biodiversa+
European Biodiversity Partnership

Issue brief

Mainstreaming resilience in forest policy: from diverse ecosystems to tailored financial incentives

European forests face growing threats from drought, pests, and declining productivity, undermining their role in climate mitigation and biodiversity support. Managing forests for resilience is critical, yet it involves complex ecological and economic trade-offs. Insights from four BiodivClim projects (FeedBaCks[1], ACORN[2], MixForChange[3], FUNPOTENTIAL[4] and SUSTAIN-COCOA[5]) point to three key levers for mainstreaming resilience in forest policy.

Key findings for resilient forest policy

1. Diversifying forests to build climate resilience

- Climate change is outpacing the natural adaptive capacity of forests. To accelerate resilience, assisted gene flow (AGF) *i.e.*, moving seeds or other reproductive material within a species' range from areas already adapted to future conditions - can help forests adapt more rapidly to environmental stress. (ACORN - Europe)

- Forests with higher species, structural, and functional diversity show greater resistance to drought and pest outbreaks. Enhancing diversity is a key strategy for long-term forest stability. (FUNPOTENTIAL - Finland, France, Germany)

- Transitioning away from vulnerable monocultures—such as Norway spruce—toward mixed-species forests reduces risk and increases resilience under changing conditions. (FeedBaCks – Europe and FUNPOTENTIAL - Finland, France, Germany)

- Adaptive forest planning can benefit from trait-based approaches. Selecting and combining drought-tolerant species based on functional traits improves forest survival in future climates. (MixForChange – Europe, Brazil and ACORN - Europe)

2. Aligning governance and finance with resilient forestry

- Promoting resilient species can come with short-term economic trade-offs. Financial tools—like subsidies or compensation schemes—can help balance economic returns with long-term forest health. (FUNPOTENTIAL - Finland, France, Germany)

- Mixed-species forestry requires supportive policies. Governance reforms and risk-reducing incentives are crucial to encourage investment in diverse forest systems. (MixForChange – Europe and FUNPOTENTIAL - Finland, France, Germany)

1. Footnotes can be found in the information sheet.

- Inclusive governance strengthens outcomes. Supporting smallholders and decentralising decision-making increases both equity and the legitimacy of West African forest management strategies. (SUSTAIN-COCOA - West Africa)

3. Closing data gaps to support adaptive forest management

- Reliable, spatially explicit forest data and harmonised monitoring systems are essential for planning under uncertainty. Improved data helps guide forest adaptation strategies. (FeedBaCks -Global and FUNPOTENTIAL - Finland, France, Germany)

- Integrating biodiversity into climate forecasting enhances predictive accuracy. Modelling biodiversity–climate feedbacks enables better risk assessment and planning. (FeedBaCks - Global)

Together, these findings demonstrate that enhancing forest resilience necessitates aligning local management with long-term policy incentives and systematic monitoring.

Context

Climate change and extreme weather events, such as droughts and storms, pose a growing threat to forest ecosystems[6]. Strong, locally tailored adaptation policies are essential to boost forest resilience and break the feedback loop, in which biodiversity loss worsens climate instability and reduces the forests' ability to mitigate climate change[7]. However, many current policies are not aligned with the principles of sustainable forest use[8].

The EU is taking steps to address these challenges. Under the new Nature Restoration Regulation, Member States are required to restore 30% of degraded habitats, including forests, rivers, and wetlands, by 20309. The EU Forest Strategy for 2030 also sets out the following commitments: (1) to promote good practices on climate adaptation and resilience; (2) to establish a coordinated forest monitoring and reporting system; (3) to strengthen risk and resilience management capacities; and (4) to support research and innovation in forestry[10].

Mainstreaming resilience into forest policy and providing targeted financial incentives is crucial for forests to continue providing socio-economic benefits and supporting rural communities.

This issue brief draws on findings from the BiodivClim projects to offer evidence-based guidance on aligning forest policies with climate and resilience goals.

Key results for implementing forest resilience policies

Mixed-species forests: Strengthening drought resilience through the right mix

Increasing forest diversity across species, traits, and structure is a powerful strategy for boosting resilience to drought, pests, and climate-related stress. Mixed-species stands can enhance productivity, stabilise tree survival, and increase long-term carbon sequestration.

Findings from the **BiodivClim** projects highlight how this can be achieved:

- **Monocultures are becoming increasingly risky**. Research by **FeedBaCks** and **FUNPOTENTIAL** showed that *Norway spruce*, which is widely planted for rapid carbon capture, has become highly vulnerable to drought, fire, and pests in Central Europe, which could reverse its role as a carbon sink.

- **Adaptation is both genetic and highly localised**. The **ACORN** project examined over 120 forest populations across Europe and found that trees are adapting to drought through natural selection at specific genetic loci (*i.e.*: Specific locations on chromosomes where particular genes are found). However, even neighbouring populations with the same genetics showed differences in how efficiently they use water, likely due to subtle variations in their local environments. This means that successful adaptation strategies cannot rely on one-size-fits-all solutions; they must be tailored to local genetic and environmental conditions.

- **It is not just about having more species, but having the right mix**. Research by **MixForChange** and **FUNPOTENTIAL** found that the benefits of diversity depend more on *the traits* the species have, like drought tolerance or growth form, than on how many species are present. The composition of species and their ecological roles influence how forests respond to drought, partly through their interactions with soil fungi and carbon cycling. This demonstrates that resilience stems from combining species with complementary functions, rather than simply increasing diversity.

- **Trait-based strategies are more effective at larger scales**. Using forest inventory data from Finland, France, and Germany, **FUNPOTENTIAL** showed that traits such as height, growth rate, and drought tolerance influence how forests respond to disturbances. While local diversity matters, functional composition across larger landscapes is often more important for long-term resilience and economic viability.

Together, these projects show that mixed-species forestry can serve as a cornerstone of climate-adaptive forest management in Europe, when trait selection of mixtures is tailored to local conditions.

Case study 1: “When diversity is not enough” – A story of forests under drought stress.

In the face of climate change, mixed-species forests are often seen as a promising strategy for helping trees withstand environmental stress, particularly drought. The idea is intuitive: greater diversity might offer greater resilience. However, recent research suggests that the relationship between tree diversity and drought response is more complex than previously thought.

As part of the **MixForChange** project, scientists set out to understand how tree species richness and functional traits influence forest responses to prolonged drought. They analysed data from nine planted forest experiments, each featuring gradients of tree species richness, from monocultures to mixtures of up to six species. These sites had all recently experienced severe droughts, providing a unique opportunity to study the effects under real-world stress conditions.

The study found that simply increasing the number of tree species did not consistently improve tree growth during drought. Instead, growth responses were more closely linked to each species’ inherent drought tolerance and to specific drought characteristics, such as duration and intensity. In other words, the identity of the neighbouring species and their ability to cope with drought mattered more than the number of species present.

Interestingly, the effects of diversity shifted depending on the length of the drought. During single-season droughts, functional diversity in neighbouring trees sometimes had a positive effect, but these benefits could turn negative as the drought persisted. Over consecutive drought years, the influence of diversity increased, but effects varied in direction by site: some forests responded positively and others negatively. These mixed outcomes suggest that both beneficial processes, such as reduced competition, and less favourable ones, such as increased water demand, may be at play.

These results show that strengthening forest resilience to prolonged drought does not simply depend on the number of species present, but rather on the quality of the mix and the local interactions between species. In other words, resilience relies on the selection of drought-adapted species with complementary ecological functions, rather than on a general increase in species richness. In the context of more frequent and severe droughts driven by climate change, it becomes essential to prioritise functional diversity adapted to local conditions, in order to better plan long-term forest management.

Overcoming the financial barriers to resilient forestry

Current financial and governance systems do not adequately support forest stakeholders in their transition to climate-adaptive forestry. Often, diversifying forests means prioritising long-term resilience over short-term economic returns. To overcome this, targeted financial incentives are required to offset the trade-offs, particularly the reduced income that may result from using less productive, yet more stable tree species.

Stakeholder surveys conducted by the **MixForChange** project in Brazil, France, Portugal, and Sweden revealed a wide range of barriers to adopting mixed-species plantations (Fig.1):

- **Operational barriers**: uneven species growth rates; damage from herbivorous mammals.
- **Financial barriers**: high implementation costs; limited markets; economic complexity of managing mixed stands.
- **Governance barriers**: dominant industry influence; cultural attachment to monocultures.
- **Systemic barriers**: lack of knowledge and best-practice references; uncertainty around market demand.
- **Transversal barriers**: difficulty coordinating across hierarchical levels; institutional inertia.
- **Regulatory barriers**: fragmented, complex permitting processes.

The decision to adopt species mixtures also depends on the type of plantation. **Commercial plantations** may opt for mixing species to improve long-term stand resilience or to broaden product portfolios. In contrast, **non-commercial plantations** often mix species to restore degraded areas and enhance ecosystem services such as carbon sequestration.

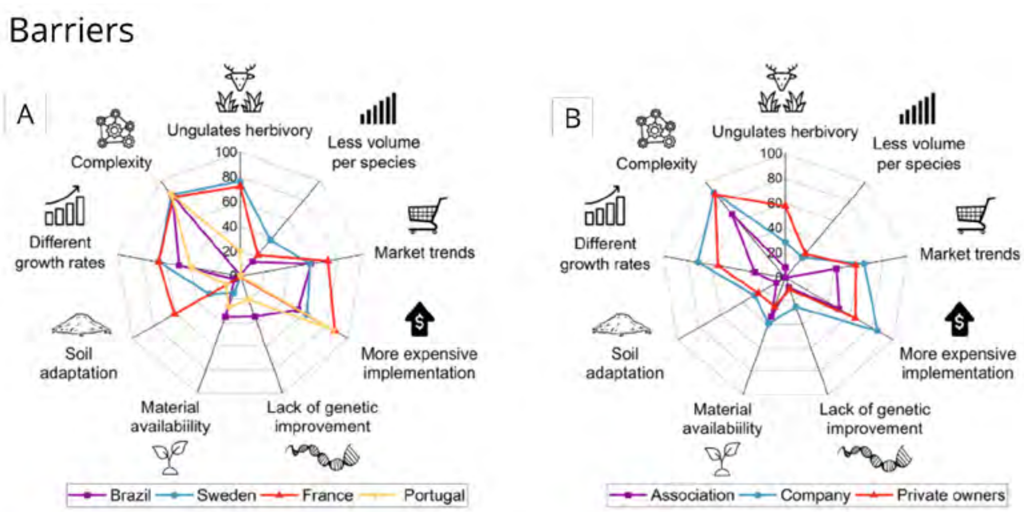

Fig. 1. Radar graphics presenting the percentages of mentions of the main barriers from the MixForChange project.

Case study 2: "The forest decision" – A story of balancing risk and resistance.

In a bio-economic modelling case study in Central Germany (Lower Saxony), the **FUNPOTENTIAL** project showed that forest managers face an ongoing complex decision process. With growing concerns about extreme weather and biological threats, they have to choose between economically attractive, fast-growing tree species and more stable but costlier forest compositions.

The modelling approach selected stand types under different scenarios with the optimisation goal of balancing economic risks and returns. Despite a generally risk-averse modelling approach, the model selected spruce-dominated mixtures. These stands regenerate naturally, keeping establishment costs low, and offer promising returns through expected high wood prices. However, their vulnerability to storms, droughts, and pests was a known risk. The resulting forest structures prioritized economic performance but were less resistant to disturbance and potentially less supportive of other ecosystem services.

This situation reflected a broader trade-off: the desire for income and productivity often conflicted with the goal of long-term ecological stability. While diverse forests are more disturbance-resistant, those benefits decreased as disturbance events increased in intensity and frequency.

To explore possible solutions, researchers introduced scenarios that included subsidies for stand establishment—covering planting and tending costs. These subsidies made it more viable to choose mixtures of species like Beech and Douglas-fir, more resistant to disturbances, but with higher initial costs and investment risks. The analysis highlighted how financial support could help overcome economic barriers to more climate-adapted forest types.

In a collaborative modelling process with forest owners, the study found that their preferences closely matched outcomes based on high risk aversion. **This suggested a shared recognition of the value of diversity** — not just as an ecological principle, but **as a practical approach to managing both natural and financial risks**.

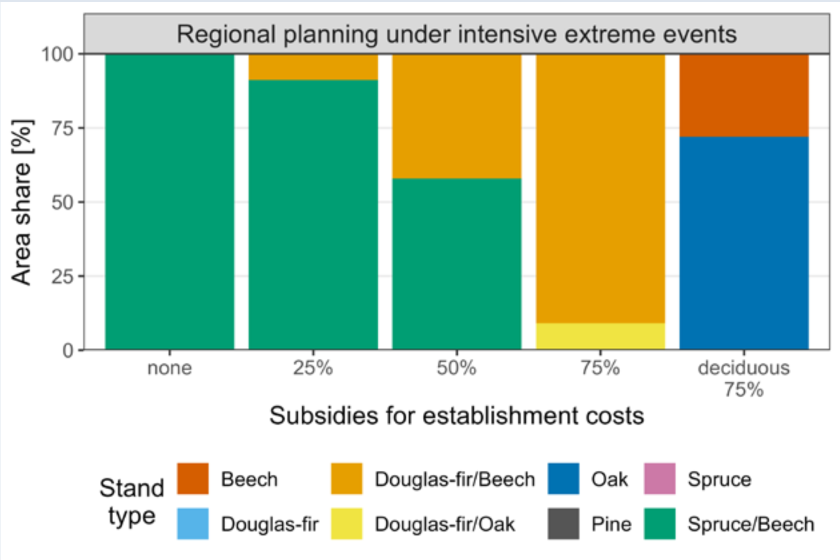

Fig. 2. Subsidy scenarios show the amount of the upfront investment covered by public payments, either for all species or deciduous species only (Fuchs et al. 2024).

There is a lack of common tools, protocols and frameworks to monitor forest health and climate resilience

The limited harmonisation of tools, protocols, and data frameworks limits Europe's ability to monitor forest health and plan for climate resilience. Without more coordinated systems, it is difficult to track changes, compare management strategies, or respond effectively to climate-driven risks.

Better modelling is critical to understand how biodiversity affects climate—and *vice versa*. Current Earth System Models treat vegetation in overly broad terms, ignoring important species and trait-level differences that shape ecosystem feedback. To close this gap, the **FeedBaCks** project developed a new biodiversity-climate model interface[11] that integrates fine-scale ecological data into climate simulations. **The findings revealed that not all Nature Futures Framework scenarios**[12] (*i.e* a set of global scenarios developed by IPBES[13] to explore different ways society might value and manage nature in the future) **are risk-free for the climate.** Implementing biodiversity policies aligned with international frameworks—such as the Kunming-Montreal Global Biodiversity Framework—will lead to major land-use changes across Europe, with significant climate implications. Depending on the priorities chosen (e.g. cultural values, ecosystem services, or biodiversity conservation), regional climate impacts may vary widely. It is therefore crucial to assess biodiversity–climate interactions carefully, to ensure policies deliver co-beneficial outcomes.

At the same time, **resilient forest adaptation strategies rely on coordinated, high-quality monitoring systems** at both national and international levels. BiodivClim projects underline the importance of continuing the existing forest monitoring schemes but have also identified major shortcomings in existing forest data infrastructure and call for the development of shared classification frameworks and data-sharing mechanisms.

One key gap is the lack of detailed spatially explicit forest data, which limits the ability to consider the landscape perspective, and restricted access to forest inventory plot coordinates, which limits connecting on-the-ground and satellite monitoring. Furthermore, a major challenge for many projects lies in comparing management strategies across countries. In response, researchers developed a standardised method for calculating stumpage values—allowing for cross-country comparisons of forest provisioning services and the financial risks posed by climate disturbances (**FUNPOTENTIAL**).

These combined insights reinforce the urgency of establishing **EU-wide monitoring standards, open datasets, and tools**. As part of this effort, **Biodiversa+ is strategically committed to strengthening biodiversity monitoring and modelling across Europe**, fostering more coherent data systems to guide climate adaptation and resilient forest management. These initiatives complement the recently adopted EU Nature Restoration Regulation and proposed instruments such as the Forest Monitoring Law and the Directive on Soil Monitoring and Resilience—each essential to improving forest data infrastructure and long-term ecological planning.

Case study 3: "Beyond the farm gate" – A story of cocoa, sustainability, and the limits of supply chain initiatives.

Across West Africa, cocoa plays a central role in the economy and livelihoods of millions. Yet it is also linked to one of the region's greatest environmental challenges: deforestation. Between 2000 and 2020, cocoa cultivation contributed to an estimated 45% of forest loss in Côte d'Ivoire and 57% in Ghana—figures that have drawn growing attention from policymakers and markets.

In response, the EU introduced new regulations requiring traders to demonstrate that products like cocoa are not sourced from recently deforested land. These rules place new demands on companies to trace their supply chains and ensure compliance.

Many companies have launched sustainability supply chain initiatives (SSIs), often focused on promoting agroforestry and improving on-farm practices. However, findings from the **SUSTAIN-COCOA** project show that these efforts remain limited in scope. **Traceability is still incomplete, most initiatives focus on preventing illegal deforestation rather than transforming land-use incentives, and smallholder farmers are often excluded from decision-making processes**.

As a result, sustainability efforts tend to fall short of driving meaningful, landscape-scale change. The findings suggest that scaling up sustainable cocoa production will require more than incremental improvements. It will depend on shifting incentives, involving smallholders more directly, and embedding both environmental and social goals into supply chain governance.

Link to sources

FeedBaCks
ACORN
MixForChange
FUNPOTENTIAL
SUSTAIN-COCOA

Scientific publications used in this policy brief can be found in the Information Sheet of this briefing downloadable from: www.biodiversa.eu/policy-briefs/

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About this Issue brief

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The series of Biodiversa+ Policy briefs can be found at www.biodiversa.eu/policy-briefs/.

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