

# MANAGING THE REWILDING-DISTURBANCE NEXUS – A NEED FOR ADAPTIVE APPROACHES



Picture credit: Marcus Lindner

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## EXECUTIVE SUMMARY

Climate change is increasing the frequency and intensity of natural disturbances across European forests, while at the same time ecosystems are facing massive biodiversity reduction. In this context rewilding is emerging as a promising approach to enhance ecosystem resilience, biodiversity and climate adaptation. However, interactions between rewilding and natural disturbances remain insufficiently reflected in current policy and management frameworks.

## KEY MESSAGES

- 1 Natural disturbances are not only threats – they can support forest resilience and climate change adaptation.** Disturbances such as droughts, bark beetle outbreaks, storms, and fires can increase biodiversity and structural complexity, promote climate-adapted species, and generate deadwood that supports forest resilience and habitat diversity.
- 2 Rewilding may lead to ecological trade-offs.** While rewilding can enhance ecosystem resilience and biodiversity over time, it may initially increase vulnerability to disturbances and reduce open habitats, creating trade-offs that require context-specific management.
- 3 Fire-smart rewilding can help managing disturbance risks.** Rewilding can increase wildfire risk through biomass accumulation and interactions between disturbances, highlighting the need for landscape-scale planning and targeted measures such as grazing or prescribed burning.



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## BACKGROUND

Since 1950, Europe has experienced a marked increase in the frequency and intensity of natural disturbances, such as wildfires, pest outbreaks, droughts and forest dieback events. These trends are primarily driven by climate change. They are compounded by a parallel global decline in biodiversity that further weakens ecosystem resistance and resilience. Projections indicate that disturbance regimes will continue to intensify, with particularly severe drought conditions, increasing pest outbreaks and wildfires by 2050. These changes are likely to trigger cascading effects with significant impacts on forest ecosystem services provisioning.

Changes in land use and management are key interacting drivers of these dynamics. In Europe, land abandonment is accelerating, with around 25% of agricultural land at risk of being abandoned. At the same time, the decline of traditional management practices, such as extensive grazing and other forms of low-intensity land use, has contributed to landscape homogenization, increased biomass accumulation, and simplified forest structures and landscapes. Such uniform, high-biomass landscapes are generally more prone and vulnerable to large-scale disturbances. Furthermore, traditional measures for disturbance suppression – like putting out every fire – are not effective under climate change anymore or may lead to even more damaging events. The same applies to bark beetle infestations: removing infested trees has long been the primary response to bark beetles and other insects, but warmer temperatures now allow multiple pest generations per year and reduce winter mortality. Outbreaks spread faster than trees can be removed, especially after droughts.

As forests face increasingly large changes, we need new management strategies. At the same time, rising costs and competing demands on public budgets make large-scale interventions difficult, creating a need for more adaptive, affordable and resilient approaches.

### Rewilding potential

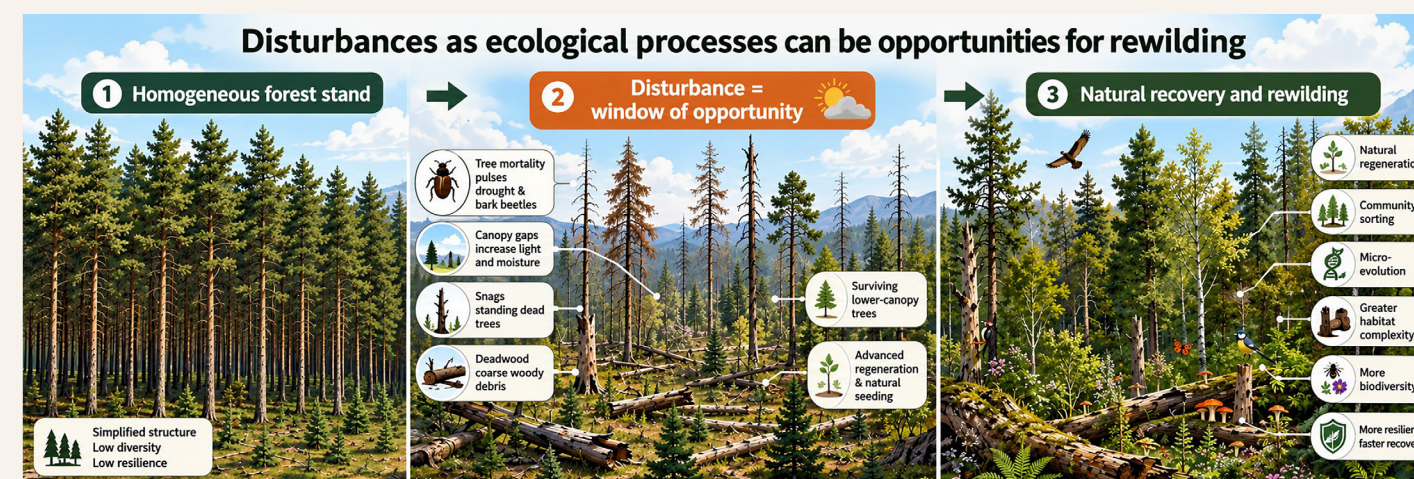
In response to these interconnected challenges, rewilding is gaining attention as a potential nature restoration strategy capable to address both the climate and biodiversity crisis. Rather than trying to recreate a specific ecosystem with a fixed set of habitats or species, rewilding aims to restore natural ecosystem processes. It accommodates the occurrence of natural disturbances, the movement and spread of organisms, and the re-establishment of food chains (also called “trophic chains”) to shape landscapes over time. Rewilding can occur through both planned and unintentional pathways. Planned rewilding involves deliberate decisions to reduce human control and restore ecological processes. In contrast, unintentional rewilding emerges as a consequence of socio-economic changes, such as agricultural abandonment, which allows natural succession and ecosystem recovery to proceed without an explicit conservation (or other) objective. In many cases, rewilding may require an initial phase of human intervention, during which people act as facilitators through actions such as dam removal, habitat restoration, or species reintroductions. Once ecological processes are reactivated, however, human influence is progressively reduced, allowing ecosystems to develop along self-organized and dynamic trajectories without imposing fixed or predetermined outcomes. A complementary approach, known as “proforestation”, focuses on allowing some existing forests to continue growing, maturing and regener-

ating naturally without active harvesting or intensive management. By doing so, the approach aims to enhance biodiversity, structural complexity, carbon storage and ecosystem resilience.

Despite the potential of rewilding, important knowledge gaps remain regarding the interactions between rewilding and disturbance dynamics. On the one hand, natural disturbances create opportunities to enhance ecosystem resilience by promoting heterogeneity, regeneration and adaptive capacity if left to develop (instead of executing high-impact interventions such as extensive salvage logging). On the other hand, the potential increase in frequency and severity of future disturbances under ongoing climate change is perceived as a major risk. Furthermore, it remains uncertain how different rewilding pathways affect these interactions.



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## KEY FINDINGS

Disturbances have traditionally been treated mostly as disasters to be prevented or mitigated. However, they can also play a critical ecological role as “windows of opportunity” for increasing biodiversity and ecosystem adaptation to climate change in a rapidly changing world. At the forest stand level, pulses of tree mortality can enhance future forest resilience by diversifying vegetation composition, structure and habitat complexity. The formation of canopy gaps can support natural regeneration, and drive shifts in species composition toward more locally adapted species (called “community sorting”). This can also

allow surviving trees to adapt genetically to changing environmental conditions rapidly, meaning over relatively few generations (known as “micro-evolution”). Beyond these compositional and structural changes, disturbances generate important biological legacies, such as standing dead trees (“snags”) and coarse woody debris, which are essential for biodiversity. This is particularly important for Boreal and Temperate regions, where up to 25-30% of forest species depend on deadwood.

Empirical evidence from recent disturbances in monospecific and structurally homogeneous forests in Europe shows that these processes can con-

siderably accelerate ecological succession, allowing multiple plant species to establish more quickly, increasing both tree and understory diversity. These changes contribute to the development of more heterogeneous forest stands over time, which tend to be more resistant and recover more rapidly following disturbance. For example, in Spain, drought-induced tree mortality in Scots pine forests has been shown to promote the establishment and growth of more drought-tolerant species, thereby increasing the forest's resilience to future drought events. Evidence from bark beetle outbreaks shows that disturbances often leave lower-canopy trees intact, preserving a surviving generation that functions as advanced regeneration. Allowing some forests to recover naturally, rather than automatically implementing salvage logging and planting, preserves natural regeneration and supports the continued development of multi-aged stands.

Moreover, deadwood produced after tree mortality increases structural diversity and tree-related microhabitats, two key elements for the maintenance of diversity. It also serves as refugium for newly recruiting tree seedlings. In contrast, extensive salvage logging usually promotes the establishment of homogeneous, even-aged forests that are more susceptible to subsequent disturbances.

**Rewilding can lead to ecological and disturbance trade-offs**

Rewilding offers significant opportunities to restore resilience – the ecosystem's ability to maintain its essential functioning and recover naturally after a disturbance – by allowing natural succession to progressively develop more diverse and complex forest structures. However, these ecosystem responses are

long-term and non-linear. Rewilding may not be risk-free, especially when considering unintentional rewilding after land abandonment. In the first decades following agricultural land abandonment, areas undergoing shrub and tree encroachment may exhibit relatively low resistance to drought and other stressors. Depending on the local conditions, it can take a century or more for these systems to reach structural, compositional and functional conditions comparable to those of mature forests. While rewilding can improve soil protection and support species that thrive in older, shaded forests, it may reduce habitats for plants and animals that depend on more open forest conditions. This can only be counteracted with planned “trophic rewilding”, a type of ecological restoration that aims to restore ecosystems by reintroducing or increasing populations of key animal species – especially large herbivores and predators – that have been lost or reduced.

A further challenge concerns the interaction between biomass accumulation, carbon sequestration and disturbance risk. As rewilded forests mature, they accumulate substantial carbon stocks, but they may also develop more continuous fuel loads, increasing mid-term wildfire hazard and the potential for large carbon losses. Similarly, in strictly protected, unmanaged areas, storm damage can create fresh deadwood resources that may facilitate bark beetle outbreaks, amplifying so-called “secondary disturbance effects”. In this context, unintentional rewilding leads to some trade-offs. In some landscapes, planned trophic rewilding or actively managed systems - such as low-intensity agricultural or agroforestry systems - may better achieve specific conservation and risk-mitigation objectives, including the reduction of wildfire hazard at the landscape scale.



Picture credit: Marcus Lindner

**REWILDING RISKS AND MANAGEMENT RESPONSES**

| MAIN PROCESS OR RISK FACTOR AFTER REWILDING                                             | POTENTIAL NEGATIVE EFFECTS                                                                                                                                               | HOW TO REVERSE OR MITIGATE THE RISK                                                                                                                                                  |
|-----------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Restoring historical conditions without accounting for future climates                  | Historical reference ecosystems may be poorly adapted (“maladapted”) to future disturbances (e.g. drought)                                                               | Use forward-looking restoration targets, promote connectivity along environmental gradients to favor species migration and adopt adaptive management                                 |
| Fuel accumulation after land abandonment in unintentional rewilding                     | Shrub and tree encroachment may promote increased fuel accumulation and vertical/horizontal continuity, resulting in higher wildfire vulnerability, intensity and spread | Model and monitor post-rewilding fuel load dynamics, reintroduce or maintain controlled herbivory, and combine targeted grazing with prescribed burning or selective fuel management |
| Loss of open habitats and associated species after natural succession                   | Scrub encroachment promotes the decline of species that depend on open or early-successional habitats                                                                    | Maintain open-habitat dynamics through grazing, browsing, mowing or prescribed burning. Tolerate small-scale natural disturbances                                                    |
| Excessive grazing, browsing, bark stripping, trampling, and rooting by large herbivores | An excess of herbivores may favor vegetation degradation, reduced regeneration, habitat loss, tree damage, altered plant successional trajectories and soil disturbance  | Regulate herbivore densities, use exclusion plots or temporary fencing, restore predator processes where feasible or apply adaptive population control                               |
| Facilitation of invasive species                                                        | Exotic plants may be favored through increased continuity in vegetation, disturbance or trophic interactions                                                             | Monitor rewilding interventions for early detection of invasive species, rapid response, and targeted control                                                                        |
| Pest outbreaks                                                                          | Vegetation accumulation and connectivity combined with stochastic disturbances (windstorms, drought) may favor pest spread and outbreaks                                 | Define acceptable disturbance thresholds at landscape scale, retain deadwood where compatible, and intervene near high-risk areas                                                    |



Picture credit: Josep M. Espelta

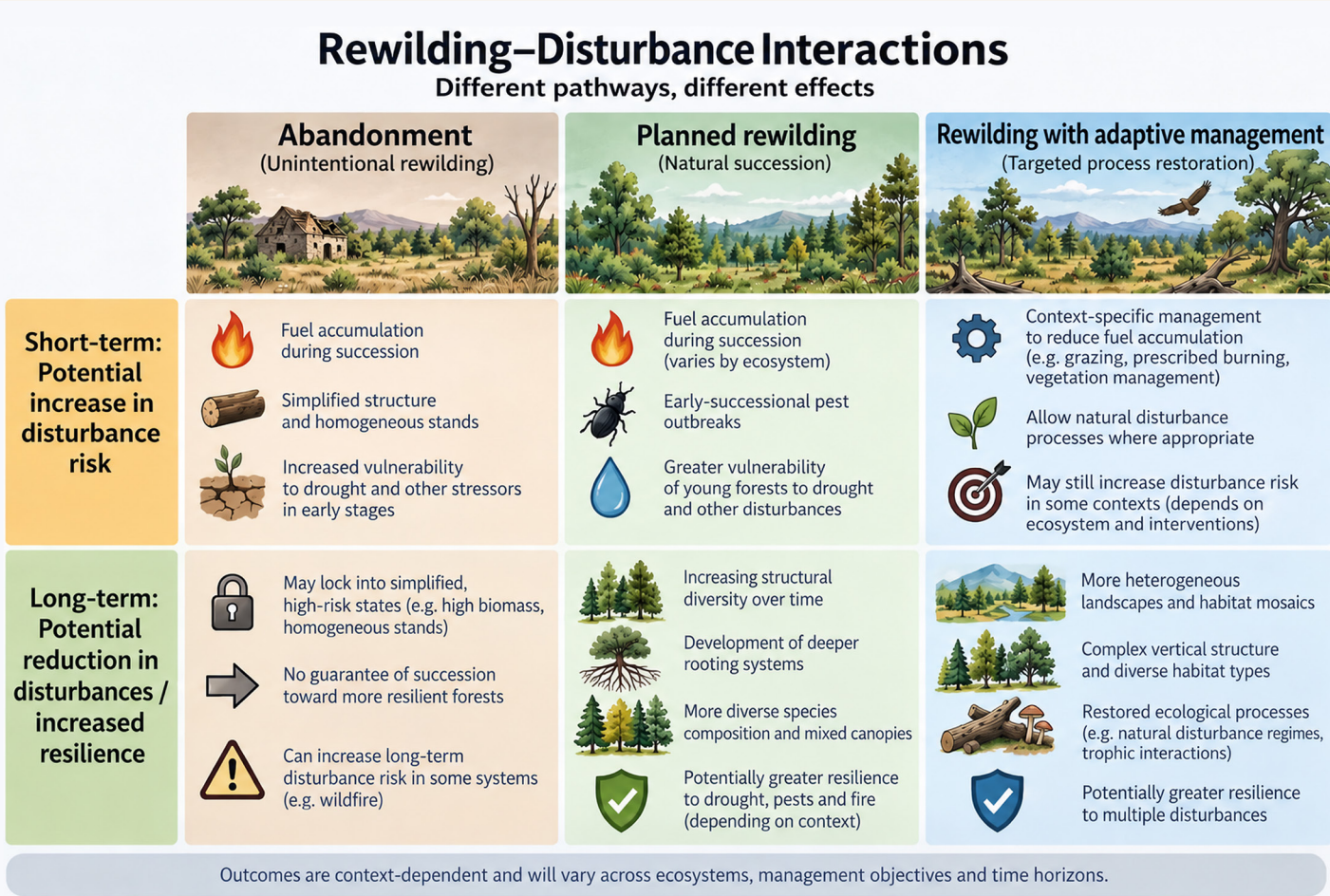
REWILDING AND DISTURBANCE INTERACTIONS: IMPLICATIONS FOR WILDFIRE RISK MANAGEMENT

While disturbances can play an important role in maintaining biodiversity, their interactions may also generate cascading effects with negative consequences. For instance, wind damage or drought can induce bark beetle outbreaks, which in turn produce large amounts of highly flammable biomass. This can temporarily increase wildfire hazard and the possibility of fire to spread over large areas.

To account for rewilding induced biomass accumulation and horizontal continuity of flammable biomass, a fire-smart rewilding strategy should be implemented. This means planning rewilding in less flammable areas and protecting rewilded areas by strategic fire prevention and fuel management tools such as targeted grazing and prescribed burning to regu-

late fire hazard until the forest systems reach greater structural maturity.

Fuel management strategies therefore require careful spatial and functional planning. Decision regarding “let it burn” approaches and active fuel treatments should be made at the landscape scale to maximise mitigation of catastrophic wildfire risk, particularly in fire-prone regions, while minimising the area of intervention. Similarly, at the stand scale, fuel management should be harmonised with habitat conservation and restoration goals. For example, fine woody debris plays a key role in fire ignition and spread, whereas coarse deadwood (i.e., pieces larger than 10 cm in diameter) rarely constitutes a fire risk. As a result, deadwood management must be context-specific and consider biomass type and size.



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PRACTICAL RECOMMENDATIONS FOR POLICYMAKERS AND LAND MANAGEMENT AUTHORITIES

1

FOREST AND NATURE CONSERVATION PRACTITIONERS

- Consider natural processes such as disturbances, forest regrowth, and the associated interactions among organisms in an ecosystem in management decisions to strengthen forest resilience.
- Apply rewilding as a nature restoration approach that combines natural ecosystem processes with targeted, adaptive management where needed.
- Use targeted interventions where necessary to facilitate rewilding processes, such as reintroduction of large grazing animals (“herbivores”), while allowing natural regeneration and self-organizing ecosystem dynamics to develop where appropriate.
- Adapt forest management to local ecological and social conditions and balance impacts of planned rewilding with multiple objectives, including biodiversity conservation, wildfire risk reduction, recreation and sustainable timber production.
- Strategically plan the amount, location and type of deadwood retained.
- Adopt mixed management approaches, including active systems such as agroforestry where local conditions require them, to optimize biodiversity and reduce environmental risks.
- Use adaptive management tools such as targeted grazing, prescribed burning and strategic vegetation management to support ecosystem health and reduce wildfire risk.
- Monitor ecological outcomes and adjust management over time based on evidence, ensuring rewilding remains effective under changing environmental conditions
- Engage actively in cooperatives to jointly implement landscape risk reduction.
- Plan ahead of natural disturbances and anticipate reaction pathways, instead of having to rely on short-term decisions once they occur.

## 2

### REGIONAL LAND-USE DECISION MAKERS AND AUTHORITIES

- Recognize that not all disturbances are harmful. Small, natural disturbances play an essential role in maintaining healthy, diverse, and resilient ecosystems.
- Use planning tools to spatially target planned rewilding and proforestation, ensuring non-intervention is applied where it enhances resilience rather than increasing risk.
- Integrate climate-smart rewilding and locally adapted forest management through regional planning and policy frameworks that balance biodiversity, climate resilience, wildfire prevention, recreation and sustainable resource use.
- Support strategic landscape planning, including habitat connectivity, climate refugia and deadwood retention, to strengthen ecosystem resilience while reducing environmental risks.
- Encourage adaptive, evidence-based management that responds to local ecological and socio-economic conditions and evolving climate challenges.
- Use flexible regional planning, allowing management rules to adapt to local climate, forest types, and stages of forest recovery, including periods when young regenerating ecosystems are more vulnerable.
- Leverage diverse landscapes as a key source of resilience by tolerating natural disturbance occurrence (e.g. droughts, pests, wildfires) and encouraging a mix of land uses, extensive grazing, and more complex ecological interactions, in line with EU nature-based solutions approaches.
- Deploy spatial planning for landscape mosaics and buffer zones to reduce disturbance propagations and support biodiversity.
- Integrate early-warning systems and disturbance modelling to inform land-use practice.
- Integrate shared data platforms and decision-support tools directly into local and regional land-use planning workflows.
- Coordinate multi-level governance to foster shared responsibility for landscape-scale risk reduction among all relevant land use actors and hazard management authorities and support management cooperation to implement landscape scale disturbance risk reduction.
- Design and execute targeted regional communication strategies to address negative public perception of "untidy" landscapes and clarify the ecological role of natural disturbances.
- Integrate Common Agricultural Policy and Nature Restoration Regulation funding streams to incentivize local practices that enhance resilience.
- Remove incentives for practices that weaken forest resilience, such as intensive salvage logging after disturbances.
- Facilitate regional pilot projects that leverage market-based mechanisms and credits to draw private investments into local, nature-positive land management.

## 3

### NATIONAL POLICY MAKERS

- Integrate natural processes such as disturbances, ecological succession and trophic interactions as core components of forest resilience into policy frameworks to enable a shift towards planned rewilding strategies.
- Integrate early warning systems and risk models into forest management to improve prevention, preparedness, response, and recovery from disturbances.
- Create policy and funding frameworks that support locally adapted, mixed management approaches, combining natural regeneration with targeted interventions where needed.
- Strengthen long-term monitoring, cross-sector collaboration and knowledge exchange to enable adaptive management and evidence-based policy decisions.

## 4

### EUROPEAN COMMISSION DGS & NATIONAL MINISTRIES RESPONSIBLE FOR ENVIRONMENT, FORESTRY, AGRICULTURE AND CLIMATE

- Align major public funding instruments, specifically the Common Agricultural Policy and the Nature Restoration Regulation more explicitly with overarching ecosystems resilience objectives.
- Restructure public subsidy frameworks to reward critical ecosystem services, such as carbon storage, water regulation and biodiversity conservation, while actively discouraging practices that undermine resilience, such as ecologically damaging intensive salvage logging.
- Establish clear legal frameworks, including updated wildfire governance land liability rules, to improve coordination and eliminate ambiguity across administrative levels.
- Mandate and fund improved access to shared data platforms and decision-support tools to enable standardized, evidence-based planning across all EU Member States.
- Establish regulatory frameworks for market-based mechanisms (e.g. carbon removal credits and emerging biodiversity/nature credits) to complement public funds and mobilize private investments.
- Invest in monitoring, knowledge exchange and Living Labs to support adaptive management, evaluate outcomes and accelerate the uptake of good rewilding practices across Europe.

# 5

## SUSTAINABLE FINANCE AND CERTIFICATION

- Develop, standardise and validate market-based mechanisms with clear certification metrics to accurately measure, reward and audit ecosystem services like carbon storage, water regulation and biodiversity conservation.
- Design and test robust private investment and certification channels that securely direct private funding into verified nature-positive, resilience-enhancing land management projects.

This Policy Brief synthesizes the key findings emerging from a Wildcard & wildE workshop on Rewilding–Disturbance Interactions and translates them into practical recommendations for policymakers and land management authorities. It highlights how adaptive, context-specific approaches can better integrate rewilding into resilient landscape governance.

This policy brief represents the conclusions of the authors, and not the views of the Wildcard and wildE consortia.



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