



Insights from ART for LIFE Project: Climate-Adaptive Forest Management for Spruce Forest Restoration in Europe

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Spruce forests across Europe are highly vulnerable to climate change and recurrent *Ips typographus* outbreaks, causing widespread ecosystem degradation. Achieving large-scale restoration requires strategies that are ecologically sound and economically feasible. ART for LIFE addresses this challenge by testing and validating, for the first time, adaptive forest management strategies in mountain ecosystems. The project has two main objectives: (i) restore degraded spruce stands by converting them into resilient, mixed forests, and (ii) promote wide adoption among forestry stakeholders.

The project will be implemented at two sites in the Northern Apennines (Italy), where relict Norway spruce populations are threatened, and one site in the Dinaric Alps (Slovenia), where most Norway spruce have been heavily affected by bark beetles. Nuclei of climate-adapted provenances of silver fir, Norway spruce, and beech will be planted in canopy gaps as regeneration hotspots. Demonstration plantations will compare spacing, species composition, and provenance mixtures to assess seedling survival, growth, and functional complementarity. A comprehensive monitoring framework will combine field surveys and advanced technologies to assess impacts on biodiversity, soils, seedling physiology, and pest dynamics. Forest modelling and digital twins will simulate long-term ecosystem responses under future climate scenarios, while life cycle assessment and costing will evaluate environmental and economic trade-offs. To ensure scalability, ART for LIFE will support replication at additional sites, and provide training and digital tools, ultimately delivering a transferable framework for climate-adaptive forest restoration across European mountain landscapes.