is most effective and fast in small streams in which stress from sunlight exposure is greatest. However, full recovery of stream and riparian functions may take centuries. Revegetating riparian areas was a main measure in 17% of 60 Spanish restoration projects.

Source: European Commission (2013)[264]

2.6 Enhance heterogeneity

Increasing the heterogeneity of the site (i.e. diversity), such as in relation to large- to micro-scale structural elements, habitat types and elements can help increase the resilience of habitats and species, and their ability to accommodate change, such as by moving within the site. Such enhancements are not normally designed for specific Natura 2000 habitats or species. Instead, they aim to improve the overall resilience of the ecosystems and create more opportunities for survival and, if necessary, accommodating in-site movements. Increasing the heterogeneity can also reduce risks from increasing variability in climate change. For example, variability in vegetation and terrain may result in some parts of the site providing the most suitable conditions for habitats and species in some years (e.g. very dry), whereas other parts may be optimal during other years (e.g. wet).

As well as being applied within Natura 2000 sites, measures to increase heterogeneity may also be applicable to habitat management in the surrounding landscape.

Through proactive management, variation in the structure of vegetation in and around the site can be increased. For example, this can be achieved by variations in land use and habitat management (e.g. grazing, forest composition, water level management) on a large or small-scale over a few metres. The diversity of terrain morphology can also be increased, such as by reprofiling or creating new water-courses, ponds, banks or other landforms.

Which measures are applicable at site level depends on the Natura 2000 habitat types and species, as well as the local context of the site

[264] European Commission (2013) Guidelines on climate change and Natura 2000. Dealing with the impact of climate change on the management of the Natura 2000 Network of areas of high biodiversity value, Office of Publications of the European Union, Luxembourg.

2.7 Increase connectivity

In highly populated and/or intensively used landscapes (e.g. conurbations or areas dominated by intensive arable farmland or artificial plantations), it is often not possible for species to disperse to maintain metapopulation structures, or to move further afield in response to climate change. Where required, action can be taken to mitigate such external constraints to some extent by assessing key species requirements and putting in place targeted measures such as corridors and stepping stones.

Most Natura 2000 species that have dispersal abilities and that are significantly constrained by habitat fragmentation, or other barriers, are habitat specialists. Evidence shows that such species do not normally benefit greatly from corridors[265]. To be effective, corridors and stepping stones (or similar elements referred to in ecological networks) need to be of the appropriate habitat condition and dimensions (i.e. typically over 100 m wide) and carefully located. IUCN guidance has emphasised that **each corridor should have a specific purpose and be designed accordingly[266]**. Other key elements of the IUCN guidance are summarised in annex 4 – Table 1.

Annex 4 – Table 1 Summary of IUCN's fundamental principles for ecological corridors

1. Ecological corridors are not a substitute for protected areas or OECMs. They are meant to complement protected areas and OECMs. The purpose of ecological corridors is to maintain connectivity, especially in regions where additional protected areas and OECMs are not possible, and connectivity is required to retain their elements and processes.

2. Ecological corridors should be identified and established in areas where connectivity is required with the aim of building ecological networks for conservation.

3. Each corridor should have specific ecological objectives and be governed and managed to achieve connectivity outcomes.

4. Ecological corridors may consist partly or entirely of natural areas managed primarily for connectivity.

5. Ecological corridors should be differentiated from non-designated areas by the specific uses that are allowed or prohibited within them.

Source: Adapted from Hilty et al. (2020)[267].

More specific guidance on increasing connectivity across the Natura 2000 network is being developed as part of the current (2022-2026) Horizon Europe project,

[265] Crick, H., Crosher, I., Mainstone, C., et al. (2020), Nature networks evidence handbook, Research report NERR081, Natural England, York, UK.
[266] Hilty, J., Worboys, G.L., Keeley, A., et al. (2020), Guidelines for conserving connectivity through ecological networks and corridors, Best Practice Protected Area Guidelines Series No 30, IUCN International Union for the Conservation of Nature, Gland, Switzerland.
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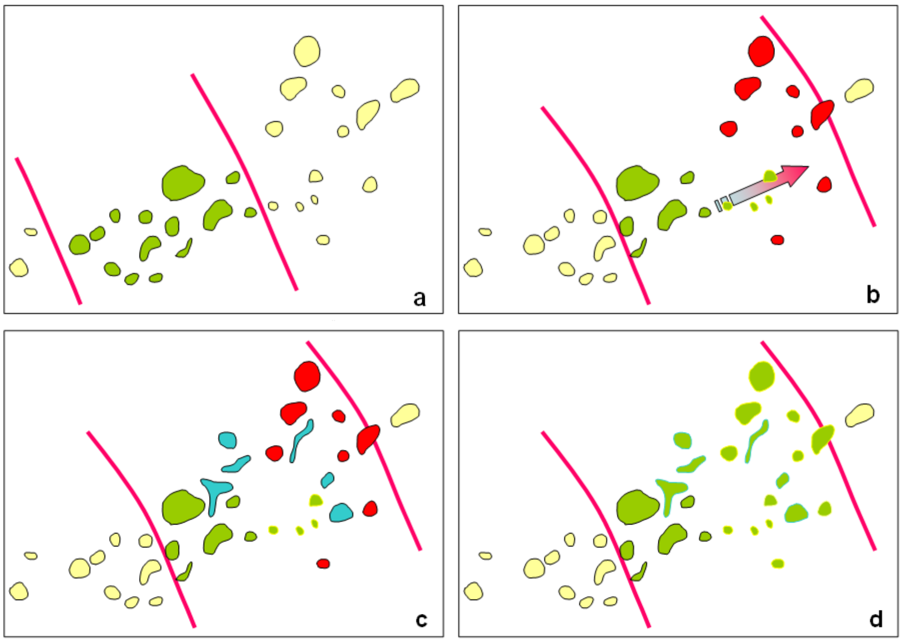
NaturaConnect[268]. This will feed into the development of the Trans-European Nature Network (TEN-N), a goal of the EU biodiversity strategy. Outputs so far include guidelines for connectivity conservation and planning[269]. Further studies around the topic of connectivity can be found in CORDIS[270].

For many species, there may be large gaps in the network of suitable areas. Therefore, it might be necessary to link suitable areas by creating new habitat patches. The need for such measures is explained and illustrated in annex 4 – Figure 1. To this end, the Nature Restoration Regulation provides the framework to take measures to improve the condition or re-establish habitat types and habitats of species in view of ongoing and projected changes to environmental conditions due to climate change, including inside and outside the Natura 2000 network.

Annex 4 - Figure 1 Illustrative example of the creation of new habitat patches to close spatial gaps

Green areas: colonised suitable habitat
Red areas: uncolonised suitable habitat
Blue areas: new habitat patches
Yellow areas: unsuitable habitat



For species x, all suitable habitat in the suitable climatic zone is currently occupied (green areas in frame a). In the future (frame b), the suitable climate zone has shifted due to climate change. Although the climate has become suitable in the red areas, they are not colonised, because the species is not able to reach the new areas (gap in the network is too large (bottleneck in the network at arrow). By creating

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268 https://naturaconnect.eu/goals-and-objectives/.
269 Moreira, F., Dias, F.S., Dertien, J., et al. (2024), Guidelines for connectivity conservation and planning in Europe, ARPHA Preprints, 5, e129021.
270 https://cordis.europa.eu/search?q=%27natura%27%20AND%20%272000%27%20AND%20%27stakeholders%27&p=1&num=10&srt=Relevance:decreasing

new habitat patches (blue areas in figure c) the species is able to colonise all suitable habitat areas of the network within the suitable climate zone (figure d). **Source:** European Commission (2013)[271].

Increasing the permeability of the habitat matrix between patches of high-quality habitat can improve the functioning of stepping stones and corridors by facilitating species movement and enhancing connectivity across the landscape[272]. This means **improving the general quality of the environment** so that it is less hostile to wildlife. **It is important to maintain, or increase, habitat heterogeneity in the wider landscape, especially through the conservation of semi-natural habitats**[273] [274] [275]. These include patches of semi-natural grasslands, heath and scrub, woodland, streams, wetlands, and elements such as native trees, rocky outcrops and boulders etc.

Landscape elements such as hedgerows, field margins, ditches and ponds also contribute to habitat heterogeneity and support biodiversity. The Habitats Directive recognises the ecological functions of such landscape elements and their ability to contribute to the coherence of the Natura 2000 network. Articles 3(3) and 10 of the Habitats Directive requires Member States, where they consider it necessary, to manage and develop landscape features such as rivers or traditional forms of field boundary (e.g. hedges), ponds or small woods.

Although this requirement is at the discretion of Member States, a study done in 2007[276] concluded that, in principle, these measures should be taken when Member States regard them as necessary to achieve the overall objectives of the directives (i.e. maintaining or restoring favourable conservation status). The Birds Directive lacks such specific provisions on landscape features, but Article 3(2) indicates that the general requirement for the preservation, maintenance and re-establishment of habitats is not just within protected areas[277]. Given the need to increase connectivity across the countryside, and to increase the general environmental quality of the wider landscape, **Member States should assume that some steps are required to maintain and where necessary restore and recreate landscape features in accordance with Article 10 of the Habitats Directive**.

Maintaining and increasing landscape features to enhance the coherence of the Natura 2000 network can also contribute to the EU biodiversity strategy for 2030 objective of ensuring a minimum of 10% high-diversity features in agricultural areas. It can also help achieve the requirements under Article 11 of the Nature Restoration Regulation

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[271] European Commission (2013) Guidelines on climate change and Natura 2000. Dealing with the impact of climate change on the management of the Natura 2000 Network of areas of high biodiversity value, Office of Publications of the European Union, Luxembourg.

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[273] Benton, T G., Vickery, J A. and Wilson, J D., (2003), Farmland biodiversity: is habitat heterogeneity the key? Trends in Ecology & Evolution No 18 (4), pp. 182-188.

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[276] Kettunen, M., Terry, A., Tucker, G.M., et al. (2007), Guidance on the maintenance of landscape connectivity features of major importance for wild flora and fauna. Guidance on the implementation of Article 3 of the Birds Directive (79/409/EEC) and Article 10 of the Habitats Directive (92/43/EEC). Report to the European Commission, Institute for European Environmental Policy, Brussels / London.

[277] See also judgment of the Court of Justice in Case C-418/04 (paragraph 179).

for Member States to put in place measures which aim to achieve an increasing trend at national level of at least two out of the three following indicators for agricultural ecosystems: grassland butterfly index; organic carbon in cropland mineral soils; share of agricultural land with high-diversity landscape features[278].

High-diversity landscape features include buffer strips, hedgerows, individual or groups of trees, tree rows, field margins, patches, ditches, streams, small wetlands, terraces, cairns, stonewalls, small ponds and cultural features. Land lying fallow can also count. **To provide a coherent approach, plans to increase landscape features in Natura 2000 sites should be integrated with measures in national restoration plans under the Nature Restoration Regulation.**

The need and priority for each type of landscape feature should be carefully assessed against the requirements of Natura 2000 species, taking into account wider biodiversity and other potential climate change adaptation and mitigation benefits. Steps to maintain and increase landscape features should therefore primarily focus on semi-natural habitat components, fallow, hedges and other features designed to support biodiversity (e.g. sown strips to produce flowers for insects and seeds for birds) that have been shown to be most effective[279]. Steps should also be taken to improve the ecological quality of existing landscape features, as many are currently of low biodiversity value.

Equally important to the maintenance of landscape features is the requirement to enhance the general ecological quality of productive farmland, i.e. in-field grassland and cropland habitats. Key actions that should be taken to achieve this include reducing the use of harmful pesticides and levels of fertiliser use, maintaining and improving the quality of grasslands, increasing crop diversity and fallow land[280] [281]. In forest habitats, steps should be taken to reduce clear felling of large areas and planting with non-native species, and to increase native tree species and age diversity, volumes of dead wood and open areas.

CAP eco-schemes and agri-environmental climate schemes can contribute to improving farmland habitats. Evidence shows that the most effective means of improving farmland habitats is to take targeted and tailored agri-environment-climate measures[282] [283]. Member states should therefore prioritise the uptake of such measures. This is especially important for specialist Natura 2000 species.

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[278] For a more detailed description of landscape features under the Nature Restoration Regulation, see Annex IV of Regulation (EU) 2024/1991.

[279] Alliance Environnement (2017), Literature reviews on the effects of farming practices associated with the CAP greening measures on climate and the environment, Report for the European Commission, Alliance Environnement, Brussels.

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2.8 Assess the need for species translocation/ assisted migration

As discussed in annex 2, section 3, certain species with limited dispersal abilities and fragmented populations may be unable to move to new areas with suitable climate conditions. While some measures may help, such as increasing Natura 2000 coverage and connectivity in the wider environment, some species (and habitats) with limited natural dispersal may need to be translocated to prevent local, or even global extinctions where climate conditions become unsuitable for their survival[284] [285].

Translocation is defined as 'the human-mediated movement of living organisms from one area, with release in another'[286] for conservation purposes. It includes (i) reinforcement and reintroduction within a species' indigenous range, and (ii) introductions comprising assisted colonisation and ecological replacement outside the species' indigenous range.

Species may be translocated to facilitate climate change adaptation for at least four reasons[287]:

- to strengthen metapopulations and thereby increase the resilience of existing populations, as well as increasing emigration rates and thereby dispersal and colonisation of new areas;
- to increase gene flow between isolated populations in order to increase the probability of adaptation to local climate conditions;
- to support the movement of species populations and range expansions in response to changing climatic conditions (assisted migration/movement) (see case study 14);
- to establish in new areas populations of species that are concentrated in sites with high risk of loss or damage due to climate change (such from extreme climate events e.g. flooding or fire) to decrease the risk of population loss or extinction.

However, the movement of species can be costly, and has well-known risks especially to new areas outside the species' natural range. Translocated species may become invasive, introduce new diseases, disrupt existing food webs and species community structures and result in the loss of distinct genetic forms. Consequently, translocations and especially those beyond natural range, raise critical ecological and ethical questions that need to be addressed.

Translocation of species is therefore generally considered to be a 'last-resort' option; to be taken only after other measures, such as improving habitat connectivity have been tried and deemed insufficient. On the other hand, some of the risks from increasing connectivity (e.g. from corridors), are similar to translocations, and arguably less controlled than the selective introduction of one species to a new area. **Therefore, as is**

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[284] Hoegh-Guldberg, O., Hughes, L., McIntyre, S., et al. (2008), Assisted Colonization and Rapid Climate Change, Science, 321 (5887), pp. 345-346.
[285] Lawler, J.J. (2009), Climate change adaptation strategies for resource management and conservation planning, Annals of the New York Academy of Sciences, 1162 (1), pp. 79-98.
[286] IUCN and SSC (2013), Guidelines for Reintroductions and Other Conservation Translocations, IUCN Species Survival Commission, Gland, Switzerland.
[287] Aitken, S N. and Whitlock, M C., (2013), Assisted Gene Flow to Facilitate Local Adaptation to Climate Change, Annual Review of Ecology, Evolution, and Systematics, 44 (1), pp. 367-388.

the case with other interventions that ecologically connect isolated habitat patches, the need for translocation should be carefully considered.

Before translocating any species, it is essential to have a thorough understanding of the species' ecology and behaviours in the new type of habitat. Hoegh-Guldberg et al. (2008)[288] developed a useful decision framework to help assess the appropriateness of using translocations as a means of assisting colonisation. Further guidance[289] and supporting tactics framework[290] are available to aid potential translocation measures.

It is also recommended that the need for translocations/assisted migration is assessed and planned strategically initially at Natura 2000 network, or at least regional level rather than through ad hoc initiatives. This can help maximise the effectiveness and efficiency of translocations. In particular, the results of network vulnerability assessments can be used to identify sites and species that are at highest risk. Such sites should then be priorities for sources of individuals for translocation to alternative sites (insurance sites). The network analysis can also be used to identify suitable climate refugia and sites where future habitat restoration or creation may provide suitable conditions for potential translocations.

Case study 14: Forest assisted migration

Starting in 2024, the Interreg North West Europe project **MigFoRest** is supporting assisted migration of European tree species and provenances to better anticipate climate change and strengthen forest ecosystem resilience across North-Western Europe. It includes 7 pilot territories in Belgium, France and Germany and focuses on assisted range expansion and assisted gene flow, strictly limited to European material, to speed up natural climate-driven species movements providing a framework to support forest owners and public authorities.

Source: Interreg NWE MigFoRest[291]

[288] Hoegh-Guldberg, O., Hughes, L., McIntyre, S., et al. (2008), Assisted Colonization and Rapid Climate Change, Science, 321 (5887), pp. 345-346.
[289] IUCN and SSC (2013), Guidelines for Reintroductions and Other Conservation Translocations, IUCN Species Survival Commission, Gland, Switzerland.
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[291] https://migforest.nweurope.eu/

ANNEX 5

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