SUPERB
Upscaling Forest Restoration

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Annex 5

Upscaling route-map - Croatian & Serbian border river floodplain demonstration area

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DISCLAIMER

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Executive Summary

This document provides guidance for those leading or planning restoration pilot projects, with a focus on how to support future upscaling. While pilot projects already bring important ecological benefits, their main purpose is to serve as starting points for larger restoration efforts. Therefore, it is essential to collect knowledge and practical experience that can help institutions and actors with the capacity to implement restoration at scale. Based on the SUPERB cross-border demo area in riparian forests of Serbia and Croatia, the guidance highlights how site-level work—such as converting vulnerable poplar monocultures into diverse native forests with species like pedunculate oak—can contribute to long-term ecological goals, including climate adaptation, biodiversity conservation, and improved ecosystem services like flood regulation and carbon storage. The document explains the importance of understanding local environmental and socio-economic conditions through detailed situational analysis. It also discusses how to identify and overcome common barriers to large-scale restoration, including technical, legal, and financial challenges. Practical recommendations are given to support alignment with EU, national, and global restoration targets. This guidance is part of the broader support provided by the SUPERB project and is complemented by resources and tools available in the "Restoration Gateway." The overall aim is to help connect local restoration actions with wider landscape-level and policy-level impacts, making restoration more effective and sustainable across Europe.

Keywords

Upscaling, forest restoration, forest ecosystem services

1. Introduction and Background

This document focuses on demonstrating effective forest restoration strategies to enhance biodiversity, ecosystem services, and forest resilience in riparian and floodplain forests. It involves restoration of these forests, mainly restoring devitalized poplar plantations into mixed-species forests using native species like in our demo area: *Quercus robur L.*, *Fraxinus angustifolia Vahl.*, *Prunus* sp., and *Sorbus* sp. This document is directly linked to SUPERB WP7 tasks related to the practical implementation of forest restoration techniques, real-time demonstration activities, and continuous monitoring of restored forests to assess ecological improvements and resilience outcomes.

Additionally, this document contributes to upscaling potential by providing insights and methodologies that can be applied beyond the initial demonstration area. In collaboration with public forest management enterprises in Serbia and Croatia, the project showcases scalable approaches that can be adapted to other regions, addressing site-specific needs while promoting sustainable forest management, resilience and ecosystem services improvement.

1.1 Purpose

This document is intended for all stakeholders working with or managing riparian forests, with a particular focus on those navigating the complexities of changing environmental conditions, climate change impacts, and the challenges related to forest reproductive material, vitality, productivity and biodiversity conservation. It is designed to support restoration practitioners, forest managers, policymakers, and researchers involved in forest management, demonstration or pilot restoration projects.

The goal is to provide actionable guidance and examples of best practices that will help extend restoration activities beyond this demo area and foster large-scale upscaling. Drawing from the experiences and best practices gained through the SUPERB project, this document highlights effective approaches to forest diversification, stakeholder engagement, and resilience-building techniques.

Based on our experience within the SUPERB project, this document provides practical insights to enhance forest restoration efforts, ensuring sustainable management and a lasting legacy of biodiversity conservation and climate adaptation.

1.2 Introduction and scope

Historically, large areas of riparian forests in Serbia and Croatia have been cleared for agriculture and urban expansion. Moreover, river regulation and damming have significantly altered natural flood regimes, leading to increased drought stress and a decline in tree vitality. Existing poplar plantations in the region are particularly vulnerable to climate-induced disturbances. There is now an urgent need to improve forest resilience while simultaneously enhancing ecosystem services and sustainable food production.

Our restoration approach focuses on strengthening forest structure and function to improve timber production, sequester more carbon, increase biodiversity, and enhance overall forest resilience to climate change. Through the SUPERB initiative, we have also engaged with local communities, raising awareness of the critical role of healthy riparian forests and fostering collaborative management practices.

The lessons and techniques developed through this project have broad scaling potential. In Serbia and Croatia, public forest management enterprises are already working to diversify poplar plantations based on site-specific conditions, creating opportunities for broader adoption of these sustainable restoration strategies across the region.

1.3 Background

The cross-border demo is composed of riparian forests alongside the Danube River. These, as well as other lowland floodplain forest ecosystems provide multiple ecosystem services. They act as natural buffers along rivers and provide protection from flooding hazards, while also preserving physical, chemical, and biological properties of the soil. They also play an important role in maintaining species diversity, since these forests are characterized by high biodiversity. This is specifically emphasized in highly agricultural areas, such as Vojvodina (in Serbia) with only about 6% forest land cover, where the Serbian part of the demo area is located. In these forests, dominant tree species are those that can cope with regular flooding.

Serbia

The Serbian part of the cross-border demonstration area is predominantly composed of riparian forests within the protected Biosphere Reserve “Gornje Podunavlje”, managed by the public forestry enterprise “Vojvodinašume”. Like other forested regions in Vojvodina, this area is public property. Located in the far northwest of Serbia, at the confluence of borders with Hungary and Croatia, Gornje Podunavlje stretches along the left bank of the Danube River. This reserve is part of a larger ecological complex that continues into Hungary’s "Danube-Drava" National Park and Croatia’s "Kopački Rit" Nature Park, forming a unified transboundary ecosystem. As a key component of the expansive "Bačko Podunavlje" Biosphere Reserve, it is part of the renowned "European Amazon", one of the finest-preserved wetland landscapes along the entire Danube. The river here meanders through an intricate web of backwaters and canals, weaving life into the floodplain forests of the reserve. In recognition of its exceptional natural value and ecological importance, the Gornje Podunavlje Biosphere Reserve was inscribed on the UNESCO World Heritage List in June 2017.

In this part of the demo area, within the SUPERB project restoration actions, low-vitality poplar monoculture forests were selected for restoration. It is important to emphasize that SUPERB actions represent one of the steps in the realization of a long-term restoration plan proposed by the PE “Vojvodinašume” which has strong support from the decision makers in Serbia. The main goal of the proposed SUPERB restoration actions within this part of the demo is to “plant the right species at the right place”. More specifically, in a proposed restoration plot to bring back the dominance of pendunculate oak in this area, which is its natural habitat, while restoring biodiversity of the broader area which was endangered with extensive use of fast-growing exotic species (such as poplars) in the past.

Croatia

The Croatian part is described as fragmented forest plantations (poplar clones) surrounded by agricultural lands used for intensive food production. Some parts of the Croatian side are also under Natura 2000 protection. Land ownership is diverse but mainly owned by public/state enterprises. The majority of forests in the Croatian case are owned by the state and managed by Croatian Forests Ltd., and some smaller parts are owned by private forest owners.

If we look at the history of this area, we can see that agriculture and urban development had a high impact on riparian forests in the way that large tracts of forests have been cleared, which caused fragmentation of habitats. The floodplain forests were historically under a lot of

pressure by intensive management, huge environmental changes and globalisation. All of these changes brought intensive wood production in these areas using fast-growing species, predominantly poplars. Lately, forest stands of invasive tree species also cover significant areas. Insight into the history of the poplar plantation establishment reveals that interest in poplar plantations arose quite early in the 20th century (ca 1920 in the Croatian part of the demo area). These poplar plantations were established in two ways: (1) by afforestation on agricultural land and (2) by planting poplar trees after clearcutting of natural mixed species forest with the aim of higher wood production and in cases where there were significant problems with the regeneration of such natural mixed forests. Another large negative impact on these forests is due to damming and regulation of rivers for agricultural needs, which has led to altered disturbance regimes and drought stress. As a result, many trees in the area are in decline. Furthermore, some stands were not managed at all due to the war, as some parts of the demo area were under landmines (recently demined under EU funded project Naturavita).

This complex intertwining of various negative factors has led to the decline of poplar trees. Most of the trees are devitalized and their value has been compromised. Furthermore, these forests are monospecific forest cultures with low biodiversity, so through the planting and supporting the variety of tree species more diverse forests with higher biodiversity will be created with higher potential to withstand new threats posed by climate change.

Through stakeholder mapping and conducting workshops, in both countries, we had explored the important insights given by the stakeholders concerning their needs and views and implemented their suggestions in our work plan.

In conclusion, the restoration of the cross-border demo area represents a multifaceted endeavour aimed at revitalising degraded ecosystems, enhancing biodiversity, and securing the long-term sustainability of these valuable natural habitats. Our goal is to further amplify our restoration efforts through the creation of this upscaling plan which will serve as a guideline for expanding restoration outside of the project scope and in a broader area.

While focusing on the evaluation of the current state of forest in the demo area main challenges emerged:

(1) Large tracts of riparian forests have been cleared due to the intensive agriculture production and urban development in the past.

(2) Damming and regulation of rivers has changed the flooding regime.

(3) Decline of trees as a result of changed disturbance regimes and drought stress of trees backed up by changes in global climate.

(4) Lower resistance of poplar clone plantations (monospecific forest stands with relatively low genetic pool) against climate disturbances.

(5) A need to increase forest ecosystem services and food production in conditions of climate changes.

(6) High impact of invasive tree species which often prevent efficient natural regeneration.

First and the main issue, because of previous actions in the past is high agriculture production and urbanization. Consequently, due to the intensive agriculture production, multiple changes in river regulations and damming have been made and are still used and are not possible to modify. In past decades most of the referred riparian forestry were extensively used for fast growing poplar species characteristic with short period of rotation. Mainly because of the fast

income, but also the climate and other environmental changes poplar plantations were a focus of the remaining forest land in this area. Climate change and change of the flooding regime, and underground water levels did also contribute to the decision process in terms of choosing poplar clones over the pendunculate oak. This resulted in multiple poplar clones' plantations in the area, even in environments and soils more appropriate for the penduncalute oak.

Serbia

The primary restoration goals for the Serbian cross-border demonstration area address key challenges by focusing on restoring the selected forest area and harmonizing ecosystem services to meet the needs of relevant actors and stakeholders. The overarching objective is to balance forestry practices with nature protection, ensuring sustainable use that maximizes the area's ecological, economic, and social values. This integrated approach aims to support biodiversity conservation, enhance forest productivity, and promote social benefits for surrounding communities. Gornje Podunavlje serves as a critical stopover and nesting site for numerous bird species, including important migratory birds such as the white-tailed eagle, great egret, and black stork. The reserve also supports diverse populations of herons, waterfowl, and raptors. In addition to its rich avian diversity, it provides habitat for various mammal species like red deer, roe deer, wild boar, European badger, European hare, European pine marten, European hedgehog, European mole, European water vole, and European rabbit. The area is notable for its unique plant communities, including wild orchids, reed beds, and native tree species such as narrow-leaved ash (*Fraxinus angustifolia*), black poplar (*Populus nigra*), and white willow (*Salix alba*).

Proposed restoration activities were discussed with relevant stakeholders during two workshops where all actors from different backgrounds (e.g. forest managers, nature protection, NGOs) agreed and supported the plans we have proposed. The focus of the proposed work was on the restoration of devitalized poplar plantations with *Quercus robur*.

These actions are expected to contribute to creating mixed-species forests compared to current poplar clone monoculture plantations. As a result, this leads to increased biodiversity, but also other ecosystem services provided by these forests. What especially might emerge is the aesthetic value of the area since poplar plantations from the citizen's point of view do not represent a "real" forest and are sometimes referred to as an agricultural land. Following this will increase the resistance, resilience but also the value of these riparian forests. In terms of forestry practice, these proposed restoration measures will have an impact in terms of the raise of the commercial value of the wood but also provide a diversity of products to offer. The appropriate selections and placement of the species will boost the carbon sequestration and result in lower greenhouse gases emission. And finally, the diversity and mentioned aesthetic qualities that will contribute to less tangible ecosystem services, but more important to the general public in terms of tourism, recreation, local forest-based business, and maintenance of cultural heritage.

2. Strategy

2.1 Why is larger-scale restoration action needed?

Transitioning from the current state of forests to diverse native species like pedunculate oak (*Quercus robur*) in the cross-border demo area requires a considerable investment of time and effort due to the complexities involved in ecological restoration. Restoring these areas to support native species such as pedunculate oak involves multiple stages and may take decades to achieve desired outcomes. It's important to note that restoration is not a one-time

effort but rather an ongoing process that requires monitoring, adaptive management, and long-term stewardship, where at least 10 years is needed to observe any changes. Succession dynamics, interactions with invasive species, climate change, and other factors may influence the trajectory of restoration efforts over time, necessitating adjustments to management strategies. While the timeline for achieving a well-restored site may be lengthy, the ecological, social, and economic benefits of restoring native habitats make it a worthy and essential undertaking for the long-term health and resilience of these ecosystems.

Riparian and floodplain forests in Europe are facing significant challenges, driven by climate change, human activity, and altered hydrological regimes. These ecosystems are critical for biodiversity conservation, water management, and climate regulation. However, they are increasingly vulnerable to degradation, making restoration efforts crucial for their survival and resilience.

These forests are vital because they provide a range of ecosystem services, including water filtration, flood regulation, carbon sequestration, and habitat for diverse plant and animal species. They further act as natural buffers, reducing the impacts of floods by absorbing excess water and preventing soil erosion. They also filter pollutants from water, improving water quality for both humans and wildlife. Additionally, these areas support a rich variety of species, many of which are adapted to specific hydrological conditions, such as migratory birds, fish, and amphibians. However, the ongoing degradation of riparian and floodplain forests is a serious concern. Climate change has altered precipitation patterns, leading to more frequent droughts and floods. The loss of natural flooding cycles, due to river regulation and damming, disrupts the natural regeneration of these forests. Urbanization, agriculture, and forestry activities have further contributed to the loss of habitat and biodiversity. Restoring these ecosystems is not only essential for preserving biodiversity but also for mitigating the effects of climate change. Healthy riparian and floodplain forests act as carbon sinks, helping to sequester carbon and reduce greenhouse gas emissions. Moreover, restoration efforts can improve water management, enhance flood resilience, and support local economies through sustainable forestry practices. By restoring these critical habitats, we can protect both nature and communities, ensuring the long-term health and stability of Europe's freshwater ecosystems.

2.2 Who are the key actors for upscaling?

The successful forest restoration process, especially in protected areas, requires collaboration among governmental agencies, conservation organizations, forest managers, local communities, and scientific experts to pool resources, share knowledge, and coordinate actions effectively. Due to the characteristics of the cross-border demonstration area, where the land is under public/state ownership and managed by public enterprises in both Croatia and Serbia, the most important stakeholders are forest landowners, in-situ managers, and government authorities, including policymakers and regulatory bodies. Following these groups are education and research representatives, whose involvement is crucial in addressing the ongoing challenges posed by climate change. This is particularly significant in light of the decline and degradation of riparian forests, which are increasingly affected by changing environmental conditions.

2.3 Where should upscaling of riparian forest restoration be targeted?

The upscaling of forest restoration techniques should initially target riparian and lowland forests in Europe, especially in Serbia and Croatia, focusing on converting monoculture poplar plantations into diverse, mixed forests. This approach increases forest productivity and biodiversity, contributing to more resilient ecosystems. These techniques can also be applied

to similar forest types across Europe, where riparian zones and lowland forests are often managed as monocultures with low ecological complexity. One prominent example is the Mura-Drava-Danube Biosphere Reserve, also known as the "European Amazon," which stretches across Austria, Slovenia, Croatia, Hungary, and Serbia. This area contains significant riparian forests that are key biodiversity hotspots and could greatly benefit from large-scale restoration efforts. By implementing mixed-forest management here, the region would enhance habitat connectivity, carbon sequestration, and flood mitigation. Another promising region is the forests surrounding the Garonne River in the Bordeaux area of France, where poplar monocultures dominate many lowland zones. Restoration efforts aimed at integrating diverse native species can improve forest structure, enhance ecosystem services, and provide a model for sustainable forestry. Similar opportunities exist in other parts of Europe, including the Oder River basin in Germany and Poland and the Po River floodplains in Italy, where forest restoration initiatives can transform large areas of degraded riparian forest. By targeting these highly visible and ecologically critical regions, the impact of restoration efforts will extend beyond local improvements, influencing governance frameworks, restoration policies, and ecosystem services on a continental scale.

2.4 What are the most important issues to be addressed?

A key step in scaling up restoration efforts is identifying potential obstacles to success. Challenges can emerge across various areas, and one effective method for examining them is the PESTEL analysis. This approach helps to systematically assess factors in political, economic, social, technological, environmental, and legal domains.

Table 1. PESTEL analysis for the Croatian & Serbian border river floodplain demonstration area.

Issue	Description	Basis/ Documentation	Urgency	Importance
Political	In Serbia, successful restoration depends on supportive government policies and regulatory frameworks. Strong decision-makers' will and clear mandates are necessary to integrate biodiversity and restoration goals into broader environmental and economic strategies. In Croatia, limited policy recognition, lack of incentives for multiple-use forestry, and weak sectoral consensus obstruct landscape approaches. Additionally, uniform legislative treatment of forest owners disregards differences in forest size, while some lack the interest, resources, or knowledge for proper management. Both countries need clearer mandates, supportive regulations, and incentives to enhance restoration efforts.	Relevant policy documents and their practical implementation	Addressed earlier	Medium importance
Economic	In Serbia, profitability and financial incentives are critical, requiring reliable funding mechanisms, subsidies, and market-based solutions to support investment in restoration. Without adequate economic incentives, many stakeholders may prioritize short-term gains over long-term sustainability. In Croatia, the perceived costs of restoration, especially in the presence of a vast number of invasive species because the management of invasive species adds complexity and cost to forest restoration, lack of market instruments, and absence of payments for ecosystem services beyond biomass production, along with no national incentives for forest restoration, create significant obstacles. Both countries need targeted financial support, market-driven solutions, and long-term incentives to enhance restoration efforts and ensure economic sustainability.	Cost analysis, existing funding options including available EU pre-accession funding mechanisms	Addressed earlier	High importance
Social	In Serbia, community engagement and public awareness are essential, as active participation of local communities, landowners, and stakeholders fosters shared experiences and collaborative learning. Social support strengthens commitment to conservation practices. In Croatia, perceived conflicts among land uses, rural depopulation, and low public interest in forest restoration create significant challenges. Both countries need strategies to enhance public involvement, promote awareness, and encourage community-driven restoration efforts to ensure long-term success.	Identified stakeholder perspectives and preferences	Addressed earlier	Medium importance

Technical	In Serbia, technological advancements in adaptive management, species monitoring, and restoration tools provide significant potential, but access to technology and data-driven insights is crucial for designing efficient, scalable strategies. In Croatia, restoration efforts are hindered by workforce shortages, low mechanization and innovation, limited availability of forest reproductive material—especially planting stock—outdated nursery production, invasive species can hinder the restoration process and consequently lead to higher expenses, low awareness among nursery managers about species diversity, and poor coordination between planning, resources, and restoration needs. In both countries, a skilled workforce is crucial for effective restoration, requiring investment in training, innovation, and resource alignment.	Identified practical challenges and knowledge gaps	Addressed earlier	Medium importance
Environmental	Changing environmental conditions pose challenges, including climate change impacts on ecosystems and species viability. Knowledge of resilient species and biodiversity-friendly practices is necessary to adapt restoration approaches to these conditions. Vojvodina's lowland landscapes and riparian forests are highly sensitive to hydrological changes, necessitating targeted efforts to manage invasive species and adapt restoration strategies to flooding and drought variability. The lack of evidence on the impact on biodiversity, perceived conflicts among environmental goals, lack of awareness and developed pre-restoration approaches, the huge impact of invasive non-native species, negative impacts of climate change, biological threats, and low biosecurity measures in the FRM production chain are key challenges in this context.	Descriptions of relevant restoration targets and obstacles for reaching them within the time frame of the restoration initiative	Addressed earlier	High importance
Legal	Legal barriers include complex permitting processes and fragmented regulations. In Serbia, restoration efforts must align with national laws considering forests, water management, and biodiversity conservation. Simplifying permitting for restoration actions, especially in protected floodplain areas, could enhance efficiency and encourage broader participation. Crucial legal issues in Croatia are management plans in protected areas, forest law restrictions on management options, conflicts between forest law and nature protection law regarding tree species selection, lack of compatibility between forestry and environmental acts, and resistance to implementing European forest and environmental policies all present significant obstacles.	Legal frameworks influencing restoration options	Addressed earlier	Medium importance

While further focusing on the successful upscaling of restoration processes, we have identified critical needs and expectations from key actors involved in forest restoration efforts, as well as our own (research point of view). Forest landowners and in-situ managers require knowledge about restoration under current rules and regulations and changing environmental conditions. They need biodiversity-related information, including lists of possible species for use in riparian forest restoration, and they are concerned with profitability. From a research perspective, we need their support in restoration actions and the sharing of experiences, as well as active engagement throughout the complete restoration process. Government bodies, policymakers, and regulating actors are focused on biodiversity and financing options. We as researchers, in return, expect their support in restoration actions within the demonstration area and in broader forest restoration efforts.

To increase restoration action and successfully upscale processes, several barriers must be removed, and enablers promoted. One of the main barriers is the knowledge gap faced by many forest landowners and managers, who lack access to current restoration methods adapted to evolving environmental conditions. Limited financial incentives also pose a challenge, as profitability concerns may deter investment in restoration projects. Insufficient collaboration and stakeholder engagement complicate the sharing of experiences and best practices. Additionally, policy fragmentation can create confusion and complicate coordinated actions and changes in the long-term planning.

Capacity building and knowledge sharing can provide landowners and managers with the necessary training and resources for biodiversity-friendly restoration practices and adaptive management. Financial support, including funding schemes, subsidies, and market-based instruments, could improve profitability and encourage restoration investment. Building stakeholder engagement platforms can foster collaboration, innovation, and alignment of restoration efforts with broader strategies. Policy integration and support are also crucial; a cohesive regulatory framework will streamline processes, align goals with broader environmental policies, and remove bureaucratic obstacles.

By addressing these, forest restoration initiatives can become more effective, scalable, and sustainable, benefiting biodiversity, local communities, and environmental resilience.

3. How to address the key issues

This section aims to address key barriers to successful large-scale restoration, as identified in the situational analysis (PESTEL). It provides practical advice and insights for those looking to build on the work done in the demonstration project. Drawing from experiences and knowledge developed during the SUPERB project, it offers guidance relevant for scaling up restoration efforts beyond the pilot phase.

3.1 Stakeholder engagement

Considering the stakeholders engagements, we reflect on this subject using the stakeholder mapping that was completed in February 2022. We must emphasize that no crucial changes have been observed since the survey was completed regarding this subject.

In Serbia, 40 stakeholders and in Croatia 52 stakeholders were mapped all belonging to as many recommended categories as possible (e.g. forest landowners and in-situ managers; government, policymakers and regulating actors; forest/landscape value chains and other economic actors; financing actors; communities, civil society, and mediating actors; education

and research). Many of the stakeholders could be attributed to several defined categories, but in the end were assigned to one based on their dominant professional engagement and/or preferences regarding this demo area All mapped stakeholders were invited to cooperate with the SUPERB Cross-Border Demo representatives, resulting in engagement of nearly 100 individuals who now represent an important starting point for future upscaling and broader stakeholder involvement. These stakeholders have been regularly informed about the demo's objectives and progress and were given the opportunity to contribute their insights and influence key aspects of the restoration activities. Their involvement has helped shape the work carried out so far and provides a strong foundation for continued collaboration, knowledge sharing, and inclusive decision-making in future restoration efforts. This established network is a valuable resource for expanding restoration activities and ensuring long-term support and ownership at the local and regional levels

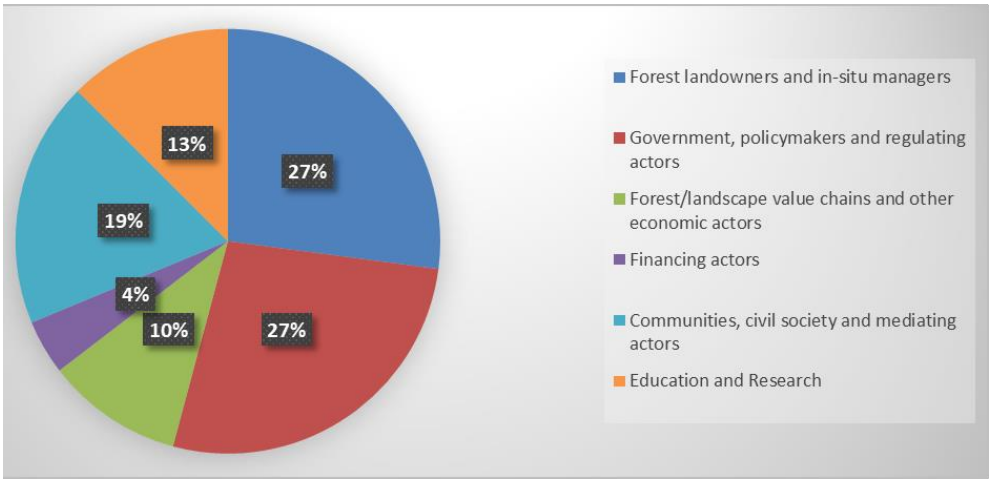

Figure 1. Dominant stakeholders' categories mapped on the Demo level.

As previously stated, due to the characteristics of the demo area, as most of the land is under public/state ownership, and run and managed by the public enterprises, as most important stakeholders' groups are Forest landowners and in-situ managers and Government, policymakers and regulating actors were identified. These two dominant groups are followed by the Education and Research representatives. This is highly important considering climate change and the currently ongoing decline and devastation of riparian forests due to the changed environmental conditions.

If defining a key actor for the cross-border demo area, we would put a highlight on two stakeholders' categories: Forest landowners and in-situ managers and Government, policymakers and regulating actors. While further focusing on successful upscaling of restoration processes, we have defined needs and expectations both, from our side, and from the side of these two categories, that are presented in Table 2.

Table 2. Needs and expectations

Key actors	Their needs and expectations	Needs and expectations
Forest landowners and in-situ managers	-Knowledge about the restoration in current, changed environmental conditions -Biodiversity; list of possible species to be used for restoration in riparian forests -Profitability	-Support in actions and sharing the experiences -Active engagement in complete process of the restoration
Government, policymakers and regulating actors	-Biodiversity -Financing options	-Support in restoration actions in the Demo and in general considering the forest restoration

Two interactive stakeholder workshops have been conducted so far.

The first stakeholder workshop was held in Novi Sad, Serbia in 2022. Its primary goal was to inform stakeholders about the demo's mission, aims, and restoration goals. The workshop also aimed to collect feedback from stakeholders on the work plan and species selection. This feedback was crucial for the demo's ongoing work and the SUPERB project's success.

The second stakeholder workshop was held in Osijek, Croatia in 2024, and it was designed to update stakeholders on the progress made since the first workshop. It showcased how their suggestions and views were incorporated into the work plan. As most participants had already attended the first workshop, this one was more informative, with a focus on knowledge exchange between institutions.

During the first stakeholder workshop, participants engaged in insightful discussions and shared their perspectives on various aspects of forest restoration. Additionally, we conducted a survey on ecosystem targets, which elicited responses from 20 stakeholders. Stakeholders described the target ecosystems as structurally diverse, and uneven aged, close to nature forest stands.

Regarding tree species composition, there is a strong preference among stakeholders for autochthonous species, and for species that are adapted to current and future climate conditions. A mixed-species composition is also preferred. In concrete, there are a few species that are frequently mentioned by stakeholders as part of the target ecosystems, which are portrayed in Figure 1 - Preferred tree species to be used as part of the restored ecosystems, according to stakeholders.

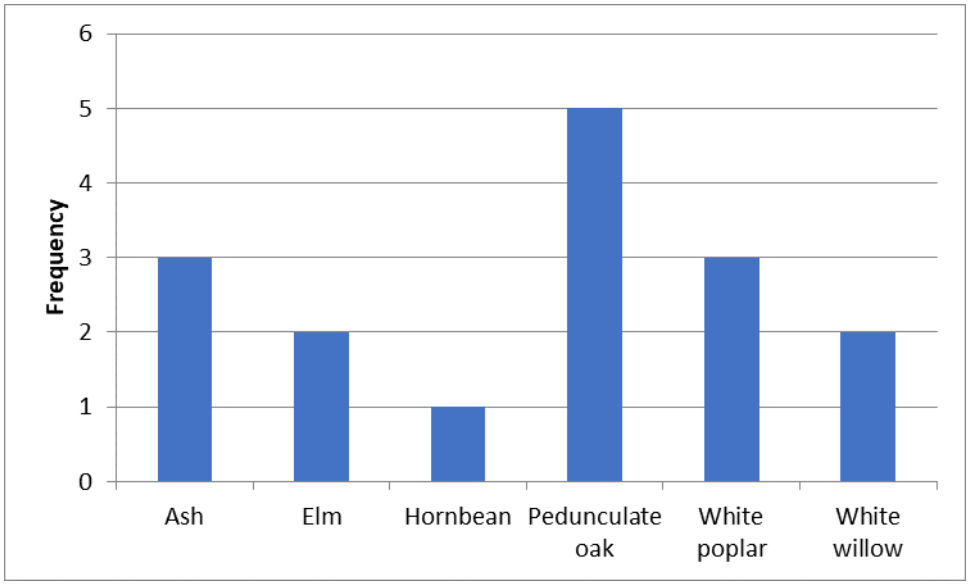

Figure 1. Preferred tree species to be used as part of the restored ecosystems, according to stakeholders.

Monocultures are most frequently mentioned as an unacceptable ecosystem condition (6 times), which apparently is seen as highly incompatible with the view of the restored forests in the demo-region. A low vitality of trees is also mentioned relatively often as inadequate with this view (3 times), whereas other features, such as a low biodiversity, dominance or a significant presence of allochthonous species, coppice-based regeneration, harvesting next to water streams, and converting to non-forest land uses, also seem to be unwanted (Figure 2).

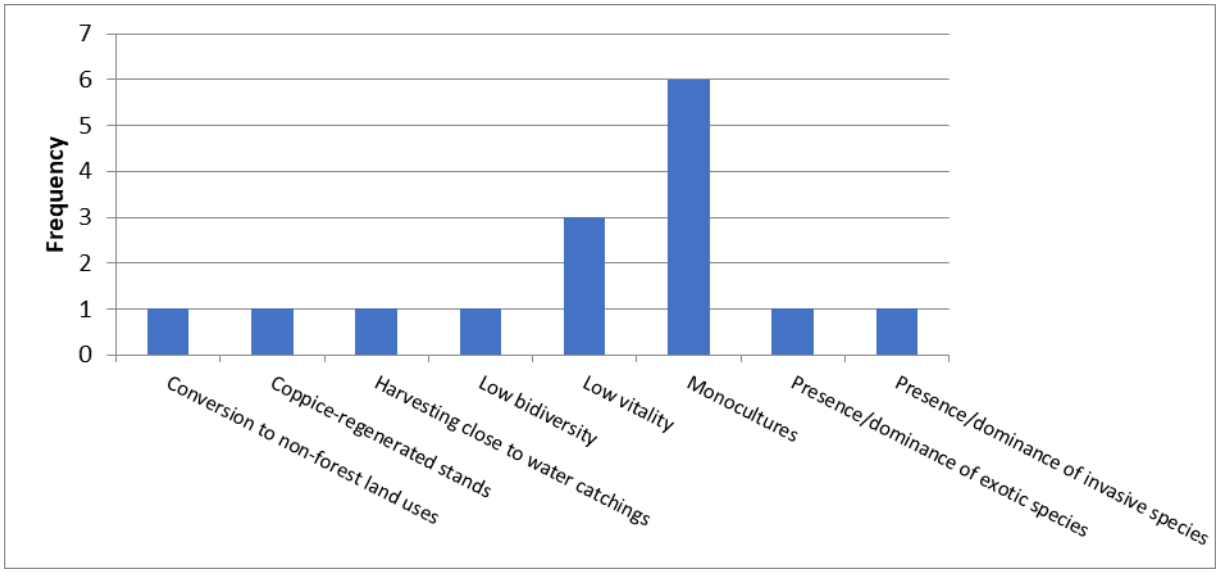

Figure 2. Ecosystem characteristics or conditions that are dimmed as unacceptable by stakeholders, according to the responses retrieved from the surveys.

In general, (1) increasing the presence of climate-adapted and of autochthonous species, (2) promoting the development of mixed forest stands, and (3) conducting a careful and integral selection of species and planting material, are frequently mentioned as adequate measures for making local forests more adaptive to global change. Other measures, such as selecting

local provenances for establishing or enriching a stand, improving soil water retention, and increasing the diversity of forest landscape through zoning, are also mentioned as adequate (Figure 3).

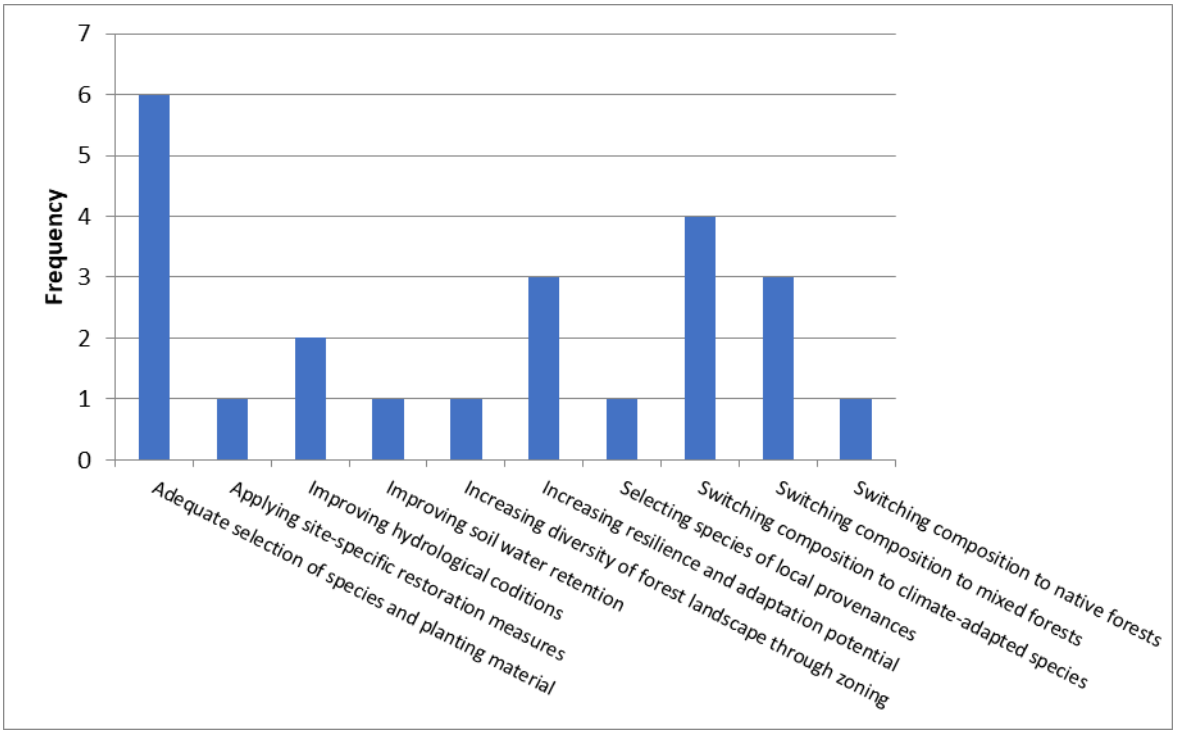

Figure 3. Adequate measures to make local forests more adaptive to global change, according to the responses retrieved from the surveys.

From the conducted surveys we can conclude that stakeholders' views align with our restoration plans. The problems as well as needed measures that stakeholders noted as important are already incorporated into our work plan.

During the second stakeholder workshop, we presented our concept for the “Upscaling Plan” to the participants. The plan was well received and additional insight from stakeholders was collected. Many stakeholders noted in the evaluation form how they like the idea of forest restoration upscaling and concluded that there is an opportunity to implement it in our demo area.

Additionally, in cooperation with Rina Tsubaki working within SUPERB WP2 an online mapping for Croatia has been conducted, presented in Figure 4.

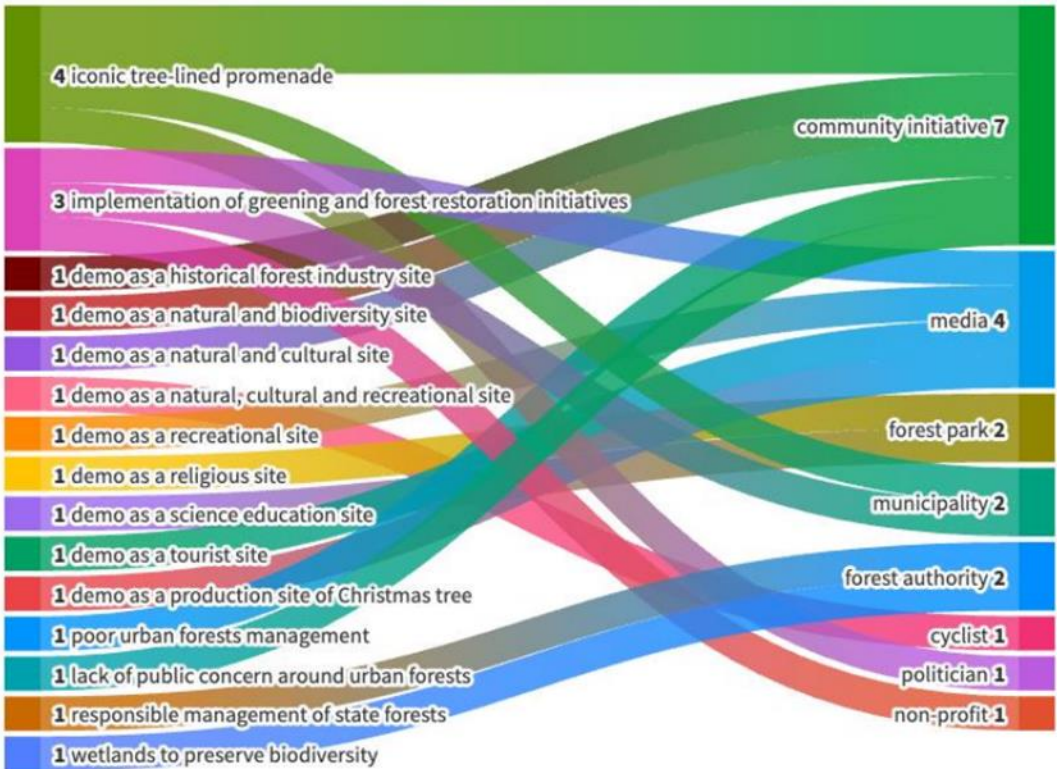

Figure 4. Results of the online mapping.

The top 20 Facebook narratives related to the Croatian side of the demo area portrayed it in diverse ways. These narratives highlighted that the demo area is not merely a natural site but is also perceived as a cultural, historical, recreational, religious, touristic, educational, and biodiversity site. This indicates that the public associates with the Croatian side of the demo area in various ways.

This diversity in perceptions underscores the importance of gathering views and insights from a broad range of stakeholders when conducting large-scale forest restoration efforts. By incorporating perspectives from different stakeholders, including local communities, government agencies, NGOs, and academia, forest restoration projects can better align with the needs and aspirations of the broader public. This inclusive approach enhances the likelihood of successful restoration outcomes and fosters greater support and engagement from stakeholders. Through our dissemination activities, we try to reach the public and raise awareness about the multifaceted value of the demo area, highlighting its significance not only as a natural habitat but also as a cultural, historical, recreational, and educational asset. By emphasizing these diverse aspects, we aim to garner broader public interest and support for forest restoration efforts. Additionally, our dissemination activities involve engaging with stakeholders from various sectors to gather their perspectives and insights, ensuring that restoration plans are comprehensive and inclusive. Ultimately, by involving a wide range of stakeholders and promoting public awareness, we strive to achieve successful and sustainable outcomes in restoring the Croatian side of the demo area.

The second stakeholder workshop helped integrate valuable feedback into our restoration strategy. It provided an update on progress since the first workshop and showcased how stakeholder input had been incorporated into the work plan. As most participants had attended the initial workshop, this session focused more on knowledge exchange and validating ongoing activities. A key highlight was the field visit to the demo area, allowing participants, especially those without a forestry background, to gain direct insights into restoration efforts.

This experience helped clarify the restoration process and strengthened stakeholder support. The workshop also emphasized the need for clearer, harmonized terminology in forest restoration across global, European, and national contexts, which will be considered in future activities. Additionally, collaboration with the DaWetRest project on the Croatian side of the demo area was identified as a promising opportunity to scale up restoration efforts. Stakeholders involved in DaWetRest expressed strong interest in cooperation, which could enhance the project's impact.

3.2 Governance and Legal considerations

Serbia

In the Serbian part of the cross-border SUPERB demo, there is a well-defined national agenda that is governed by state rules and regulations and deals with the conservation and restoration of forests, forest land, and biodiversity. Also, a strong public interest in forest preservation, restoration, and biodiversity conservation, particularly for native tree species is present. As a result, the SUPERB project's outcomes would have a significant influence not just on the demonstration sites, but also on broader forest restoration operations on a national level, and even broader, dominantly on riparian forests in Europe, known as an "European Amazon".

Proposed actions of the restoration of the Serbian part in the cross-border area provide a good basis for further development of national restoration and forest management strategies of the Republic of Serbia leading further the process of equalization of Serbia's laws and regulations with those on the EU level. Besides mentioned, in Serbian forestry the FSC standards are being followed and implemented in any action regarding forestry practice.

FSC standards prescribe forest management rules, and they are harmonized with other actors. Forest management plans must have conditions from nature conservation, water management etc. On the largest scale FSC supports management plans. Potentially limited restoration options are in use of non-native species. Legislation restricts the use of non-native and invasive species. According to current legislation native species are allowed to be planted. Targeted species such as pedunculate oak are possible to be planted in suitable site conditions. According to Serbian legislation only native provenances are allowed. In the Serbian part of the demo area, it is considered that seed sowing is a better solution than the seedlings planting. This is a subject of discussion, it's widely acknowledged that natural restoration is often not feasible due to factors such as invasive species, light competition, and soil resource limitations, necessitating human intervention for successful regeneration. In case of the restoration by sowing seeds, it's expected regeneration of "accompanying tree species". If you look at it this way, the legislation assumes that "accompanying tree species" should come from natural regeneration. Pedunculate oak restoration in suitable sites is noted as a regeneration "accompanying tree species". With silviculture measurements it is necessary to remove all species, which threatens the restoration of pedunculate oak. Plant "accompanying tree species" is required if seedlings are planted. Seedling production is harmonized with EU rules.

Rules and regulations that are also applied in this specific part of the demo area are those referring to the nature protections, since Biosphere Reserve "Gornje Podunavlje" where the Serbian part of the demo area is located in a protected area. Any actions to be done in the area (e.g. management plans, restoration actions, cuttings, planting, plant care, fencing) must be in line with the guidelines provided by the governmental body, the Institute for nature conservation of Vojvodina Province. On the other hand, this area is attractive for international organisations for nature conservation (WWF, IUCN). All activities of international organisations must be in accordance with the adopted plans.

We note that the activities taken within the SUPERB project and riparian demo area can be linked with multiple processes and initiatives in our country, such as:

- Conversion study for PE Vojvodinašume for period 2020-2029

- Management Plan of Biosphere Reserve “Gornje Podunavlje” for 2021-2030

- Actions for increased carbon sinks in forests

- National protection of the environment (State of Serbia)

- National protection of nature (State of Serbia)

- Regulation of the ecological network (State of Serbia)

In this document we would also like to emphasize the importance of current SUPERB actions regarding the further restoration actions on dominantly riparian forests in Vojvodina, Serbia, specifically those planned within the Conversion study for PE “Vojvodinašume” for period 2020-2029, the total area of 520 ha.

Croatia

In Croatia, current legislation, policies, and governance structures play a critical role in shaping the landscape of restoration efforts in our demo area and the broader region/country. In our assessment, we have identified the extent to which these frameworks align with restoration objectives and the major policy barriers that impede progress.

The most important legislation and policies are given:

- Natura 2000 management plan(s)

Natura 2000 plays a vital role in conserving and restoring Europe's high-value forest ecosystems by providing legal protection, management guidance, and opportunities for research and stakeholder engagement. Through habitat restoration measures, integrated landscape planning, and collaborative efforts, Natura 2000 contributes to biodiversity conservation and sustainable forest management across designated areas of European significance.

While Natura 2000 aims to conserve forest ecosystems, its implementation can sometimes face challenges such as bureaucratic hurdles, conflicts with landowners over land use restrictions, and insufficient funding for restoration activities. Additionally, strict regulations may hinder adaptive management approaches needed for effective forest restoration in response to changing environmental conditions.

- Strategy and action plans for nature protection in the Republic of Croatia for 2017-2025

This document outlines a comprehensive strategy to enhance nature protection and sustainable resource use. Key objectives include establishing clear legislative frameworks, creating functional conservation networks, standardizing management practices, and improving communication. It also emphasizes sustainable resource management, biodiversity conservation, capacity building, data availability, and public engagement. These efforts aim to strengthen the effectiveness of nature protection mechanisms, reduce direct pressures on ecosystems, enhance institutional capacities, expand knowledge on nature, and foster public support for conservation initiatives.

Overall, while the document outlines important goals for nature protection and sustainable resource management, there is a risk that forest restoration may not receive sufficient prioritization, funding, and public support within this framework, potentially hindering effective restoration outcomes.

- National forest policy and strategy

National Policy and strategy is divided into the following areas:

A. Management of Forest Ecosystems;

B. Forest Administration and Legislation;

C. Non-Timber Products – Tourism, Hunting and Other Forest and Forest Lands Products;

D. Timber Industry;

E. Environment and Physical Planning;

F. Education Research and International Co-operation; and

G. Public Relations and Promotion.

The overall policy aim is:

Through sustainable management, use and comprehensive protection of forest resources and biodiversity increase the contribution to the national economy, applying research results, while respecting international trends and local community rights.

The National Forestry Policy and Strategy is not designed as a static document but will change and adapt over time in response to the needs of the sector, economic environment and overall Government policy.

- Strategy and action plan for the protection of biological and landscape diversity of the Republic of Croatia

The Strategy and Action Plan for the Protection of Biological and Landscape Diversity in Croatia is a national strategic document aimed at conserving biological, landscape, and geological diversity for the country's development. It emphasizes sustainable development, addressing various sectors such as agriculture, forestry, hunting, tourism, transportation, energy, and mining, to ensure their practices minimize impacts on biodiversity. Key objectives include conserving biodiversity in different ecosystems, promoting sustainable land and sea resource management, enhancing disaster preparedness, and addressing climate change impacts on biodiversity. Implementation responsibilities lie with central state authorities, primarily the Ministry of Culture and the State Institute for Nature Protection, in collaboration with various stakeholders including scientific institutions, resource managers, and the public. The strategy also outlines financial mechanisms, public participation, and monitoring programs to support effective implementation.

- Strategy for adaptation to climate change in the Republic of Croatia for the period up to 2040

The Climate Change Adaptation Strategy of the Republic of Croatia, adopted in April 2020, aims to address the projected impacts of climate change on various sectors by 2040 and 2070. It emphasizes the importance of integrating adaptation measures into existing policies to reduce vulnerability in the environment, economy, and society. The strategy identifies key sectors and thematic areas vulnerable to climate change, outlining 83 adaptation measures

across five groups. Implementation will be facilitated through action plans developed every five years, with measures aligned with the European Green Plan objectives. Monitoring mechanisms will track implementation effectiveness in coordination with stakeholders and sectors.

- Strategy for low carbon development of the Republic of Croatia for the period up to 2030

A low-carbon development strategy encompasses a holistic approach to reducing greenhouse gas emissions and mitigating climate change while promoting sustainable economic growth. It involves setting emissions reduction targets, transitioning to clean energy sources, improving energy efficiency, fostering sustainable transportation, investing in green infrastructure, implementing carbon pricing mechanisms, promoting sustainable agriculture and land use practices, and mobilizing green finance and investment. It seeks to decouple economic growth from emissions, enhance resilience to climate change impacts, and contribute to global efforts to combat climate change while fostering sustainable development. Integrating forest restoration considerations into low-carbon development planning and implementation is essential to mitigate these negative impacts and maximize crucial to minimize these effects and support both climate and biodiversity goals.

- Management plan of Mura – Drava regional park (In development)

The Government of the Republic of Croatia adopted the Regulation on the Declaration of the Mura-Drava Regional Park on February 10, 2011. According to the Nature Protection Act ("Narodne novine" No. 80/13, 15/18, 14/19, 127/19), the entire course of the Mura and Drava rivers is protected as a regional park. This marks the first regional park in the Republic of Croatia.

According to the Nature Protection Act ("Narodne novine" No. 80/13, 15/18, 14/19, 127/19), a regional park is a spacious natural or partially cultivated area of land and/or sea with significant biodiversity and/or geodiversity, featuring valuable ecological and landscape characteristics typical of the area where it is located.

The entire area of the Mura-Drava Regional Park, due to its exceptional value for the preservation of biodiversity, has been included in the Natura 2000 ecological network.

- Other legal acts which have direct impact on the sector include:

1. Law on Forest Planting Materials;
2. Law on Environmental Protection;
3. Law on Nature Protection;
4. Law on Plant Protection;
5. Law on Fire Protection;
6. Law on Hunting;
7. Law on Water;
8. Law on Financing Water Economy;
9. Law on Public Roads;
10. Law on Protection Against Natural Hazards.

- Law on Forest Planting Material

This law regulates the production, marketing, and import of reproductive material of forest and ornamental trees and shrubs, as well as the conditions that suppliers must meet to be registered in the Register of Reproductive Material Suppliers. Harmonised with EU directives, it ensures the use of high-quality, habitat-adapted material for sustainable forest management and biodiversity protection.

Reproductive material, as defined by this law, includes seed material, plant parts, and planting material of species/varieties and hybrids of forest and ornamental trees and shrubs intended for use in forestry, scientific research in forestry, and landscaping.

The law mandates the use of local provenances, allowing imported material only if ecological conditions match precisely, which may limit flexibility, especially under changing environmental conditions. Adaptations may be needed to maintain the availability of suitable reproductive material in the future.

- FSC certification

Croatian Forests Ltd. achieved FSCX certification in 2002, reflecting a long-standing tradition of sustainable, natural forest management without major operational changes

- Accompanying species

In the context of forestry or ecology, accompanying species refer to plant or animal species that coexist or are found in association with a particular focal species or habitat. In Croatia,

According to the forestry laws and silvicultural principles in Croatia and Serbia, there is no need for planting the accompanying tree species since they occur naturally. The situation in practical forestry follows the principles prescribed by law – accompanying tree species do occur naturally. It is expected that these species will spread naturally from surrounding areas, and they will be further supported through silvicultural measures in restoration area.

3.3 Financing

Serbia

Forests in the Serbian part of the cross-border demo can be referred to as economically highly important. The economic value of these forests might also be observed as a main driver for future restoration of these forests among forest managers and governments of the need to secure wood production for the future and enhancement of forest-related biodiversity. On the other hand, some actors have a strong commitment to preserve and enhance biodiversity as well as other ecosystem services besides wood production. Hence, the PE “Vojvodinašume” that manages the area uses the wood production income for nature preservation dominantly of strictly protected areas but also promotes the importance of nature preservation and biodiversity using these natural resources in various educational activities with mainly local children and youth.

Most of the restoration actions planned within the management plans of the PE “Vojvodinašume” for this part of the demo area is funded from public/governmental resources mainly gained from the wood production income. On the other hand, in recent years there is also a certain amount of funding gained through various international projects mainly financed by EU funds. The whole demo area from the Serbian part is in state ownership. In that case the potential for joint financing by public and private funders (e.g. individual persons or private companies) is not a realistic option. At the state level, a system for financing the improvement

of forests has been developed. Restoration financing support system can finance a main volume of restoration in our demo area according to Serbian law.

Opening restoration projects for external, international, and potentially private funding is possible, but with respect to national legislation. Smaller financing is possible through projects, but all activities through the projects of international organizations must be in accordance with the adopted plans.

If we consider the above, developing a “market-place” for financing in the case of the Serbian part of the demo area is not a realistic option. Most realistic option financing by state level and through the projects of international organizations. Gornje Podunavlje's appeal to international nature conservation and similar organizations is not only due to its ecological significance but also its potential for attracting funding to support conservation efforts. However, it's imperative that any financial contributions from these organizations align with locally adopted management plans. Ensuring financial resources are directed in accordance with established plans not only enhances transparency and accountability but also maximizes the impact of funding by focusing it on priority areas identified through collaborative planning processes involving local stakeholders. Private financing is not feasible as these forests are under state ownership. Therefore, alternative funding mechanisms must be explored for their management and conservation.

The restoration costs in general for this area are not always met with the financing opportunities and possibilities. A rough estimation of the costs planned for the presented case can be found in Table 3.

Table 3. Restoration cost estimation in Serbian part of the demo for action period

Cost category	Unit	Price (€)
Site preparation	€/ha	600
Materials	€/ha	600
Plants	€/ha	1200
Labor	€/ha	5500
Total costs	€/ha	7900

Croatia

Forests in the Croatian part of the cross-border demo are one of the economically most important in the Republic of Croatia. Pedunculate oak from this region is branded as “Slavonian Oak” that can get higher prices than regular Oaks from different regions of Croatia. Public enterprise “Croatian Forests Ltd” is the main landowner in the demo area (more than 90% of total forest area). Most of the income comes from managing forests and selling wood products, which enables further actions and restoration initiatives. Most of the restoration actions planned within the management plan of Croatian Forests Ltd. are funded through their own expenses which are gained from the wood production income.

The WP4 identified four categories of different actors that have been identified for financing:

1. Landowners/managers (i.e., the people making decisions about land use, incl. restoration);

2. Mediating agents (i.e., the people/companies or organisations working to raise funding for land-use change that includes restoration, and connecting landowners to financing agents);

3. Financing agents (people, companies or organizations funding restoration or making/influencing decisions funding (e.g. restorations agents);

4. Regulatory authorities (i.e., the people or organisations setting the rules that govern the financing of restoration projects).

In Croatia, the situation is somewhat different considering Croatian Forests manage 76% of all forests in Croatia. We can say that Croatian forests Ltd. are fulfilling the first three out of four categories while the Ministry of Agriculture serves as a Regulatory authority.

Additionally, forestry activities are funded through ecosystem services fees. According to the Forest Law, contributors to the payment of contributions for the general benefits of forests include legal and natural persons subjected to corporate income tax, as well as natural persons subjected to personal income tax who carry out registered activities in the Republic of Croatia and earn an annual income exceeding 995.421,06 EUR.

From these funds, the following activities are financed:

1. Management activities in protective forests and forest land,

2. Costs of preparing and approving forest management plans,

3. Management activities in commercial forests of public forest owners, except for the works of obtaining timber and non-timber forest products,

4. Management activities in commercial forests of public forest owners, institutions, legal entities, medium, and large forest owners, including:

    - Establishment of new forests on non-afforested forest land,
    - Rehabilitation and restoration of forests damaged by biotic and abiotic factors,
    - Maintenance of springs, wells, and cisterns,
    - Forest protection from harmful organisms and fires,

5. Demining of forests and forest land,

6. Scientific and professional work in the field of forestry,

7. Firefighting activities.

The compensation for the use of general forest functions is paid at a rate of 0.015% of the total income generated during the business year.

Example:

995.421,06 EUR x 0,015% / 100% = 149,31 EUR

This fee, although rather small, serves well as an additional source of income for managing forests and enables additional funding of restoration activities.

The budget provided for the implementation of restoration activities in the Croatian part of the demo area covered just the cost of site preparation, purchase and transport of forest reproductive material and fencing, without the additional expenses and full staff working hours. It is important to note that these costs are for a total area of 53.5 hectares.

Table 4. Restoration cost estimation in Croatian part of the demo for action period

Cost category	Unit	Price (€)
Site preparation	€/ha	209
Materials	€/ha	355
Plants	€/ha	1.524
Labor	€/ha	885
Total costs	€/ha	3.728

(Source: Croatian Upscaling Plan, Superb | WP7)

The actual costs of restoration activities are much higher. Especially in the presence of the vast number of invasive species that adds complexity and cost to forest restoration projects, as resources must be allocated for invasive species control alongside other restoration activities. The actual costs associated with forest restoration activities surpass initial estimates. According to data provided by Mr. Dragomir Pfeifer, the restoration cost for a restoration stand 1a covering 31.09 hectares amounts to €271,425. It's noteworthy that economic downturns and inflationary pressures have contributed to increased expenses. These factors emphasize the necessity for meticulous financial planning and allocation of resources to ensure the successful implementation of restoration projects.

3.4 Technical

In the demo area, practical and scientific knowledge work in synergy. All activities are grounded in detailed soil maps, reflecting the principle that soil characteristics determine the type of vegetation in lowland regions. Using this foundation, a map identifying the most suitable vegetation types is developed, accompanied by recommendations for planting or sowing methods. Expanding this knowledge could significantly enhance restoration efforts beyond the demo area, extending to other regions in need of ecological recovery.

Hereinafter, we will elaborate according to gained practical and scientific knowledge.

Serbia

In the Serbian part of the demonstration area, our restoration efforts focused on introducing native *Quercus robur* into forests previously dominated by low-vitality monoculture poplar stands. The restoration process involved multiple stages, with significant technical adjustments made between the first and second year to address environmental challenges. In the first year, following the complete clearing of the degraded poplar stand, we implemented a traditional method commonly used in these areas—direct acorn sowing. Unfortunately, this approach resulted in low success. Most acorns failed to germinate, and the few seedlings that emerged did not survive due to severe drought conditions. The increasing frequency of drought in the Vojvodina region is a consequence of climate change, which has altered historical water flow patterns, led to a decline in groundwater levels, and reduced the occurrence of natural flooding events that traditionally supported riparian ecosystems. In the second year, we adopted a more refined and resource-intensive approach. After clearing the area once again, we planted *Quercus robur* seedlings rather than using direct acorn sowing. Each seedling was planted in a manually dug hole, and hydrogel was added to the soil to enhance moisture retention. Additionally, the seedlings were watered regularly to mitigate the impact of drought conditions. This combination of improved planting techniques and consistent watering proved successful, with a significant increase in seedling survival and growth. This experience highlights the importance of adapting restoration techniques to changing climatic

conditions. While traditional methods may no longer be reliable in regions facing water scarcity, innovative strategies—such as incorporating moisture-retaining materials like hydrogel and providing supplemental watering—can improve restoration outcomes. This adaptive management approach serves as a model for future restoration efforts in other drought-prone regions.

Applied research is needed to monitor the development of restored areas in the context of biodiversity and carbon sequestration. In the adopted plans is a defined area of restoration needs. In the same plans the method of production of planting material is described with risk factors. These plans do not predict natural regeneration when new stands develop. In the demo area, restoration is most often carried out with pedunculate oak. A small area is planned for *Fraxinus angustifolia*, as the species is severely affected by ash dieback. This significantly limits its suitability for restoration and long-term survival in the demo area. Restoration potential with narrow-leaved ash is small due to the small area on which it is intended for planting. In case they must be planted resistant strains would become available. Currently, efforts are being made to find resistant individuals of this species.

Long-term monitoring is essential for tracking restoration success and supporting future upscaling efforts. While current resources may limit detailed data collection to basic measurements such as diameter, height, and wood volume—information that is critical for forest planning—there is great potential to expand monitoring activities in the future. Ideally, monitoring would also include biodiversity indicators and carbon sequestration metrics, which are key to demonstrating ecological and climate benefits. Even if such comprehensive monitoring is not yet fully established, integrating relevant tools from SUPERB WP6 within existing frameworks like the National Forest Inventory can provide valuable evidence of restoration progress. Ultimately, developing robust stand development models alongside enhanced monitoring of biodiversity and carbon storage will be crucial for projecting forest dynamics and motivating continued investment in large-scale restoration.

Croatia

In Croatia, collaboration efforts are underway between Croatian Forests Ltd., the Croatian Forest Research Institute and the Ministry of Agriculture, Forestry and Fisheries. This collaborative framework fosters the exchange of not only new scientific findings but also practical insights and expertise among these institutions. By working closely together, they leverage their respective strengths and resources to address key challenges in forest management and conservation. This collaborative approach ensures that the latest scientific advancements and practical techniques are effectively integrated into forest management practices, ultimately enhancing the sustainability and resilience of Croatia's forest ecosystems. To ensure that there are no knowledge gaps, management plans with 10-year cycles are made in which all the potential problems and successes are analysed. Additionally, new scientific insights are shared with forestry practitioners.

The Croatian Chamber of Forestry and Wood Technology Engineers organizes "Professional Development Lectures" annually, during which scientists present new scientific discoveries to forestry practitioners. Over the past two years, Dr. Martina Đodan held lectures for forest practitioners, focusing on the topic of forest restoration and the SUPERB project. Her involvement provides forest practitioners with valuable insights into the latest trends and developments in forest restoration efforts.

The quantity and quality of seed yield depend on the quality of forest stands, with environmental conditions playing an essential role. In recent years, we have witnessed frequent crop failures in various tree species. In these newly emerged ecological conditions,

the reproductive capacity and regularity of seed yield are often compromised, further endangering the production process of nursery seedlings and, consequently, forest restoration processes.

Due to the particular sensitivity of stands during rehabilitation, replacement, conversion, and/or restoration, high-quality forest reproductive material is of great importance. Stands are especially sensitive in the presence of a vast number of invasive species. Invasive species can hinder the restoration process and consequently lead to higher expenses. The lack of such material prolongs the time from the need for restoration to the actual start of the interventions, thus increasing biological risks such as erosion and additionally, greater economic loss.

The absence of adequate nursery production planning is a problem present in the Republic of Croatia, at a time when habitat-adapted seedlings have become a crucial tool in artificial regeneration, restoration and replacement of predominantly pure stands and forest cultures, but especially in the biological remediation of areas after forest damage. Increased pressures on nursery production arise due to intensified pressures of climate change and consequently, the emergence of biotic and abiotic threats. Therefore, for the successful implementation of forest restoration, it is necessary to apply principles of adapted forest management and to begin planning nursery production of habitat-appropriate and high-quality seedlings that will meet all the increasingly complex habitat requirements, but for a longer period, not on an annual basis as is currently the case in the Public enterprise.

We can conclude that the following components of nursery production are important:

1. Nursery production planning must be aligned with long-term needs due to the time required to produce quality seedlings. The production program must be in line with international commitments and the principles of modern forest management and bioeconomy.

2. The fact that 100% of the registered production in the Republic of Croatia is conducted by Croatian Forests Ltd. provides a unique opportunity to implement the most optimal concept currently available, which is Target Plant Concept (TPC). Collaboration within the organizational units of Croatian Forests Ltd. enables the production and planning of targeted seedlings that will ensure the highest survival rate and optimal growth after transplantation to the field.

3. Improving technology in existing nurseries is essential to achieve a production program that meets modern needs (considering shifts in distribution areas, assisted gene migration, principles of mixed planting, biodiversity, the Kyoto Protocol, etc.).

The production of forest seedlings adapted to the habitat (the so-called "Target Plant Concept" - TPC) depends on quality production planning, aiming to produce seedlings that will have the highest survival and best growth and development on a specific site. It has been observed that forest seedlings with the same morphological characteristics (quality) have significantly different success rates, so we cannot define the quality of seedlings universally for all seedlings of the same species (provenance) in Croatia, but rather according to the requirements of the site. With the TPC concept, measurable characteristics of seedlings are set as the goal of nursery production. Unlike the criteria currently applied, these attributes are frequently adjusted and set for a specific site after determining the survival, growth, and development of seedlings after replanting. In addition to the height, length and diameter of the root collar of the seedling, many different morphological and physiological attributes can be assessed. It is emphasized that this is particularly important for areas where biological restoration is carried out after damage. This type of nursery production planning is flexible but of higher quality because it occurs in real-time, encompasses real threats under which

seedlings must grow and develop, and allows for the establishment and development of growth models for seedlings as well as the development of predictive models.

We conclude that short-term production planning, as well as forestry interventions that do not encompass shifts in species/provenance distribution and predictive models of biotic and abiotic threats, are not sustainable concepts. Therefore, it is recommended to improve and establish a more long-term production program in close collaboration with forestry experts both before and after planting in the field.

The use of climate projections and models, such as those developed under the SUPERB project, offers insights into species selection, management strategies, and adaptation to changing environmental conditions. While these tools hold significant potential, stakeholders emphasize the need for cautious interpretation due to limitations in remote sensing accuracy. Expanding monitoring at the European level presents opportunities for cross-border collaboration and policy alignment, with political engagement needed to address challenges like data sharing and funding allocation.

Carbon sequestration is a key focus of restoration activities, aiming to enhance carbon storage and mitigate climate change. Both Euro-American poplar plantations and pedunculate oak mixed forests show high potential for carbon sequestration. Poplars excel in rapid biomass production and substitution effects for fossil fuels, while pedunculate oak provide long-term carbon storage in forests and as long-lived products, along with biodiversity benefits and economic value, particularly through high-quality "Slavonian oak" products. Although part of the production from Euro-American poplar plantations goes into wood products, poplar wood and its wood products are generally less durable than oak due to its lower density, hardness, and carbon storage capacity. Research indicates that pedunculate oak forests become carbon sinks as early as 5 years of age and maintain this role beyond 160 years. However, further studies are needed to optimize carbon sequestration strategies and balance ecological, economic, and social objectives.

4. Recommendations

Tackling restoration issues in our demo area:

Forest restoration in the Serbian and Croatian part of the cross-border demo area is shaped by distinct challenges influenced by their political, economic, social, technical, environmental, and legal contexts. Despite the fact that forest restoration in both countries faces common obstacles, the nature and severity of these challenges differ due to their specific circumstances as a non-EU and an EU country.

In the Serbian part of the demo area, forest restoration efforts depend on supportive government policies and regulatory frameworks. Political will and clear mandates are needed to integrate future restoration goals into broader national environmental strategies. In contrast, in the Croatian part of the demo area, there is a struggle with limited policy recognition of restoration benefits, weak incentives for multiple-use forestry, and a lack of consensus among stakeholders. The country's legislative regulations treat all forest owners equally, disregarding the differing capacities of landholders, which impedes tailored restoration strategies.

Economic factors in both countries creating this cross-border demo area emphasize the need for financial incentives to support forest restoration. In the Serbian part of the demo area, reliable funding mechanisms and market-based solutions are essential for motivating landowners to invest in restoration. Without such incentives, stakeholders may prioritize short-term gains over long-term sustainability. The Croatian part of the demo area, however, faces

the challenge of perceived high costs for restoration activities, the lack of market instruments, and the absence of national incentives beyond biomass production. These economic barriers limit the ability of Croatian landowners to participate in effective restoration.

Community engagement is critical to the success of restoration efforts in both countries. In the Serbian part of the demo area, active participation from local communities, landowners, and stakeholders fosters shared experiences and strengthens commitment to conservation practices. The Croatian part of the demo area, however, faces significant social challenges such as rural depopulation, perceived conflicts between land uses, and a lack of public interest in forest restoration. These issues hinder widespread support for restoration initiatives.

Main technical issue in the cross-border demo area is a lack of skilled workforce. In Serbia, technological advancements in adaptive management, species monitoring, and restoration tools offer opportunities to overcome technical barriers. However, the lack of an adequately trained workforce to implement these tools limits their effectiveness. Croatia faces a broader range of technical challenges, including low levels of mechanization, outdated forest nursery processes, limited availability of forest reproductive material, and poor coordination between planning activities and restoration needs. Both countries face workforce-related obstacles, but Croatia's technical challenges are more extensive, requiring significant improvements in innovation, resource availability, and workforce training.

Both parts of the cross-border demo area face environmental challenges induced by climate change and invasive species. The presence of a vast number of invasive species poses a significant challenge to forest restoration efforts especially in Croatia's part of the cross-border demo area. Invasive species are represented by tree species (*Fraxinus pennsylvanica* Marshall., *Acer negundo* L., *Ailanthus altissima* (Mill.) Swingle.)), shrubs (*Amorpha fruticosa* L.), and ground vegetation (*Asclepias syriaca* L., *Datura stramonium* L., *Echinocystis lobata* (Michx.), *Erigeron annuus* (L.) Pers., *Phytolacca americana* L., *Reynoutria japonica* Houtt., Solidago sp.). These invasive species can hinder the restoration process and consequently lead to higher expenses. They compete with native vegetation for resources, disrupt natural habitats, and may require additional resources and measures to control or eradicate them. The management of invasive species adds complexity and cost to forest restoration projects, as resources must be allocated for invasive species control alongside other restoration activities.

In Serbia, climate change impacts on ecosystems and species viability necessitate the use of resilient species and biodiversity-friendly practices, particularly in sensitive areas like Vojvodina. Croatia faces a broader set of environmental issues, including a lack of evidence on biodiversity impacts, conflicts between environmental goals, and low biosecurity in the forest reproductive material production chain

Serbia's legal barriers include complex permitting processes and fragmented regulations, which hinder restoration activities, especially in protected areas. Simplifying these processes could enhance efficiency and participation. Croatia faces more complex legal challenges, such as conflicts between forest and nature protection laws, restricting management options and hindering effective restoration.

Cross-border insights: general recommendations for riparian forest restoration

Stakeholder engagement:

- **Focus on Forest Landowners and In-situ Managers:** Given their dominant role in managing and utilizing forest areas, it is crucial to involve forest landowners and in-situ managers in the restoration processes. Their cooperation is essential for successful implementation and sustainability of forest restoration projects.
- **Engage Government and Policymakers:** Government bodies, policymakers, and regulatory actors must be engaged early to ensure that restoration efforts are aligned with national and regional policies, regulations, and financial frameworks. Their support is necessary for facilitating legal and financial structures that enable large-scale restoration.
- **Strengthen Education and Research:** Collaboration with educational and research institutions is key for gathering data, monitoring progress, and adapting restoration techniques to the changing environmental conditions.
- **Emphasize Climate Change Adaptation:** As climate change is altering the hydrological patterns and increasing the vulnerability of riparian forests, stakeholders must prioritize climate-resilient restoration practices to mitigate these impacts on forest ecosystems.
- **Promote Collaborative Partnerships:** Engaging a diverse set of stakeholders from different categories ensures a more comprehensive approach to restoration. Facilitating dialogue between forest landowners, policymakers, civil society, and research institutions can enhance cooperation and increase the effectiveness of restoration efforts.

Governance and Legal Considerations:

- **Align with National and EU Legislation:** Restoration efforts should continue to align with national legislation and forestry management rules, ensuring that Serbia's laws are harmonized with EU standards, particularly regarding the use of native species and forest management practices.
- **Foster Strong Public and Institutional Support:** Given the strong public interest and existing governance framework, restoration initiatives should engage key institutions to ensure activities comply with local and national regulations.
- **Follow FSC Standards:** Forest management practices should follow FSC standards, including the implementation of management plans that incorporate nature conservation and water management, to ensure sustainability and environmental protection.
- **Consider Ecological Networks and Carbon Sequestration:** Link restoration actions to broader national and international processes, such as increased carbon sinks in forests, protection of ecological networks, and biodiversity conservation, aligning efforts with national protection strategies.
- **Incorporate International Conservation Partnerships:** Work in partnership with international organizations, ensuring that activities align with international nature conservation goals, and that actions are in accordance with adopted plans
- **Monitor and Evaluate Long-Term Impacts:** Ensure ongoing monitoring and evaluation of restoration activities, particularly the long-term effectiveness

Financing:

- **Maximize Public Funding and Wood Production Income**: Given that in this case, the majority of funding comes from public/governmental sources, it is crucial to continue utilizing wood production income for forest restoration and biodiversity conservation efforts, while ensuring a balance between wood production and ecological preservation.
- **Maximize EU and International Funding:** Continue exploring EU and international funding opportunities, particularly through environmental and nature conservation projects. These funds can be instrumental in supporting restoration actions, provided they align with local management plans and national legislation.
- **Ensure Alignment with National Legislation:** All financial contributions from external and international organizations should adhere to national laws and the adopted management plans. This will ensure that funds are directed towards restoration efforts that comply with the country's environmental and legal frameworks.
- **Explore Alternative Funding Mechanisms**: While private financing may not be feasible in this case due to the state ownership of these forests, exploring new funding models, such as public-private partnerships or fundraising through international conservation organizations, could be beneficial for supplementing public funds.
- **Address Restoration Cost Gaps:** Acknowledge that the costs of restoration may exceed the available financing. Therefore, a strategic approach should be taken to identify funding gaps and prioritize restoration activities that can be supported within the existing financial constraints.

Technical Considerations:

- **Plant the Right Species in the Right Place**: Restoration efforts should focus on selecting and planting species that are best suited to the stand environmental conditions, including soil type, water availability, and climate. This ensures species thrive and contribute to a resilient, diverse ecosystem.
- **Adapt to Climate Change:** Restoration techniques must be adapted to the changing climatic conditions, particularly in drought-prone regions like Vojvodina. This includes the use of moisture-retaining materials such as hydrogel and consistent watering to support seedling survival and growth.
- **Planting and Plant Care Techniques:** Based on lessons learned, planting methods should be continuously refined. The use of high-quality reproductive material, hydrogel, careful soil preparation, and seedling watering has proven effective, and these methods should be incorporated into future restoration efforts in similar ecological contexts.
- **Long-Term Monitoring Frameworks**: Beyond short-term project durations, long-term monitoring frameworks are essential to track forest development, including diameter, height, and wood volume, as well as other ecological indicators. These data will inform future forest management and restoration strategies.
- **Research and Monitoring:** Applied research and long-term monitoring projects should be conducted to assess biodiversity and carbon sequestration in restored areas. Additionally, efforts to identify and plant resistant strains of species are crucial using high-quality reproductive material, ensuring the long-term success of restoration in the face of climate change challenges.
- **Adaptive Management**: Restoration activities should be flexible and adapt to the changing environment. It is essential to continuously evaluate the effectiveness of

restoration methods and adjust strategies as needed, especially in areas vulnerable to climate-induced water scarcity.

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