RESTORING FOREST ECOSYSTEMS: Evidence-based insights for policymakers

EU NATURE RESTORATION LAW

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Restoring forest ecosystems: Evidence-based insights for policymakers

Executive Summary

- Restoring forest ecosystems not only has the potential to enrich biodiversity, but also to mitigate climate change, support climate adaptation, mitigate the effects of droughts and floods, enhance water availability, improve water quality, reduce erosion, and lower avalanche induction.
- Given their wide range of ecosystem services, the EGU Biodiversity Task Force strongly supports the restoration of forest ecosystems going beyond Natura 2000 sites.
- To restore forest ecosystems effectively, a range of indicators needs be used in the Nature Restoration Law, including tree species diversity, and standing and lying deadwood.
- The complexity associated with forest ecosystem restoration means that expert consultation will be required to ensure the measures implemented are effective.

European forests constitute an essential component of terrestrial ecosystems due to the myriad ecosystem services and functions they provide. Not only do forest ecosystems support biodiversity, but also climate change mitigation and adaptation, ecosystem resilience, water quality and availability, human wellbeing, well-regulated water flows, and atmospheric moisture circulation. However, shifting ecosystem dynamics as a result of climate change, and urban and industrial expansion - leading to ecosystem fragmentation, invasive species, wildfires, and pollution - has the potential to adversely impact the health, integrity, and resilience of existing forest ecosystems and subsequently diminish their environmental, societal, and economic value [1]. Actively prioritising the restoration and conservation of forest ecosystems, and ensuring effective strategies and methods are used, is essential to minimising the impacts of these shifting ecosystem dynamics and pressures. Furthermore, while forest areas across Europe expanded significantly between 1945 and 2003 [2], this expansion has since slowed. Increasing the EU's forest area may help to support the EU's current Carbon Sink Targets.

Forest ecosystems and the EU Nature Restoration Law

Given the extensive scientific evidence demonstrating the environmental, societal, and economic value European forests provide through a diverse range of ecosystem services, the EGU Biodiversity Task Force believes that the protection and monitoring of forest ecosystems should be considered beyond Natura 2000 areas in the Nature Restoration Law. Scientific evidence relating to the interconnected ecosystem services provided through the restoration of forest areas is outlined in the table on the next page.

Additionally, to ensure that the complexity of forest ecosystem resilience and health can be adequately measured, the EGU Biodiversity Task Force encourages the Parliament, Council and

Member States to consider including a greater number of non-optional indicators as well as greater expert consultation during the creation and implementation of Member State Restoration Plans. These considerations are also outlined in more detail below.

The interconnected benefits of forest ecosystem restoration

	Scientific evidence
Biodiversity enrichment	European forests host a wide diversity of flora and fauna that support vital ecological processes underlying the delivery of ecosystem functions and services [3]. Biodiversity is encouraged not only by the living elements of the forest ecosystem, but also by the decaying wood and detritus it generates, sustaining a diverse range of organisms that play essential roles within the trophic system [4]. Furthermore, forest ecosystems provide habitat and travel corridors for many species by establishing connectivity between habitats throughout Europe's heavily fragmented ecosystems, supporting greater genetic diversity and migration [5].
Climate change mitigation	European forests are a major carbon sink, sequestering an average of 155 million tonnes of carbon per year between 2010 and 2020 [6]. Forest ecosystems with greater biodiversity have been shown to increase soil microbial functioning, further increasing rates of carbon sequestration [7].
Climate change adaptation	Forests are essential climatic regulators, playing a vital role in the land-atmosphere feedback cycles through evapotranspiration which preserves and recycles moisture [8]. Evapotranspiration also contributes to cloud formation which provides greater top-of-cloud surface albedo reflectivity and subsequently reduces the impact of incoming solar radiation [8]. This enables them to influence both the micro- and meso- climates of their surroundings.
Mitigation of drought effects	In times of drought, most tree species have extensive and comparatively deep root systems that can tap underwater reservoirs. Not only does this enable species to sustain themselves in times of drought, but it also makes these otherwise untapped water resources available to be redistributed throughout the ecosystem [9].
Mitigation of flooding effects	Forest ecosystems contribute significantly to hydrological processes and play a pivotal role in regulating the hydrologic cycle [8]. The high level of organic matter within forest soil increases its ability to store water, improves water infiltration capacity, and results in more water being absorbed. Evapotranspiration can moderate surface runoff during periods of heavy rainfall and floods and increase the availability of water during dry periods, subsequently improving the resilience of forest ecosystems and surrounding areas to current and future extreme weather events [10]. The potential for this additional rainfall to be absorbed is dependent upon the extent and density of tree and forest cover and the intensity of the rainfall.
Supports water availability	Increased tree, forest, and vegetation cover can increase the magnitude of precipitation across land surfaces by a factor greater than one [11]. Though these effects are typically not apparent at the local scale, they are distinctly evident at larger regional and continental scales [8]. Healthy forest ecosystems also support water infiltration and groundwater recharge, subsequently promoting water availability, improving water quality, and reducing overland

	flow. Furthermore, moving water under the land surface helps increase the availability of clean water by reducing sediment flows and erosion [8].
Improves water quality	Forest cover can reduce sediment flows in along rivers, filtering out pollution and excess nutrients from agriculture [12]. Water from more heavily forested areas typically requires the least treatment and is often used to help "purify" less viable water resources. Increased tree and forest cover can thus further promote the availability of clean water resources [13].
Reduced erosion	The root structure and soil stability created by forest ecosystems, as well as the improved soil infiltration capacity, can help to reduce wind and water erosion that may otherwise remove fertile topsoil, reduce soil quality through loss of organic matter, desertification, and the siltation of nearby rivers and other water bodies [14].
Reduced avalanche induction	Alpine forest ecosystems, especially at the tree line, have the potential to prevent snow avalanches by reducing the formation of firm bedrock, balancing the radiation and temperature budget of the snowpack, and reducing the accumulation of wind-driven snow by decelerating wind speed [15].

Tracking the restoration of forest ecosystems through key indicators

Forest health and resilience are complex. To ensure that the measures put in place by the EU Member States to restore forest ecosystems are effective, a wide range of indicators should be used in the Nature Restoration Law. Below are two indicators that the EGU Biodiversity Task Force believes are particularly important and that should be included in each Restoration Plan.

Tree species diversity

Biodiversity is widely acknowledged as a significant factor influencing ecosystem function and a pivotal contributor to forest resilience [16] Forest ecosystems that exhibit high levels of diversity can better withstand disturbances, including pests, invasive species, drought, and wildfires [17]. They also tend to be more effective in delivering a range of ecosystem functions and services with more efficient symbiotic nitrogen fixation and accelerated rates of nutrient cycling [18]. However, while certain combinations of species are complementary, environmental conditions can also influence the functionality and resilience of the ecosystem structure [19, 16]. Given its importance to ecosystem function and resilience, the EGU Biodiversity Task Force encourages the European Parliament, Council, and EU Member States to consider tree species diversity as a key indicator in the Nature Restoration Law and incorporate it in the EU Member State Restoration Plans.

The value of deadwood in forest ecosystems

Deadwood plays a vital role in supporting organisms within forest ecosystems and is globally acknowledged as an indicator of forest health. As wood decomposes, it provides greater diversity in habitat structure and the availability of food sources [4]. Furthermore, the decomposition of deadwood enriches forest soil with organic matter and aids the recycling of biomass, subsequently supporting microhabitat soil organisms, increasing the availability of nutrients, and supporting the growth of neighbouring plant species [4].

Under some management practices deadwood in dry forest ecosystems is removed as it is seen as flammable and having the potential to exacerbate wildfires. However, many studies challenge this perception, considering the fire propagation potential of deadwood to be negligible [20]. In normal climatic conditions, deadwood may still be relatively moist during the peak of a normal fire season [20]. Deadwood in forests with high canopy cover can even preserve their moisture content during dry periods and cool the forest's microclimate [21]. Furthermore, deadwood's limited surface-to-volume ratio results in it generally being situated away from the surface, leading to a minimal contribution to fire ignition and spread [20]. The presence of deadwood in a recently burnt area may also be critical in supporting wildlife whose trophic hierarchy has been debilitated.

Given the role that deadwood plays in ecological succession, biodiversity, and in forest ecosystem resilience, the EGU Biodiversity Task Force believes that it should be considered by the EU Parliament, Council, and Member States as a non-optional indicator within the Nature Restoration Law. However, given the range of forest ecosystems, climatic conditions, wildfire risk across Europe, and potential growth of substrate, we recommend site-specific decisions based on scientific evidence be made in its management.

The need for expert consultation throughout restorative processes

It is essential for scientific experts, independent from national or local forest management authorities, to be consulted during the creation and implementation of effective Member State Restoration Plans to ensure local conditions, likely future climatic scenarios, and the steps and resources needed to restore the area, are adequately considered. Specific examples of how experts can support decision-making are outlined in the two examples below.

Planting 3 billion trees by 2030 - the role of experts

While Increasing the EU's current forest areas by planting 3 billion trees by 2030 is likely to be necessary to support the EU's biodiversity targets as well as the EU's current Climate and Carbon Sink Target, it is vital that independent experts are consulted during these processes for site selection, and to ensure expanding forest areas considers ecosystem functionality and interactions in between and with the abiotic components of the ecosystem. Member States should also consult with scientific experts to go beyond establishing new forest areas through preserving, rewilding, and expanding existing forest ecosystems by restoring their degraded ranges with native vegetation. Furthermore, experts should be consulted in the selection of tree species and steps needed to ensure successful regeneration. Not only is this likely to result in a more effective use of resources, but it can also provide greater ecosystem functionality and subsequent ecosystem services.

Pre-empting climate change impacts and acting through the Nature Restoration Law

Climate Change is a major driver of forest ecosystem transformation and biodiversity loss [22]. To ensure that the measures implemented by individual Member States can meet the Nature Restoration Law targets, it is vital that Restoration Plans consider the likely impact that climate change will have on restoration efforts. While some transformation as a result of climate change will be unavoidable, the EGU Biodiversity Task Force encourages the use of robust scientific models to help predict areas that are likely to be vulnerable due to increasing natural hazards such as droughts [23], changing fire regimes [20], and flooding [10]. Understanding which regions are sensitive to climate variations and how they are likely to be impacted will help Member States to take actions to manage climate change impacts. Conversely, failing to consider them may result in lower overall restoration of degraded areas, and subsequently reduce potential ecosystem services and benefits that the Member State receive. The EGU Biodiversity Task Force is concerned that justifying the non-fulfilment of the obligations outlined in the Nature Restoration Law due to unavoidable habitat transformations directly caused by climate change may dissuade scientific consultation and pre-emptive planning in this area. We would therefore recommend removing this section from Article 10 and include recommendations for greater expert consultation.

Summary

As an active member within Europe's scientific community, the EGU Biodiversity Task Force supports evidence-informed policymaking in Europe. The Task Force acknowledges that the forest restoration exhibits a particularly high level of interconnection and complexity, and consequently many stakeholders and nuanced factors need to be considered. Within this, however, the role of scientific evidence cannot be understated in both bringing clarity to these complex policy discussions and when considering the potential outcomes of policy decisions. Evidence shows that forest restoration has the potential to provide significant ecosystem functions and services that benefit both the environment and society. Thus, we encourage the restoration targets for these ecosystems to go beyond Natura 2000 and for its implementation to be guided by expert co-creation and consultation that includes a wide range of indicators.

About the EGU Biodiversity Task Force

As Europe's largest geoscience society, the European Geosciences Union (EGU) is uniquely positioned to facilitate knowledge transfer from research into practice and to connect policymakers to the most relevant geoscience experts. In early 2022, EGU's Science for Policy Working Group created the EGU Biodiversity Task Force with the aim of bridging the gap between science and policy, delivering scientific information and expertise to where it is most needed. The Task Force has previously provided recommendations informed by scientific evidence to strengthen the EU Nature Restoration Law and is also available to support policymakers on both a European and Member State level by answering evidence-based questions, translating scientific research, participating in meetings, writing fact sheets, and providing summary documents to help policymakers understand the legislative relevance of ground-breaking geoscience research. For further information, please contact policy@egu.eu.

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