commentary

European Academies
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Opportunities in Nature Restoration

Contents

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Summary

Purpose and scope. The EU Nature Restoration Regulation (NRR; Regulation (EU) 2024/1991) sets legally binding targets to restore degraded ecosystems on land and at sea. This commentary synthesises scientific evidence and policy options to support implementation across Member States, drawing on previous EASAC work on biodiversity, soils, forests, agriculture, bioenergy, water, and wildfires. It emphasises restoration as a cost-effective strategy for climate mitigation and adaptation, biodiversity recovery, water security, and disaster-risk reduction.

Why restoration matters. Europe faces intertwined crises: biodiversity decline, climate impacts (droughts, floods, heat), soil degradation, and weakening natural carbon sinks—especially in forests and peatlands. Ecosystem services (nature's contributions to people) underpin food and water security, health, and prosperity, yet are largely non-market public goods and thus under-provided. The NRR aims to correct this by setting targets, requiring national restoration plans (NRPs), and aligning with the Biodiversity Strategy, Green Deal, CAP, Water and Marine Directives, and the Forest Strategy.

Targets, plans, and economics. Headline goals include restoring at least 20% of EU land and sea by 2030 and progressively more degraded habitats to 2050; specific targets address peatland rewetting, forest condition indicators, agricultural ecosystem features, free-flowing rivers, and urban green–blue infrastructure. Commission assessments indicate multi-fold net benefits (public health, avoided damages, resilience, recreation, carbon) far exceeding costs, but financing must bridge the gap between who pays and who benefits.

Evidence base: biodiversity and ecosystem services. Biodiversity enhances multiple ecosystem functions across scales (pollination, pest control, nutrient cycling, soil formation, water regulation). Declines in insects and birds, high land-use intensity, and 'extinction debts' threaten agricultural stability and broader resilience. Accounting shows substantial annual value in EU ecosystem services, especially forests, water purification, and nature-based recreation.

Ecosystem-specific guidance

- **Agricultural landscapes.** Regenerative agriculture offers a goal-based pathway to rebuild soil organic matter, biodiversity, water retention, and climate resilience while sustaining yields. Priorities: diversified rotations/intercropping, cover and perennial crops, reduced tillage, agroforestry, landscape elements, and integrated pest management (IPM). Pay for measured outcomes (soil carbon, biodiversity, water), enable landscape-scale coordination, strengthen advisory systems, and align value chains.

- **Forests.** The forest carbon sink is weakening owing to harvest pressure and climate-amplified disturbances. Adopt close-to-nature silviculture, mixed-species and mixed-age stands, protect and connect habitats, and manage fuels and mosaics to reduce extreme wildfires. Reform bioenergy incentives towards true wastes/residues and cascade of use; rebuild stocks to meet Land use, land-use change, and forestry (LULUCF) trajectories.

- **Peatlands.** Rewet and restore drained peatlands (including paludiculture) to cut emissions, lower wildfire risk, improve water retention, and recover biodiversity.

The Nature Restoration Regulation can become a cornerstone of Europe's climate and biodiversity strategy if it

1. recognises and finances nature's strategic assets, valuing measurable public-good outcomes;

2. delivers cross-sectoral policy coherence and governance, aligning incentives and institutions; and

3. mainstreams preventive restoration, investing ahead of crisis to secure resilience, fair transition and autonomy.

Together, these actions shift restoration from a compliance task to a strategic investment in Europe's security, prosperity, and ecological stability.

NATURE RESTORATION

A Strategic Investment in Security, Prosperity, and Ecological Stability

In Europe, **only 1.4%** of the landscape comprises untouched forest and **just 3.3% having minimal intervention**.

The use of natural resources has
more than tripled
over the past 50 years.

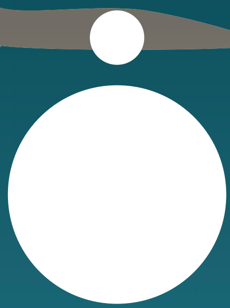
The target is to restore at least **20%** of the EU's land and sea areas by 2030 and increase the share of restored degraded habitats to

30% by 2030

60% by 2040

90% by 2050

€150 billion
costs
born by Stakeholders



€1,800 billion
benefits
for health, economic resilience, recreation by restoring peatlands, marshlands, forests, heathland and scrub, grasslands, rivers, lakes, and coastal wetlands

The Nature Restoration Regulation is a cost-effective opportunity for Member States to regrow their natural capital. Implementing it they should

1. Recognise and finance nature's strategic assets, valuing measurable public-good outcomes.
2. Deliver cross-sectoral policy coherence and governance, aligning incentives and institutions.
3. Mainstream preventive restoration, invest ahead of crisis to secure resilience, fair transition, and autonomy.

1 Background

1.1 Introduction

The European Union's Nature Restoration Regulation (NRR) – (EU) 2024/1991 – marks a historic step in European environmental regulation by establishing legally binding targets to restore[1] degraded ecosystems on land and at sea. Adoption followed vigorous political debate among Member States and stakeholder groups; yet the Regulation reflects a strong and widening consensus that the EU's twin crises – biodiversity loss and climate change – are intimately connected and must be tackled together by restoring ecological functions, rebuilding resilience, and protecting people and prosperity.

EASAC has analysed several of the related issues (e.g. biodiversity and ecosystem services) and the science that underpins the regulation (e.g. EASAC, 2017, 2022a, 2023, 2025a) and EASAC Council asked the Environment Programme to update their relevance to the current debate on the NRR. This commentary thus draws on previous analyses to inform policy-makers on some key issues related to the regulation. In particular, the regulation can become an effective tool for restoring degraded ecosystems to increase biodiversity, restoring the contributions that nature makes to society, and combatting climate change through bolstering carbon capture and storage capacities in natural ecosystems. We first provide some scientific background to the challenges the NRR is seeking to address, then move to evidence of how its objectives may be achieved through win–win approaches such as, for example, enabling nature to help farming, mitigate climate change, reverse land degradation, prevent natural disasters and reduce risks to food security.

1.2 Key aspects of the Nature Restoration Regulation

The NRR operationalises core objectives of the EU 2030 Biodiversity Strategy (Hermosa *et al.*, 2022) and complements the European Green Deal, the EU Climate Regulation, the EU Forest Strategy, the CAP and Farm-to-Fork Strategy, the Marine Strategy Framework Directive, the Water Framework and Floods Directives, and the Urban Greening and Soil agendas.

The Regulation's objective (EC, 2024) is as follows:

'Restoring wetlands, rivers, lakes, floodplains, forests, grasslands, marine ecosystems – including seagrasses and coastal habitats – and urban green and blue infrastructure, together with the species they host.'

The NRR's rationale is to secure public-good functions of nature – water purification, pollination, carbon sequestration and storage, soil fertility, climate and microclimate regulation, coastal protection, disaster-risk reduction – at scale and across sectors, not only in protected areas. The Regulation emphasises connectivity (e.g. free-flowing rivers and ecological corridors), coherence with other policies, and monitoring and reporting to track outcomes.

Targets and timelines: Headline targets include restoring at least 20% of the EU's land and sea areas by 2030 and increasing the share of restored degraded habitats to 30% by 2030, 60% by 2040, and 90% by 2050. Specific targets address peatlands (rewetting and restoration milestones), forests (indicators such as organic carbon, deadwood, tree diversity, connectivity), agricultural ecosystems (pollinator trends, landscape features, soil organic carbon), rivers, and floodplains (barrier removal, reconnection), coastal and marine ecosystems (seagrass, saltmarsh, benthic habitats), and urban ecosystems (green space, tree canopy, green–blue infrastructure).

Economic assessments (EC, 2023) estimate that the benefits of restoration efforts for health, economic resilience, recreation of restoring peatlands, marshlands, forests, heathland and scrub, grasslands, rivers, lakes, and coastal wetlands are more than €1,800 billion, with costs of around €150 billion. On these calculations, every EUR spent in land restoration would bring an economic return of EUR 8 to EUR 38. Similar calculations on the costs of restoring areas protected under the Habitats Directive would amount to approximately €154 billion with benefits of €1,860 billion (cost:benefit ratio of 1:12). The challenge is that many of these values are in terms of public goods so that stakeholders may not receive these in directly monetary terms. As a result, restoration measures may erroneously be seen as costs rather than opportunities. Communicating the clear benefits and designing policies to support and reward restoration measures are thus important across agricultural, grassland and forested landscapes.

Under the NRR, Member States should submit national restoration plans by mid-2026 and describe where and how they plan to deliver key targets. The plans should detail measures planned up to 2032, with a strategic overview of actions to 2050. As a result, Member States are encouraged to start planning as soon as possible and cover the areas to be restored and their habitat types, and the connectivity between habitats for different species. The plans should identify

[1] The concept of restoration is often interpreted narrowly as the re-establishment of species compositions that once occurred in a given area. In this commentary, we adopt the definition used in the NRR, which emphasises actions that restore vital functions of degraded ecosystems. Such restoration may involve novel combinations of species rather than strictly reintroducing those previously present. This interpretation is both more operational and realistic, particularly in the context of shifting species distributions driven by climate change. It also places the emphasis on reviving ecological processes – such as grazing, fire regimes, and natural flooding – rather than merely reconstructing historical structures.

the synergies with climate change mitigation and adaptation, reversing land degradation, contributing to disaster prevention, interaction with agriculture and forestry policies, and how the public is to be engaged in the planning. Detailed advice on the compilation of plans is offered by non-governmental organisations such as WWF (2025), IEEP (2024), and others. Two core objectives of NRR are ecosystem services and biodiversity; we start by discussing the links between these.

2 Ecosystem services and biodiversity

The terms 'biodiversity' and 'nature' can be abstract concepts and even politicised on the basis of perceived conflicts—for instance between nature and farming, between biodiversity and development. Such perceptions have been prevalent throughout history, as expressed by the 17th century philosopher John Locke's assertion that nature has no value until put to use or developed by man. Indeed, since then, nature has been extensively exploited and changed to the extent that in Europe, only 1.4% of the landscape comprises untouched forest and just 3.3% having minimal intervention (Schnitzler, 2014). Locke's simplistic view of nature is no longer supportable because we now better understand the value of nature and biodiversity in providing 'ecosystem services' (what IPBES calls Nature's Contribution to People (NCP)).

The problem is, however, that neo-classical economics continues to down-play the role of nature and natural resources in economic development. Robert Solow, whose growth theory still forms somewhat of the basis for modern theories of economic growth, even postulated that '*The world can in effect get along without natural resources, so exhaustion is just an event, not a catastrophe*' (Solow, 1999). The reason, according to Solow, was that human ingenuity had proved so strong that people had managed to develop substitutes whenever they experienced resource scarcity.

Solow's growth model was built upon and extended by leading economists such as Robert Lucas (e.g. Lucas, 2002) and Paul Romer (e.g. Romer, 1994) who both gave strong emphasis to knowledge and technology. The role of natural resources was consequently toned down.

It is possible to understand that the view of nature in relation to innovations and technology gave priority to knowledge and technology during the early 20th century. At that time, natural resources seemed to be infinitely large while the shortage of knowledge and innovation was obvious. But it is difficult to understand that this view continues to dominate. If recent history has showed anything, it is the high dependence of humans and our economy on nature and natural resources and their sinks—and the challenges experienced when resource use is wasteful and unjust.

The use of natural resources has been growing by between 2% and 3% yearly since the 1970s—more than a tripling over the past 50 years. According to a recent report by the International Resource Panel (IRP) – 'Bend the Trend' – the extraction and processing of material resources accounts for at least 55% of the generation of greenhouse gases and 90% of impacts on land-use related biodiversity loss and water stress (Bruyninckx *et al.* 2024). The IRP warns that unless the use of natural resources is undergoing drastic change in terms of much more intelligent and efficient use, the long-term effects for both the climate and biodiversity would be catastrophic.

Luckily there has been – and is – critique forthcoming from within the ranks of leading economists. In his major review for the UK Government in 2021 on 'The importance of biodiversity and ecosystem services', Sir Partha Dasgupta made a striking comment: '*Nature is a blind spot in economics that we ignore at our peril*'. He continues: '*Truly sustainable economic growth and development means recognizing that our long-term prosperity relies on rebalancing our demand of nature's goods and services with its capacity to supply them. To detach nature from economic reasoning is to imply that we consider ourselves to be external to nature.*' (Dasgupta 2021).

For EASAC, the Nature Restoration Regulation – together with a recent initiative by the European Commission, Nature Credits – represent serious attempts by the EU to complement neo-classical economics, the objective being to take the role of nature and natural resources in economic development fully into account.

2.1 Ecosystem services

Nature is seen as having three kinds of value (Pascual *et al.*, 2023):

- **Intrinsic values** refer to the inherent worth of nature itself, irrespective of its link with humans; sometimes called existence values. Intrinsic values are shared by many people as shown by membership of nature conservation and wildlife groups, and surveys show a majority support for the protection of nature and its restoration[2]. Economists have attempted to attach a value to these (e.g. by

[2] See, for example, https://www.gov.uk/government/statistics/england-biodiversity-indicators/public-awareness-understanding-and-support-for-conservation; Eurobarometer survey on biodiversity (2018-2019) https://europa.eu/eurobarometer/surveys/detail/2194.

Box 1 Ecosystem services and their value

Ecosystem services are often classified into four categories:

1. Provisioning services that comprise food (e.g. meat, milk, honey), water (e.g. for drinking, irrigation, cooling), raw materials (e.g. fodder, fertiliser, timber, bioenergy), genetic resources (e.g. medicinal purposes, gene banks), medicinal resources (e.g. biochemical products, models, and test-organisms), ornamental resources (e.g. decorative plants).

2. Regulating (and supporting) services such as air quality regulation (e.g. capturing dust, chemicals), climate regulation (carbon sequestration, storage, greenhouse-gas balance), moderation of extreme events (e.g. flood prevention), regulation of water flows (e.g. natural drainage, irrigation and drought prevention), waste treatment (especially water purification, nutrient retention), erosion prevention (e.g. soil loss avoidance, vegetated buffer strips), maintenance of soil fertility (incl. soil formation), pollination (e.g. effectiveness and diversity of wild pollinators), natural regulation of pests, weeds and diseases.

3. Habitat services such as for migratory species (e.g. bio-corridors and stepping stones), maintenance of genetic diversity (especially in gene pool protection).

4. Cultural and amenity services typified by aesthetic information (e.g. harmonic agricultural landscape), recreation and tourism (e.g. agrotourism), inspiration for culture, art and design, spiritual experience, cognitive development.

Attempts to quantify the value of ecosystem services have been made. For instance, Costanza *et al.* (1997) estimated their annual value at US$33 trillion (range US$16–54 trillion annually) which was larger than global gross domestic product at that time. This was intended to demonstrate the economic significance of the ecosystem services that are invisible to and not recognised by the market. In the same way, Eurostat (INCA, 2021) valued the EU's ecosystems services at €234 billion in 2019, with forests, water purification and nature-based recreation the largest contributors.

surveys of willingness to pay for protecting tigers, elephants, gorilla, landscapes, etc.).

- **Instrumental** values are those where nature directly or indirectly helps satisfy human needs or interests. The Economics of Ecosystems and Biodiversity (TEEB) project and national studies such as Dasgupta (2021) have developed approaches to quantify their values to humankind. These are the values most often used in policy debates and are described in more detail in Box 1.

- **Relational** values reflect the relationships between nature and people; for instance, the strong link and duty of care farmers may have with their land; many non-Western countries also have strong cultural or religious connections with the land.

Only some of the services in Box 1 are marketed goods (e.g. raw materials, tourism) and subject to prices, but most are of benefit to society as a whole (non-market or free goods). This means that the loss of nature's services is not borne by the developer causing a loss (of forest, wetland, natural grassland, etc.) but are borne by society as a whole. There is thus no cost-benefit balance through the market; only through any regulatory processes (e.g. planning regulations) that seek to weigh one against the other. This raises the question whether, from the view of society as a whole, there is a proper balance between the resources that subsidise the exploitation of nature and those that support its protection or restoration. In this context, subsidies for nature's exploitation are estimated by the OECD (2020) to be US$4–6 trillion globally per year, and to far exceed investments in conservation and restoration (US$68 billion per year). Biodiversity and associated ecosystem services are also central for physical and mental wellbeing across a range of environments, including urban spaces, which may represent significant health cost reductions (Marselle *et al.*, 2021; Methorst *et al.*, 2021).

As mentioned earlier, the Commission's impact assessment (EC, 2023) found that when the benefits to society are expressed in economic terms and non-monetary values are taken into account, the NRR should be considered as a cost-efficient investment over the long term. It can be seen as a means of compensating for market failures, by creating a regulatory overlay to limit the damage to society from actions that destroy or degrade nature. The NRR also allows the EU to deliver on commitments made under the Convention on Biological Diversity (CBD), the United Nations Convention to Combat Desertification (UNCCD), the 2030 Agenda for Sustainable Development and the UN Decade for Restoration, all of which call for the protection and restoration of ecosystems. The importance of restoring ecosystems from a climate perspective was also emphasised at COP26 following the call from the IPCC AR6 for the urgent restoration of degraded ecosystems to mitigate climate change and reduce its impacts, especially degraded wetlands and rivers, forests, and agricultural ecosystems.

2.2 Biodiversity and its decline

Biodiversity underpins multiple ecosystem functions and services across scales (Mace *et al.*, 2012; Ricketts *et al.*, 2016; Le Provost *et al.*, 2023). Its loss increases

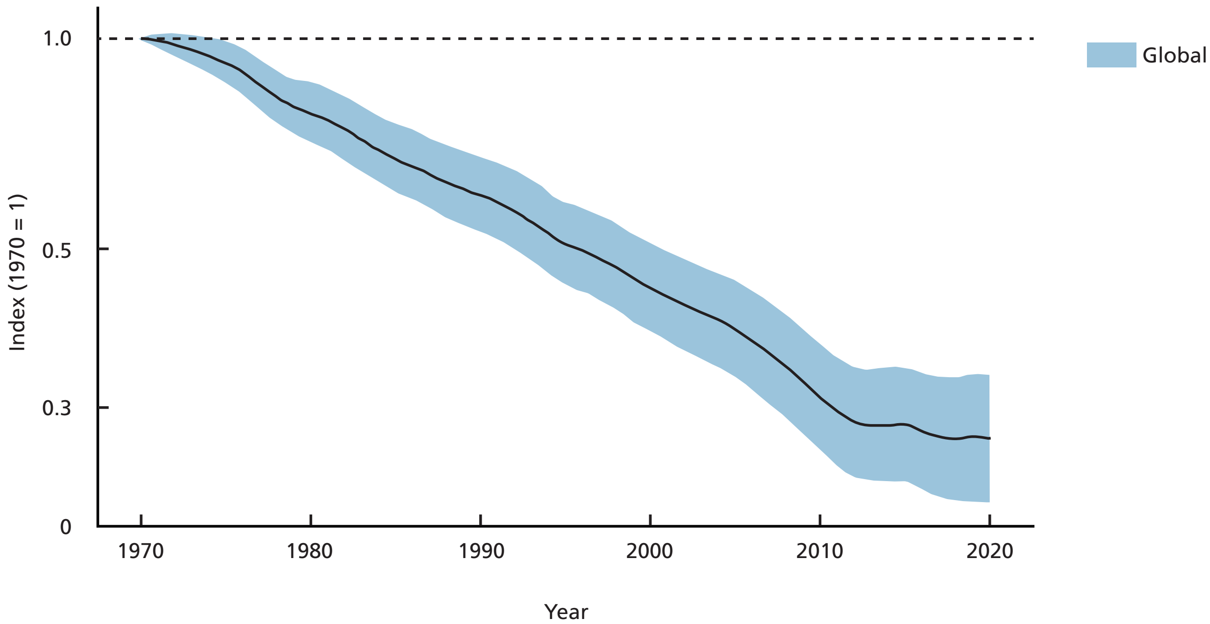


Figure 1 The Living Planet Index: 1970–2020. The bold line shows the index values and the shaded areas represent the statistical certainty surrounding the trend (95%). The index represents 34,836 populations of 5,495 species. Source WWF (2024).

vulnerability of agroecosystems—reducing pollination, natural enemy control, soil productivity, and yield stability (Lanz *et al.*, 2018). The set of indicators used by the Convention of Biological Diversity (CBD shows persistent declines in populations, habitat condition and community composition (Butchart *et al.*, 2010; IPBES, 2024). The WWF Living Planet Index indicates a global decline of more than 70% since 1970 (Figure 1). In Europe, insect declines are severe – even in protected areas (Hallmann *et al.*, 2017) – with implications for birds (Gregory *et al.*, 2023; Rigal *et al.*, 2023). Europe's high land-use intensity and Human Appropriation of NPP (HANPP) risk extinction debts playing out over decades (Dullinger *et al.*, 2013; Krausmann *et al.*, 2013; Matej *et al.*, 2025).

The NRR explicitly recognises that 81% of Annex I habitats under the Habitats Directive are in unfavourable condition, many with deteriorating trends (EEA, 2021). Reversing these trends is foundational to restoring the functions on which agriculture, forestry, fisheries, water, and urban systems depend (EEA, 2024).

3 The Nature Restoration Regulation and different ecosystems

3.1 The Nature Restoration Regulation in the agricultural landscape

National Restoration Plans should systematically address how restoration measures interact with agriculture. Restoring ecosystem functions – soil structure and fertility, pollinator networks, natural enemies, water infiltration and retention, microclimate regulation – contribute to strengthen long-term farm viability (Figure 2).

The NRR aligns with the Farm-to-Fork Strategy (EC, 2020), which seeks food systems with a neutral or positive environmental impact, enhanced climate resilience, biodiversity recovery, and food and nutrition security.

EASAC (2022a) reviewed regenerative agriculture as a goal-based approach to improve soil health and biodiversity while sustaining productivity. Regenerative agriculture is inclusive of practices and innovations (from mechanical to biotech) but sets ecological outcomes – soil organic matter, biodiversity, water retention, and reduced externalities – as guiding metrics (Box 2).

3.1.1 Regenerative agriculture and carbon storage

Regenerative agriculture may contribute to increase the amounts of carbon captured and stored in soils; for instance, through cover cropping and reduced tillage, intercropping and overall enhancement of soil organic matter (as in the 4permille initiative after COP15; Minasny *et al.*, 2017). Regenerative agriculture reduces reliance on synthetic fertilisers, so that less carbon dioxide (CO_2) is emitted in their production and there is less surplus nitrogen in the soil that can oxidise to nitrous oxides with its high greenhouse gas potency (see EASAC 2022a). The amounts of carbon stored in different soils differ greatly (Figure 3), so that selecting practices such as agroforestry and regenerative agriculture can store substantial amounts of carbon (Bossio *et al.*, 2020; Lal 2020; EASAC 2022a).

The EU has much potential for restoring soils since 61% to 73% of agricultural land suffers soil degradation,

Soil organisms in agricultural soils

Maintain soil productivity. Ensure the availability of air, water, and nutrients in the soil for crops.

Semi-natural habitats managed by agriculture

Provide feed for livestock, and habitat and food for pollinators and pest predators. Contribute to crop pollination and natural plant protection.

Non-agricultural ecosystems that support agriculture

Forests and natural grasslands reduce the risk of soil erosion.
Wetlands filter and purify water, manage excess water during floods and release it in dry periods.

Landscape features in agricultural land

Can enhance pollination and natural plant protection. Can prevent soil erosion, reduce nutrient losses, filter air and water, and sequester carbon.
Trees and hedges make weather conditions more favourable for crops and farm animals by reducing wind, providing shade and cooling the air on hot days.

Crop and livestock diversity

Crop diversity maintains soil health and productivity, and protects crops against pests, reducing the need for pesticides and fertilisers.
Mixed use of grazing livestock species contributes to reducing wildfire risk and reduces animal health risks.
Diversity increases environmental and socio-economic sustainability and the resilience of agricultural production.

Crop and livestock genetic diversity

Maintaining the diversity of crop varieties and livestock breeds adapted to specific environments supports production in diverse and harsh environments. Genetic diversity also supports resilience and adaptation to changing bioclimatic and agronomic conditions.

Figure 2 Key elements of biodiversity and how they support agriculture (EEA, 2024).

Box 2 Regenerative agriculture

The concept of regenerative agriculture was developed in the 1970s, and is a broad approach (Newton *et al.*, 2020; Giller *et al.*, 2021) to sustainable agriculture along with more specific approaches such as agroecology, conservation farming, organic farming, ecological intensification, and carbon farming (Oberč and Arroyo Schnell, 2020). Regenerative agriculture aims to maintain agricultural productivity, increase biodiversity, and enhance ecosystem services including carbon capture and storage. It is a flexible approach based on setting the goals that should be achieved, and applying the practices and technologies that will, over time, achieve these goals. Regenerative agriculture seeks opportunities for restoration, especially for soils in the agricultural landscape, and to find synergies between production methods of different crops and farm animals (both ruminant and non-ruminant). Regenerative agriculture does not exclude the use of, for example, modern plant and animal breeding technology, tilling, inorganic fertilisers, or pesticides, but instead aims for a limited and more targeted use. It aims to not just reduce negative environmental effects of agriculture but to improve environmental externalities (Oberč and Arroyo Schnell, 2020) through restoration (particularly of soil health, including increasing the capacity of soils to capture and store carbon to mitigate climate change), and reversal of biodiversity loss.

Examples of approaches available include the following:

- increased diversification in and among crops;
- introduction of permanent and perennial crops;
- expanded agroforestry;
- intercropping;
- keeping green plant cover on all farm fields during all seasons;
- reduced tillage.

The objective of regenerative agriculture is to deliver synergies between carbon storage and enhancing biodiversity, while avoiding negative effects on food production, especially in the long term. However, some measures may involve trade-offs: for example, conversion of arable land to grasslands could increase carbon storage and biodiversity but food production could decrease (EASAC, 2022a).

Regenerative agriculture does not explicitly address landscape and regional scales, despite several processes, particularly for maintaining biodiversity, operating at these larger scales (EASAC 2022a).

However, coordination of management practices at the landscape/ regional level can simultaneously enhance biodiversity, carbon capture and storage and many other ecosystem services. Financial support needs to be flexible and, in addition to benefiting individual farmers, be eligible for communities and associations of farmers managing landscapes in a coordinated way. Restoration efforts can take advantage of existing and new semi-natural habitat patches such as landscape elements (species rich hedges, waterways/ponds, flower strips, etc.) that connect with natural and restored sites to enhance biodiversity at the landscape and regional scales. Targeting only the farm scale is insufficient.

and erosion alone is estimated to cause the loss of almost 3 million tonnes of wheat and 0.6 million tonnes of maize per year (EC, 2022). Sixty per cent of EU soils are also judged to be unhealthy owing to reduced soil biodiversity, pollution, loss of organic matter, compaction, salinisation, and soil sealing (Veerman *et al.* 2020). Similarly, Hiller *et al.* (2020) point to 60% to 70% of EU soils being in unhealthy condition and costs associated with soil degradation exceeding €50 billion per year. Climate change-related droughts also lead to reductions in production (Rakovec *et al.*, 2022), and in 2022–23, EU cereal yield was reduced by 6.9% compared with the 5-year average and maize production by 24.3% (EC, 2023).

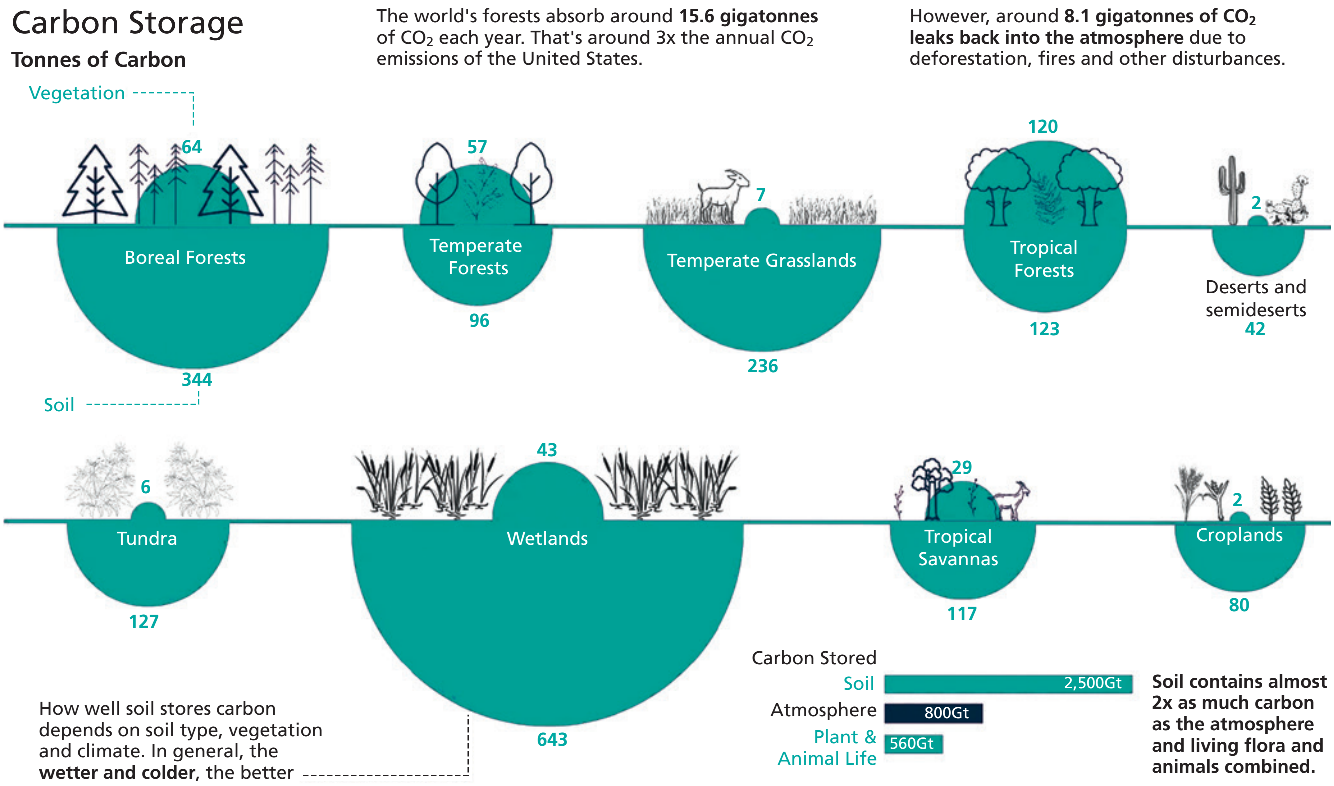


Figure 3 Distribution of carbon below and above ground in different types of ecosystem. Source: IPCC, NASA, https://www.visualcapitalist.com/sp/visualizing-carbon-storage-in-earths-ecosystems/, Miranda Smith.

Most (84%) of peatlands are in unfavourable conservation status with their draining responsible for the majority of agricultural land carbon emissions. Restoring wetlands is thus one of the most effective means of removing carbon dioxide from the atmosphere.

With regard to livestock management, practices such as rotational grazing can improve pasture health and increase carbon storage in grasslands. Careful management can turn pastoral land into carbon sinks rather than sources of emissions. Regenerative agriculture also emphasises circular practices, where on-farm waste is repurposed, reducing methane emissions from organic waste decomposition (EASAC, 2022a).

3.1.2 Regenerative agriculture and biodiversity

Numerous studies reviewed in EASAC (2022a) demonstrate that regenerative systems often support greater biodiversity compared with conventional agricultural practices, including diversity of insects and soil organisms. Of particular importance are the following approaches:

1. **Enhancing crop diversity.** Growing only one crop – monoculture –can deliver economies of scale but is associated with the environmental costs of intensive production. In contrast, crop diversification, especially increased diversity in crop rotations, and agroforestry practices enhance biodiversity (see, for example, Aguilera *et al.*, 2020; Tamburini *et al.*, 2020; Beillouin *et al.*, 2021). Furthermore, field borders, flower strips, and other permanent edge habitats enhance biodiversity and several ecosystem services in agricultural landscapes (e.g. Sexton and Emery, 2020). Insect loss can be mitigated by retaining nearby natural habitat (Outhwaite *et al.*, 2022) (Figure 4).

2. **Restoring grasslands.** Restoring grasslands may increase biodiversity, although this may take many decades (SER, 2002), and effects will depend on restoration management and past land use. Evidence for long-term increases of biodiversity after conversion from arable to grasslands (e.g. Sexton and Emery, 2020) is limited by the lack of long-term monitoring studies with appropriate controls (Nerlekar and Veldman, 2020).

3. **Managing at landscape scale.** Large-scale intensification of agricultural practices at the landscape level is detrimental to biodiversity and ecosystem services (e.g. Tscharntke *et al.*, 2021). Reversing this depends on management at scales

Figure 4 Decline in farmland biodiversity owing to intensification of land use. Source: Sustainable use of plant protection products.

larger than individual fields through coordination at the landscape level and increasing landscape diversity as illustrated in Figure 4. Diversity at the landscape level, for example through landscape elements, is not only crucial for biodiversity recovery. It also increases ecosystem functioning in agricultural landscapes and contributes to sustainable, regenerative agrifood systems (Petit and Landis, 2023).

3.1.3 Implementing regenerative agriculture and the Nature Restoration Regulation

Strong opposition to the NRR during 2023 and 2024 came from farming-related interests including stakeholders dependent on markets for pesticides, fertilisers, and other components of intensive agriculture, and from farmers (especially large-scale intensive farmers represented by the main Brussels groups typified by COPA-COGENA). Underlying the opposition were concerns whether yields and farm income could be retained under a regenerative approach (e.g. by applying IPM). Since many of the economic benefits described earlier are for social goods (carbon uptake, biodiversity recovery, etc.), a major challenge is to devise a system of monetary rewards to incentivise farmers to work in harmony with the NRR's objectives.

Existing agricultural policies do not stimulate regenerative practices and discourage farmers from making the necessary changes. Farmers need clear pathways to sell their produce at fair prices and they need long-term payment for landscape maintenance, as an additional source of income. A new revised CAP will be crucial for adopting regenerative practices and reduce the economic risk of transitioning. Knowledge sharing through farmers networks or cooperatives is also essential so peers who have successfully implemented regenerative practices can act as mentors. Providing hands-on training and workshops can increase awareness and skills relating to regenerative practices, making them more accessible. Engaging forerunner farmers, non-governmental organisations and agricultural extension services in promoting and supporting the transition to regenerative practices can expand resources available to farmers. In addition, it is important that markets embrace the demand for sustainable products to motivate farmers to transition to regenerative methods. This can include certification programs that recognise regenerative farming and make it easier for consumers to support these methods.

3.1.4 The role of pesticides and integrated pest management

The EU's debate on the Sustainable Use of Plant Protection Products (SUR) has been contentious. Regardless of regulatory pathway, IPM is central to the NRR's aims because it reduces dependence on hazardous chemicals, rebuilds ecosystem functions, and is consistent with productivity (Lechenet *et al.*, 2017). The toxic load of pesticides has increased markedly (di Bartolomeis *et al.*, 2019), with impacts on pollinators and natural enemies. IPM's hierarchy – prevention, monitoring, thresholds, mechanical/biological controls, targeted chemical use as last resort – can halve pesticide reliance while sustaining yields in many systems. Precision agriculture, forecasting and breeding/CRISPR-enabled resistance can further reduce chemical demand.

An enabling IPM strategy (EASAC, 2023) includes (Box 3) the following: common IPM definitions, advisory services, monitoring infrastructure, incentives under CAP, landscape perspectives for mobile pests and natural enemies, and civil-society engagement to align consumer demand with sustainable production.

Box 3 Recommended contents of an IPM strategy

- **Ensuring that there is a common understanding of IPM** where chemical control is the option of last resort.
- **Education and awareness**. IPM increases the complexity of farming management and requires additional decision-making, and detailed husbandry knowledge and experience, increasing the need for external advice and support.
- **Help for farmers to make new investments**.
- **Providing basic monitoring services**, since pest control strategy requires more data on intensity and location of threats before action.
- **Incentive-based policies** through actions to support deployment by farmers and encourage further integration of IPM practices and technologies through the incentives in the Common Agricultural Policy (CAP).
- Recognising the potential for **carbon offsetting** in support mechanisms under the CAP.
- **Agrochemical industry** can support the transition to IPM by moving away from mass-market sales of treated seeds and crop protection options, to more target-specific and niche markets that support farmers' moves to increase crop biodiversity and apply biological and other control mechanisms.
- It is important to take a **landscape perspective** that extends beyond the single farm; pest populations migrate across farms and wider areas, so coordinated pest control actions are the optimal approach.
- **Consumer Awareness Campaigns**: strengthening public understanding of the negative ecological and human health impact of pesticides can drive demand for more sustainably produced food.
- **Stronger Regulation on Hazardous Pesticides**: the EU should continue restricting harmful pesticide classes and banning emergency loopholes that allow for their continued use.

3.2 The Nature Restoration Regulation and forested landscapes

The NRR mandates Member States to 'achieve an increasing trend at national level of at least six out of seven' forest indicators, which include traits such as the amount of non-living woody biomass in standing and lying deadwood, organic carbon stocks, forest connectivity and tree species diversity, reflecting the key elements of forest ecosystems described in EASAC (2017).

In particular, the crucial role of forests in carbon uptake has been weakening in recent years (Pugh *et al.*, 2020; IPCC AR6, 2021; Pan *et al.*, 2024), and national reporting by EU states shows major reductions or reversals in their land sinks, with some becoming net emitters. Overall, the EU forest carbon stock has been declining at a rate of 3.4 million tonnes of carbon dioxide equivalent (Mt CO_2e) per year (from 2017 to 2022) and would need to be drastically reversed to take up 8.3 Mt CO_2e per year if the Land Use Change and Forestry Regulation to remove 310 Mt CO_2e by 2030 were to be met (Korosuo *et al.*, 2023).

There are multiple causes for this decline:

- increased harvesting leads to reduced carbon stock and may lead to deforestation and land degradation in some regions;
- climate impacts are manifested in insect outbreaks, storms, higher temperatures, droughts, and more frequent wildfires;
- loss of forests to urbanisation and infrastructure.

Forests face competing demands from market-driven demands for timber, pulp and paper and energy which interact with non-market 'free goods' such as air quality, biodiversity, resistance to natural disasters and recreation. Demand for bioenergy has led to increasing harvesting rates to provide the primary woody biomass required for heating and electricity generation (Camia *et al.*, 2021). This demand is currently driven by public subsidies for 'renewable' energy, and is a highly contested tool for climate mitigation (Norton *et al.* 2019; Searchinger *et al.*, 2018). Previously (EASAC, 2022b), we pointed to the importance of limiting feedstocks for bioenergy (and for emerging BECCS projects) to genuine wastes that do not depend on additional harvesting of forest wood, and would thus contribute to achieving targets for increasing forest carbon stocks.

The increased importance of carbon stock and biodiversity underline the importance of regarding forest as a limited resource whose benefits need to be managed on a longer-term basis. The EU has previously offered guidance on forest management priorities in a cascade of use (Figure 5) and integrating this with the NRR offers an opportunity to develop a longer-term approach to forest management that better balances the conflicting pressures.

Forests have also been increasingly vulnerable to fire and pest damage owing to the warming climate reducing supply. Similarly, EASAC in a report on Changing Wildfires (EASAC, 2025b) stressed that wildfire risk could be substantially reduced through promoting mixed land use, increase biodiversity and structural

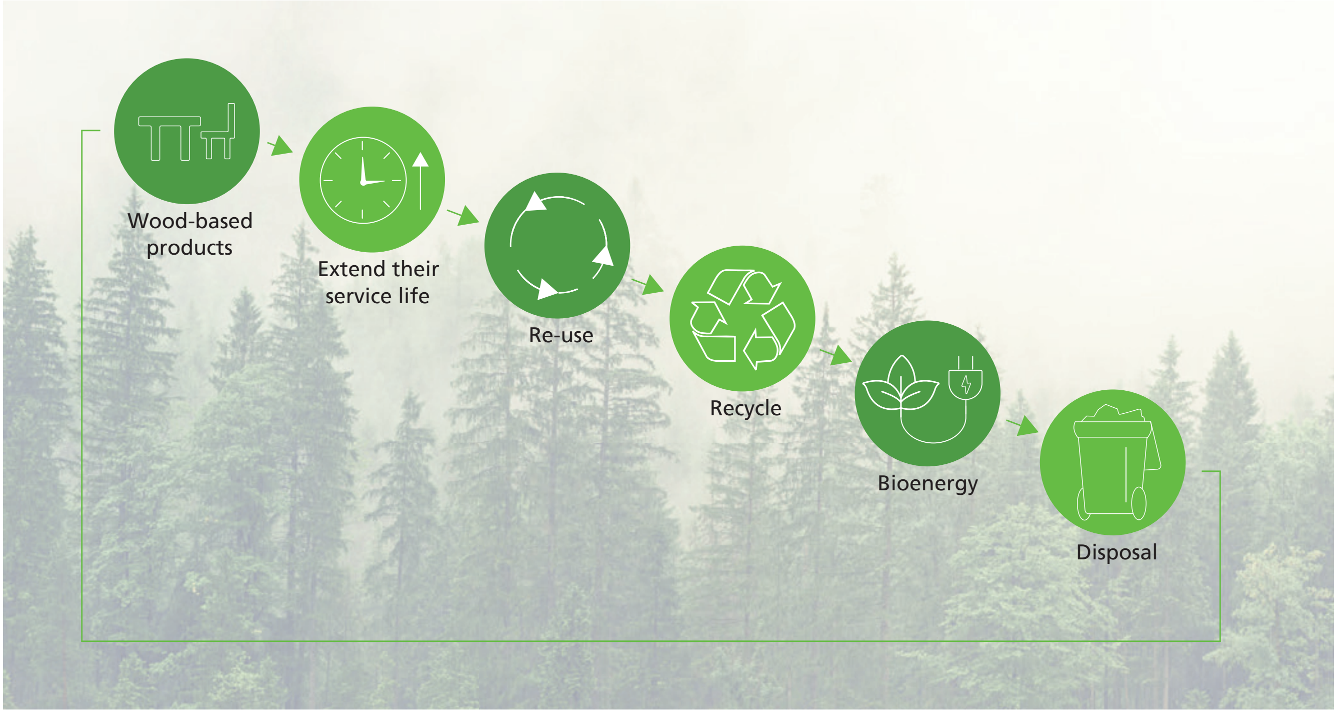


Figure 5 EU Cascade priorities for forest biomass.

diversity in the landscape, invest in agroforestry and targeted conservation to create more fire-resilient environments. Preventive restoration (see further in section 3.7) is here an interesting emerging concept, namely restoration efforts after a large-scale wildfire should focus on designing a mosaic landscape with increased structural and biological diversity with the aim of reducing future wildfire risks.

3.3 The Nature Restoration Regulation and peatlands

As shown in Figure 3, peatlands are among the most efficient carbon sinks globally and store approximately two times more carbon per hectare than boreal forests. Peatlands accumulate carbon over millennia through waterlogged conditions that slow plant decay and are thus ancient stores of carbon, making the loss of these ecosystems a significant concern for climate feedback loops (Witze, 2020). Peatlands are particularly vulnerable to drying in a warming climate, while conversion to agriculture by drainage leads to release of carbon dioxide as the exposed peat weathers or becomes susceptible to combustion. For example, the Arctic wildfires of 2019 and 2020 burned millions of hectares releasing large amounts of carbon dioxide (Hugelius *et al.*, 2020). Unlike forests, peatlands recover very slowly after fires, with carbon losses often becoming permanent.

Rewetting and restoring degraded peatlands are important strategies for mitigating carbon loss. In many cases (however there are important exceptions) this can be achieved by rewetting drained peatlands to allow padiculture (growing crops on peat), re-wetting degraded and dried deposits, re-establishing peat-forming vegetation or converting cropland to permanent grassland and managing the hydrology. Restoration may increase resilience to wildfires and enhances their carbon sequestration capacity and often offers dual benefits for biodiversity conservation and climate change mitigation (Wilkinson *et al.*, 2023).

3.4 The Nature Restoration Regulation and marine/coastal ecosystems

The NRR explicitly covers marine and coastal ecosystems – seagrass meadows (eelgrass/*Posidonia*/*Zostera*), saltmarshes, kelp forests, shellfish reefs, coastal wetlands, dunes, and barrier systems – which are central to blue carbon, coastal protection, biodiversity, and fisheries. Restoration priorities and measures are focused on the following:

- Seagrass and saltmarsh restoration: seedling/propagule planting, sediment stabilisation, water-quality improvements (nutrient/sediment reduction), anchoring management.
- Biogenic reefs (oyster/mussel): substrate provision, reef re-seeding, harvest management, water-quality controls.
- Dune and barrier restoration: re-vegetation, sand-fencing, setback of hard infrastructure, room-for-the-coast.

- Estuaries and lagoons: tidal exchange restoration, removal or retrofitting of tidal barriers, fish passage.

- Pressures management: limit bottom-towed gear in sensitive habitats; address nutrient/sediment loads from catchments.

The benefits would include rebuilding blue-carbon stocks and fluxes, attenuating waves and storm surge, reducing coastal erosion, improving water quality through filtration/sequestration, and restoring nursery habitat. Plans should integrate with Marine Strategy Framework Directive, maritime spatial planning, Fisheries Policy, and coastal adaptation strategies and the use of measures such as Marine Protected Areas (MPAs) to achieve legally binding targets for the restoration of marine habitats and species.

3.5 The Nature Restoration Regulation and inland aquatic/riparian systems

Rivers, lakes, wetlands, and floodplains are linchpins of restoration because they regulate hydrology, water quality, biodiversity connectivity and disaster risk and restoration efforts include the following:

- Free-flowing rivers: remove barriers; build bypasses or nature-like fishways where removal is infeasible; prioritise by ecological gain.

- Floodplain reconnection: levee set-backs, side-channel and oxbow restoration, two-stage ditches, re-meandering, groundwater recharge zones.

- Riparian buffers and shading: trees and woody debris improve thermal regimes, habitat complexity, and nutrient retention.

- Wetland creation/restoration: denitrifying wetlands for nutrient reduction, sediment capture, biodiversity, and flood storage.

- Water allocation and abstraction management: ecological flows, drought plans, conjunctive use with managed aquifer recharge.

The benefits would include reduced flood peaks, enhanced baseflows and drought resilience, improved water quality, lower treatment costs, restored migratory corridors, and boosted recreation and cultural services.

3.6 The Nature Restoration Regulation and urban ecosystems

Urban areas are explicitly included in the NRR through targets for urban green space, tree canopy, and green–blue infrastructure. Cities host most of Europe's population and are where heat, pluvial flooding, air quality, and equity intersect. Here, restoration efforts would include the following:

- Green infrastructure: street trees, parks, pocket forests, green roofs/walls, community gardens, urban wetlands.

- Sponge-city design: permeable pavements, bioswales, rain gardens, detention/retention basins, blue-green corridors linking parks to rivers.

- River daylighting and riparian restoration for water quality, habitat, and amenity.

- Connectivity: nature networks across neighbourhoods, peri-urban buffers linking to regional landscapes.

- Governance: embed nature-based solutions (NBS) in planning codes, financing (including cohesion and recovery funds), and maintenance budgets.

The benefits would include reduced urban heat island effects, improved air quality, increased physical and mental health benefits, stormwater management, biodiversity refugia, and energy savings through microclimate regulation—central to climate adaptation and social resilience.

3.7 Preventive restoration and disaster-risk reduction

It is the view of EASAC that the NRR would enable a strategic shift from reactive disaster response to proactive risk reduction by rebuilding landscape functions. Preventive restoration would contribute to reduce hazard, exposure, and vulnerability to, for example, the following:

- **Wildfires**, through, for example, fuel mosaics and pyrodiversity: mixed species/age patches, agroforestry belts, woodland–grassland interfaces, strategic fuel breaks based on ecology and topography, peatland rewetting: lowers ignition risk and severity, close-to-nature forestry: continuous cover, reduced slash accumulation, species mixes less vulnerable to synchronous stress and increased grazing and agro-silvo-pastoral systems: maintain low-flammability mosaics (EASAC, 2025b).

- **Flooding**, through, for example, Natural Water Retention Measures (NWRM): floodplain reconnection, wetlands, riparian buffers, soil-health restoration, farm ponds; Urban sponge measures: infiltration and detention systems. These measures contribute to flatten flood peaks, reduce downstream damages and insurance losses, and recharge aquifers.

- **Landslides and erosion**, through re-establishing vegetation on slopes (deep-rooted species), contour hedgerows, forest restoration in critical zones, and improved soil structure reduce mass movements and sediment delivery to rivers.

- **Drought and heat** through, for example, increasing soil organic matter and mulching increase water holding capacity; Shaded riparian corridors reduce evapotranspiration and support baseflows; Urban tree canopy decreases heat stress and health risks.

4 Policy recommendations

The aims of the Nature Restoration Regulation (NRR) – to improve biodiversity, restore ecosystem services, mitigate and adapt to climate change, and reduce disaster risks while supporting food and water security – require coherent action at both national and EU levels. The following recommendations address finance, governance, and implementation in an integrated framework aligned with the Regulation's objectives.

4.1 Recognise and finance nature's strategic assets

Europe's natural capital – its soils, biomass, peatlands, wetlands, rivers, and marine ecosystems – provides essential public goods that underpin carbon storage, water regulation, biodiversity, and food and energy security. These assets must be recognised, measured, and financed as strategic national and European priorities.

- Close the value-funding gap for public goods by paying for measured ecosystem outcomes such as carbon sequestration, water regulation, and biodiversity.
- Treat ecosystem carbon and water-regulation functions (in soils, peatlands, blue carbon, forests, wetlands) as strategic assets within fiscal and planning frameworks.
- Deploy results-based schemes under the CAP, Cohesion Policy, and national funds, linking disbursements to soil/biomass carbon indicators, water metrics, and biodiversity outcomes.
- Develop natural-capital accounts and fiscal frameworks to track ecosystem benefits and liabilities, enabling Ministries of Finance to justify stable, multi-year restoration budgets.
- Use public procurement, green bonds, and insurance instruments to scale restoration of urban green-blue infrastructure, river corridors, and wetlands.
- Incentivise carbon farming, soil-health practices, paludiculture, and climate-smart silviculture through integrated monitoring and results-based payments.
- Establish integrated monitoring systems for carbon, water, and biodiversity, coordinated with EU research infrastructures to enhance accuracy and reduce cost.

This recommendation directly operationalises Key Message 1: Recognise, measure and pay for public-good outcomes.

4.2 Deliver cross-sectoral policy coherence and governance

Achieving the NRR's objectives requires aligning Europe's sectoral policies and governance mechanisms. Restoration cannot be delivered in isolation—it depends on coherence across agriculture, forestry, water, energy, marine, and urban systems, supported by clear institutional mandates and accountability.

- Remove perverse incentives and align sectoral policies with NRR goals, ensuring coherence across the Green Deal, CAP, LULUCF, energy, and cohesion frameworks.
- Reform bioenergy policy to avoid subsidies that stimulate additional forest harvest for energy; prioritise residues, wastes, and cascading use, and favour long-lived wood products.
- Implement LULUCF Regulation with credible national pathways to rebuild Europe's forest and soil carbon sinks.
- Integrate NRR targets into River Basin Management Plans, Marine Strategies, maritime spatial plans, flood/drought risk strategies, urban plans, and CAP Strategic Plans.
- Coordinate National Restoration Plans across ministries (environment, agriculture, energy, transport, housing, finance), with transparent mandates, delivery milestones, and inter-ministerial oversight.
- Embed cross-sectoral governance and accountability mechanisms to ensure policy coherence from EU to local levels.
- Support open data systems and research collaboration to link monitoring, reporting, and adaptive management, enabling continuous learning and improvement.

This recommendation delivers Key Message 2: Cross-sectoral coherence across forestry, agriculture, water, energy, marine, aquatic, and urban policies.

4.3 Mainstream preventive restoration and build capacity for fair transitions

Preventive restoration is the most effective and cost-efficient strategy for reducing disaster risks, protecting assets, and enhancing Europe's resilience and strategic autonomy. Investments in prevention strengthen both natural and economic systems against climate extremes and ecological degradation.

- Make preventive restoration a core principle in all planning and investment—embedding it in spatial plans, River Basin Management Plans, Marine Strategies, CAP eco-schemes, Cohesion Policy, disaster-risk reduction frameworks, and insurance systems.
- Invest in advisory and extension services, municipal capacity for nature-based solutions, and farmer-to-farmer and fishery partnerships to accelerate uptake.
- Ensure equitable access for smallholders, cooperatives, and small municipalities to restoration finance and technical assistance, using low-transaction, outcome-based schemes.
- Support participatory planning and co-design to build legitimacy, recognise cultural and relational landscape values, and foster stewardship.
- Manage forest fuel loads, landscape mosaics, and peatland hydrology to reduce wildfire and emission risks through active, preventive management.
- Promote integrated pest management (IPM), precision agronomy, and resilient crop varieties as preventive measures that sustain yields and biodiversity.
- Prioritise investments through multi-benefit appraisals that evaluate ecological, economic, and social co-benefits, ensuring transparency and value for money.
- Maintain long-term monitoring to evaluate outcomes, build public trust, and enable adaptive management.

This recommendation advances Key Message 3: Mainstream preventive restoration to cut risks and costs while strengthening Europe's climate resilience, fair transition and strategic autonomy.

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EASAC

EASAC – the European Academies Science Advisory Council – is formed by the national science academies of EU Member States, Norway, Switzerland and the UK as well as by the Academia Europaea. EASAC's 29 member institutions collaborate with each other in giving advice to European policy-makers. In its entirety, EASAC provides a strong means for the collective voice of European science to be heard.

EASAC's mission reflects the view that science is central to many aspects of modern life and that an appreciation of the scientific dimension is a pre-requisite to wise policy-making. This view underpins the work of many science academies at the national level. Given the importance of the European Union as an arena for policy-making, academies have recognised that the scope of their advisory functions needs to extend beyond the national domain and cover the European level. Therefore, European academies formed EASAC in 2001 so that they can speak in a strong voice at EU level.

Through EASAC, the academies provide collective, independent, strictly evidence-based advice about scientific aspects of policy issues to those who make or influence policy and legislation within the EU institutions and in EU Member States. EASAC aims to deliver advice that is comprehensible, relevant, and timely.

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