Poplar cultivation and the Nature Restoration Law in Italy: conservation trade-offs versus Bioeconomy synergies

A Discussion Paper

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Executive summary

Italy's wood-based sector operates within a structural paradox: despite forest cover expanding to over one-third of the national territory, the country remains reliant on timber imports, sourcing up to 80% of its wood and wood-based products abroad. Within this context, poplar (*Populus* spp.) plays a strategic role. Occupying less than 1% of the national forest surface, poplar plantations generate approximately 40% of domestic industrial broadleaf timber, acting as the backbone of the high value "Made in Italy" plywood, packaging, and furniture supply chains. However, domestic cultivated area has contracted sharply from over 150,000 hectares in 1970 to approximately 53,000 hectares in 2024, resulting in annual roundwood imports exceeding 500,000 m^3 (equivalent to 32-42 million Euro/year). Efforts to expand domestic cultivation toward the 100,000-hectare threshold required by industry face several barriers, intersecting, and potentially conflicting, with the European Union Nature Restoration Law (Regulation EU 2024/1991) and the Italian National Restoration Plan. Concentrated primarily in the floodplains of the Po Valley (Northen Italy), intensive monoclonal poplar monocultures pose ecological concerns regarding riparian habitat degradation, low genetic resilience, and agrochemical runoff. Conversely, uncoordinated restrictions on poplar cultivation risk triggering environmental and carbon leakage by shifting wood procurement to non-domestic sources, contributing to the risk of impact displacement, and finally affecting the development of a domestic forest-based bioeconomy.

This discussion paper examines the trade-offs between timber supply security and ecological restoration targets. It proposes an integrated spatial and policy framework based on: (1) functional spatial zoning that reserves active floodplains (*golene*) for riverine naturalization while relocating high-yield production to agricultural hinterlands (*retro-golene*); (2) the adoption of enhanced environmental sustainability clones resistant to biotic stressors; and (3) market and policy levers, including forest certification, Common Agricultural Policy measures and voluntary Payments for Ecosystem Services. This framework indicates that modern poplar cultivation, when strategically aligned with spatial planning, can bridge industrial wood demands with European biodiversity and bioeconomy objectives.

The paper leaves some open questions to stakeholders, to stimulate discussion around this topic.

1. Background

While more than one third of Italy is covered by forests whose area has tripled in the last 70 years (Gasparini *et al.*, 2022), the Country remains a net wood importer. According to some estimations, Italy imports up to 80% of wood and wood-based products that are domestically consumed and processed (Khan *et al.*, 2026). This structural supply deficit is linked to multiple factors, including high forest estate fragmentation, morphological barriers, demographic and socioeconomic trends in marginal rural areas, decrease in the primary sector investments and infrastructures, just to mention a few.

Within this context, poplar (*Populus* spp.) plantations play a strategic role. Poplar cultivation is widespread globally, particularly in China, Iran, and South America, and is also highly developed in Europe, where it is especially prominent and valued in Mediterranean countries. In this context, France, Spain, Belgium, Hungary, and Italy lead European production. Italy stands out for the quality of its poplar production, which stems from a long-standing tradition that has refined specific cultivation techniques, including the use of the 'I-214' clone. Initially selected for its rapid growth rate and resistance to spring defoliation, this clone became widely established due to its high adaptability to various environments and its lightweight, light-colored wood, which is ideal for a broad spectrum of industrial applications. The cultivation system adopted is predominantly intensive, typically featuring a planting density of 280 trees/ha and a rotation period ranging on average from 10 to 12 years, yielding high-value timber production of around 200 m^3/ha, with an average annual increment of approximately 20 m^3/ha (Zanuttini and Chiarabaglio, 2025).

Despite occupying less than 1% of the national forested surface, poplar plantations account for roughly 40% of Italy's domestic industrial broadleaf timber production (Mancini, 2025). As the backbone of the Italian plywood, packaging, and furniture sectors, poplar is a vital raw material for the high-value 'Made in Italy' wood-furniture supply chain and is increasingly regarded as a strategic resource for the national bioeconomy (CNBBSV, 2026). Poplar plywood is also widely utilized in the automotive industry (particularly for campervan and caravan components) and the construction sector. Furthermore, poplar wood serves as a key input for particleboard manufacturing, paper pulp, and bioenergy production. Beyond provisioning services, poplar offers valuable environmental benefits: as a fast-growing species, it sequesters atmospheric carbon dioxide into long-lasting bio-based products, while contributing to riparian soil stabilization and flood risk mitigation (Zanuttini and Chiarabaglio, 2025).

However, domestic poplar supply meets only about half of total industrial demand (approx. 1.1 million m^3 annually) (Mancini, 2025), leaving the sector heavily reliant on imports mainly from France, Hungary and Belgium. As a direct consequence of this supply deficit, poplar roundwood imports have exceeded 500,000 m^3/year over the last four years, resulting in an annual expenditure of between 32 and 42 million Euro. To close the demand gap, Italian industries would require poplar production originating from at least 100,000 ha of plantations (corresponding to an annual harvest of 8,000–10,000 hectares). However, inventory data highlight a progressive decline in cultivated area, dropping from historical peaks exceeding

150,000 ha in 1970 to approximately 53,000 hectares in 2024, even when accounting for young plantations (CNBBSV, 2026). Overall, this corresponds to a 65% reduction in planted area.

Efforts to scale up domestic cultivation to secure raw materials and shorten supply chains face several critical bottlenecks. From a financial perspective, poplar plantations directly compete with less risky annual cash crops such as maize for agricultural land. Although plantation investments offer internal rates of return of up to 7% – among the highest for forest investments in Europe – poplar growers face substantial land opportunity costs due to foregone annual revenue stream opportunities associated with arable crops, which are frequently subsidized through European Union (EU) PAC funds. From a management standpoint, the increasing incidence of pests and diseases poses severe risks and economic uncertainties for long-term investments. In ecological terms, the reliance on sensitive riparian areas, potentially intensive chemical inputs, and monospecific (or even monoclonal) stands raise significant environmental concerns. These trade-offs are now brought into sharp focus, as expanding high-yield poplar plantations across river basins and agricultural plains directly interacts – and potentially conflicts – with the ecological targets set by the EU Nature Restoration Law (NRL) and the Italian National Restoration Plan (NRP) – in Italian, *Piano Nazionale di Ripristino* – currently under development.

2. The policy paradox: poplar cultivation vs. the EU Nature Restoration Law

The EU Nature Restoration Law (NRL), enacted under Regulation (EU) 2024/1991, establishes legally binding targets to restore at least 30% of degraded habitats by 2030, 60% by 2040, and 90% by 2050. In Italy, where the National Restoration Plan (NRP) is translating these mandates into national and sub-national spatial frameworks, the floodplains of the Po Valley (*Pianura Padana*) represent a primary focal area. Because the Po basin accounts for over 80% of Italy's poplar plantations (Figure 1) and is characterized by an extensive network of rivers and channels, intensive agricultural activities, and highly urbanized areas, the intersection between agricultural land use, industrial timber demands, and ecological restoration objectives creates a series of complex trade-offs.

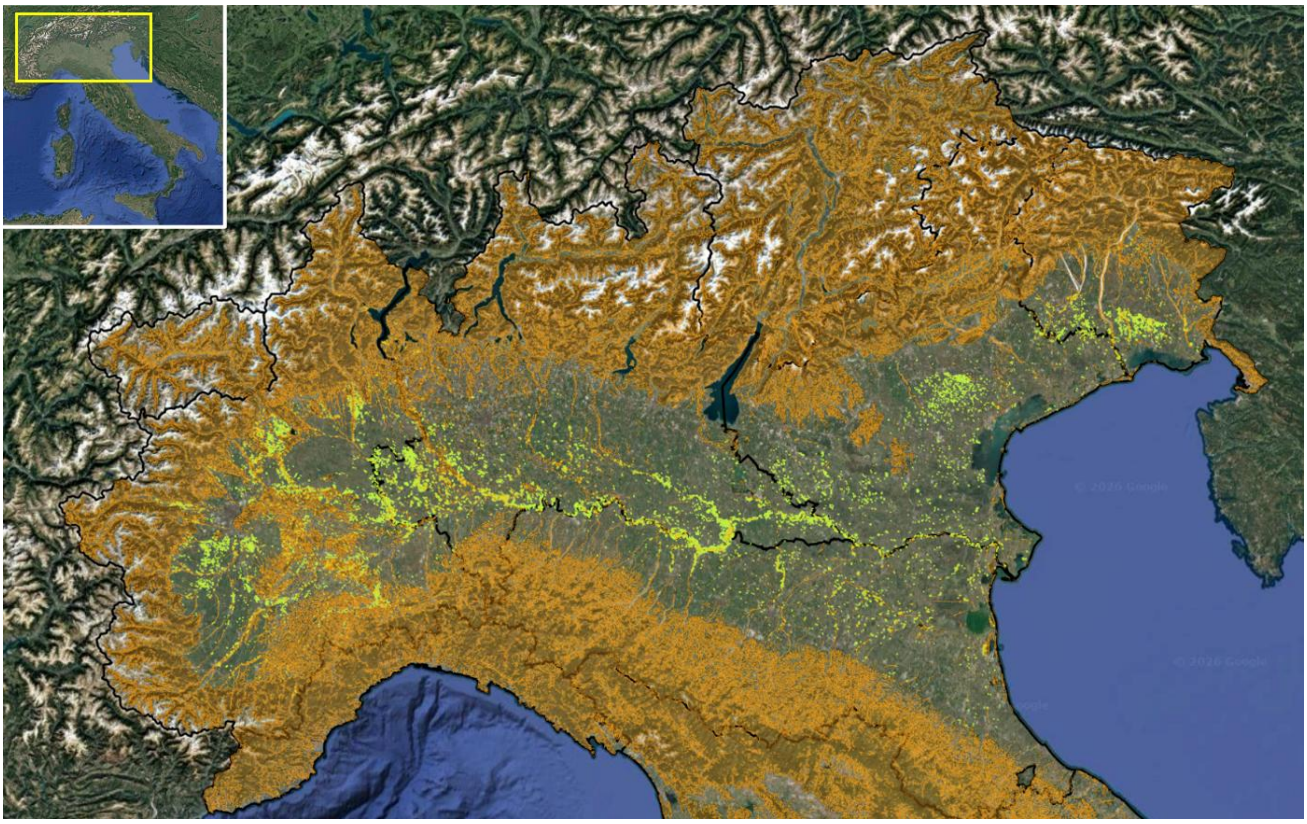

Figure 1: Seminatural forests (orange) and poplar plantations (yellow) in Northern Italy. Source: Sinfor (2026)

The early draft of the NRP outlines eight distinct forest restoration measures targeting a total area of approximately 1.42 million hectares. These measures include the naturalization of planted forests, close-to-nature forestry practices, the control of invasive alien species, afforestation, reforestation, forest management planning, wildfire prevention, and the establishment of (potentially) permanent multispecies and polycyclic plantations. In addition,

other key measures target agriculture practices as well as the ecological restoration of riverine ecosystems and corridors, specifically aimed at re-establishing free-flowing rivers and enhancing alluvial plain connectivity.

While poplar plantations provide essential provisioning ecosystem services and may play a key role in shifting to a bioeconomy, traditional intensive management systems diverge significantly from the ecological criteria defined by the NRL.

NRL articles 4 and 9 prioritize the restoration of free-flowing rivers, natural floodplains, and native alluvial forests (*Alno-Padion*, *Salicion albae*). Intensive poplar plantations situated within active floodplains (*golene*) may displace multi-layered, species-rich riparian vegetation in favor of single-layered stands, interrupting natural succession and degrading riverine habitat connectivity.

Additionally, over 70% of Italian poplar plantations rely on a narrow genetic base, predominantly the 'I-214' clone. While economically advantageous due to uniform growth and wood quality, monoclonal stands exhibit low ecological resilience. They offer limited structural diversity for wild fauna (avian, insect, and soil communities) and remain highly susceptible to emerging pest outbreaks and climate-driven stressors. Moreover, meeting the growth targets of intensive rotations (20 m^3/ha/year) often entails mechanical soil preparation, irrigation, and the application of synthetic fertilizers and chemical pesticides to control defoliators (e.g., *Cryptorhynchus lapathi*, *Saperda carcharias*). In alluvial zones immediately adjacent to watercourses, chemical runoff conflicts with NRL objectives aimed at restoring soil microbiology, reducing chemical contamination, and improving water quality under Directive 2000/60/EC (EU Water Framework Directive).

However, restricting poplar cultivation in river basins without developing alternatives for wood supply introduces a structural paradox into several European environmental policy. The persisting (or even increasing) supply gap would increase raw timber imports from abroad and may therefore simply displace negative impacts rather addressing them. At the same time imports imply Carbon leakage in wood logistics. Transporting roundwood over thousands of kilometers neutralizes the carbon mitigation benefits gained from local habitat restoration, increasing the net lifecycle emissions of the Italian wood-furniture value chain. A shrinking raw material supply directly undermines the objectives of the EU Bioeconomy Strategy and the Italian Circular Economy Roadmap, jeopardizing thousands of high-skilled manufacturing jobs reliant on high-quality domestic plywood.

At the same time, establishing new poplar plantations on agricultural land offers multiple ecosystem co-benefits compared to traditional farming alternatives: it improves the net greenhouse gas balance through rapid carbon sequestration, enhances soil water infiltration and retention capacities, and enriches landscape quality, while providing – albeit to a more limited extent – incremental support to local biodiversity.

3. Reconciling Bioeconomy Needs and Restoration Targets: A Strategic Framework

Addressing the dual challenge of achieving the ecological objectives set by the EU NRL and the NRP while meeting the raw material demands of the Italian wood-based industry requires a shift from traditional monocultural approaches toward an integrated, multi-functional management framework. Rather than viewing poplar cultivation and ecological restoration as mutually exclusive, policy instruments and spatial planning tools can be aligned to create synergies between industrial autonomy and environmental stewardship.

3.1 Spatial zoning: active floodplains and agricultural hinterlands

A central strategy for resolving land-use competition in the Po Basin is a functional spatial separation based on ecological sensitivity and hydrological dynamics. Whenever possible, areas within the active river channel and primary flood-dikes (*golene*) should be prioritized for naturalization, close-to-nature forestry, and river corridor connectivity under the NRP. In these high-value riparian zones, intensive monoclonal poplar plantations should gradually transition toward native multi-species alluvial forests (*Alno-Padion*, *Salicion albae*) or low-intensity, multi-rotation and multispecies plantations. This would be consistent with the NRL mandate to restore free-flowing rivers, enhance natural flood-attenuation capacities, and rebuild habitat connectivity.

To offset the loss of productive capacity in active floodplains and reach the 100,000 ha threshold required by industry and bioeconomy development, new high-yield poplar plantations should be established on arable lands outside primary flood zones. Establishing plantations on agricultural land – frequently substituting intensive annual cash crops like maize – delivers substantial ecosystem co-benefits: it improves net greenhouse gas balances through rapid biomass carbon accumulation, support riparian protection against erosion and flood risks, enriches rural landscape structure, and reduces the heavy nitrogen and pesticide loads associated with continuous annual cropping. To mitigate the financial risks associated with replacing annual crops with long-rotation poplar plantations, these delivered environmental services should be remunerated through dedicated payment for ecosystem services (PES), PES-like or other market-based mechanisms for landholders and growers (see 3.3).

3.2 Technological innovation: clones with enhanced environmental sustainability

To minimize environmental trade-offs in newly established plantations, the Italian poplar sector must accelerate the adoption of clones with enhanced environmental sustainability (in Italian: *Maggior Sostenibilità Ambientale*, MSA). Traditional management relies heavily on the 'I-214' clone, which requires frequent chemical interventions to control defoliators and fungal

diseases. In contrast, newly bred MSA clones offer genetic resistance to key biotic stressors (e.g., *Marssonina brunnea*, woolly poplar aphid *Phloeomyzus passerinii*, and rusts).

Widespread adoption of MSA clones enables a drastic reduction of synthetic pesticide applications, directly supporting NRL targets on pesticide reduction and soil biology restoration. Moreover, utilizing a mosaic of distinct MSA clones across regional landscapes mitigates the systemic vulnerability of monoclonal stands, fostering greater resilience against climate-driven pest outbreaks while creating more heterogeneous habitat conditions for local avifauna and beneficial insects.

3.3 Certification schemes and financial policy levers

Aligning industrial practices with EU ecological standards requires robust market-based mechanisms and targeted public incentives.

Increasing the share of certified poplar stands (under the Forest Stewardship Council (FSC) or Program for the Endorsement of Forest Certification (PEFC) national standards) ensures that wood entering the "Made in Italy" supply chain meets rigorous sustainable forest management requirements. Certification frameworks mandate the retention of unharvested buffer zones along watercourses, the release of set-aside areas (up to 10% of a forest management unit, in the case of FSC standards), the protection of deadwood microhabitats, and strict bans on hazardous pesticides, aligning private plantation management with public restoration goals. Past experiences and projects, such as the Ecopay Connect one, show that cooperation mechanisms and agreements among growers, plywood industry and local protected area managers leading to win-win solutions are feasible and effective (Box 1).

The Common Agricultural Policy (CAP) strategic plan and regional Rural Development Programmes (PSR) offer eco-schemes and agri-environment-climate commitments that may be adapted to poplar growers. These subsidies should compensate landholders for the initial capital costs and long-term cash-flow lag of converting annual cropland into longer-term (10 to 12 years) poplar plantations.

PES mechanisms and other payment schemes could be set-up for poplar growers who adopt MSA clones, maintain uncultivated ecological corridors, or implement multi-species border strips etc., monetizing their contributions to carbon sequestration, soil conservation, and regional flood risk mitigation.

Box 1: **Ecopay Connect, a win-win PES-scheme**

Within the framework of the EcoPay Connect project, an innovative PES scheme was developed in the Po Valley (Northern Italy), bringing together smallholder poplar growers, a leading poplar plywood manufacturer (Panguaneta), and a close-by protected area authority (Parco Regionale Oglio Sud). Under FSC certification standards, poplar growers are required to set aside 10% of their FMU as representative sample areas to restore native ecosystems. Recognizing the burden this places on smallholders, FSC standards allow small farmers to identify and maintain these representative areas outside their individual FMUs. To incentivize poplar cultivation, support FSC certification, and secure a continuous supply of certified logs, the plywood company provided financial and technical support for ecosystem restoration within the protected area. This offsite arrangement enabled smallholders to fulfill their conservation obligations without sacrificing productive land within their plantations - thereby resolving production trade-offs - while providing the Regional Park with dedicated funding to implement urgent restoration actions (e.g., reforestation, wetland and peatland restoration, and the establishment of ecological corridors) that would have otherwise remained unfunded. To further drive adoption and scale up the mechanism, the plywood company guaranteed a price premium for FSC-certified, locally grown poplar roundwood (Figure 2).

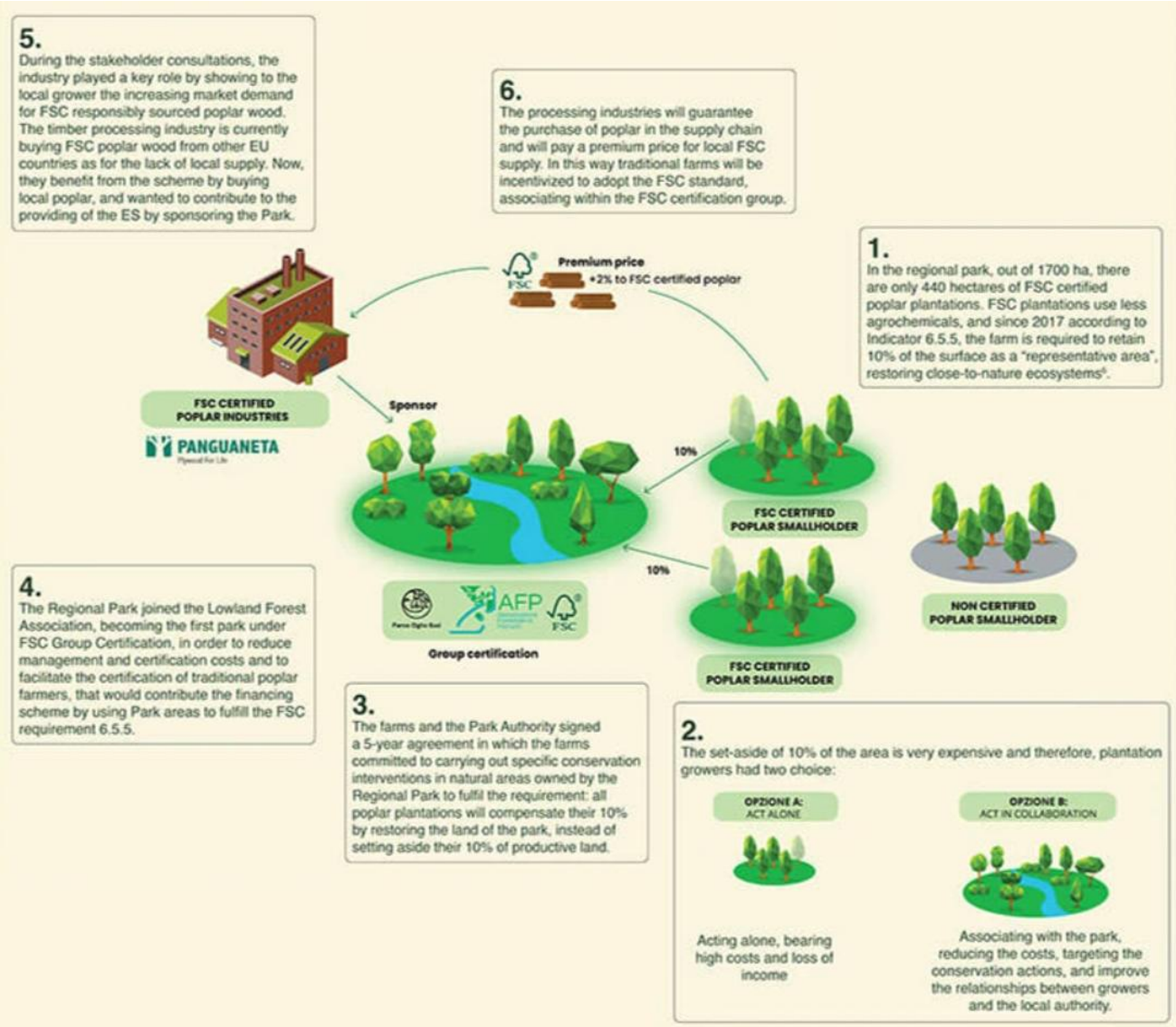

Figure 2: Overview of the key actors and components of the PES-mechanism. Source: Etifor (2018)

4. Concluding remarks and open questions for stakeholders

The intersection between Italy's wood-based industrial demands and the mandates of the EU NRL represents a pivotal case study for European bioeconomy governance. Resolving the paradox of vast domestic forest growth alongside a high reliance on timber imports requires moving past binary debates that pit ecological restoration against wood production.

Poplar cultivation, when managed through a modern and spatially nuanced framework, offers a unique bridge between these agendas. By shifting high-yield production from ecologically sensitive active floodplains to agricultural hinterlands, replacing intensive cash crops like maize, and deploying disease-resistant MSA clones under certified management (FSC/PEFC), Italy can safeguard its high-value timber supply chain while simultaneously fulfilling its restoration commitments under the NRP.

4.1 Key Policy takeaways

This paper delivers three main policy takeaways:

1. **Avoid "Carbon and Environmental Leakage":** Restricting domestic poplar production without addressing industrial raw material demand risks shifting environmental burdens to exporting countries with weaker governance, increasing transport-related emissions, and weakening Italy's industrial autonomy as well as development opportunities for a national forest-based bioeconomy.
2. **Implement Functional Spatial Zoning:** Clear land-use zoning and planning in the Po Valley should reserve riverine corridors for biodiversity and free-flowing river dynamics under the NRL, while incentivizing high-yield poplar plantations coupled with permanent multispecies and polycyclic plantations, and low-impact farming on arable hinterlands.
3. **Align Agricultural Policy with Forest Goals:** The CAP and regional RDP, together with voluntary market-based instruments can help bridging the financial gap for farmers transitioning from annual crops to 10 to 12-year poplar rotations through dedicated payments and capital support.

4.2 Key Questions for stakeholders and future research

To translate these strategic principles into actionable policy, several critical questions remain open for debate among key stakeholders like policymakers, industry (e.g., FederlegnoArredo), farmer associations, environmental non-government associations, and research institutions:

Land-Use Allocation & Food Security: What proportion of agricultural land in the Po Basin can be realistically transitioned from annual crops to poplar cultivation without compromising regional food security or triggering land-use competition with other essential agricultural

sectors? To what extent can this be integrated with (potentially) permanent multispecies and polycyclic plantations?

PES Financial Architecture: What specific market and public funding mechanisms, such as voluntary carbon or nature credits, CAP eco-schemes, or watershed protection funds, are best suited to guarantee long-term financial liquidity for farmers during the 10 to 12-year poplar rotation period?

Regulatory Flexibility under the NRP: How will the Italian NRP treat certified, low-impact poplar plantations (e.g., using MSA clones in agriculture hinterlands)? Will they be recognized as multi-functional agricultural landscape elements that contribute positively to regional biodiversity targets, or restricted under rigid land-use definitions?

Genetics and Climate Resilience: How can breeding programs accelerate the selection and commercial deployment of diverse MSA clones capable of withstanding emerging pest pressures and altered hydrological regimes driven by climate change in northern Italy?

4.3 Final considerations and a concluding open question

To draw some concluding remarks, a fundamental question emerges from this analysis – one that may border on the rhetorical, yet remains deeply crucial for the future of the sector: is the current challenge merely technical, requiring us "simply" to push for further technological innovation? Or do we instead need broader collective actions, stronger networking, and a more structured coordination among key local actors?

While technological advancements, such as precision forestry, improved clonal selection, and automated supply-chain tracking, are undoubtedly essential, they run the risk of remaining isolated exercise of efficiency if detached from the socio-economic fabric of the territories. Innovation alone cannot overcome market fragmentation, land-use conflicts, ecosystem service tradeoffs, or the structural gaps between wood production and industrial processing. Therefore, technological progress must be paired with an equally ambitious wave of social and institutional innovation.

This strategic shift towards integrated territorial governance could be significantly fostered and supported by Italian regional governments, particularly those that in 2025 have signed with key stakeholders an agreement for the development of the poplar sector (*Nuova Intesa per lo sviluppo della filiera del pioppo*[1]). Rather than acting purely as regulators or financial distributors, public authorities should embrace an active coordinating role. By serving as

[1] https://cnbbsv.palazzochigi.it/media/f0uikn5f/allegato-1.pdf

strategic enablers, they can bridge the gap between smallholders, industrial processing hubs, research centers, and local communities.

Ultimately, public coordination should not just imply top-down control; rather, it should aim at creating a fertile ecosystem where effective, market-driven, and socially responsible solutions can be spearheaded by the private sector and civil society. Only by aligning public policy with private initiative and territorial needs can the Italian poplar sector transform its environmental and economic potential into a resilient, long-term bioeconomy model.

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