Interreg Co-funded by the European Union

Alpine Space

Forest EcoValue

REGIONAL FEASIBILITY ASSESSMENT FOR THE LL TERRITORIES BASED ON THE RESULTS OF THE PILOT EXPERIENCE

O.2.3

EDITORS: ANDREA EMMER, STEFAN MARZELLI, HIERONYMUS JÄGER, THOMAS DICHTL / PP6

VERSION 1

DISCLAIMER

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Alpine Space

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Carbon neutral and resource sensitive Alpine region
SO 2.2: Promoting the transition to a circular and resource efficient economy

Forest EcoValue: Supporting multiple forest ecosystem services through new circular/green/bio markets and value chains

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List of the Forest EcoValue project partners

PP1. Finpiemonte SpA – Regional financial and development agency / **Coordinator** [FINPIE]
PP2. Lombardy Foundation for the Environment – Fondazione Lombardia per l'Ambiente [FLA]
PP4. National Research Institute for Agriculture, Food and Environment – Institut National de Recherche pour l'Agriculture, l'Alimentation et l'Environnement [INRAE]
PP5. Slovenia Forest Service – Zavod za Gozdove Slovenije [ZGS]
PP6. Institute for Environmental Planning and Spatial Development GmbH & Co. KG – Institut für Umweltplanung und Raumentwicklung GmbH & Co. KG [Ifuplan]
PP7. Lombardy Green Chemistry Association – Cluster Lombardo della Chimica Verde [LGCA]
PP8. University of Graz, Institute of Environmental Systems Sciences [UNIGRAZ]
PP9. Regional Centre for Forest Property Auvergne-Rhône-Alpes – Centre Régional de la Propriété Forestiére [CNPF]
PP10. The French National Forest Office – Office National des Forêts [ONF]
PP11. Holzcluster Steiermark – Woodcluster Styria [HCS]

Document information

Authors:	Andrea Emmer, Hieronymus Jäger, Stefan Marzelli, Thomas Dichtl (PP6)
Main contributor(s):	Lucio Vaira (PP1) Tina Simoncic, Ziva Boncina (PP5) Andrea Emmer, Hieronymus Jäger, Stefan Marzelli, Thomas Dichtl (PP6) Victoria Yavorskaya (PP8) Lauriane Hennet (PP9) Martin Grau (PP10) Kilian Silberschneider (PP11)
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Summary

Glossary

Tba

List of abbreviations

France

FES: Forest Ecosystem Service

ES: Ecosystem Service

LL: Living Lab

DREAL: Direction Régionale de l'Environnement, de l'Aménagement et du Logement

DRAAF: Direction Régionale de l'Alimentation, de l'Agriculture et de la Forêt

CNPF: Centre National de la Propriété Forestière

ONF: Office National des Forêts

ASL: Association Syndicale Libre

GF: Gestion Forestière

AURA: Auvergne Rhône Alpes

UFP74: Union des Forestiers Privés 74

COFOR: Communes Forestières

LBC: Label Bas Carbone

SME: Small and Medium Entrerpises (?)

EPCI: Etablissement Public de Coopération Intercommunale

DGFIP : Direction Générale des Finances Publiques

PDIPR : Plan Départemental des Itinéraires de Promenade et de Randonnée

ETF : Entreprise de Travaux Forestiers

Slovenia

SFS – Slovenia Forest Service

FES- forest ecosystem service

BDHS - biomass district heating systems

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Introduction

O 2.3 is intended to be promoted in particular to small private forest owners, corporate forest owners and public forest owners. As well as local /regional policy makers other relevant private /public decision makers can play a crucial role in the set-up of FES markets in such territories. The content of the feasibility assessments represents the experiences collected in the single living labs which may be transferable and usable also for other areas.
The Regional Feasibility Assessment is a summary of the project outcome for the forest owners in the living lab area in terms of assessed forest ecosystem services and suitable business models.

Project overview

Forests of the Alpine Space play a key role in climate change mitigation and resilience, providing multiple ecosystem services (ES) and environmental and social benefits such as CO_2 absorption, air pollution reduction, biodiversity enhancement, and protection against natural hazards. However, they are threatened by abandonment, climate change, and territorial degradation, which progressively reduce natural resources and the provision of forest ES (FES). Maintenance costs of Alpine forests are high, and public funds and traditional wood value chains are insufficient to cover them. Economic valuation and payment schemes for FES are widely discussed but rarely successfully applied.

The Forest EcoValue project addresses this challenge by developing innovative, sustainable business models for forest management and maintenance, supporting new bio-based value chains and ES markets, and involving different sectors, public and private actors, and citizens. Restoring and maintaining healthy forests has been recognised as a source of value for the Alpine region, while also creating business opportunities and green jobs for Alpine communities.

The project focuses on a subset of FES from the following categories:

- ***Provisioning** (e.g. biomass, raw materials, chemicals) with a specific focus on non-timber forest products, and on the production of woody biomass for energy, integrated into circular energy markets.*
- ***Regulating** (e.g. biodiversity, natural risk reduction, CO_2 absorption) concretely working on carbon and biodiversity credits, natural risk management through protective forests, and innovative environmental finance instruments such as green bonds and reverse auctions.*
- ***Cultural** (e.g. recreation, habitat experience, health) particularly enhancing recreational and tourism services and spiritual and cultural services.*

These services have been explored and tested within Living Labs (LLs) across five countries, located in different Alpine territories and representing diverse ecological and socio-economic contexts:

- ***Italy – Valle Tanaro, Piedmont:** The LL in Valle Tanaro explores innovative approaches to valorising chestnut groves, promoting non-timber forest products, developing carbon and biodiversity credits, and fostering experiential activities linked to forest and rural heritage.*
- ***France - Haute-Savoie:** Grand Annecy and Thonon LLs focus respectively on two aspects 1) recreational ecosystem services, enhancing the value of forests through the sale of experiences such as ecotourism, outdoor activities, and educational programmes 2) enhancing the value of water regulation services through a public-private partnership.*

- ***Slovenia – Karavanke Mountains, municipality Tržič:*** *The Slovenian LL addresses natural risk management with a focus on torrent control, advances solutions for wood biomass supply chains and promotes sustainable tourism and recreational use of forests.*
- ***Austria – Province of Styria:*** *The Styrian LL concentrates on biodiversity and habitat provision and carbon sequestration and storage through innovative financing mechanisms such as reverse auctions.*
- ***Germany – Tegernsee Valley, Upper Bavaria:*** *The German LL explores spiritual and cultural services, such as forest cemeteries with biodegradable urns, while also fostering habitat and biodiversity conservation through collaborative public–private partnerships.*

Accordingly, the project is aiming to:

- *Map and analyse the Alpine Space forests delivery capacity of FES;*
- *Identify and estimate the economic potential, define business models and FES market frameworks;*
- *Test the models/tools developed by the consortium in pilot LLs involving local players;*
- *Compare results at transnational level, identifying obstacles and facilitating factors;*
- *Analyse the need for innovative policies to foster forest maintenance, FES markets, and new value chains;*
- *Elaborate refined transferable tools/models and policy proposals to enable new markets and value chains and ensure the expected FES.*

Throughout the project, a continuous participatory process is carried out within the Living Labs. Stakeholders' active involvement in these labs is essential for co-designing and testing models and tools, ensuring that the innovative approaches are rooted in local realities. In parallel, public events and capacity-building workshops have strengthened engagement, supported knowledge transfer, and provided regular updates on project activities. This participatory and long-term approach, tested across the five territories, is paving the way for refined, transferable tools and policy proposals that can unlock new markets and value chains while safeguarding the provision of ecosystem services in the Alpine Space.

Project duration: 36 months

LIVING LAB AUSTRIA

State of Styria

Output 2.3

Living Lab Austria

Characteristics of the Living Lab area

Geographical location

The Living Lab in Styria is primarily located in the central region of Austria, characterized by its rich forest ecosystems and diverse land use practices. Styria, known for its mountainous terrain and extensive woodlands, is situated in southeastern Austria, bordered by the provinces of Upper Austria, Lower Austria, Burgenland, Carinthia, and Slovenia.

17 forest owners, whose applications for participation were accepted, have their forest properties located in 14 municipalities and nine districts. Figure 1 gives an overview of the macro region and the location of districts:

- *Langenwang municipality in Bruck-Mürzzuschlag district (15 applications in total)*
- *Sankt Stefan ob Stainz municipality in Deutschlandsberg district (one application in total)*
- *Fürstenfeld, Sankt Lorenzen am Wechsel and Waldbach-Mönichwald municipalities in Hartberg-Fürstenfeld district (four applications in total)*
- *Kammern im Liesingtal municipality in Leoben district (one application in total)*
- *St. Peter am Kammersberg and Murau municiaplities in Murau district (five applications in total)*
- *Sankt Margarethen bei Knittelfeld municipality in Murtal district (four applications in total)*
- *Fehring municipality in Südoststeiermark district (three applications in total)*
- *Geistthal-Södingberg municipality in Voitsberg district*
- *Birkfeld, Gasen and Thannhausen municipalities in Weiz district (11 applications in total).*
- *One application was impossible to locate.*

Land use

In Styria, land use is primarily divided among the following categories:

- ***Forests:** Approximately 60 % of Styria's land area is covered by forests, making it the most forested region in Austria.*
- ***Agricultural Land:** About 30 % of the land is used for agriculture, primarily for crop and livestock production.*
- ***Urban Areas:** Cities and towns account for around 10 % of the land, with Graz being the largest urban center.*

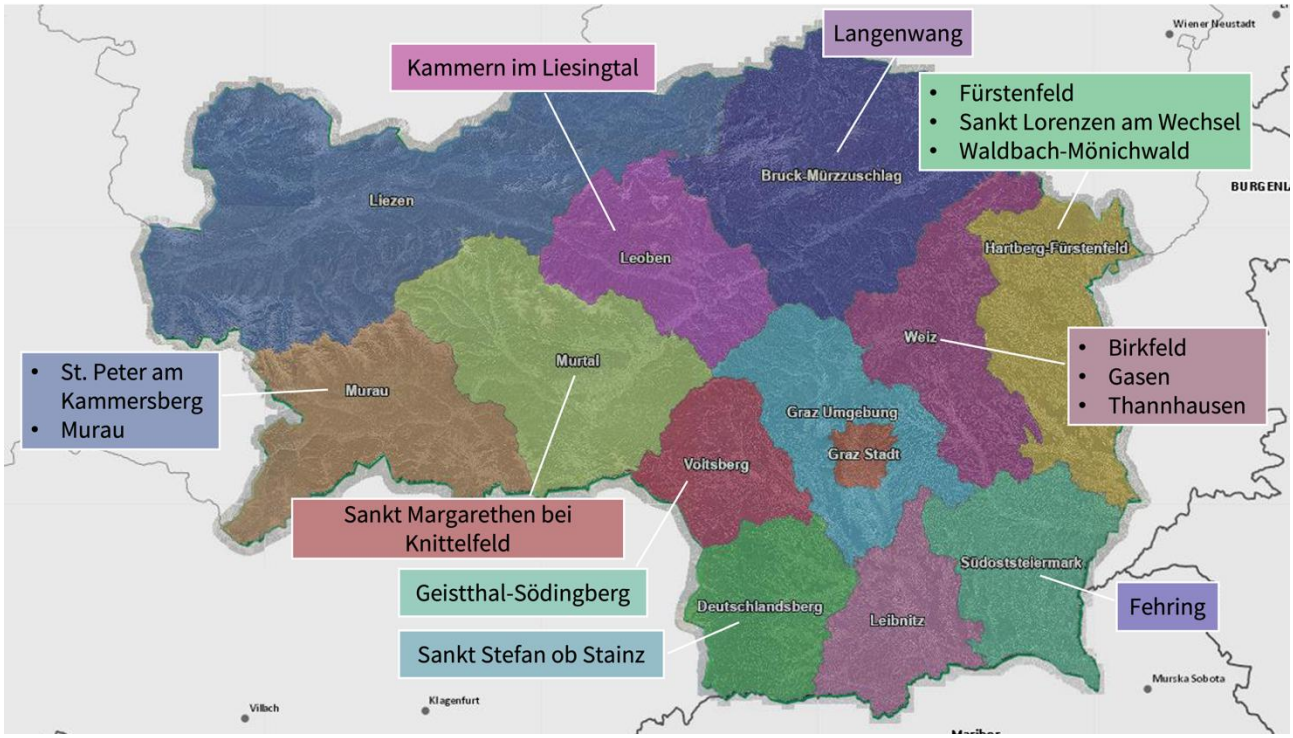

Figure 1: *Map of macro region with districts (boxes present municipalities where the participating forest properties are located). Source: GIS Steiermark (ed.), 2025, https://gis.stmk.gv.at/wgportal/atlasmobile/map/Basiskarten/Kataster, accessed on:*

Topography and climate

Styria has a temperate continental climate characterized by warm summers and cold winters. The region experiences significant seasonal variations in temperature and precipitation. The average temperature in the capital of Styria (Graz) is 9,2 Degree Celcius. Mean annual average precipitation is about ***900 – 1,200*** *mm per year, depending on the elevation. The elevation ranges from around* ***200 m*** *in the lowland areas to over* ***2,000 m*** *in the mountainous regions.*

Geology and pedology

The region consists mainly of the Northern Limestone Alps, featuring a diverse geological landscape, including limestone, dolomite, and sedimentary rocks. Prevailing soil types are predominantly clay, loam, and sandy soils, with fertile agricultural soils in valley areas and less fertile soils on steep slopes. The groundwater table varies significantly, generally lying between ***1 – 5 meters*** *below the surface, but can be deeper in mountainous areas.*

Organizational structure

The ***Styria Forestry Directorate*** *oversees forestry management in the region, implementing national policies and ensuring sustainable practices. Local municipalities also play a role in forest management and land-use planning.*

Various associations exist to represent private and communal forest owners, providing support, resources, and advocacy for sustainable forestry practices. The main one is "Waldverband Steiermark".

Local authorities manage municipal forests, enforce land use regulations, and facilitate community involvement in forestry initiatives.

Ownership

*Approximately **87 % of forests** in Styria are privately owned, **9 % are public**, and the remaining **4 % are owned by municipalities**. The average size of privately owned forest properties in the region is around **5 – 10 hectares**, with larger holdings often found among public and communal lands.*

Ownership goals focus on promoting sustainable forest management practices, increasing biodiversity, and enhancing forest resilience to climate change.

Status of forests in the Living Lab

Characteristic of forests and their management in the LL area

*Approximately **60 %** of the land in Styria is covered by forests, with a significant portion of this land falling within the Living Lab area.*

*The distribution of tree species is roughly **31 % deciduous** (e.g., oak, beech) and **69 % coniferous** (e.g., spruce, fir).*

The most common species in the growing stock include:

- *Spruce (59 %)*
- *Beech (8 %)*
- *Larch (6 %)*

*The density of mixed forests is approximately **70 %**, while pure forests, primarily dominated by a single species like spruce, account for around **30 %**.*

- *Stock composition*

Styria's forests typically exhibit a multi-layered structure, including:

- ***Overstory:** Dominated by mature trees.*
- ***Understory:** Comprising younger trees and shrubs.*

*About **40 %** of the forest area consists of natural forest communities, which include a mix of indigenous tree species.*

The predominant forest types are:

- ***Montane forests:** ~50 %*
- ***Subalpine forests:** ~30 %*
- ***Lowland forests:** ~20 %*

*The average growing stock is estimated at **200 – 300 m^3/ha** (s. Figure 2).*

*The mean annual increment is around **6 – 10 m^3/ha**.*

The age distribution of forests in the area (% of forest area) is as follows:

- ***Even-aged regeneration:*** *~25 %*
- ***Even-aged intermediate:*** *~30 %*
- ***Even-aged mature:*** *~20 %*
- ***Uneven-aged:*** *~25 %*

*The presence of deadwood is crucial for biodiversity. Standing deadwood constitutes about **10 %** of the forest biomass.*

*The average annual logging rate is approximately **10 – 15 m^3/ha**, depending on local management practices.*

Certain tree species are well-suited to the varying soil and climatic conditions in Styria, with species like spruce and beech being favored for timber production.

Common forest management techniques include:

- *Young stand and juvenile stand maintenance.*
- *Thinning to promote growth and health of remaining trees.*
- *Regeneration systems: Both natural regeneration and replanting are employed.*
- *Forest establishment: This includes both plantations and promoting natural rejuvenation.*

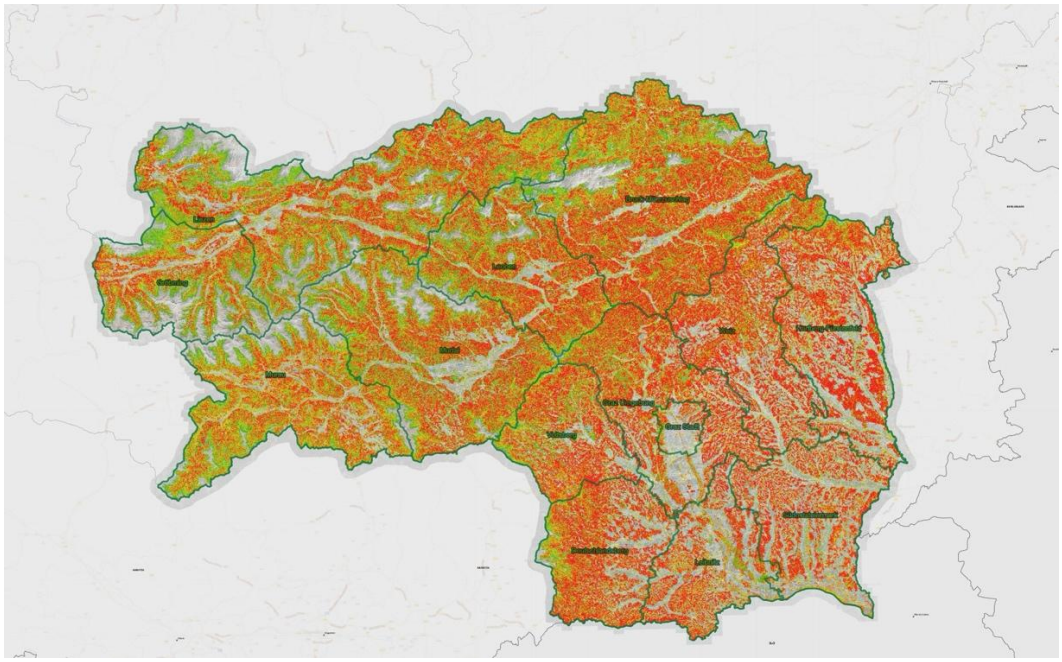

Figure 2: *Timber volume in Styria. Source: GIS Steiermark (ed.), 2025, https://gis.stmk.gv.at/wgportal/atlasmobile/map/Basiskarten/Kataster, accessed on:*

Forest Ecosystem Services in the Living Lab area

To facilitate transnational comparability and practical use of the assessment results the assessment was carried out in three districts, where most applications to participate in the Living Lab came from, namely Bruck-Mürzzuschlag, Murau and Weiz. The Austrian LL provides multiple forest ecosystem services:

- *Provision of timber, fire- and fuelwood*
- *Provision of habitats for wild plants and animals*
- *CO_2 storage and sequestration in forests*

These ecosystem services have been assessed on local and large-scale level. The results of forest ecosystem services assessment and the potential effects of forest management on ecosystem services supply are presented in D2.2.1 Forest Ecosystem services assessment pilot action report and are summarized here.

Potential effects of forest management on FES supply

This section will undergo further refinement and integration until the end of the Forest EcoValue project.

Business portfolio in place

Styria (Austria) is one of Europe's leading wood regions, with a fully integrated value chain based on sustainable forest resources. The sector plays a vital economic role and spans from raw material supply to high-tech end products.

- ***Forestry & Timber Harvesting:** Styria has over 800,000 hectares of forest, with active and sustainable forest management by thousands of private and public owners. The region supplies high-quality softwood and hardwood, forming the basis for the entire value chain.*
- ***Primary Processing (Sawmilling, Biomass**): Modern sawmills such as Mayr-Melnhof Holz and Hasslacher operate with high efficiency, producing construction timber, glulam, and wood chips. Wood residues are used for bioenergy and industrial pellets.*
- ***Wood-Based Industries:** Styria hosts companies in the panel board and engineered wood sectors. These include producers of CLT (cross-laminated timber), LVL, and plywood, which are exported globally for use in construction and industrial applications.*
- ***Construction & Prefabrication:** The region is a hub for timber construction, with numerous SMEs and larger companies (e.g., Weitzer Group) building residential, commercial, and public buildings using timber systems. Prefabrication and digital building technologies are key drivers.*
- ***Furniture & Interior Design:** Styria's wood competence also extends to high-quality furniture, flooring, and interior elements, combining traditional craftsmanship with modern design. Local hardwoods are increasingly used in value-added products.*
- ***Innovation & Bioeconomy:** Styria invests in wood-based innovation: new materials (e.g., bioplastics, insulation), circular products, and biochar. The region supports R&D through clusters, universities, and research institutes.*
- ***Logistics & Trade:** Well-developed infrastructure connects Styrian wood businesses to Central Europe and global markets. Export rates are high across almost all segments.*

Economic valuation of Forest Ecosystem Services

Similarly to the FES mapping, the assessment was carried out in the municipality of Thannhausen (Weiz District), where most of the winning projects were located. While full economic valuation of FES in Thannahausen is reported in D 2.3.1 Transnational pilot testing FES economic assessment and market frameworks in each LL, for the purpose of this feasibility assessment, we present valuation results for the ecosystem services that were in focus of the LL activities, namely timber wood biomass provision, carbon

sequestration, and habitat provision for wild plants and animals. Please, refer to D 2.3.1 for further details on valuation methodology.

The results of the adjusted unit value transfer for the municipality of Thannhausen are presented on Figure 3. Two sets of value estimates were produced:

- *Adjusted unit value transfer for all FES, except for the carbon sequestration valuated using voluntary market carbon pricing (VMCP), hereinafter, 'Value transfer and VCMP';*
- *A mix of market price (MP) valuation for timber wood, firewood and fuelwood biomass provision, upper-bound estimates of recommended carbon pricing (RCP) for carbon sequestration, and adjusted unit value transfer for other FES, hereinafter, 'Mixed-method and VMCP'.*

The results presented prove social relevance of the FES that were selected for the pilot action in the LL. Provision of habitats has a relatively high adjusted unit value, rounding the top three most socially relevant (per ha) ecosystem services in the area. Value of provision of wood biomass is sensitive to valuation method, as Alpine average (i.e., adjusted unit value) underestimates its social relevance by almost half. Valuation of carbon sequestration demonstrates even higher sensitivity to the methodological choices: while voluntary carbon market pricing suggests a value per ha in the range of other provisioning services, valuating this FES with the upper-bound carbon pricing recommended to achieve climate mitigation compatible with the global climate targets, places this FES among the three most valuable regulating services in Thannhauesen, surpassing habitat provision relative value. This sensitivity calls for caution in communication and the process of decision making. While it is intuitively easier to account for the values derived from existing market (market prices for timber and carbon sequestration) in decision-making, social value of FES not captured by the market (habitat provision and recommended pricing of carbon sequestration) could go unnoticed, leading to detrimental effects on well-being of local communities.

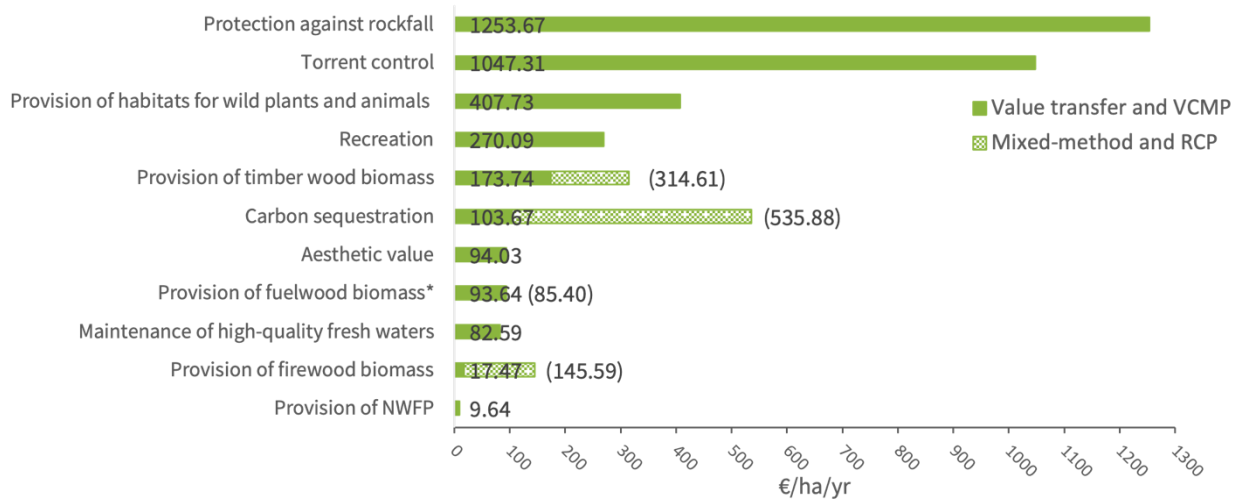

Figure 3: *Unit value estimates in 2023 euros per ha. Bold green depicts values estimated with the Value transfer and VMCP. Patterned green depicts additional values estimated with the Mixed-method and RCP, with the estimates indicated in parenthesis. NWFP stands for non-wood forest products, including chestnuts, mushrooms and berries. *As MP estimates provided a higher value for fuelwood biomass FES than adjusted unit value transfer, the patterned green part of the bar is not visible on the figure.*

Estimates of the total economic values (TEV) of forests in Thannhausen, using both valuation approaches, are demonstrated in Figure 4. Two valuation approaches produce different relative weights of FES contributions in the TEVs, highlighting sensitivity of the results to the approach chosen. In the first TEV, timber wood provision is the second biggest contributor (30%), while to cumulative share of regulating services is 32%. The second approach doubled the TEV via a dramatic increase of contribution of carbon sequestration (from 18% to 46% of TEV). Although, in absolute terms the contribution of provisioning FES has also increased, the relative contribution became slightly lower. Despite the highest social importance (i.e., highest unit value), contributions to provision of habitats is relatively marginal. This suggests that targeted efforts on expansion of the forest area providing this FES will have a substantial effect on the TEV of Thannhausen forests. It must be noted, that provided TEV estimates are a serious underestimation, as the number of FES included in the calculation was restricted to five. Despite underestimation, value of timber provisioning service constitutes about 30% of the forest TEV, suggesting that the social importance of forests in Thannhausen extends well beyond timber production. At the same time, we must keep in mind that provisioning FES are provided by the same forest area as carbon sequestration and partially overlaps with other FES. This hints at potentially detrimental losses in social value of forests if forest management is fully oriented at timber provision.

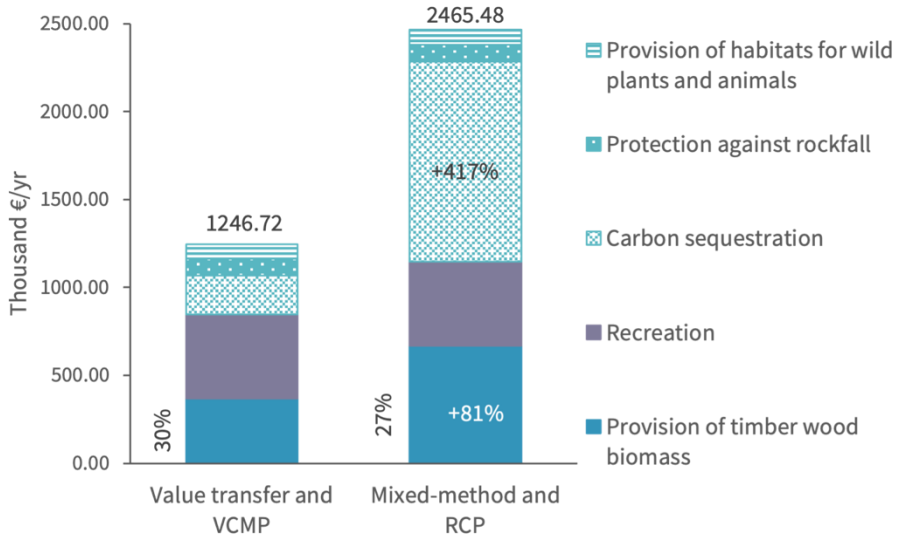

Figure 4: *Estimates of total economic value (TEV) of forests in Thannhausen, calculated using two different approaches. Total values per year for each FES are estimated based on the forest surface areas providing respective services. Percentages for provision of timber wood biomass placed on the left of the bars indicate a contribution of timber wood provision to the TEV. Percentages for timber wood biomass and carbon sequestration placed inside the bar indicate difference in total values of these FES between TEVs estimated using different methods. Numbers on the top of the bars indicate the TEVs.*

Spatial distribution of FES social values in Thannhausen further details our understanding about the FES provision in the Living Lab (s. Figure 5). Not all values are evenly distributed throughout the territory of the Living Lab, with most of the forest area providing below expected average value per ha (939.91 €/ha/yr[1]). While further supplementation of this map with the spatial distribution of forest ownership and residential areas could shed more light into FES providers and beneficiaries dynamics in the area, already at this stage we can see a high risk of potential trade-offs when forest management plans are focused only on one ecosystem service. As most of the area has a value above 277 €/ha/yr (i.e., value provided both by timber wood

[1] *As forest areas providing timber wood biomass, carbon sequestration and habitats for wild plants and animals has a 100% overlap, at least three FES are expected to be at each ha, therefore, expected average is a representative midpoint value. It was calculated as follows:* $Expected\ average = Average\ of\ all\ FES\ values\ per\ ha \times 2$

biomass and carbon sequestration), solely focusing on either FES could strip off the area of other socially relevant FES, like habitat provision, which are already represented only scarcely. However, it must be noted that the assumptions behind biophysical assessment of habitat provision FES take into account only forest areas with high habitat value. Other indicators like deadwood per ha or habitat connectivity could uncover even higher risk of costly trade-offs.

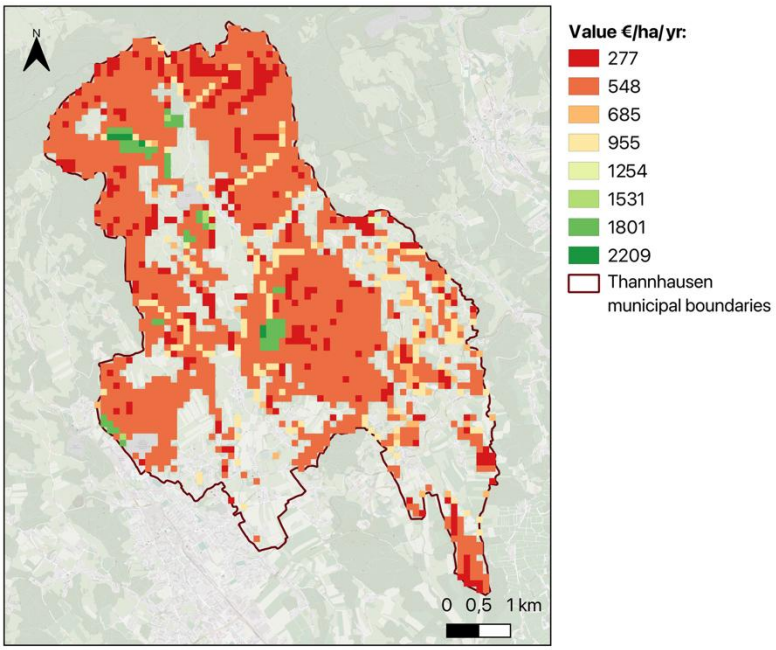

Figure 5: *Spatial distribution of unit values in Thannhausen. Only estimates produced with the Value transfer and VCMP were used for mapping. Some degree of spatial under- and overdistribution is present for the unit value of carbon sequestration as unit value estimation is based on mean carbon sequestration per ha, not carbon sequestration specific to the forest unit.*

Feasibility Assessment

Development scenario

In Styria, the Dynamic Forest Typization (www.waldbauberater.at) is an effective tool for forest owners to choose tree species that can cope with climate change effects. On a scale of 30 x 30 m, specific recommendations for choosing species can be given (free of charge) based on projected temperatures, as well as water and nutrient supply. Moderate and strong climate change risk scenarios2 can be chosen (RCP 4.5[3] and 8.5[4], respectively). Included is a detailed information about soil, precipitation, and more geologic

[2] *Representative Concentration pathways (RCPy) are climate change scenarios that serve as an input for climate modelling, where 'y' refers to the level of radiative fording resulting from the scenario in 2100. They describe future greenhouse gas (GHG) concentrations based on the amount of GHG emitted in the future. The latter in turn depends on the socio-economic development, implemented climate policies and technological solutions implementations.*

[3] *RCP 4.5 scenario is an intermediate or stabilization scenario, where radiative forcing level stabilizes at 4.5 W/m2 before 2100 by implementation of a range of mitigation technologies and strategies. In this scenario emissions peak around 2040, then decline. RCP 4.5 is more likely than not to result in global temperature rise between 2 °C and 3 °C by 2100.*

[4] *In RCP 8.5 scenario is generally described as the basis for the worst-case climate change scenarios. GHG emissions continue to rise throughout the 21st century and the global temperature exceeding the working of 4 °C.*

parameters. The results are also linked to fundings, as only species that can cope with climate change are being funded for reforestation.

In the coming decades, the tree species boundaries are expected to shift upwards within the range between 500 - 1000 m. Figure 6 illustrates a general trend in changes in species suitability using the example of spruce, the most common species in Styria. When taking in consideration increasing risks of bark beetle attacks on spruce forest stands, intensified by changing climate, it becomes even more apparent that more than half of Styrian forests require intentional transformation, both in species representation and management practices (s. Figure 7).

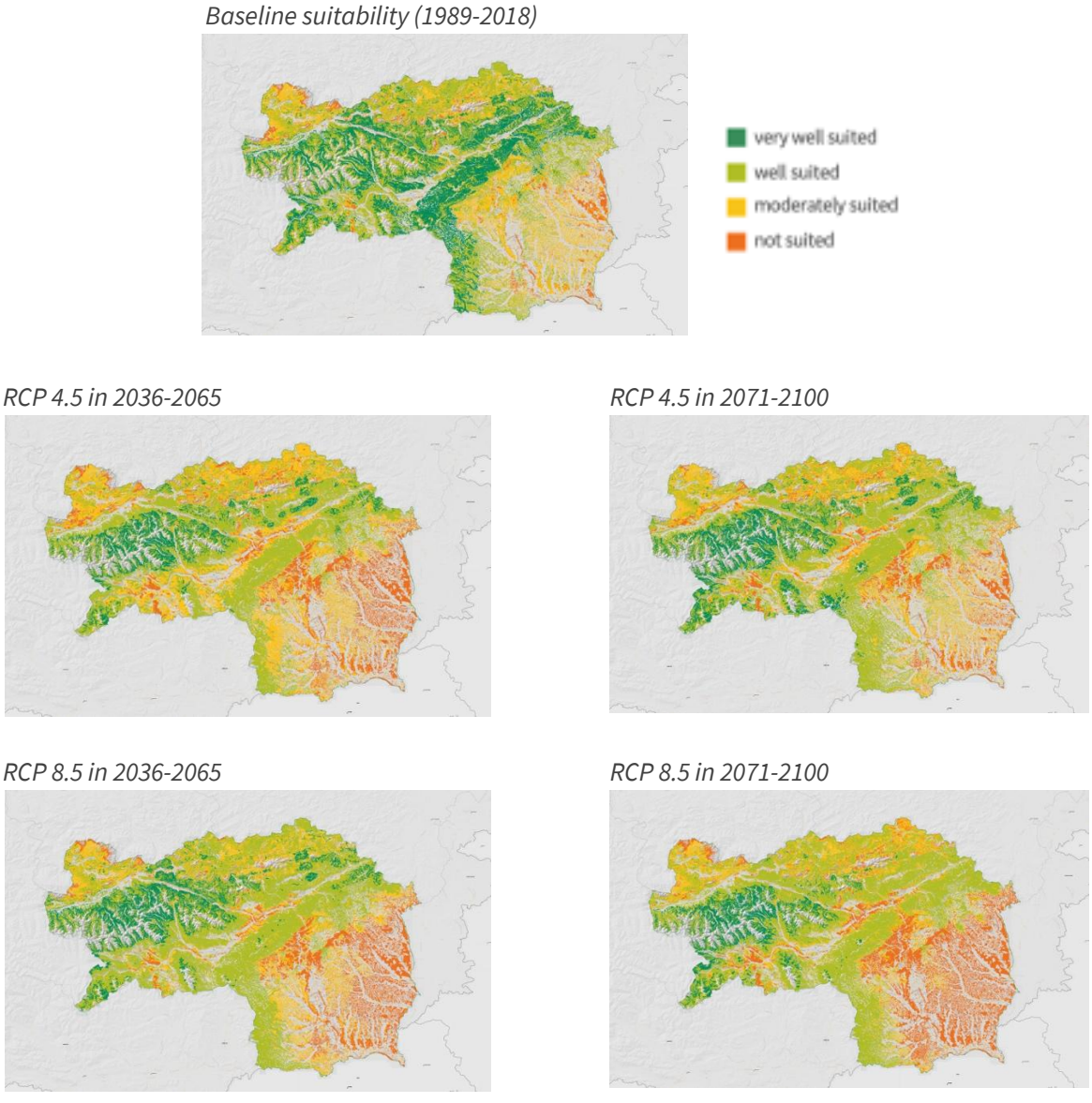

Figure 6: *Suitability of spruce in Styria, according to different climate change scenarios. GIS Steiermark "Dynamic Forest Typization", 2025, www.waldbauberater.at, https://gis.stmk.gv.at/wgportal/atlasmobile/map/Forstwirtschaft%20-%20Landwirtschaft/dynWaldtypisierung, accessed on:*

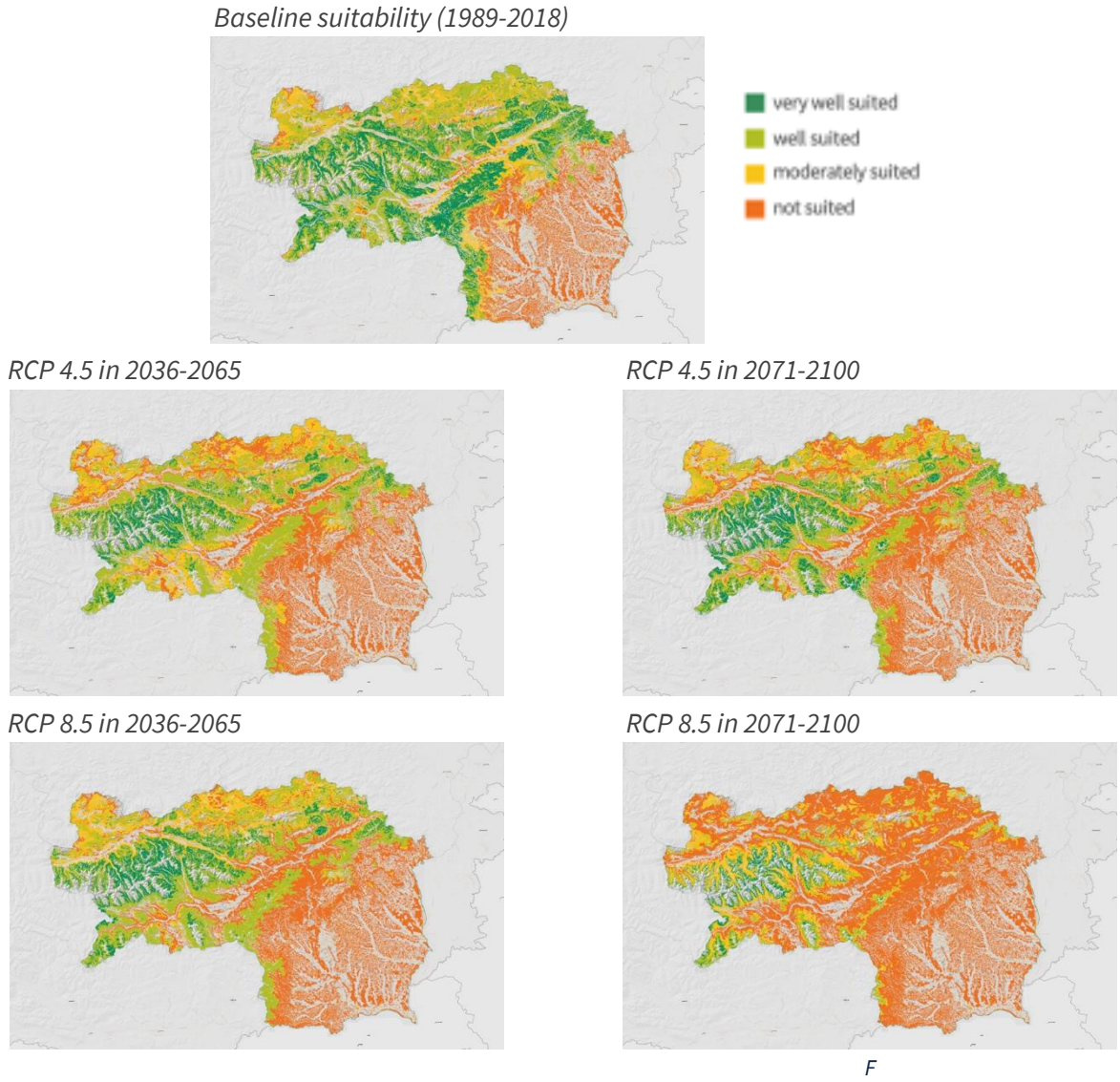

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Figure 7: *Suitability of spruce with a risk of bark beetle attacks in Styria, according to different climate change scenario. Source: GIS Steiermark "Dynamic Forest Typization", 2025, www.waldbauberater.at, https://gis.stmk.gv.at/wgportal/atlasmobile/map/Forstwirtschaft%20-%20Landwirtschaft/dynWaldtypisierung, accessed on:*

Objectives

Ecological objectives

The ecological objectives for the Austrian Living Lab are:

- *Conserve and restore degraded forest ecosystems, particularly those impacted by monocultures, overexploitation, or biodiversity loss, aiming to re-establish ecologically functional and climate-resilient forest stands.*
- *Stabilize the carbon cycle through continuous cover forestry and diversified forest structures.*
- *Enhance biodiversity by preserving and improving habitats, tree species diversity, and structural complexity.*

Economic objectives

The economic objectives for the Austrian Living Lab are:

- *Create new funding opportunities for sustainable management and ecosystem service provision.*
- *Demonstrate viability, cost-efficiency and socio-ecological effectiveness of the of the proposed business model(s).*
- *Simplify procedures and improve advisory services to make sustainable forestry and ecosystem-based business models more accessible — especially for small-scale forest owners.*
- *Strengthen interest in active forest management, especially among owners with low management intensity or limited technical capacity.*
- *Support small-scale private forest owners, especially in implementing climate-adaptive and biodiversity-promoting measures.*
- *Ensure continuity of the pilot beyond the project duration, through stakeholder commitment and financial sustainability.*

Measures

In the Living Lab, we focused on the following measures:

- ***Provision of timber, fire- and fuelwood:*** *integration of management practices that enhance non-instrumental FES while not restricting continuous wood provision*
- ***Provision of habitats for wild plants and animals:*** *One of the simplest and most used methods to increase biodiversity in the forest is to leave* ***biotope trees*** *or* ***standing/lying deadwood*** *untouched in the forest. This measure helps to increase biodiversity in the forest as the tree trunk serves as a habitat. A tree should be left untouched for at least 20 years. The tree must be located in a forest so that it can contribute to the biodiversity of the forest. In the event of non-compliance, the forest owner must notify this and either reimburse the subsidy or set a new deadline.*
- ***CO_2 storage in forests: Continuous cover forestry*** *to stabilizes carbon cycle and ensures that carbon can be absorbed from the atmosphere more quickly. Transformation from the unnatural form of monoculture forest to a mixed forest helps to make the forest area more stable and resilient to infestation and disease as well as a changing climate. Forest owners who have a secondary spruce monoculture stand younger than 60 years in their forest and want to transform it can apply for this measure. This measure requires the creation of a mixed forest (optionally through natural regeneration). The forest conversion must be initiated within 5 years of signing the contract (i.e. the contract period is 5 years). A deadline for the start of conversion will be specified in the contract. In the event of non-compliance, the forest owner must notify this and either reimburse the subsidy or set a new deadline.*

Another measure that could be added in the future:

- ***Protection of natural regeneration:*** *as climate resistant tree species are actually present, but suffer dramatic loss by the influence of wildlife population, protection of natural regeneration is a cost-effective measure of building climate resistant forests (by individual protection, fencing or repellents)*

Priorities

Within the Forest EcoValue project, it becomes clear that the existing business portfolio of Styrian forest owners can be strategically expanded to ensure future viability. ***Active and sustainable forest management remains the core foundation****, serving both economic utilization and the preservation of the forest's ecological functions.*

Options for business portfolio development, which business models are of general interest for the forest owners

- *Timber production and value-added wood products remain economically central.*

Carbon sequestration – forests as long-term carbon sinks offer growing opportunities for climate services, especially in the context of the EU's Green Deal and climate neutrality goals.

- *Monetisation of ecosystem services, including:*
    - *Carbon credits,*
    - *Biodiversity services and water retention,*
    - *Compensation measures for land-use impacts.*
- *Non-wood products such as mushrooms, game, berries, or resin offer complementary income streams.*
- *Recreation and leisure services (e.g., nature tourism, hunting, outdoor activities) are gaining relevance.*

Description and rationale for priorities for the business model needed and ecosystem services to be maintained

The expansion of the business model should contribute to the ***economic resilience of forest owners*** *while enhancing the societal value of forests. New revenue sources must* ***align with active forest management*** *and help* ***secure it for the long term****.*

Key priorities include business models that:

- ***Ensure compatibility with sustainable forest management:*** *Models must support ecological stability, forest health, and biodiversity.*
- ***Prioritize carbon-related business models:*** *The Forest Owners' Association (Waldverband) shows particular interest in models linked to carbon sequestration and climate adaptation, as these also align with national and EU strategies.*
- ***Diversify revenue opportunities:*** *Private forest owners shared experience suggests the need for mixed-income strategies (e.g., timber + biodiversity bonus + carbon payments).*
- ***Promote ease of implementation:*** *Low administrative burden and simplicity are critical for uptake among small-scale owners.*
- ***Enhance regional value creation:*** *Local processing, eco-tourism, and bioeconomy initiatives should be linked to ecosystem service-based models.*
- ***Leverage digital tools and advisory platforms:*** *Tools like waldbauberater.at help owners make climate-adaptive decisions.*

- ***Encourage cooperation and collective approaches**: Joint implementation models via associations or cooperatives reduce risks and increase scale.*
- ***Are easy to understand and implement**, particularly for forest owners without technical or administrative capacity,*
- *Include specific strategies to reach and engage small-scale forest owners, who make up a significant share of forest ownership in Styria.*

Selected business ideas

Reverse Auction as an Enabling Mechanism

Reverse auctions are a form of organizing a PES (Payment for Ecosystem Services) scheme, where landowners bid the price for providing ecosystem services or implementing sustainable management measures aimed at FES provision. Such a model promises higher cost-efficiency, as landowners are invited to state their opportunity costs in the competitive context, i.e., they are motivated not to overestimate their costs. There many reverse auction types, and discriminatory price auction is considered to be the most fitting one to the context of forests in Alpine area, due to their high heterogeneity that influences opportunity costs. In such an auction, each bidder that falls within the budget threshold will be paid the price that they asked for. This way it is also possible to include other ecological and social criteria to evaluate effectiveness of the bid. This approach also allowed to reward forest owners who already have experience with forest restoration and conservation, as they are nudged towards thinking about their real opportunity costs, not profit generation, while those who had no prior experience were encouraged to look at their forests through the lens of these practices. In the Living Lab, we tested two measures for biodiversity and carbon cycle stability, however, the list of measures could expand with growing familiarity with the model (see above).

Reverse auctions offer a flexible and performance-oriented tool to implement the outlined priorities (see above) in practice. By allowing forest owners to propose their own price for delivering ecosystem services, the auction model reduces transaction costs, enhances transparency, and lowers the barrier to participation—especially for small-scale owners.

For intermediaries such as the Forest Owners' Association, the model presents a scalable mechanism to allocate funding efficiently and attract contributions from the private sector or the public. The auction format is particularly well-suited to fragmented forest ownership and diverse ecological objectives. It also avoids the complexity and rigidity often associated with traditional subsidy schemes, thus enabling wider participation and innovation.

Factores for feasibility assessment

Technical and ecological feasibility

Management of ecological conditions and assessed ecosystem services (source : D2.2.1)

***Timber, fire-, and fuelwood provisio:** Implementation of sustainable silvicultural practices. This ensures harvest volumes remain below natural increment, fostering continuous forest cover, regeneration, and the vitality of site-adapted species, thereby guaranteeing a renewable resource supply.*

***Habitat provision for wild plants and animals**,: enhancing structural and species diversity, achieved by retaining critical habitat features like deadwood, biotop trees, and mixed-species stands, creating a mosaic of age classes crucial for robust biodiversity.*

***CO_2 storage and sequestration**: maintaining healthy, actively growing stands through appropriate interventions, enhancing both atmospheric carbon uptake and long-term storage within biomass, soil, and durable wood products.*

This section will undergo further refinement and integration until the end of the Forest EcoValue project.

Economic feasibility

Economic perspectives for innovative value chains

Reverse auction is a cost-efficient tool to distribute funding for FES provision that is flexible enough to address heterogenous forest areas and adaptive to the goals of the initiative. It offers a viable alternative to grants and subsidies. By reducing transaction costs, it becomes more attractive for private sector to donate. Among other advantages are local scale (i.e., local industry rewards local forest owners) and low reputational risks (i.e., no credits, practice oriented, targeting forest owners who are already committed to cause). Low transaction costs and reduced burden of controlling is also attractive to the intermediaries (in our case, Forest Owners' Association, but could be any multiplier who has connection to the forest owners, like consultancies, forest services, Chamber of Agriculture, etc.). Finally, reduced bureaucratic burden automatically reduces the barriers for small holders to participate, engage in forest management and learn new techniques.

Expected costs

- *Forest owners: opportunity costs, forest management costs (e.g., thinning, seedling, costs associated with transition to continuous cover forestry, etc.)*
- *Intermediary/Forest Owners' Association: info events and consultations for prospective applicants, application assessment and control, post-contract control*

Potential revenue

- *Forest owners: requested funding*
- *Intermediary/Forest Owners' Association: indirectly creating additional customer segment of non-traditional forest owners*

Financial risks

- *Forest owners: underestimation of opportunity costs*
- *Intermediary/Forest Owners' Association: Model is donation-based*

Operational feasibility

Forest owners

- *Deadwood/biotope tree: ensuring that ongoing forest management does not pose risks to the contracted tree. In case of a hazardous event, action might be needed.*
- *Continuous cover forestry: implementation of the contracted measures, personally or with the forestry services. Actions that stabilize forests must be taken. Regarding the future structure, protection against weevils, wildlife and overgrowing weeds and plants must be taken.*
- *These actions are usually done by the forest owners themselves.*

Intermediary/Forest Owners' Association

- *Monitoring of compliance with the conditions of the payment*
- *Marketing to promote the auction among forest owners and potential donors*
- *Project manager (a person who runs and coordinates the auction, does assessment, distributes the budget, contacts donors, etc.)*
- *Potentially, monitoring legal compliance and contract development*

Legal compliance

Generally, suggested model and measures comply with forest and nature conservation laws and regulations and forest policy strategies.

In the case of deadwood/biotope trees, it's important to keep in mind risks of flooding (avoiding areas close to the rivers) and exclude spruce (especially, infested with bark beetle) from participation. Moreover, a longer duration (min 20 years) does not correspond to the duration set for governmental subsidies for the same measure; however, it is a tradeoff for the sake of ecological effectiveness.

LIVING LAB FRANCE

Grand Annecy & Thonon Agglomeration

Output 2.3

Living Lab France

Characteristics of the Living Lab area

Grand Annecy is a highly touristic area where forests play an important role in regional attractiveness. However, climate change threatens these forests, and many tree species may experience high mortality rates. To ensure that forests continue to provide ecosystem services, especially recreational value and landscape permanence, management actions must be undertaken.

Geographical location

The Living Lab is in the Grand Annecy area, in Haute-Savoie department, in the Auvergne-Rhône-Alpes region of France. It is located in the northern Pre-Alps, around 35 kilometres south of Geneva, and includes the city of Annecy with 33 other communes, for a total of 34. The agglomeration covers about 515 km². At the centre of this territory there is Lake Annecy, a glacial lake of 27 km², which plays a central role for the landscape, the economy and the culture. On a regional map, Grand Annecy appears as a space between the Geneva basin and the alpine valleys, and on the local map it is visible that the city is at the north of the lake with valleys and mountains rising around it (s. Figure 8).

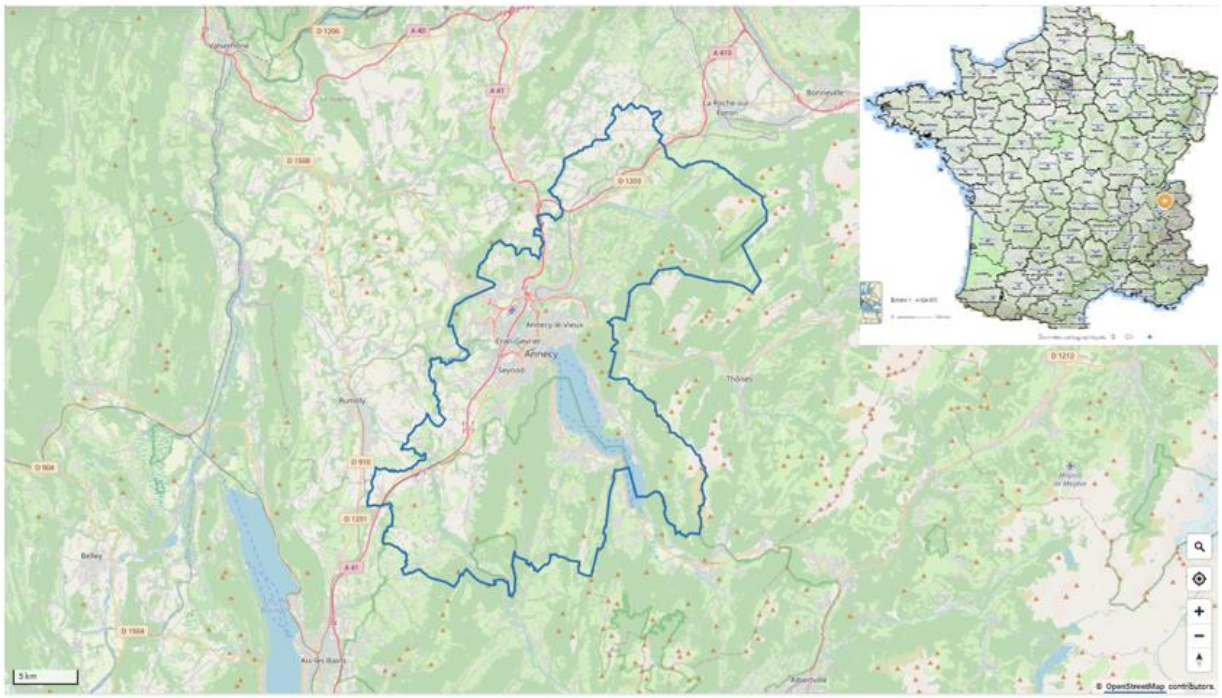

Figure 8: *Location of the French Living Lab region Grand Annecy.*

Land use

Land use in Grand Annecy is shaped by a combination of urban concentration around the city and a mosaic of rural and natural landscapes in the wider territory. The city of Annecy and its neighbouring municipalities host residential areas, business districts, and industrial zones, largely located on the valley floor and close to the lakeshore. Beyond this urban core, agriculture remains an important land use, with pastures and hay meadows spread across low slopes and valley bottoms. The hillsides areas are predominantly forested, with

a mix of broadleaf and coniferous woodland, while flat areas around the lake are mostly used for agriculture, urban planning and some nature reserves. Tourism infrastructure, from lakeside beaches to ski, hiking areas and cycling routes, is another defining element of land use.

- ***Urban & suburban:*** *Annecy city and linked suburbs, services, industry and residential zones concentrated on the lake's northern shore and valley floors. 10–15 %.*
- ***Agricultural land****: Patchwork of pastures, hay meadows and small farms on valley floors and gentle slopes. 20–25 %.*
- ***Forests and natural areas:*** *Forested slopes, pre-alpine woodlands and protected natural sites (shoreline reserves, mountain pastures): around 50% - Water bodies / wetlands: Lake Annecy (~27 km²), river corridors (Thiou, Fier) and small wetlands.*
- ***Tourism & recreation:*** *lakeshore beaches, trails, ski/low-snow resorts (Semnoz, Talloires), cycling routes. 10-15 %.*

Topography and climate

Climate description

Topographically, Grand Annecy occupies the basin of Lake Annecy at about 446 metres above sea level, surrounded by the pre-alpine mountains of Semnoz, Parmelan, and La Tournette. The climate is typically montane, influenced both by the moderating presence of the lake and by the orographic effects of the surrounding ranges. Winters are cold, with frequent snow at higher altitudes, while summers are warm and often humid, punctuated by thunderstorms.

Mean annual average temperature (°C/year) and annual average precipitation

The mean annual temperature in Annecy is close to 9.5 °C, and annual precipitation is relatively high, averaging around 1,600 to 1,650 millimetres, distributed fairly evenly throughout the year but with wetter episodes in late spring and early summer.

Elevation (m)

The elevation of the urban territory ranges from around 396 metres in the valley floor to over 1,100 metres in nearby uplands, while the surrounding peaks rise well above 1,500 metres. This diversity creates a striking visual landscape and strong ecological gradients. The city of Annecy (city centre) is around 450 - 500 metres above sea level.

Geology and pedology

Geologically, Grand Annecy belongs to the French Pre-Alps. The mountains are mostly limestone and marls from the Mesozoic period, while the valleys and the basin of Lake Annecy are filled with deposits from glaciers and rivers during the Quaternary.

Prevailing soil types

Soils depend on the location: close to the lake and on the valley floors, they are alluvial or lacustrine, with silts, sands and sometimes organic layers in the wetlands. On the slopes, soils are often shallow and calcareous, directly over the limestone bedrock, while in forested areas the soils can be deeper and more fertile.

Ground water table and surface distance of groundwater table

Groundwater is also linked to this geology. In the valley areas, aquifers are shallow and connected directly with the rivers and with the lake. In the limestone mountains, the water circulates in fractures and karst systems, and feeds many springs, including some under the lake. The depth of the groundwater varies with the season and the type of terrain, from almost at the surface in the valleys to several metres deep in the bedrock.

Organizational structure

The DREAL (Regional State Authority for Biodiversity) and DRAAF (Régional State Authority for Forests) represent the government departments responsible for forests in Auvergne Rhône-Alpes. They oversee forestry stakeholders, namely the ONF (AURA Regional Directorate) for public forests and the CNPF (CRPF Regional Directorate) for private forests. Together with these stakeholders, they define the guidelines for forest management in AURA, in compliance with the laws and framework texts defined by the ministries.

The ONF is the direct manager of all public, state-owned and communal forests. As manager, it is responsible for the development, exploitation and monitoring of public forests. A departmental service ensures the local implementation of forest management thanks to forestry technicians.

The CNPF is the public institution responsible for promoting sustainable management of private forests. It does not directly manage private forests but supports private owners in acquiring the tools they need for sustainable forest management. Private stakeholders manage their own forests, receiving advice, authorizations when necessary, and following regional regulations for forests larger than 20 ha, with oversight from the CNPF. Local forest experts and managers also support owners with larger operations or those grouped in forest owner associations (ASL). There is currently only one ASL in Grand Annecy, La Forestière Val Laudon, although other types of family-owned forest associations exist (GF).

The AURA Region also participates in regional forestry policy as a representative of local authorities at regional level.

Forest owner association

The Union of Private Forest Owners (Union des Forestiers Privés UFP74) represents private forest owners and their interests. This organisation provides support in dealing with the difficulties encountered by owners. A union of forest owners is an important stakeholder, representing forest owners collectively at the local level.

Association of Forest Municipalities (COFOR) represents the interests of forest municipalities. It plays an advisory, training and regional coordination role. It also locally brings technical support, representation of interests and promotion of political messages.

Municipalities and district administration

Great Annecy is the urban area surrounding the city of Annecy. As an urban community, Great Annecy has mandatory powers, as well as optional and discretionary powers. The latter are decided in consultation with the municipalities, which may transfer them to Grand Annecy. The local authority does not own any forests but has a role in influencing the management of surrounding forests. It implements a forestry strategy and has jurisdiction over tourism in the area.

Annecy municipality directly represents the local authorities. As the owner of one forest (Forêt communale d'Annecy le Vieux) on its municipal territory, it has exclusive rights to make decisions regarding its management. This management is implemented by the ONF.

Ownership

Forests are an integral part of Grand Annecy, with nearly 42 % of its surface area now covered by woodland, representing more than 23,300 hectares of forest.

The National Forestry Office sustainably manages nearly 11,500 hectares of state-owned and communal forests in the Grand Annecy area. Some iconic forests, such as Semnoz and the communal forest of Veyrier du Lac, are now popular destinations for locals and tourists alike, as well as being areas for timber production and risk reduction. It mainly consists of continuous plots larger than 50 – 100 ha.

The National Centre for Forest Ownership (CNPF) supports nearly 11,000 forest owners across 11,800 hectares of private forests, typically composed of plots averaging 2,500 m², with an average of 1.5 ha per individual owner.

Status of forests in the Living Lab

Characteristic of forests and their management in the LL area

The Grand Annecy territory is largely covered by forests, which represent around 45 % of the land area. This high proportion is explained by the pre-alpine topography, where steep slopes and uplands are naturally wooded, while the valleys are reserved for urban and agricultural uses.

The Grand Annecy Forest covers over 23,322 hectares and lays in four distinct areas:

- *the Semnoz-Val-Laudon massif,*
- *the Tournette-Veyrier massif,*
- *the Parmelan-Glières forest,*
- *and a final area comprising land that acts as reservoirs and/or biological corridors (e.g. Plateau des Bornes, Montagne d'Age, waterways, etc.).*

The forests in the Annecy basin are located between 700 and 1,900 metres above sea level. There are three vegetation zones: a colline zone of deciduous trees (oak and beech), a montane zone of mixed and coniferous forests (fir and beech/spruce), and a subalpine zone above 1,500 metres (spruce).

In terms of tree cover, deciduous forests dominate, making up approximately 65 to 70 %, while coniferous stands represent around 25 to 30 percent, with a smaller share of mixed formations. The deciduous forests are mostly composed of European beech (Fagus sylvatica), which is the most common species, followed by oak species (Quercus petraea and Quercus robur) at lower altitudes, and hornbeam and chestnut in some sites. Conifers are mainly silver fir (Abies alba), Norway spruce (Picea abies) and Scots pine (Pinus sylvestris), especially on cooler slopes and in higher altitude stands. Mixed forests of beech–fir or beech–spruce, are frequent in transitional zones.

The density of pure forests compared to mixed ones is relatively balanced (Pure deciduous stands, mainly oak, maple and beech, occur on many slopes and plateaus, while coniferous monocultures are less common. Mixed deciduous–coniferous forests are widespread and play an important role in the structure of the

landscape. Stock composition reflects this diversity, with beech and fir contributing the largest volumes of growing stock, followed by spruce and oak.

In vertical structure, most stands present two-tree layers, with a dominant canopy and a sub-canopy of younger trees or shade-tolerant species. In some mixed forests there are also understorey layers of hornbeam or hazel. Natural forest communities represent a majority of the forested area, around 70 to 80 %, while the rest is semi-natural or planted stands. Prevailing forest types are beech–fir mixed forests, pure beech forests, and spruce or fir dominated conifer forests.

Average growing stock in the region is around 300 to 350 m^3/ha, which is relatively high compared to national averages, reflecting the productivity of mountain forests. The average increment is about 6 to 7 m^3 per hectare per year. The age structure is mixed: even-aged stands are present due to past management, especially intermediate (20 – 60 years) and mature (60 – 100 years) phases, while uneven-aged structures are frequent in mixed mountain forests, where natural regeneration under canopy is common. Roughly speaking, one can estimate 20 % in regeneration or young stages, 30 % intermediate, 30 % mature, and 20 % uneven-aged or irregular stands.

Deadwood is present in both standing and lying form, though the volumes vary depending on the management intensity. Due to large beetle outbreaks in the recent years, deadwood stock is planned to increase drastically. In many semi-natural stands, significant amounts of coarse woody debris are found, which supports biodiversity. The average annual cut is estimated at 4 to 5 m^3/ha, which remains below the annual increment, meaning that forests are currently accumulating biomass.

In terms of species suitability, the natural potential vegetation indicates that beech, silver fir, and oak are well adapted, with spruce suitable in higher and cooler sites. Climate change scenarios suggest that beech and fir will remain dominant, while spruce may become less favourable at low altitudes.

The mountainous area is naturally home to a balanced fir and beech forest, a functional mix of beech, silver fir, sycamore maple and, depending on the altitude, a variety of deciduous species (lime, white service tree, wild cherry, oak, ash, elm, rowan, birch) and conifers (common spruce, larch, Scots pine). Spruce, a subalpine species with shallow roots, has until now been favoured by forestry in the mountain zone. Today, weakened by water shortages and the spread of the typograph, this species is in decline and will no longer be systematically promoted to the detriment of other species in the mix

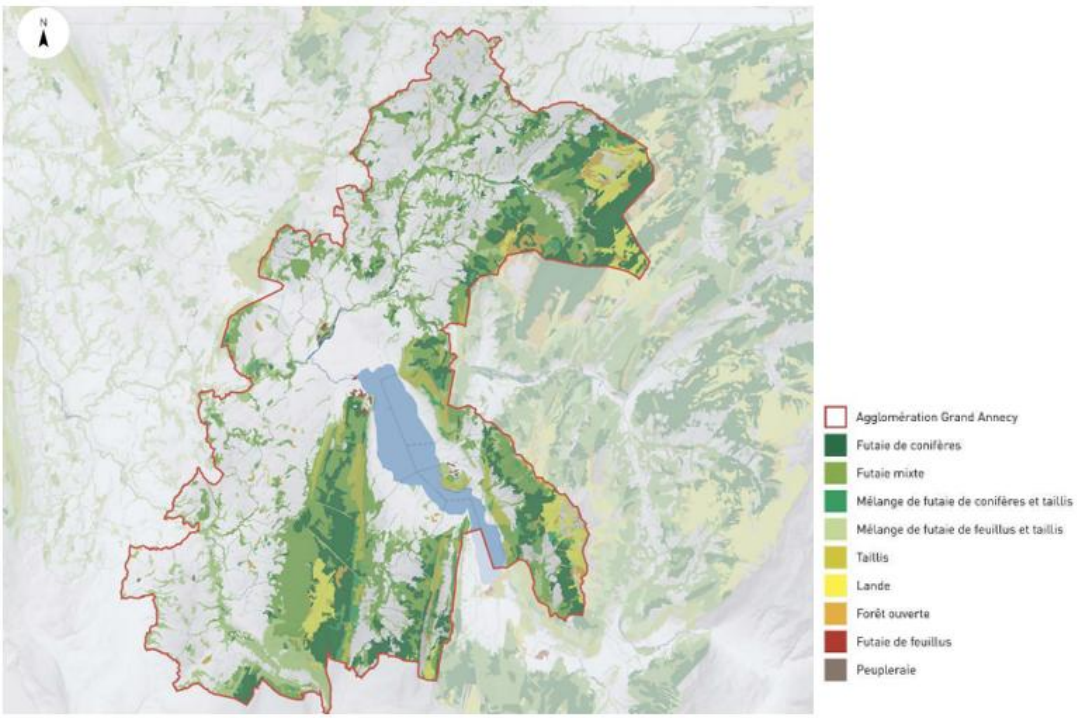

Figure 9: *Map of the different types of forest in Grand Annecy (Source: CENTS of Grand Annecy, CAUE 2018).*

Forest Ecosystem Services in the Living Lab area

The forest provides multiple forest ecosystem services to Grand Annecy. The synthesis in Table 1 lists each FES with its associated indicator and value.

- ***Provision of biodiversity:*** *a veritable reservoir of biodiversity, forests enable the development of numerous animal and plant species. They also ensure the preservation of water resources and soil protection.*
- ***Carbon sink:*** *forests account for a significant proportion of the territory's carbon sequestration (93% of carbon absorbed annually).*
- ***Risk prevention:*** *the forest acts as a retention net for boulders that have broken away over the years on the right bank of the lake (municipalities of Veyrier, Talloire and Menthon-Saint-Bernard). It plays a significant role in intercepting boulders, as depending on the area, it intercepts more than 80% of them. The forest also helps to reduce the energy of the boulders reaching the protective screens needed to withstand their impact. The departmental council suggests studying the administrative and land-use procedures to ensure that there is no significant deforestation in these areas.*
- ***Provision of wood biomass****: according to the Grand Annecy Atlas, the timber industry represents nearly 1,600 jobs in the region. As a source of timber, industrial wood and wood energy, the forest is an important economic activity.*
- ***Recreational function of the forest:*** *walking, hunting, mushroom picking.*

Table 1*: Synthesis table listing each FES with its associated indicator and value.*

Total Annecy LL	*Biodiversity/Habitat support*	*Protection against rockfall*	*Production (biomass, carbon)*	*Tourism/recreation*

Total area (ha)	*1290,87*	*8190,42*	*26208,82*	*26372,83*
mean carbon stored (t/ha) (Storage)	*194,39*	*179,66*	*164,21*	*154,00*
mean timber volume (m3/ha)	*409,25*	*378,24*	*345,71*	*324,2*
mean annual growing stock (m3/ha.year)	*5,07*	*6,42*	*7,8*	*5,93*
mean carbon sequestrated (t/ha.year)	*2,41*	*3,05*	*3,71*	*2,82*

Potential effects of forest management on FES supply (D2.2.1)

The highly diverse environmental conditions (altitude, exposure, substrate, etc.) give rise to rich and varied ecosystems. The lowland forests in the west of the Annecy area and the foothills of the various mountain ranges have not been subject to much forestry activity to date. Often neglected and fragmented, they are subject to sporadic management in private forest. The public forests in the peri-urban massif serve a protective function, welcome the public and contribute to the heritage and landscape.

Thus, to preserve the role of mountain forests and multifunctionality - protecting from natural hazards; producing wood; welcoming the public for numerous outdoor activities; maintaining significant biodiversity- in public forest (required by the forestry code), public foresters prioritise forestry based on natural dynamics and irregular structure: mixing species provides a better ecological balance and diversification of harvested forest products. However, many forest plots from plantations are still managed using regular forestry methods (even-aged forest especially for the spruce). In mountain forests, cluster forestry should be developed: on steep slopes, it facilitates harvesting and limits harvesting damage, particularly to seedlings and pole trees.

Today, the preferred approaches here aim to initiate a process of gradual complexity and renewal. Regardless of the maturity of the forest ecosystem (from ash to beech and oak forests), the dominant species will be managed in close association with all existing and potential species undergoing natural regeneration. The aim is to achieve a heterogeneous population and diverse natural regeneration. The forest cover must be maintained as much as possible in order to preserve an atmosphere and humidity levels conducive to renewal. This is to avoid any new sources of stress (heat gain, edge effect, etc.) that would constitute an additional disturbance for the spruce or other tree species.

In forests with a specific protective role, the sustainability of the forest cover guide forestry practices:

- *A layered structure allows for faster regeneration of forest cover after severe disturbance.*
- *Aiming for moderate standing capital promotes regeneration and limits economic losses in the event of windfall due to severe storms. With this in mind, very large trees should be harvested as a priority.*

***Table 2:** Synthesis table listing each FES with its associated indicator and value.*

Total Annecy LL	*Deciduous stand*	*Coniferous stand*	*Mixed stand*
Total areal (ha)	*9024,22*	*6611,83*	*8680,95*
mean carbon stored (t/ha) (Storage)	*154,54*	*169,58*	*178,92*
mean timber volume (m3/ha)	*325,34*	*357,01*	*376,68*
mean annual growing stock (m3/ha.year)	*4,49*	*6,27*	*5,94*
mean carbon sequestrated (t/ha.year)	*2,13*	*2,98*	*2,82*

Business portfolio in place

There are only two FES already targeted in the area: wood production and carbon storage. Indeed, various subsidies from the conurbation, the department, the region, and private entities support forest planting, maintenance and harvesting with the objective of wood production.

For carbon storage, the Label Bas Carbone (LBC, or Low Carbon Label) provides private funding for carbon credits through tree planting. This is a scheme implemented at the national level.

Economic valuation of Forest Ecosystem Services

Grand Annecy concentrates a significant number of Ecosystem Services within its territory:

- *Leisure and eco-tourism in the forest,*
- *Production and supply for the forestry and timber industry,*
- *Preservation of Alpine biodiversity and related species,*
- *Protection against natural hazards (avalanches, landslides),*
- *Protection and preservation of water quality,*
- *Carbon sequestration and reduction of air pollution.*

All these services ***constitute clear economic, environmental and social*** *benefits for the Grand Annecy area.*

Selected Forest Ecosystem Services (FES) were water, recreation, protection, and biodiversity. Since a service only exists when there is corresponding demand:

- *the "water" service is in fact almost nonexistent: the conurbation relies almost entirely on the lake, which is fed by a watershed located mainly outside its boundaries. The spring waters within the conurbation that flow into the lake are limited. Therefore, we did not pursue this FES further.*
- *the "recreation" service*
- *the "protection" service*
- *the "biodiversity" service*
- *ECONOMIC ASSESSMENT MISSING (FredxCarlotta)*

As a window of opportunity was perceived with Grand Annecy we pursued further only work on recreational service. However, all ecosystem services continue to be promoted and communicated about throughout our work with the stakeholders.

While full economic valuation of FES in Grand Annecy is reported in D 2.3.1 Transnational pilot testing FES economic assessment and market frameworks in each LL, for the purpose of this feasibility assessment, we present valuation results for the ecosystem services that were in focus of the LL activities, namely provision of forest spring water, maintenance of high-quality fresh waters, protection against rockfall, and provision of habitats for wild plants and animals. Please, refer to D 2.3.1 for further details on valuation methodology.

The results of the adjusted unit value transfer for the French Living Lab in Grand Annecy are presented on Figure 10. According to conservative value estimates, regulating services associated with natural hazards risks mitigation have the highest value per ha of forest, followed by provision of habitats for wild plants and animals. Interestingly, unit value for protection against rockfall used locally (€409.44/ha) is almost twice lower than the adjusted Alpine average (€831.07/ha), indicating local underestimation. Recreation service

has a moderate social value and is among the top four or five most relevant FES in the area, depending on valuation scenarios.

FES associated with the water (provision of forest spring water and maintenance of high-quality fresh waters) are among the least valued FES. However, it must be noted that in case of provisioning service, direct market valuation based on the real market prices for water capturing could be a significant underestimation of the overall social value of this FES, as it does not account for other non-marketable benefits received from water captured in forest springs (i.e., cheap does not mean less valuable). As for the regulating service, data used locally in the LL area for valuation of maintenance of high-quality fresh waters is more than three times lower than Alpine average value, indicating a possibility of higher relevance and value for locals than in the current estimates used by policy- and decision-makers.

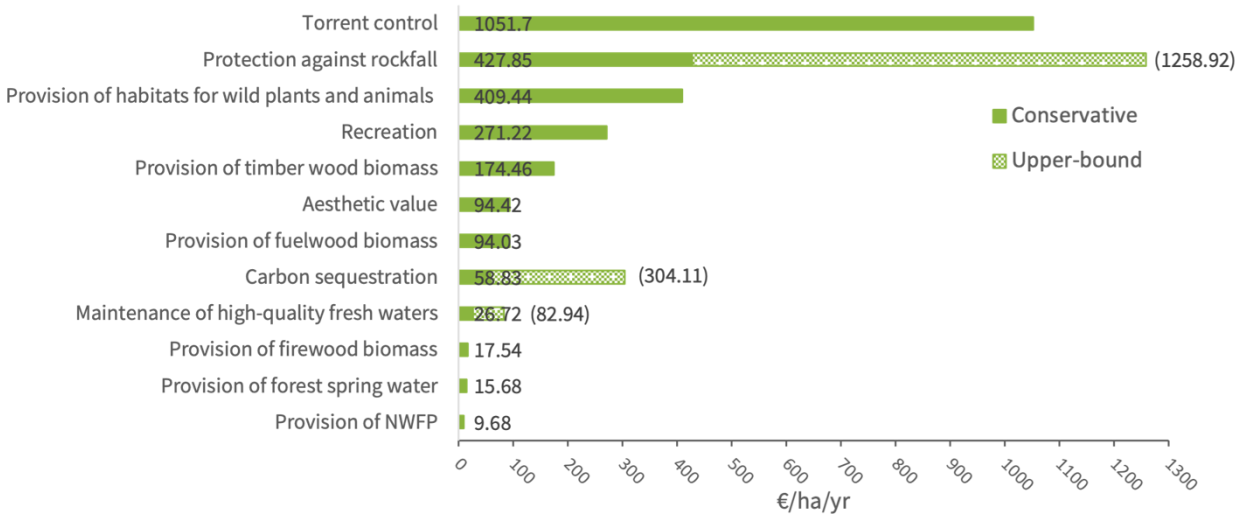

Figure 10: *Unit value estimates in 2023 euros per ha. Upper-bound value estimates are provided in parenthesis. NWFP stands non-wood forest products, including chestnuts, mushrooms and berries.*

Estimates of the total economic values (TEV) of forests in Grand Annecy, using both conservative and upper-bound unit value estimates, are demonstrated in Figure 11. Due to data scarcity, we could not perform this and spatial analysis (see below) for provisioning and regulating water services, Recreation brings the biggest contribution to the conservative TEV estimate, while protection against rockfall is the biggest contributor in the upper-bound TEV estimate. This indicates a relative balance between the social value of these FES and the forest areas providing them. Contrastingly, contribution of provision of habitats FES, although with a high unit value, is minor. This suggests that targeted efforts on expansion of the forest area providing this FES will have a substantial effect on the TEV of Grand Annecy forests.

It must be noted, that provided TEV estimates are a serious underestimation, as the number of FES included in the calculation was restricted to five. Despite underestimation, value of timber provisioning service constitutes a relatively small share of the forest TEV, suggesting that the social importance of forests in Grand Annecy extends well beyond timber production. At the same time, we must keep in mind that the forest area providing provisioning services fully overlaps with the one providing carbon sequestration, almost fully overlaps with the one providing recreation (88%) and partially with other FES, hinting at potentially detrimental losses in social value of forests if forest management is fully oriented at timber provision.

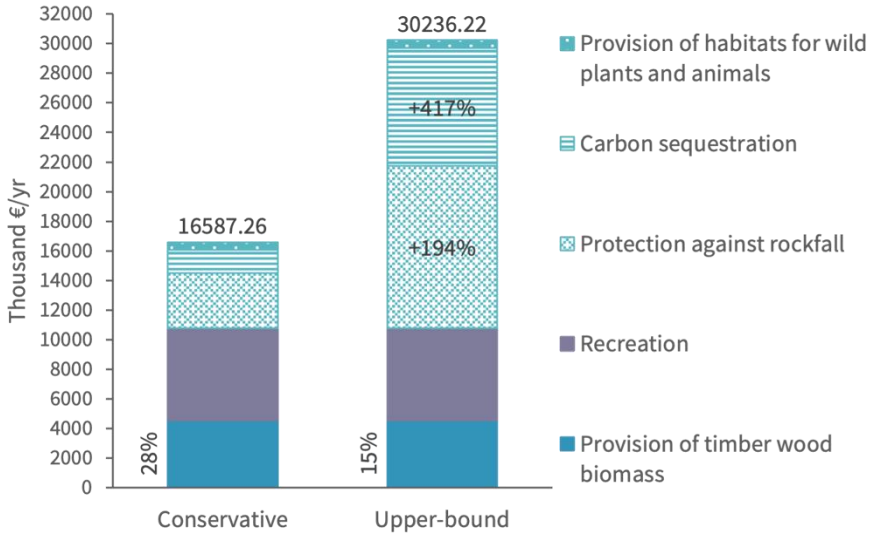

Figure 11: *Conservative and upper-bound estimates for total economic value (TEV) of forests in Grand Annecy. Total values per year for each FES are estimated based on the forest surface areas providing respective services. Percentages for provision of timber wood biomass placed on the left of the bars indicate a contribution of timber wood provision to the TEV. Percentages for protection against rockfall and carbon sequestration placed inside the bar indicate difference in total values of these FES between conservative and upper-bound TEVs. Numbers on the top of the bars indicate the TEVs.*

Spatial distribution of FES social values in Grand Annecy further details our understanding about the FES provision in the Living Lab (Figure 12). Not all values are evenly distributed throughout the territory of the Living Lab. While most of the forest area provides slightly below expected average value per ha (537 €/ha/yr[5]), areas providing above expected average value per ha are concentrated around Annecy Lake as well as in the south and east of Grand Annecy. Highly valuable forest patches are very scarce and underrepresented. While further supplementation of this map with the spatial distribution of forest ownership and residential areas could shed more light into FES providers and beneficiaries dynamics in the area, already at this stage we can see a high risk of potential trade-offs when forest management plans are focused only on one ecosystem service. However, it must be noted that the assumptions behind biophysical assessment of habitat provision FES take into account only forest areas with high habitat value. Other indicators like deadwood per ha or habitat connectivity could uncover even higher risk of costly trade-offs.

[5] *As forest areas providing timber wood biomass and carbon sequestration has a 100% overlap, at least two FES are expected to be at each ha, therefore, expected average is a representative midpoint value. It was calculated as follows:* $Expected\ average = Average\ of\ all\ FES\ values\ per\ ha \times 2$

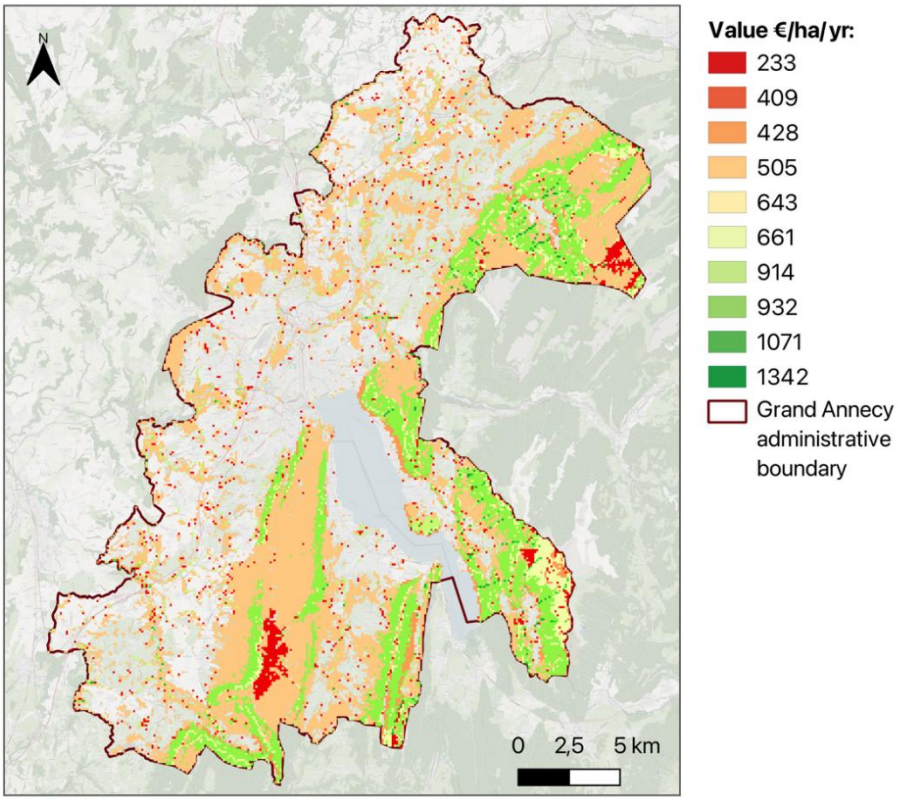

Figure 12: *Spatial distribution of conservative unit values in Grand Annecy. Minor overdistribution (> 0.2%) is present for the unit value of protection against rockfall. Some degree of spatial under- and overdistribution is present for the unit value of carbon sequestration as unit value estimation is based on mean carbon sequestration per ha, not carbon sequestration specific to the forest unit.*

Feasibility Assessment

Development scenario

However, in the face of climate change, Alpine forests are becoming increasingly vulnerable. Several forest species, animal species and plant species are under threat, as are the many services provided by the forest. It is estimated that 35 % to 50 % of French forests will experience climatic discomfort over the next 50 years, based on current climate trends, representing a very high risk of mortality for many stands (source: ONF, 2024). The mortality rate of trees in French forests has already increased by 80 % since 2015, with spruce, chestnut, fir, beech, ash and certain oak species being the most affected.

In this context, preserving the landscape and maintaining a pleasant forest environment, within the framework of sustainable forest management, is a challenge for private and public forest managers. Given the importance of welcoming the public to the forest and the high number of visitors to the Grand Annecy area, the conservation and maintenance of forest areas and infrastructure is a key factor in strengthening the tourist offer and local well-being. This focus must be reconciled with other important forest issues. Maintaining ecosystem services in the Grand Annecy area is also a current focus for elected officials: climate change, increased risk of fire, consequences for water resources, public access. The Grand Annecy forest will require a series of investments to maintain or even improve the level of these services. However, ***forest managers and owners, whether private or public, receive little or no remuneration*** *for these services.*

The projection for the Living Lab is ***to engage recreational users in forest management, fostering their sense of stewardship and ownership*** *over the challenges facing natural ecosystems.*

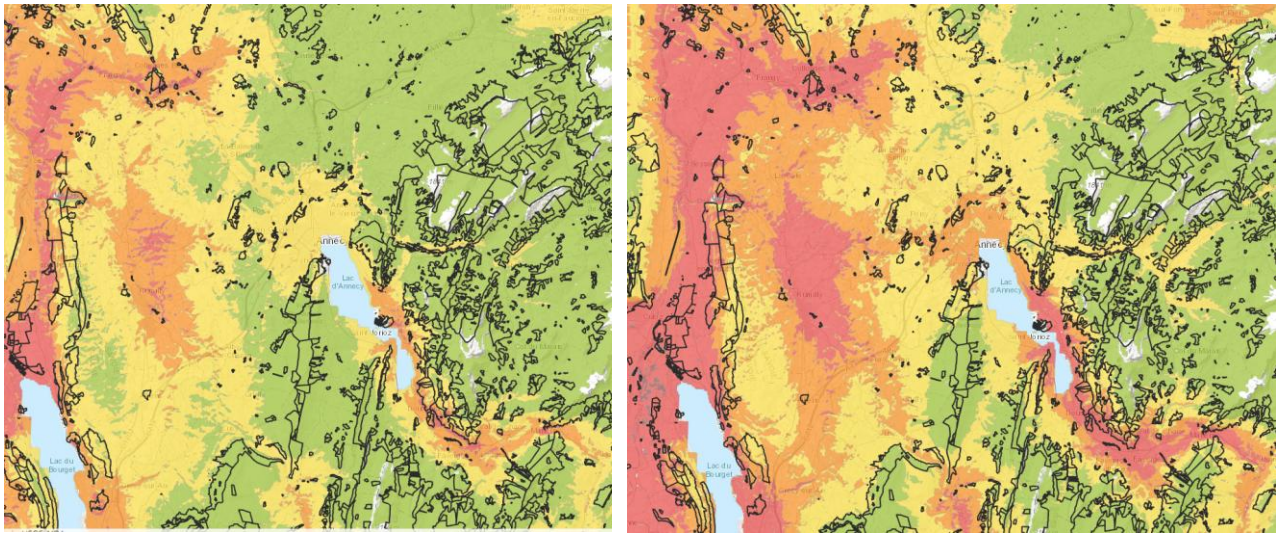

Figure 13: *Climate compatibility maps for tree species according to the limiting factor 'water shortage' (DHYa) with useful reserve data at 90 m resolution, for 2085 for beech (left) and silver fir (right). (source ONF).*

Objectives

Ecological objectives

Grand Annecy forests, especially in the direct surrounding of the city of Annecy are impacted by recreational users that roam forets following or not existing paths, day and night. Stewardship of forests by the general public via channeling of the tourisme tax is expected to have different benefits for forests' ecology. We expect:

- *Lessen recreation impact on forest soils and biodiversity*
- *increase awareness among visitors and local residents of these impacts, in order to pave the way for more conscious use of forest, less conflict with foresters and biodiversity respect during the night*
- *support continuous-cover forestry which is more positive for biodiversity via the decreased pressure of profitability thanks to a new funding source;*
- *encourage more active adaptation to climate change as a secondary benefit of providing additional income to foresters.*

All outcomes are positively linked to the sustainability of biodiversity and the overall health of forest ecosystems.

Economic objectives

The Grand Annecy forest will require a series of investments to maintain or even improve the level of the forest ecosystem services. Forest managers or owners, whether private or public, currently receive little or no remuneration for these services. They must take into account the constraints associated with this high visitor numbers, in particular by adapting their operating methods or work schedules. This adaptation even entails additional costs for forest managers or owners. Diversifying current funding sources is therefore a major challenge for the sector.

We aim at:

- *increasing funding sources for foresters in Grand Annecy via an innovative approach involving channeling a part of the tourism tax for foresters;*
- *improving forest profitability by decreasing unaccounted costs via the financing of costly actions intended at mitigating recreation impacts or preventing security issues for foresters (see below);*
- *implementing sustainable management practices in an easier way thanks to less pressure from profitability and thus, in the long term, increasing harvests value, economic profit and carbon storage;*
- *enhancing knowledge intake of the forestry sector from the general public and ease economical activity.*

Measures

An initial proposal bringing together a series of actions to preserve these forest ecosystem services. This series of actions mainly consists of measures to reconcile, sustain and pool recreational and environmental uses of the forest. As forest management is the basis for action for forest managers, these measures aim to support and promote forest management that is adapted to the forests of Grand Annecy and its challenges.

Reconciling different uses

- *Support for securing the surroundings of frequently used trails*
- *Support for improving safety at high-risk forestry sites*
- *Use of low-impact forestry methods in areas with recreational value*
- *Restoration of forest tracks to recreational standards*
- *Educational initiatives*

Mitigating the impacts of visitor numbers and protecting forest soils

- *Ecological engineering developments*
- *Designation of hiking trails and closure/renaturation of surplus and/or degraded trails*
- *Educational materials*

Landscape

- *Facilitating choices that prioritise canopy continuity*

Priorities

Foresters are accustomed to working in partnership with the conurbation, notably receiving funding for plantation and, besides providing FES to inhabitants, visitors and companies, giving back as partners when organizing events. Using the conurbation as an intermediary to collect funds is ideal for forest owners, as it allows them to benefit from the conurbation's influence and existing working relationships without requesting additional funding from its current budget.

Other silvicultural actions and choices may be prioritised based on knowledge gained in the coming years. To this end, the specifications may be revised retrospectively.

Selected business ideas

Sharing the tourism tax with foresters

We aim to allocate a share of the tourism tax that has been in place since 2017 (approximately 3 million nights per year in the Grand Annecy area) to fund actions that support foresters and forests in coping with the impacts of tourism and outdoor activities in the region.

Two possible solutions have been proposed:

- *either by increasing the tax by 2 or 3 cents per tourist overnight stay.*
- *or by allocating a percentage of the current tax between 1% and 2 %.*

An estimate of the amount of tourist tax collected could be between € 50,000 and € 60,000 annually to co-finance these actions and the activities provided by technical partners.

Factores for feasibility assessment

Technical and ecological feasibility

The mapping of Ecosystem Services has made it possible to represent them visually, highlighting the Services provided by the forest in the Grand Annecy area. This identification was based on the definition of several criteria using available data and developed methodologies (D.2.2.1).

The technical measures can be implemented by public and private forest managers (ONF - CNPF), who have the expertise and technical resources to do so.

This work could be fully integrated into existing frameworks for public forests (forest management scheme, mid-term review) and private forests (simple management plan). Eligibility criteria for forests will be based on the existence of at least these management frameworks.

This work must be supplemented by a technical committee, bringing together elected officials and technical partners, to prioritise the issues at stake. This initial version will need to be shared and revised with elected officials and technical partners to ensure that the choices made are relevant and appropriate to the issues identified beforehand.

Economic feasibility

The economic organisation of the system and the management of the targeted measures will be carried out by Grand Annecy, but also by technical partners such as the ONF and the CNPF.

Although the business model does not create a market per se, the mobilisation of local stakeholders – public and private, forestry and tourism, etc. – should ensure the integration of all partners and facilitate the emergence of this scheme.

This collective approach must also be considered in terms of diversification and the spread of this territorial innovation across the Alpine region.

Expected costs, potential revenue and financial risks

We expect € 40,000 to be used for the funded actions, and € 20,000 (one-third) to be allocated to Grand Annecy, ONF, and CNPF or other selected stakeholder for the organization and coordination of these actions. Given

that the amount collected is up to ten times higher for luxury accommodations compared to low-end ones, applying a proportional contribution system would be beneficial. We thus anticipate that this amount could be increased during discussions, depending on whether a percentage-based system is used.

The direct financial risks are low, as the tax on which the value of the scheme is based is calculated on the total number of tourists overnight stays in the area. Only an event with a massive impact on tourist flows, and therefore on the tax base, could have a significant impact on the scheme.

The indirect financial risk, mainly of a political nature, is high. As the tax and the modulation dedicated to the proposed scheme are voted on by the Grand Annecy Community Council, a change in leadership could affect the choice of such a scheme.

Operational feasibility

Table 3 *shows the measure needed, expected workload for maintenance, existing workforces for the implementation.*

Table 3: *Technical measures and objectives for the Living Lab.*

Goal	*Action*	*Stakeholder*
Support for securing the surroundings of frequently used trails	*Felling of hazardous trees*	*SME; Owner ONF/CNPF;*
*Support for strengthening safety measures on forestry worksites with specific issues***	*Outreach / awareness-raising around forestry worksites*	*ONF/CNPF; Fibois*
	Communication, consultation, and organization of detours through meetings and media outreach	*ONF/CNPF; UFP; Fibois*
	Communication materials or detour signage	*ONF/CNPF; Fibois*
	Specific equipment for trail marking, diversion, and closure	*ONF/CNPF; Fibois*
Restoration of forest tracks to recreational use standards	*Machinery operations with "special finishing"*	*SME; Owner ONF/CNPF;*
*Use of low-impact silvicultural methods in areas with recreational value***	*Additional cost for timber extraction / skidding using animal traction*	*SME; Owner ONF/CNPF;*
*Educational and interpretive actions and materials for welcoming the public in forests***	*Design*	*ONF/CNPF; owner; ASL*
	Communication materials	*ONF/CNPF; owner; ASL*
*Ecological engineering developments***	*Technical study*	*ONF/CNPF; owner; ASL*
	Equipment	*ONF/CNPF; owner; ASL*
	Installation of equipment	*ONF/CNPF; owner; ASL*
	Consultation, designation, and formal agreement on a single trail (outside the PDIPR)*	*ONF/CNPF; owner; ASL*

Designation of hiking routes and closure/restoration of redundant and/or degraded trails		
	Restoration study or other works (outside the PDIPR)	*ONF/CNPF; owner; ASL*
	Restoration works, other works or cleaning, redirection materials and installation (outside the PDIPR)	*ONF/CNPF; owner; ASL*
	Dismantling of unsuitable / unauthorized equipment	*ONF/CNPF; owner; ASL*
Facilitation of decisions prioritizing canopy continuity (Maximum 10 % of the annual budget)	*Expert analysis*	*ONF/CNPF; owner; ASL*
	Additional cost – forestry works contractor (ETF)	*ONF/CNPF; owner; ASL*
	Bonus	*ONF/CNPF; owner; ASL*
	Compensation for potential losses within 3 years	*ONF/CNPF; owner; ASL*

Amounts for each action, projects leaders and supporting documents for reimbursement are to be adjusted locally.

Stakeholder interests based on Living Lab experiences

Both private and public forest owners welcome a new approach to reducing costs and increasing the currently very low margins for sustainable forest management. While the implementation workforce is already in place, it is facing increasing work overload pressure, particularly due to the growing impacts of climate change and societal demands. Additional funding sources would allow for the employment of more workers to support these efforts. The ONF and the CNPF would strongly support this innovative approach, which promotes the services provided by forests, which are currently underappreciated.

Local authorities and elected officials are interested in the approach and model of the scheme because it allows them to invest in the forests in their area while maintaining economic activity. The use of tourist tax, which is possible in Greater Annecy, varies greatly from one political area to another.

Legal compliance

Compliance with forest and nature conservation laws, regulations and forest policy strategies

There is compliance to be confirmed with financial regulation in particular on the redirection of funds collected through tourist tax towards environmental maintenance and conservation operations. Tourist tax rates are adopted in accordance with the scale set by the legislator, which is revised each year. This scale sets a minimum and maximum price. The surcharge can therefore fall within the price range proposed by the legislator. The tourist tax is collected by the EPCI (public establishment for inter-municipal cooperation, in Grand Annecy) responsible for tourism.

It cannot cover all types of expenditure and is allocated to expenditure intended to promote tourism in the municipality or group of municipalities, or to expenditure relating to the protection and management of natural areas for tourism purposes. Seeking the assistance of partners such as the Directorate-General of Public Finances (DGFIP) could enable us to verify the eligibility of the proposed scheme.

There is full compliance with forest regulation and strategies as:

- *There is no forest management practices modification.*
- *There is integration and alignment with existing management frameworks in public and private forests.*
- *Visitor safety is expected to improve; anyhow, foresters already maintain safety measures voluntarily in accordance with the law. They do not generally choose to close their land to visitors, which would be an easier option.*
- *Other actions serve as additional benefits for foresters, allowing them to restore and manage visitor access on their land, as they retain ownership rights.*

LIVING LAB GERMANY

Tegernsee Valley & Tölzer Land

Output 2.3

Living Lab Germany

Characteristics of the Living Lab area

Geographical location

The Living Lab is situated in Upper Bavaria, south of Munich, within an area bounded by the cities of Murnau, Tegernsee, Starnberg, and Munich itself. This region spans four administrative districts: Munich, Miesbach, Bad Tölz-Wolfratshausen, and Garmisch-Partenkirchen. For a visual overview of the macro region please refer to Figure 14.

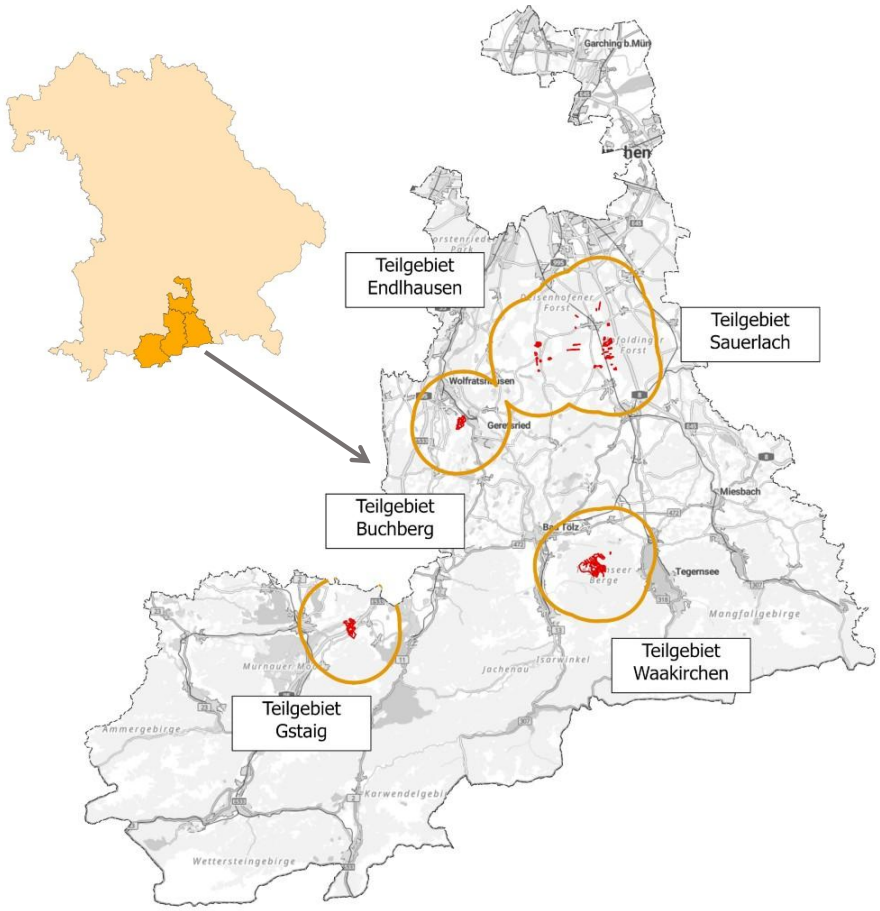

Figure 14: *Overview of the makro region.*

The Living Lab consists of five sub-areas. The areas Endlhausen, Sauerlach, Buchberg and Gstaig belong to the Archdiocese Munich and Freising (Living Lab Endlhausen) whereas the forest nearby Waakirchen belongs to the private forest owner L.B. (Living Lab Waakirchen). In the following we refer commonly to Living Lab Endlhausen and Living Lab Waakirchen. Table 4 gives an overview of the specific location of forest areas by municipality and administrative district. Figure 15 shows an overview of the local Living Lab areas.

Table 4: Overview of Living Labs by municipality and administrative district.

No.	Name of sub-area	Name of Living Lab	Property of	Municipality	Administrative district
1	Endlhausen	Living Lab Endlhausen (No. 1)	Archdiocese Munich-Freising	Egling, Sauerlach	Bad Tölz - Wolfratshausen
2	Sauerlach	Living Lab Endlhausen (No. 1)	Archdiocese Munich-Freising	Sauerlach, Otterfing	München, Miesbach
3	Buchberg	Living Lab Endlhausen (No. 1)	Archdiocese Munich-Freising	Geretstried	Bad Tölz - Wolfratshausen
4	Gstaig	Living Lab Endlhausen (No. 1)	Archdiocese Munich-Freising	Ohlstadt	Garmisch-Partenkirchen
5	Waakirchen	Living Lab Waakirchen (No. 2)	Private Forest Owner L.B.	Gaißach, Waakirchen	Bad Tölz – Wolfratshausen, Miesbach

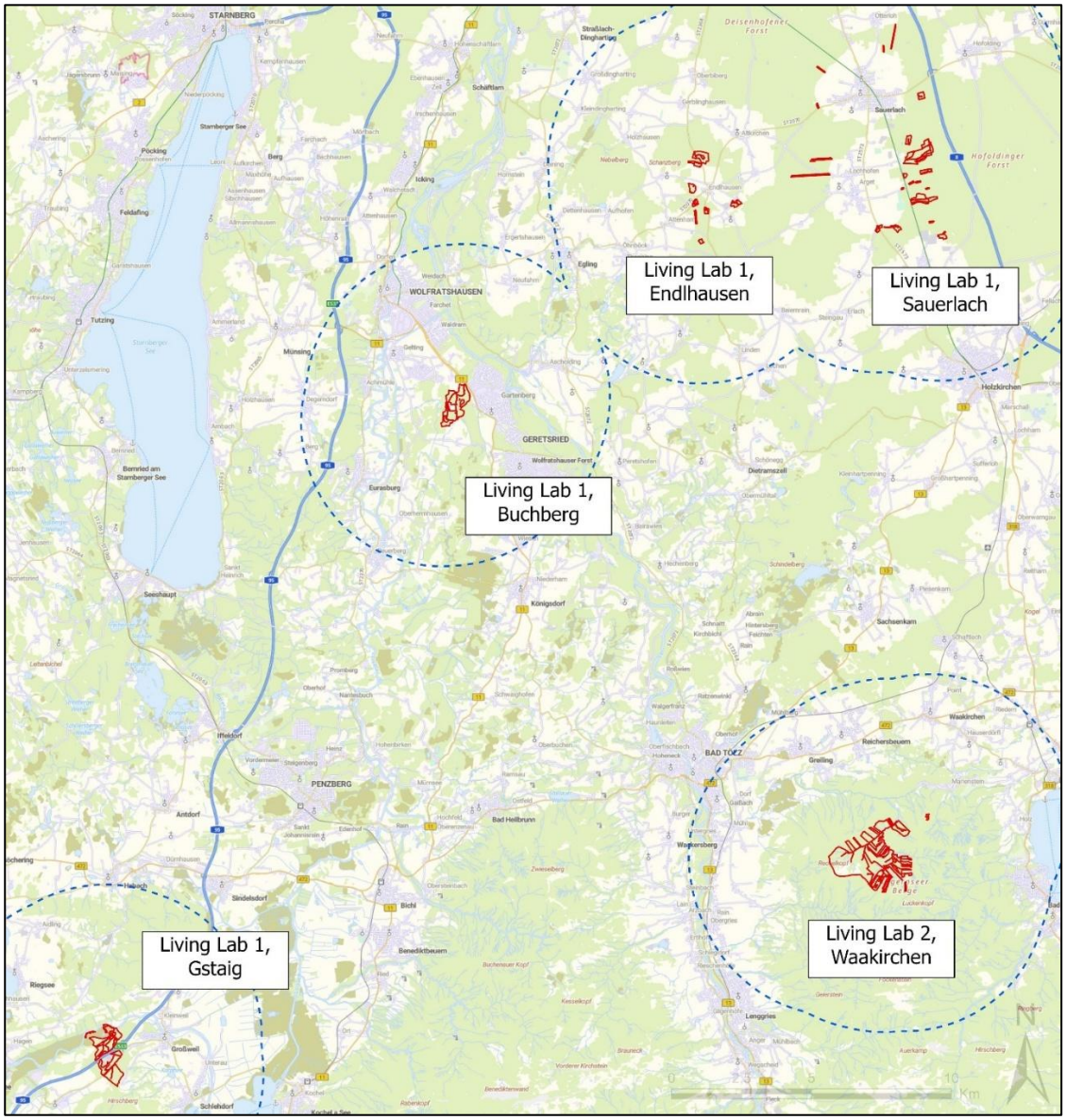

Figure 15: Overview map of the Living Lab areas (© 2025 basemap.de).

Land use

Data from the Bavarian State Surveying Office (Bayerische Vermessungsverwaltung 2025) on actual land use in the districts of Bad Tölz-Wolfratshausen, Miesbach, Munich, and Garmisch-Partenkirchen was used for the following description of land use.

The forest occupies the largest proportion of the pilot area with 53.43 % followed by agricultural land with 26.52 %. Table 5 gives an overview of the land use distribution.

***Table 5:** Overview of landuse in the Living Lab in percentage.*

Land use	*Percentage of land use (%)*
Forest	*53.43 %*
Agriculture	*26.52 %*
Area without vegetation	*6.26 %*
Urban areas, settlements	*6.24 %*
Water figures	*2.69 %*
Infrastructure	*3.05 %*
Moor and swamp	*1.47 %*
Other[6]	*0.34 %*

Topography and climate

The pilot area is mainly within the moist-continental climate zone. With warm summers, cold winters, and consistent precipitation throughout the year. The area spans two main Bavarian climate regions: the Alpine Foothills (53 %) and portions of the Northern Limestone Alps (47 %). The mountain ranges experience higher precipitation and lower temperatures compared to the foothills.

Across the pilot area, mean annual temperatures range from about 7.9°C in the Alpine Foothills to 5.7 °C in the Alps (LfU 2025a), while annual precipitation varies considerably, averaging between approximately 1100 mm and up to 2000 mm (LfU 2025b). Elevations within the region extend from 591 meters up to 1328 meters above sea level (Bayerische Vermessungsverwaltung 2025). While parts of the area, such as Endlhausen and Sauerlach, are relatively flat, others — notably Waakirchen—are hilly, featuring steep slopes that reach the highest elevations.

Geology and pedology

There are many different geological units in the pilot area. The geology is predominantly characterized by Rhenodanubian Flysch, specifically the Lower Variegated Marl (Ofterschwanger Layers) up to the Anthering Formation. Widespread gravel deposits from the Würm period include formations from the lower terrace and late glacial terrace. Early Würm-period lake deposits can be also found in Alpine valleys. The landscape is further shaped by young moraine formations from the Würm period, featuring terminal moraine ridges—some of which contain advance gravel deposits. Peat deposits are present in some parts of the region (LfU 2024).

The predominant soil type is Brown Earth or Para-Brown Earth, covering more than half of the Living Lab area, see Table 6. Gley and Pseudogley soils are the second most common, occurring particularly extensively

[6] *Other land use includes heathland, open-cast mine, pit, quarry.*

in the Forest of the private owner. Other soil types found in the forests of the Archdiocese of Munich and Freising are (Para-)Rendzina and Fen soils (LfU 2024).

***Table 6:** Soil types in the Living Lab in km².*

Soil type	*Living Lab Endlhausen*	*Living Lab Waakirchen*
Brown earth and para brown earth	*255.14*	*120.74*
(Para-) rendzina	*26.30*	*-*
Gley and pseudogley	*12.25*	*158.38*
Fen soil	*0.70*	*-*

Groundwater is a vital component of the local water cycle and ecosystem. Table 7 summarizes measured groundwater depths, offering insight into local aquifer conditions based on data from the Hydrological Service (LfU 2025c).

***Table 7**: Ground water table and surface distance of groundwater table.*

Measurement point ("Grundwassermesspunkt")	*Ground water level (above sea level)*	*Below the surface*
Sauerlach Q9	*571.37 m*	*30.25 m*
Wolfratshausen 883 (WOL 017)	*572.99 m*	*7.88 m*
Arzbach 246C	*660.22 m*	*6.18 m*
Weindorf 573	*651.04 m*	*30.25 m*

Surface waters such as rivers and lakes are prominent features in certain pilot areas, contributing substantially to the landscape and biodiversity. In Gstaig, the pilot area has a 2330-meter-long border with the Loisach River, which is both a Flora-Fauna-Habitat (FFH) site and a Special Protection Area under Birds Directive (SPA area). Additionally, there are three small ponds covering a total area of 243 m², as well as three larger lakes nearby. The lake Riegsee, designated as a landscape conservation area, and Froschhauser Lake, a nature conservation area, 3 km northwest of the pilot area. Kochelsee, located 2.7 km southeast, is a FFH site and a SPA site.

The Waakirchen area is equally shaped by its water features, especially given its location in the Alpine foothills. The region's steep terrain fosters the development of numerous temporary streams and gullies, which together extend over 12,400 meters. The most prominent of these is the stream Große Gaißach. During heavy rainfall, these watercourses can become highly dynamic, occasionally causing erosion and leading to washed-out trail segments. Although lake Tegernsee lies just outside the pilot area to the west, it significantly influences the region's character and is a key attraction for tourism.

Organizational structure

Responsible regional and local authorities for forest management

*The Bavarian forestry administration is responsible for the interests of forestry in Bavaria. The supreme authority is the **Bavarian State Ministry of Food, Agriculture and Forestry (BayStMELF)**, Department F. At local level, responsibility lies with the **Office for Food, Agriculture and Forestry (AELF)**, which reports to the BayStMELF (Art. 27 BayWaldG). In our pilot area, the **AELF Ebersberg-Erding**, the **AELF Holzkirchen** and the*

AELF Weilheim i.OB *are responsible for the local concerns of forest owners in the four administrative districts Miesbach, Bad Tölz – Wolfratshausen, Garmisch-Partenkirchen and München.*

The authorities are responsible for forest supervision and for preventing, stopping or prosecuting infringements of the regulations (Art. 26 BayWaldG). (Art. 26 BayWaldG). The tasks of the forestry authorities (Art. 28 Para. 1 BayWaldG) include

1. *specialist forestry planning (Art. 5 and 6),*
2. *the establishment of natural forest reserves (Art. 12a),*
3. *the implementation of afforestation for reasons of public good (Art. 16 para. 5),*
4. *the management and execution of operations in the corporate forest taken over by contract (Art. 19),*
5. *the preparation of forest management plans and forest management reports in the corporate forest (Art. 19),*
6. *the promotion of forestry and its self-help facilities (Art. 19 to 22),*
7. *forest supervision (Art. 26), unless other authorities are responsible,*
8. *forest education as an educational mission,*
9. *the restoration of protection forests in accordance with Art. 10 para. 1,*
10. *surveys on the situation of forest regeneration and the condition of the forest at regular intervals.*

The district foresters of the Lower Forestry Authorities (AELF) are responsible for forest protection (Art. 32 and 34 BayWaldG) in their respective districts, too. As the "police of the forest", the district foresters as so-called forest protection officers are therefore responsible for ensuring that the legal provisions relating to the forest are complied with and that infringements by third parties are prevented, stopped or prosecuted (Art. 33 and 35 BayWaldG).

District administration and municipalities

There are four different ***district administrations*** *(German: Kreisverwaltungsbehörden (KVB)) in the pilot area: Miesbach, Bad Tölz, Garmisch-Partenkirchen and Munich. District offices have various responsibilities, such as waste disposal, social and youth welfare, healthcare, local fire safety measures, and environmental protection and nature conservation. The lower nature conservation authority and the lower hunting authority are located in the district administrations (KVB).*

The ***communities (cities, municipalities)*** *are at the lowest level of administration and take on self-governing tasks. The municipality's mandatory tasks include the supply of water, sewage, electricity, and gas, funeral services, the construction of elementary schools and kindergartens, urban land-use planning; and fire protection.*

In the Living Lab the municipalities of Egling, Sauerlach, Otterfing, Geretsried, Ohlstadt, Gaißach and Waakirchen are responsible (see Table 4).

Forst owner Association

Private forest owners can join together to form forestry associations, so-called ***„Forest Owner Association"*** *(German: "Waldbesitzervereinigungen (WBV)) or „Forest Management Association (German: Forstbetriebsgemeinschaften (FBG)). As self-help organizations, which are state supported by the Free State of Bavaria (cf. Art. 22 para. 3 No. 7 BayWaldG), their aim is to improve the management and afforestation of associated forest areas. The associated area can be variable and can extend beyond the county boundaries. The association is intended to overcome disadvantageous structural deficiencies, such as a small area size, an unfavorable area shape or ownership fragmentation (§ 16 BWaldG).*

The tasks of a WBV or FBG include, among others, the coordination of operational plans, operational reports and business plans, the coordination of the sale of timber and other forest products, the execution of plantations, stand maintenance work, the construction and maintenance of roads, the execution of logging and the procurement and use of machinery and equipment (Art. 17 BWaldG).

The German Living Lab is located in the catchment area of two different forest owner associations : WBV Holzkirchen w.V. and WBV Wolfratshausen e.V., both representing the districts of Miesbach, Bad Tölz-Wolfratshausen, and Munich, as well as the interests of local forest owners.

For more information about the organizational structure in the Living Lab please refer to the Policy Analysis of the German Living Lab (TOOL D 9 Policy Analysis for the German Living Lab).

Ownership

The forest in Germany is classified into privately owned forest, federal forest, state-owned forest and communal forest owned by cities or municipalities. In the administrative districts of Miesbach (48 %) and Bad Tölz-Wolfratshausen (60 %), most of the forest is privately owned, closely followed by state-owned forest (46 % and 37 %). Municipal forest accounts for only a small proportion, at 3 % for Bad Tölz – Wolfratshausen and 6 % for Miesbach respectively (AELF 2025Quelle einfügen). The Living Lab is represented by two private forest owners:

Living Lab Endlhausen

This LL belongs to the Archdiocese Munich-Freising, which owns approximately 5000 hectares of forest distributed across 1270 properties in southern Bavaria. These holdings include both lands owned directly by the Archdiocese and parcels belonging to various church foundations (Pfründestiftungen), which are associated with individual parishes. Fragmented forest ownership is characteristic for the Archdioceses holdings. Numerous small and scattered forest parcels pose special challenges for forest management. The forest land of the Archdiocese is divided into seven districts. The Forest EcoValue

Living Lab area lays in the district Endlhausen which has an area of 1170 hectares in total, spread across 91 forest sites. In the Endlhausen district, 4 sub-areas were selected as pilot areas for assessing forest ecosystem services and testing business models in the Living Lab. The areas consist mainly of forest, but also include a well-developed network of paths, lumberyards, game fields or game meadows and cultivated agricultural land. The first area ***Endlhausen*** *has a total of 30,16 ha. The second area at* ***Sauerlach*** *is comprised of smaller, individual estates with a total area of 132,58 ha.* ***Buchberg*** *(85,07 ha) and* ***Gstaig*** *(139,37 ha) are contiguous tracts of forest (see Table 8).*

The Archdiocese is a large ecclesiastical organization that places significant emphasis on ethical questions and sustainable forest management. Their guidelines are structured around three core pillars: economy, ecology, and social responsibility. Thus, reflecting a commitment to fostering resilient forests, protecting nature, supporting local communities, and encouraging research and education initiatives.

The goal of the Archdiocese is to achieve harmony between economy, ecology and social responsibility. The Archdiocese has set the following mission statement (Erzbischöfliche Finanzkammer, Abteilung Forst 2025Quelle):

1. *Climate protection through conversion of forests into climate-resistant, stable, and mixed forests by selecting stand-appropriate deciduous and coniferous tree species.*
2. *Establishment of mixed, multi-layered, structurally rich forests with trees of varying ages, preferably continouse cover forests (“Dauerwälder”), through targeted silvicultural measures.*

3. *Forest protection should first be carried out using logistical means before resorting to herbicides or pesticides.*
4. *Protection of forest soil through permanent skid trail network.*
5. *Biotope and species protection through road concept and the renunciation of use of difficult-to-cultivate locations.*
6. *Deadwood enrichment to preserve and promote biodiversity.*
7. *Responsibility as a representative of public interests.*
8. *Promotion of education through involvement of kindergartens, schools, and public institutions and openness to forest research.*
9. *Social responsibility for employees and companies operating in the forest through forest training and adaption of modern methods for harvesting.*
10. *Strengthening rural areas and reducing CO_2 emissions through short transportation routes by supplying local and regional businesses with wood and using the own wood for church buildings.*

Living Lab 2 Waakirchen

The LL is located in the municipality of Waakirchen and is owned by the private forest owner L.B. The property has an area size of approximately 280 ha (see Table 8). He manages the forest independently in cooperation with the forest owner's association Holzkirchen and contractors. His goal is a sustainable forest management through the promotion of climate-tolerant, stable and permanent forests. Other goals are biotope and species protection through the promotion of forest structures and deadwood enrichment. At the same time, he places great importance on making the forest an open space for everyone and raising awareness of its ecological and social value. As a member of an NGO the nature conservation organization BUND and the ecological hunting association, the forest owner actively supports forest-friendly wildlife management. The forest owner also attaches great importance to the social value of the forest. His commitment extends to fostering creativity and dialogue within the forest environment.

***Table 8**: Area of the forests depending on the forest owner[7].*

No.	*Name*	*Living Lab*	*Property of*	*Total area in ha*	*Forest area in ha of the total area*
1	*Endlhausen*	*Endlhausen*	*Archdiocese Munich-Freising*	*30,16 ha*	*27,55 ha*
2	*Sauerlach*	*Endlhausen*	*Archdiocese Munich-Freising*	*132,58 ha*	*116,37 ha*
3	*Buchberg*	*Endlhausen*	*Archdiocese Munich-Freising*	*85,07 ha*	*72,87 ha*
4	*Gstaig*	*Endlhausen*	*Archdiocese Munich-Freising*	*139,37 ha*	*100,32 ha*
5	*Waakirchen*	*Endlhausen*	*Private Forest Owner L.B.*	*279,13 ha*	*124,06 ha*
			Total	*666,31 ha*	*441,17 ha*

*[7] The size of the property of the Archdiocese was determined from the GIS and differs slightly from the size of the area stated in the district books. The **total area** in hectares is the area of forest including paths, pastures, agricultural land or lumberyards. The **forest area** in hectares is the area of the forest minus paths, pastures, agricultural land or lumberyards, etc.*

Status of forests in the Living Lab

Characteristic of forests and their management in the LL area

Living Lab Endlhausen

Description of forest characteristics

The forest areas of the Living Lab Endlhausen are located in the Endlhausen district and are divided into 4 sub-areas. All information is taken from the district books, which are based on the forest inventory (forest management planning) of the Archdiocese Munich-Freising for the years of 2016 to 2018.

The Endlhausen area has a total of 30,16 ha with 27,55 ha of commercial forest and 2,61 ha agricultural land, forest meadows or lumberyards. The areas belong to two different church foundations and consist of small, scattered parcels. Spruce stands or mixed stands of spruce, beech and partially other tree species of different age classes - from thickening to mature trees - dominate the Endlhausen sub-area. Especially young and medium-aged stands of age class 2 (21 to 40 years) and 3 (41 to 60 years) or mature old stands with an age range of 101 to 140 years characterize the forest landscape. Small areas of young beech stands are present as well. To the east of the village of Endlhausen, there is a large mixed stand of beech and spruce trees with numerous biotope trees and deadwood. Other tree species such as noble hardwood, douglas fir, larch or oak can be found sporadically in the stand area. The stands are mainly single-layered and are mostly of the same age within a stand. According to Walentowski et al. (2020), the natural forest composition in the area would be a mixture of beech and spruce trees with scattered fir trees.

*The forest organisation data of 2018 shows, that the average area age ranges between 60 to 73 years and the timber stock between 384 to 473 Efm / ha (= harvestable cubic metre per ha). The stands are very rich in stocks and therefore have high stocking rates of between 1.1 and 1.3. This is reflected in the fact that the spruce-dominated stands in particular form small crowns and are therefore prone to snow breakage, wind breakage or windthrow. The average annual increment ranges between 12.6 to 13.2 Efm / ha * a. The average annual cutting rate ranges between 11.3 and 17.6 Efm / ha * a. Natural regeneration is present in most of the stands and mainly consists of spruce, in some places also of beech, which is, however, strongly browsed by roe deer (Erzdiözese München-Freising 2018).*

The Sauerlach area has a total area of 132.58 ha. The forest consists of many small, scattered plots of land, totalling 116.37 ha. These belong to many different forest owners which are managed by the Archdiocese. There is a well-structured network of forest roads and lumberyards in the forest areas. Young or medium aged spruce stands – pure stands or in mixture with other tree species – characterize the forest area. Mixed tree species for example are beech, pine or oak. Especially in the western part young and medium aged stands of spruce and pine dominate the area. Stands of deciduous trees play a minor role and are mainly of younger age with a high need of maintenance. The spruce stands are predestined for wind breakage and snow breakage or bark beetle infestation. Bare patches or clear cutted areas can be found in the forest especially in the eastern part of it. Walentowski et al. (2020) describe the potential natural forest composition of the area as a mixed stand of beech and spruce with occasional fir.

*The timber stock ranges between 173 to 391 Efm / ha. The average annual increment ranges between 12.5 to 13.0 Efm / ha*a. The forest inventory states that the cutting rate has been at 5.8 Efm / ha * a (Erzdiözese München-Freising 2018).*

The Buchberg area, which is located west of the city Geretsried has a total of 85.07 ha with 72.87 ha of commercial forest area. The minor part of the area are forest meadows, forest roads, agricultural land, lumberyards or high-voltage power lines. The area is property of the Archdiocese and is a single contiguous area. The stands consist largely of medium to mature mixed forests in the age class of 101 to 120 years. These

have already reached their target diameter and are designated for regeneration harvesting. The predominant tree species are spruce and beech, partly forming mixed stands together with pine, larch, and, in some areas, fir.

In certain sections, beech is the dominant deciduous species, lending its name to the district of "Buchberg." Much of the old-growth forest shows a well-developed natural regeneration of beech and spruce. Young growth and juvenile stands of an age between 10 to 60 years also cover a significant portion of the Buchberg area. Even within these younger stands, spruce remains the dominant species, followed by beech, other deciduous trees, larch, and noble hardwoods.

*The average area age is 64 years and the timber stock is 337 Efm / ha which corresponds to the standard stock of the area. The average annual total increment lays at 11.7 Efm / ha*a in the period of 2016. With a value of 14.7 Efm / ha * a, the annual cutting rate is higher than the average annual total increment (Erzdiözese München-Freising 2018).*

The fourth area at Gstaig, with a total of 139.37 ha of which 100.32 ha is commercial forests, is divided into two forest complexes by the course of the A95 highway. On the southeast of the highway, enclosed by spruce forests, there is a leased gravel extraction area of 11 ha. The other non-forest land consists of agricultural land, forest roads, meadows or sites for high-voltage power lines. Most of the forest area is made up of pure spruce stands of different age classes, with regeneration stands of ages between 85 to 135 covering the largest share. In many areas, spruce also forms stands with beech and larch or noble hardwoods (e.g. around the gravel extraction area). There are also some small areas of young mixed stands consisting of beech, deciduous wood or spruce. In some parts, mainly in small areas at the border of forest and agricultural land, stands of noble hardwood mixed with beech form the landscape (Erzdiözese München-Freising 2018).

There is currently no information about timber stock, average annual total increment or the cutting rate.

Forest management in the Living Lab area

The forests of the Archdiocese are primarily managed forests, which are subject to sustainable management practices and thus in accordance with the silvicultural objectives of the Archdiocese of Munich-Freising. The forest management planning, which is implemented every ten years, is an instrument for planning these objectives. All following information are taken from the forest management planning (forest inventory) from 2016-2018.

Since the stands mainly consist of even-aged or two-storied age-class forests, appropriate silvicultural measures are applied for the respective age classes. ***Table 9*** *provides an overview of the percentage distribution of silvicultural measures by type of forest utilization / stand age.*

On 11.90 % of the area, tending of young stands is planned. In this stage measures like game protection through hunting or tending is applied. Undesired trees or other competing vegetation is removed from the juvenile stand to influence the future target tree species composition. Approximately 26.39 % of the area is managed through early thinning of young stands with a DBH (= diameter at breast height) of about 10 cm. For 14.72 % of the stands, thinning in adult stands of an age between 41 to 80 years is intended. Thinning is the process of reducing the number of trees in a stand to accelerate the growth of the remaining trees by managing the amount and distribution of growing space. There are different practices applied by the Archdiocese. A popular practice is the selective thinning (target tree thinning, German: Z-Baum-Durchforstung). The objective of this method is to promote 100 selected future crop trees by means of targeted and frequent interventions, in which only a few competing trees are removed every 7 to 10 years.

The majority of the stands, covering 42.52 %, are in the regeneration phase. Here, the focus lies on regeneration of the tree population through targeted selective fellings and crown thinning. To promote natural regeneration, the shelterwood system (in particular applied in the Sauerlach sub-compartment) is predominantly used. To protect the natural regeneration from browsing by roe deer, some of these areas are fenced. In addition, hunting measures are also being taken to counteract browsing damage.

Furthermore, around 1 % of the area is under irregular management. About 2.16 % consists of gaps or clearcut areas, which may have arisen due to stochastic events (e.g. bark beetle infestation or windthrow) and are therefore designated for replanting.

***Table 9:** Area and percentage of the type of forest measures applied in the Living Lab Endlhausen.*

Type of forest utilization	*Sum in ha*	*Share in %*
Planting	*7.47*	*2.16*
Early thinning (pre-commercial thinning)	*91.33*	*26.39*
Young stand tending	*41.17*	*11.90*
Long-term treatment/management	*4.46*	*1.29*
Regeneration felling	*147.12*	*42.52*
Mature stand thinning	*50.94*	*14.72*
Irregular management system	*3.54*	*1.02*
Total	*346.02*	*100*

Infrastructure

The forest areas are very well accessible. The sites near Sauerlach and Endlhausen are located close to small villages, in some cases directly adjacent to local roads. The Buchberg sub area lies west of the town of Geretsried, next to the federal road B 11, and is therefore also well connected. The Gstaig forest is intersected by the A 95 highway and bordered by another state road to the east.

The forests are served by a well-developed and structured forest road network. The forest roads are maintained using a special technique developed by the company Laga. An adequate number of timber storage areas is available. In addition, a regular grid of skid trails is in place, which is particularly important for timber harvesting and extraction. The skid trails have continuous intervals of 25 m to 35 m.

Living Lab Waakirchen

Description of forest characteristics

The forest areas owned by private landowner L.B. cover approximately 279.13 hectares, of which about 124.06 hectares are forest land and the rest is non-forest land, primarily used as alpine pasture. The forest stands are situated in a larger, continuous woodland area to the west of Lake Tegernsee. While most of the property forms one coherent forest area, part of the ownership is highly fragmented and interspersed with neighboring owners' woodlands.

The forest itself is a typical mountainous mixed forest composed of spruce, beech, and fir, with coniferous species dominating. Scattered within the stands, however, one also finds other tree species such as oak, maple or pine. This composition corresponds closely to the natural forest community of the region (Walentowski et al. 2020). The stands are characterized by their multi-layered structure and diverse species mixture. All age classes are represented more or less evenly throughout the area.

In the western part of the property, near the Sigrizalm alpine pasture mainly grow conifer-dominated stands (age classes 81–100 years and over 100 years). Younger stands (age class 1–20 years) are mostly located in the relatively central eastern sections of the forest complex, in the compartments Geigenbach and Stacheleck, or in compartment Kehrberg (age class 21–40 years). Middle-aged stands are concentrated mainly in the compartments Gfällberg and Ochsenhütte (age class 61–80 years).

*Figures on average growing stock, annual increment, or annual allowable cut are not available. However, during joint field visits with the forest owner, it became clear that the average total increment is above the German national average (total increment is 11.2 m^3 / ha * a, BMEL 2014). The site productivity and the high growing stock of the stands were confirmed during the on-site inspection in February 2025 together with the owner.*

Forest management in the Living Lab area

For the large private forest estate, a forest management plan is prepared every ten years to assess and record the condition of the stands. Management and supervision of the woodland are carried out by the Forest Owners' Association in Holzkirchen (WBV Holzkirchen). There is no written statement of management objectives, but discussions with the owner indicate that he places strong emphasis on sustainable, multi-functional forest management. The goals are to ensure continuous timber production, while also maintaining and promoting a diverse and healthy forest. In addition, the owner values social functions such as recreation and education, and integrates biodiversity, nature conservation, and climate protection into his management objectives.

At the beginning of each year, the owner and the association's forester agree on management priorities and necessary measures. The forest is managed according to the principle of sustainability: only as much timber is harvested as can grow back naturally. Thinning is not carried out according to fixed schemes, but rather as needed, with natural regeneration being the primary method of renewal.

Since the forest is a healthy mountainous mixed forest with a varied vertical and horizontal structure, major bark beetle outbreaks or storm damage are relatively rare. Several years ago, however, a large windthrow occurred nearby the mountain „Rechelkopf". The affected areas were reforested in a planting and education project together with families, the local Nature Conservation Association („BUND-Naturschutz"), the Office for Food, Agriculture, and Forestry („AELF Holzkirchen") and the local Mountain Forest Initiative („Bergwaldoffensive").

Most of the thinning and tending operations are carried out by the owner himself, with the support of external timber contractors. The timber is felled by forestry contractors (harvester or cable car operators) who work with the WBV Holzkirchen, transported away, and marketed via the WBV Holzkirchen. Wood extraction is mainly done by cable yarding systems, as the terrain is steep and only partly accessible. For this method of harvesting, the owner receives financial support from the AELF Holzkirchen.

Protection of natural regeneration relies entirely on hunting measures. The forest is managed as a private hunting district, where roe deer and red deer are hunted in order to protect the sensitive regeneration of fir and beech from browsing and bark stripping.

Infrastructure

The forest area is located approximately 1.5 km from the nearest village, Marienstein (Waakirchen). It is well connected to the road network of the surrounding municipalities and towns. Within a radius of about 5 km there are several settlements, such as Gmund am Tegernsee and Waakirchen to the northeast, as well as Bad Tölz, Reichersbeuern, and Greiling to the northwest.

Most of the stands are well developed and served by an extensive forest road and trail network. In areas where machine thinning with a harvester is not possible due to limited accessibility, cable winches are used for timber extraction.

Forest Ecosystem Services in the Living Lab area

The forests in the Living Labs Endlhausen and Waakirchen provide multiple ecosystem services. These ecosystem services have been assessed on local and large-scale level. The results of forest ecosystem services assessment and the potential effects of forest management on ecosystem services supply are summarized in D2.2.1 Forest Ecosystem services assessment pilot action report.

Provision of wood biomass

The production output of the forest is primarily determined by the provision of wood as a raw material. The wood obtained during felling can be categorised as stem wood, energy wood, industrial wood and non-utilisable wood. Sustainable timber production and utilisation ensures that the amount of timber harvested does not exceed the annual growth. This ensures a constant supply of the raw material. The ability of the forest to produce wood, and thus the availability of the renewable raw material, is significantly influenced by the management method, environmental factors and species composition. The indicator which has been chosen to describe the provision of wood biomass in the Living Lab is the ***absolute timber stock of timber without bark in Efm D. o. R. / ha (= harvestable cubic metre without bark per ha)****.*

There is currently an average harvest stock of 310 Efm / ha (= harvestable cubic metre per ha) in the German Living Lab area. The forest areas of the Archdiocese of Munich-Freising (Living Lab Endlhausen) have an average harvest stock of 271.85 Efm / ha. Significantly higher values are to be expected for the forest areas of large private forest ownership in Living Lab 2 (423.62 Efm / ha).

Water provision

The ecosystem service of providing drinking water includes the natural filtration and purification of water suitable for human consumption. Forests, along with wetlands and aquifers, play a crucial role in maintaining water quality. The selected indicator which describes the ecosystem service best in the Living Lab is a ***forest structure indicator****. The forest structure indicator considers the proportion of deciduous trees in the stands and the forest cover, or the presence of cleared forest areas. A higher proportion of deciduous trees in forests leads in general to better drinking water quality, as deciduous trees absorb fewer pollutants from the air than conifers and release less nitrate into seepage water. In addition, deciduous forests produce more seepage water than coniferous forests, which leads to higher groundwater recharge and dilution of pollutants (Hegg et al. 2004; Rothe & Mellert 2004). Forest cover is relevant because (permanent) forests contribute to nutrient uptake through their vegetation, which reduces nitrate concentrations in groundwater while maintaining soil structure, retaining water and thus improving water quality. In contrast, clear-cutting can impair these positive effects by destabilising the soil structure and reducing water filtration.*

The supply of drinking water in the foothills of the Alps is currently stable, but climate change could affect water quality and jeopardise natural filtration through soil and vegetation. In particular, damage to forests due to heat, drought and pest infestation weakens their filter function. In addition, more frequent heavy rainfall events could flush more pollutants into the groundwater.

Habitat provision

The forest ecosystem service is described by the ***proportion of old trees*** *based on the forest management data of the forest owners and* ***an habitat quality index*** *based on the "Species and Habitats" protected asset map by the Bavarian State Office for the Environment (LfU 2025). The assessment criteria for the "Species and*

Habitats" protected asset map are the protected area classification (nature conservation areas, Natura 2000, natural forest reserves), the hemeroby and the valuable areas substantiated by technical bases (e.g. ABSP areas, areas of species conservation mapping (from 1990), mapped biotopes and areas with high biotope density (distribution and size of near-natural habitats). Based on a hierarchical decision cascade, forest areas were assigned value levels from 1 to 5, which were determined based on protection status, the proportion of old trees, and the presence of deciduous forests.

Based on the results of the indicator mapping, the habitat provision in the pilot region is for the most part rather low and is mostly at a value of 3 or below, which speaks in favour of medium to low habitat quality. Only the area in the Tegernsee mountains has larger areas with values of 4 and 5, which indicate habitat provision with high habitat quality. In the four other areas, such high values occur only sporadically, if at all.

Protection against natural hazards

A large number of natural hazards can pose a risk to human health and infrastructure. Forest ecosystems can mitigate the effects and ensure that rockfalls are intercepted and the triggering of avalanches is prevented. In addition, tree roots ensure greater stability of the terrain, which can prevent slope failures. Forests slow down and protect against shallow landslides and avalanches and can absorb rockfalls. Although forests cannot guarantee complete safety, the consequences can be greatly mitigated (Perzl 2006). The ecosystem service is represented by the ***percentage of forest, protective forest or functional forest per survey area****.*

In the Living Lab 2 Waakirchen there are avalanche protection forests according to Art. 6 of the Bavarian Forest Act (Bayerisches Waldgesetz - BayWaldG) and protection forests according to Art. 10 BayWaldG. The other parts of the Living Lab are in areas that are less susceptible to geogenic natural hazards, as there are no steep slopes for example. Only to the west of Großweil there is still a risk of shallow slope failures in a small corner. In the vicinity of the Living Lab the natural hazard of flooding plays a major role. Due to the massive human intervention in the natural drainage behaviour and heavy rainfall events, which have already intensified and increased due to climate change, there is a great risk of flooding and inundation. Numerous measures are therefore being taken to minimize the consequences. These include the designation of floodplains, for example to preserve water retention areas and the construction of new dams (Kreisstadt Miesbach 2025).

Carbon storage

The ecosystem service describes the ability of forests to absorb carbon dioxide (CO_2) from the atmosphere and bind it in the long term. This happens through the process of photosynthesis, in which trees absorb CO_2 and store it in the form of carbon in wood, leaves and roots. The indicator best suited to describe the ecosystem service is ***ton of cabon per hetarce (t C / ha)*** *and describes the amount of carbon (C) that is stored or sequestered per hectare (ha). For the calculation, the living, above-ground and below-ground quantity of carbon is considered. This indicator shows how much carbon a particular type of forest or vegetation stores per hectare per year. A detailed description of the assessment procedure is provided in the corresponding indicator factsheet. A high value means that the ecosystem binds a lot of carbon, while a low value indicates lower carbon storage. The ecosystem performance depends on the amount of living wood biomass in the living lab.*

Recreation

The forest ecosystem service recreation refers to the intangible benefits that people derive for their well-being and health from spending time in forest ecosystems. This cultural service includes opportunities for stress reduction, mental and physical regeneration as well as active and passive leisure activities in a natural

environment. The ecosystem service is described by the ***potential recreational value****. The potential recreational value is an assessment approach that classifies forest areas based on specific criteria with regard to their suitability for recreational use. It describes the perceived naturalness within a 40 metre radius of the existing trail network (based on Schulz & Meyer 2021). The aim of this assessment is to determine the attractiveness and benefits of forest areas for leisure and recreation. The categorisation is based on three main factors: Proximity to the trail network, age of the forest and mix of stands. These factors significantly influence the perception and usability of the forest areas by visitors (Edwards et al. 2010; Schulz & Meyer 2021). A detailed description of the assessment procedure is provided in the corresponding indicator factsheet.*

In recent years, the intensity of utilisation of forests for recreational purposes has increased significantly, leading to growing management challenges, particularly with regard to the balance between recreational use, nature conservation and forestry interests. The high demand for forest-based recreation emphasises the central role of this ecosystem service for the region.

Potential effects of forest management on FES supply

The ability of the forest to produce wood and other ecosystem services is significantly influenced by the forest management method, environmental factors and the species composition. A sustainable, multifunctional and nature-near forest management contributes to the permanent performance of the forest ecosystem and the preservation of biodiversity (UBA 2024). Sustainable forest management in general is characterized by the long-term maintainance of forest functions. The definition of Forest Europe below summarises the different effects : "Sustainable forest management means the stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfil, now and in the future, relevant ecological, economic and social functions, at local, national, and global levels, and that does not cause damage to other ecosystems."[8]

The principle of sustainability plays an important role in forestry and means that the amount of timber harvested does not exceed the annual growth. This allows the forest to be used in the long term and maintain its productivity. Sustainable forest management not only ensures a long-term supply of wood biomass but also has a positive impact on climate protection through long-term carbon storage and on biodiversity by providing habitats for wild animals and plants. Other services that fall under regulatory ecosystem services, such as the regulation of mass movements (avalanches, rockfalls, or landslides) in the Alpine region, or the regulation of floods, can also be supported through sustainable management practices. Positive side effects of a sustainable managed forest include enhancing the recreational experience for forest visitors. In opposite, unsustainable forest management practices, such as clear-cutting or the use of pesticides will have a negative impact on the provision of forest ecosystem services and reduce the supply or regulatory effect of the forest.

Business portfolio in place

The Living Lab already hosts some forest ecosystem service-related activities, which are described for both forest owners .

Living Lab Endlhausen

The forest in the Living Lab Endlhausen (Archdiocese Munich-Freising) serves primarily for sustainable timber production, which is the main business activity within the area. Coniferous wood, especially spruce, accounts for the majority of the timber harvest, as this is the predominant tree species in the Living Lab and is also affected by drought, storms, and bark beetle infestation. In 2024, the Archdioceses'timber harvest for

[8] *Forest Europe, download 21.10.2025: https://foresteurope.org/sustainable-forest-management/*

example was divided into 66 % stem wood, 8 % industrial wood, 8 % energy wood, and 18 % other usable wood (Erzdiözese München-Freising 2025 Quelle eingeben). There are no other business models in Living Lab Endlhausen.

Living Lab Waakirchen

The forest owner L.B. has the following business portfolio:

- ***Sustainable timber production*** *(Sale of timber to regional sawmills through the Holzkirchen Forest Owners' Association and use of energy wood in own wood chip plant*
- *Implementation of* ***cooking concepts and cooking courses*** *at his own alpine hut*
- ***Leasing of the alpine hut***
- ***Artistic events*** *and sculpture trail in the forest by the association Almresidency e.V., which are financially funded by the ministery*

In addition, the following subsidies are utilized to complement the business portfolio

- ***Contractual Nature Conservation Program*** *("VNP Wald"), a Bavarian funding scheme. The program aims to preserve and enhance valuable habitats for flora and fauna, support the Natura 2000 network, and contribute to Bavaria's biodiversity strategy. Farmers and forest owners receive compensation for managing their land in an environmentally friendly manner, covering additional costs and income losses. Through this program, habitat trees as well as standing and lying deadwood structures are promoted across the entire forest area.*
- ***FNR funding scheme for Climate-Adapted Forest Management*** *("Klimaangepasstes Waldmanagement"): The purpose of this funding is the conservation, development, and management of climate-resilient forests.*
- ***Financial government support for silvicultural measures****, e.g. cable transport or measures to sustain the protective forest*

Economic valuation of Forest Ecosystem Services

Living Lab Waakirchen

While full economic valuation of FES in Waakirchen is reported in D 2.3.1 Transnational pilot testing FES economic assessment and market frameworks in each LL, for the purpose of this feasibility assessment, we present valuation results for the ecosystem services that were in focus of the LL activities, namely the provision of timber wood, firewood and fuelwood biomass, habitat provision for wild plants and animals, protection against rockfall, carbon sequestration and recreation. No valuation was performed for water provisioning services, due to data unavailability. Please refer to D 2.3.1 for further details on valuation methodology.

The results of the adjusted unit value transfer for the German Living Lab in Waakirchen are presented inFigure 16. Only values obtained through the adjusted value transfer method (Alpine average) and voluntary carbon market pricing for carbon sequestration are reported as conservative estimates. Upper-bound estimates include direct market valuation for timber and firewood biomass provision, a unique adjusted value transfer for provision of habitats from a single primary study conducted in Germany on the national scale, and recommended carbon pricing (upper-bound) for carbon sequestration.

According to conservative value estimates, protection against rockfall has the highest value per ha of forest. Provision of habitats for wild plants and animals is the third most valued FES; however, the difference

between the top two most valued and habitats provision is significant. An upper-bound value for this service derived from a German nationwide primary study mitigates this difference, making provision of habitats the second most valued per ha FES in the LL. The same dynamics are observed for timber and firewood biomass provision. Their values per ha increase almost threefold and

The value per ha of timber provisioning increases almost threefold when local market price estimates are used for valuation, indicating an underestimation of the Alpine average.

- *High sensitivity to valuation method: Upper-bound unit values incorporate direct market pricing for firewood biomass, which raises per-hectare estimates relative to conservative average Alpine values (i.e., adjusted unit transfer). This highlights the influence of valuation methodology on the estimated unit value of firewood.*
- *Low relative importance: Regardless of valuation method, provision of firewood biomass remains second the last FES in terms of social value per ha, revealing its rather low relative importance in the area.*
- *No total economic value (TEV) analysis: Forest area providing this FES fully overlaps with timber wood biomass provision (i.e., total forest area). Meanwhile, only a small subset of non-provisioning FES could be valued in TEV terms, and even those estimates are likely underestimated due to indicator limitations and data scarcity. To avoid double counting and an inflated valuation of provisioning services, this FES was excluded from the TEV analysis.*

Carbon sequestration, according to the revenue potential on the voluntary carbon market, is valued almost as much as timber wood biomass (using the Alpine average). However, the value of this FES increases by five times when recommended carbon pricing is applied. This indicates a higher priority of carbon sequestration for the broader society, making it the fourth most valued FES in the LL after the other three regulating services. In the current FES portfolio, a unit value of recreation is relatively moderate and very dependent on the estimate choice (i.e., conservative vs. upper-bound).

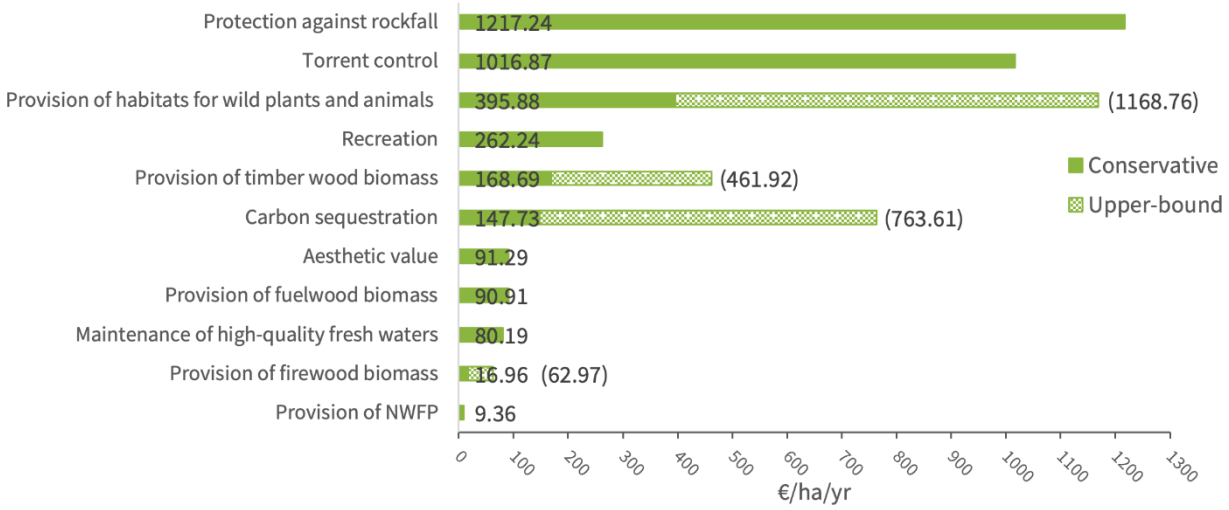

Figure 16: *Unit value estimates in 2023 euros per ha. Upper-bound value estimates are provided in parenthesis. NWFP stands non-wood forest products, including chestnuts, mushrooms and berries.*

Estimates of the total economic values (TEV) of forests in Bad Tölz, using both conservative and upper-bound unit value estimates, are demonstrated in Figure 16. According to the conservative estimates, each FES contributes to TEV almost equally, with timber wood biomass provision having the biggest contribution

(29%), followed by carbon sequestration (25%), recreation (23%), and provision of habitats (22%). Although the share of contributions to upper-bound TEV changes, the inconsistency between the value per ha and the total value for provision of habitats persists: Although this FES is among the top three most valued FES (and all of them are regulating services), in absolute terms timber wood brings a bigger contribution to TEV. This suggests that targeted efforts on expansion of the forest area providing habitats for wild plants and animals will have a substantial effect on the TEV of forests in Bad Tölz. Another inconsistency between the relative (value per ha) and absolute value is observed for the most valued FES in relative terms – protection against rockfall. The forest area dedicated to this FES is so small (only 55 ha) that the total contribution of this FES to TEV is rather marginal. This observation might indicate that this FES is provided only in a few small areas of the LL this FES is provided and expansion of the forest areas holds a huge potential for increasing TEV of the LL forests.

It must be noted, that provided TEV estimates are a serious underestimation, as the number of FES included in the calculation was restricted to five. Nevertheless, the unit value results, discussed above (see Figure 17), suggested the importance of these five FES for the Living Lab. Despite underestimation, value of timber provisioning service constitutes less than 30% of the forest TEV, suggesting that the social importance of forests in Bad Tölz extends well beyond timber production. At the same time, we must keep in mind that the forest area providing provisioning services fully overlaps with the one providing carbon sequestration and partially with other FES, hinting at potentially detrimental losses in social value of forests if forest management is fully oriented at timber provision.

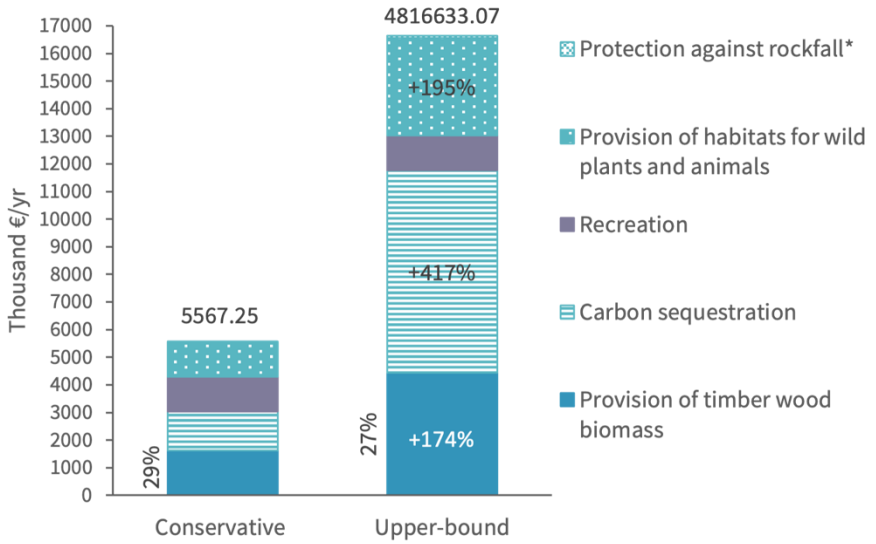

Figure 17: *Conservative and upper-bound estimates for total economic value (TEV) of forests in Bad Tölz. Total values per year for each FES are estimated based on the forest surface areas providing respective services. Percentages for provision of timber wood biomass placed on the left of the bars indicate a contribution of timber wood provision to the TEV. Percentages placed inside the bar indicate difference in total values of FES between conservative and upper-bound TEVs, when such difference occurred. Numbers on the top of the bars indicate the TEVs. *Total value of the protection against rockfall FES is marginal (67 thousand euros per year) relative to other FES, therefore, it is invisible on the graph.*

Spatial distribution of FES social values in Bad Tölz further details our understanding about the FES provision in the Living Lab (s. Figure 18). Not all values are evenly distributed throughout the territory of the Living Lab.

While most of the forest area provides well below expected average value per ha (878 €/ha/yr[9]), in only a few areas values per ha are relatively close to the expected average. These areas are present in the north-east of the LL (mountain Taubenberg) and in the mountainous area west to the Tegernsee. Areas with relative values above the expected average are very scarce and practically absent in the LL.

This map can support future land use policies and steer the discussion on what areas must be protected (i.e., highly valued areas) and what areas demand special attention and changes in forest management (i.e., areas with lower value per ha). Supplementing this map with spatial distribution of forest ownership as well as residential and recreational areas could shed more light on the FES providers and main beneficiaries, thereby, providing further foundation for decisions about payments for FES (payment to whom?) and equal access to the benefits provided by forests.

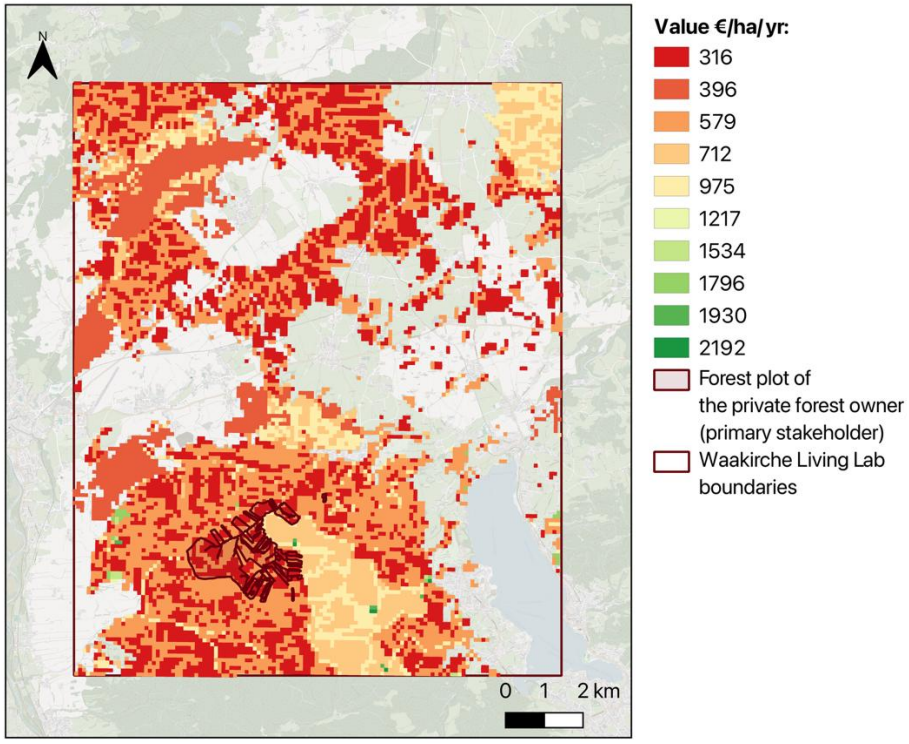

Figure 18: *Spatial distribution of conservative unit values in Bad Tölz. Minor overdistribution (1%) is present for the unit value of the provision of habitat for wild plants and animals. Some degree of spatial under- and overdistribution is present for the unit value of carbon sequestration, as unit value estimation is based on mean carbon sequestration per ha, not carbon sequestration specific to the forest unit.*

Feasibility Assessment

Development scenario

The German living lab is already experiencing the effects of climate change especially in the form of increasing temperatures and extreme weather conditions such as droughts, heavy storms and alterations in precipitation (Klima Report Bayern 2021). Different climate scenarios show that these factors will increase in

[9] *As forest areas providing timber wood biomass and carbon sequestration has a 100% overlap, at least two FES are expected to be at each ha, therefore, expected average is a representative midpoint value. It was calculated as follows:* $Expected\ average = Average\ of\ all\ FES\ values\ per\ ha \times 2$

the next decades. The increase of climate change effects influences the stability and vitality of forests significantly and have serious consequences for the ability of forests to continue providing socially desirable ecosystem services in the future (BfN 2020; Höltermann 2021). Trees' susceptibility to harmful influences and their reaction to damaging factors increased – caused by extreme weather conditions (Köhl et.al. 2023). Factors such as longer vegetation periods and droughts not only weaken trees and increase their susceptibility to windthrow, but also promote diseases and insect outbreaks (e.g. bark beetle infestations), which ultimately lead to a loss of biodiversity (Kölling, Zimmermann 2007; Köhl et.al. 2023).

Studies indicate that due to projected climate change, Germany's most common tree species are expected to retreat from the warmer edges of their current distribution ranges (Kölling, Zimmermann 2007; Köhl et.al. 2023). Specifically, species such as Picea abies and Pinus sylvestris are shifting their core habitats northward and to higher elevations (Köhl et.al. 2023). In mountainous regions, this translates to an anticipated upward shift in altitudinal limits of 300 to 400 meters (Kölling, Zimmermann 2007).

These changes conclude to:

1. ***Increased vulnerability and forest destabilization:*** *there will be an increased risk of windthrow and greater vulnerability to diseases and insect outbreaks.*

2. ***Geographic shift in forest composition:*** *The current species composition will change as species are forced to move simultaneously with their ecological niche. The shift will be directional towards north and altitudinal in higher elevations.*

3. ***Degradation of ecosystem services and loss of biodiversity:*** *The ability of forests to provide socially desirable ecosystem services (like clean air, water regulation, recreation, and timber) is threatened in areas with shifting forests. The stress from pests and diseases, which are thriving in the new conditions, directly leads to a reduction in biological diversity.*

In response to these challenges, forest management strategies must prioritize the promotion of climate-tolerant, site-appropriate mixed forests to enhance the resilience of the forest ecosystem. Furthermore, this requires proactively adjusting future tree species compositions to align with projected climate changes, thereby ensuring the long-term stability and function of forests at different altitudes and geographical areas (Köhl et.al. 2023).

Objectives

Ecological objectives

The following section gives an overview of the ecological objectives for the treatment of FES in the Living Lab:

Provision of wood biomass

Ecological objective: *Establishment of stable, mixed and multi-layered forests to ensure long-term and sustainable wood biomass supply.*

Both forest owners who represent the Living Lab aim to have a sustainable and long-term provision of timber. This should be achieved through the establishment, preservation and management of stable, mixed forests that are structurally rich and composed of trees of different ages, ideally maintained as permanent cover forests ("Dauerwälder"). Management practices focus on maintaining soil fertility through adapted harvesting techniques, while ensuring that annual harvest levels do not exceed the natural increment.

Targeted silvicultural measures foster mixed, multilayered forests that do not only support long-term timber production but also contribute to climate protection and enhance resilience against storms, drought, and bark beetle outbreaks.

Water provision

Ecological objective: *Ensuring a sustainable supply of clean drinking water.*

The ecological objective is to maintain near-natural forest soils that act as natural filtration and storage systems by the establishment and preservation of broadleaved and mixed forests. One key aspect involves the strict avoidance of clear-cuts and the continuous preservation of full forest cover. This approach will minimize soil erosion, optimize infiltration, and stabilize the water cycle. Furthermore, recommended is the targeted establishment and significant increase in the proportion of broadleaved trees and diverse, site-appropriate mixed forests. Such forest types might enhance climate resilience, improve soil water retention, and foster stable, high-quality groundwater recharge. Through the examination of these practices, the goal would be to optimize natural water storage within soil layers and maximize groundwater formation, which is crucial for mitigating droughts and ensuring consistent water supply. This would also promote healthy soils and their natural filtration functions, supporting the overall stability of water-related ecosystem services.

Provision of habitats for wild plants and animals

Ecological objective: *Maintenance and Promotion of habitats for animals and plants*

Biodiversity is supported by retaining habitat trees, deadwood, and structural diversity within stands. Further objectives include promoting very old trees (Methuselahs), rare tree species, and open structures in the forest (e.g. clearings). Biodiversity is also promoted by refraining from timber harvesting in parts of the forest or by developing and sustaining species-rich forest edges. These ecological objectives ensure the maintenance of diverse habitats, strengthen ecological networks, and foster resilient forest ecosystems. Some of these measures (e.g. habitat trees) are already implemented in the living labs to a certain extent. It could be evaluated if existing subsidies could be used for some of those measures.

Protection against natural hazards

Ecological objective: *Protecting people, infrastructure, and property by promoting sustainable forest structures*

This objective is primarily relevant to Living Lab Waakirchen, where the focus is on defining recommendations for forest management in areas susceptible to rockfall. A central objective is to ensure the permanent and uninterrupted forest cover across the landscape, crucially involving the strict avoidance of clear-cuts. Such continuous forest presence is considered fundamental for slope stability and effective rockfall prevention. Therefore, forest stands must be developed in a way so they can be highly resilient to climate change impacts. Promoting deep-rooted tree species is seen as a key strategy to significantly enhance slope stabilization, which is vital for effective protection against rockfall. For altitudes between 650m and 1200m, such a climate-stable forest would ideally be composed of a diverse mix of native, site-appropriate tree species. This could include a significant proportion of deep-rooting broadleaves (e.g. beech, sycamore maple) alongside resilient conifers (e.g. silver fir), chosen for their projected climate stability and robust soil-binding capabilities. Such a mixed and structurally diverse forest, with varying age classes, would enhance resilience against future climatic changes and secure its protective function.

Carbon sequestration and storage

Ecological objective: *Long-term carbon sink effect through permanent, climate-stable mixed stands*

Carbon storage and sequestration are promoted by maintaining mixed stands with a climate and site adapted tree species composition and extending rotation periods. Thus, carbon can be retained in the living biomass. The use of harvested wood in long-lived products, such as construction timber, further contributes to carbon storage outside the forest. Retaining standing deadwood adds an additional carbon pool and supports ecosystem functions.

Recreation

Ecological objective: *Preserving and promoting regional tourism in the Alps in harmony with nature conservation and forestry*

Forests provide recreational benefits through attractive, near-nature landscapes and well-maintained trails.

For both Living Labs, the recreation objectives focus on maintaining and enhancing the ***ecological integrity and aesthetic appeal of forest landscapes****. This appeal is notably heightened by the presence of* ***diverse, structurally rich, and uneven-aged forest stands****, which provide high-quality, near-natural environments that support diverse forms of human well-being and a profound connection to nature. The overarching goal is to facilitate a sustainable coexistence between forest-based recreation and the ecological functions of the forest.*

Building upon these ecological foundations, the Living Labs also aim to explore specific business models for recreation, namely environmental education program in Waakirchen, and the development of a spiritual approach through a burial forest in Endlhausen, both leveraging the unique recreational potential of the forest.

Economic objectives

The following section gives an overview of the objectives for the development of new economic value chains for both forest owners:

Internalization of positive externalities (monetization of ecosystem services)

A sustainably managed mountain forest provides many forest ecosystem services for society (e.g., protection against avalanches, clean drinking water, carbon storage). On the other hand, there are ***costs*** *that the forest owner has to bear, for example, for maintenance measures in the forest or forgoing harvesting. Apart from the provision of raw timber, the forest owner receives no direct remuneration for this. The new business ideas are intended to indirectly* ***compensate for the additional ecological services****, so that customers pay not only for the product (e.g., trees) but also for the* ***"added value"*** *that results from sustainable forest management.*

Diversification of revenue sources and risk minimization

Another objective of both forest owners is to generate stable and predictable income streams through ***entrepreneurial risk diversification****. In addition, the aim is to ensure that the forestry operation is* ***solvent*** *at all times and that* ***no liquidity bottlenecks*** *arise. To achieve this, business models that are independent of timber sales are to be established, as traditional forestry is heavily dependent on timber prices. A slump in the timber market, bark beetle infestation, or storms can have a massive impact on annual revenues. Business models such as those mentioned below are* ***independent of timber market and timber prices****. For example, the burial forest generates long-term, contractually secured revenues. This creates a high degree of financial planning security.*

Maximizing the contribution margin of the new business idea

After deducting variable costs (e.g., administrative expenses, marketing), the business ideas should generate a ***positive contribution margin****. The aim is to make the new services so efficient and attractive that they not only cover their own costs but also contribute significantly to the* ***financing of other operational tasks*** *(e.g., maintenance of young stands, expansion of the road network). Initial investments, for example in the burial forest for the expansion of infrastructure or approval costs, must be* ***amortized over the term****.*

Increasing long-term company and "brand" value

By establishing innovative, sustainable business models, the company is positioning itself as a modern and forward-looking player. This should increase not only its pure financial value (asset value) but also its ***intangible value*** *(brand value, reputation). Both the establishment of a burial forest and a "green initiative" can promote a* ***positive public image****. The forest owner is recognized by the public as a provider of multiple services. The positive image can thus have an impact on timber sales and make the business attractive to future employees or partners. This increases the overall value of the forestry business.*

Measures

The conversion of vulnerable pure stands (e.g., spruce monocultures) into site-appropriate, structurally and species-rich mixed forests is an effective measure to maintain and improve many ecosystem services. It increases stability against storms and pests, creates diverse niches, improves groundwater recharge and filtration, and ensures continuous carbon storage in biomass and soil through a permanent canopy.

- *A plenter and femel system preserve the forest character in the sense of recreational and spiritual value, ensures continuous stocking to protect against natural hazards, and avoid the drawbacks of clear-cut areas.*
- *Deliberately leaving dead trees and old, cavity-rich deciduous trees standing is essential for animal, fungal, and plant species. Deadwood also stores carbon and water and serves as a nutrient source for the next generation of the forest.*
- *The use of cable crane systems, horses, or machines with wide tracks reduces soil compaction. This protects the soil as a carbon repository, preserves its filtration function for clean drinking water, and safeguards the livelihood of forest vegetation.*

Measures that are mostly negative for the forest ecosystem services are: Extensive clear-cutting maximizes short-term timber revenue, but leads to erosion, an abrupt loss of habitats, a temporary suspension of protective functions, and releases large amounts of carbon from the soil due to strong sunlight. The recreational value is also severely affected. The use of heavy equipment on unsuitable soils leads to severe soil compaction, which accelerates water runoff, hinders water filtration, and damages root growth, thereby affecting the long-term vitality of the forest. At last, the removal of any residual wood and deadwood for energy use deprives the forest of important nutrients and destroys the habitat for a variety of organisms.

To summarize not all measures can support all kinds of ecosystem services. Therefore, it's important to focus on a multifunctional forestry. To manage the conflicts of objectives, the management should occur mosaic-like and adapted to the location by placing different emphases on various partial areas (s. ***Table 10****).*

Table 10: *Forest Ecosystem Services and Forest measures.*

	Measure						
	forest conversion to stable	*Plenter system,*	*Keep Dead wood,*	*Soil-friendly timber*	*Extensive clear-cutting*	*Use of heavy equipment*	*Complete 'clearing*

	mixed forests	Femel system	habitat trees	harvesting methods		on unsuitable soils	out' of the forest
Provision of wood biomass	reduce	keep	reduce	Keep	improve	keep	keep
Water provision	improve	improve	improve	Keep	reduce	reduce	reduce
Habitat provision	improve	improve	improve	Keep	reduce	reduce	reduce
Protection against natural hazards	improve	improve	Improve	Keep	reduce	reduce	reduce
Carbon storage	improve	improve	improve	Keep	reduce	reduce	reduce
Recreation	keep	keep	keep	keep	reduce	reduce	reduce

Priorities

Both forest owners participating in the Living Lab want to expand their existing business portfolio and have expressed interest in various business models, which are briefly described below.

Living Lab Endlhausen

Options for business portfolio development, which business models are of general interest for the forest owners

The current business model of the Archdiocese of Munich-Freising consists mainly of timber production and the sale of wood biomass. In addition, the Archdiocese also sells Christmas trees and fir branches during the Christmas season. The Archdiocese would like to maintain sustainable timber production and is considering the following business ideas for expanding its forestry business :

- *Establishment of a burial forest to promote recreation and the spritual value of the forest*
- *Promotion of the ecosystem service of habitat provision through participation in the Forest Contractual Nature Conservation Program (VNP)*
- *Rewarding the carbon storage capacity of forests through the sale of CO2 certificates*
- *Setting up an eco-points account (Ökopunktekonto) for nature conservation measures*
- *Promoting the provision of drinking water from forests through cooperation with beverage manufacturers*
- *Recreation and leisure services (e.g., nature tourism, outdoor activities) are gaining relevance.*
- *Providing forest areas for wind turbines*

Description and rationale for priorities for the business model needed and ecosystem services to be maintained

In this section, the priorities of the business model and the related ecosystem services are defined and justified. The Archdiocese of Munich and Freising aims to develop a ***burial forest*** *that complements its existing forestry activities while ensuring the long-term provision of essential ecosystem services. The rationale for these priorities lies in balancing economic diversification, ecological sustainability, and the Church's social and ethical mission.*

- *Strategic diversification of forest income: The concept offers an innovative non-timber-based revenue stream, reducing economic dependence on fluctuating timber markets and aligning with the Archdiocese's objective of sustainable, multifunctional forest management.*
- *Alignment with ethical and societal values: As a church forest owner, the Archdiocese seeks to provide spaces for spiritual connection, remembrance, and ecological awareness — integrating moral, social, and ecological dimensions into one coherent land-use model.*
- *Sustaining key ecosystem services:*
    - *Habitat provision: limiting disturbance and maintaining structural diversity foster habitats for forest species, enhancing biodiversity.*
    - *Recreation and cultural services: the burial forest enhances recreation and spiritual well-being, creating cultural and emotional value while improving public acceptance of forest management.*
    - *Carbon storage: maintaining continuous forest cover and extending rotation periods increases carbon sequestration potential.*
    - *Provision of wood biomass: continued low-intensity forest management ensures long-term timber growth and selective harvesting for sustainable use.*

Living Lab Waakirchen

Options for business portfolio development, which business models are of general interest for the forest owners

The forest owner L.B. aims for a holistic approach to promoting forest ecosystem services and is striving to supplementing the current forestry operation with the following business ideas:

- *Sale of valuable timber to promote the provision of wood biomass*
- *Sale of CO2 certificates to promote the FES carbon storage*
- *Participation in the eco-account (Ökopunktekonto) to enhance habitat provision*
- *Establishment of a cluster association "Green Initiative" consisting of various local associations to promote recreation and environmental eduction in the region*
    - *Offers for forest education tours and forest education programs*
    - *Carrying out nature conservation activities with local people*
    - *Organizing culinary and artistic events*
    - *Workshops at the mountain hut about "Management consulting in the forest"*

Description and rationale for priorities for the business model needed and ecosystem services to be maintained

The interest mainly lays in establishing a "Green Initiative," a cluster of various local associations. By forming a cluster, the actor can jointly develop and offer activities that promote ***forest-based education, biodiversity conservation, and recreational experiences****, thereby strengthening both ecological outcomes and regional identity.*

The key forest ecosystem services targeted are:

- *Recreation, by providing accessible forest experiences and nature-based events that support human well-being;*
- *Habitat provision, through active biodiversity management and species protection initiatives;*
- *Carbon storage, by maintaining healthy forest ecosystems and supporting climate regulation;*
- *Provision of wood biomass, through sustainable and educational demonstrations of forest use.*

The priorities therefore lie in fostering cross-sector collaboration, maintaining key ecosystem functions, and positioning the Waakirchen forest as a regional hub for education, conservation, and sustainable recreation. This aligns closely with the forest owner's strong social and ecological commitment and contributes to long-term, multifunctional forest management.

Selected business ideas

Two business models are being considered in the pilot area, one for each part of the living lab. The first business model for the Buchberg section of the living lab involves establishing a burial forest. The second model for the Living Lab 2 Waakirchen is dedicated to implementing a so called "Green Initiative". The following section gives a description of the selected business ideas.

Living Lab Endlhausen

Selected business model: *Burial Forest in Buchberg*

Affected ecosystem services: *Spiritual value of the forest / "recreation "*

The selected business idea "burial forest" is an alternative to the traditional cemetery. There, the deceased can be buried in an urn under a previously selected tree. A ***burial forest*** *is legally classified as a special type of cemetery. In Bavaria, such a project is subsumed under the category of a* ***natural cemetery*** *(Naturfriedhof). According to the Bavarian State Ministry of the Interior, for Sport and Integration, natural cemeteries are facilities on largely natural grounds where burials, such as the interment of urns at the roots of trees, take place. This classification means they are legally considered full-fledged cemeteries within the meaning of the* ***Bavarian Burial Act (BestG)****.*

The so called "burial tree" is marked with a small name plaque. The burial forest should be kept as natural as possible, floral decorations or candles are therefore prohibited. There are also restrictions in forest management, interventions are carried out only when necessary and as minimally as possible. Examples are re-plantings, if burial trees collapse, or measures to promote natural regeneration. Forest owners also have an increased duty to ensure and maintain safety, for example inspection of trees or securing paths. The forest areas can be accredited with the PEFC seal.

There are two ways to implement the business model, which are briefly explained below.

Option 1: *Leasing of forest land to operators of a burial forest*

- *Leasing of forest land to burial forest companies (lease according to contractual agreement)*
- *Income is only generated by the lease of forest land. However, the costs of implementation are borne by the operator.*
- *Implementation, consulting services, and funeral planning are carried out by the operator.*
- *Forest lessors can provide support, e.g., with forest tours, burials, etc.*

Option 2: *Independent operation of a burial forest*

- *Implementation, consultation and funeral planning in own hands of the forest owner*
- *Income is generated from tree burials, but all costs are borne by the independent operator, in this case the forest owner*

The following conditions apply to the establishment of burial forests: *The area should be at least 5 to 10 hectares in size. There should be a well-maintained network of paths and connections to public infrastructure. In addition, it is necessary to establish a ceremonial site where the funeral ceremony can be held. The forest should be located near a densely populated area, such as a city or big town. A mixed forest with old trees is particularly suitable for a burial forest.*

The forest area on ***Buchberg****, owned by the church forest owner, would be suitable for the burial forest. The feasibility of implementation is being discussed internally in the forest administration of the Archdiocese, so no decision has been made up to now if the Archdiocese will choose an independent operation or will lease their forest land to operators of burial forests.*

Living Lab Waakirchen

Selected business model: *Green Initiative in Waakirchen*

Affected ecosystem services: *Recreation, Habitat Provision, Carbon Storage, Provision of Wood Biomass*

The second business idea, "Green Initiative," aims to contribute to sustainable regional development. The focus here is on making the forest a place of learning, inspiration, and ecological engagement. This can be achieved by bringing together various associations of the regional level to form a kind of sustainable forest cluster. This is because there are often many different associations in the regional context that deal with the same forest ecosystem services but do not work together.

For example, the German Alpine Club deals with tourism and Alpine nature conservation. The topic of nature conservation, on the other hand, is also taken up by local nature conservation associations, nature conservation administration or ecological hunting clubs. The municipality could be a possible sponsor of the cluster. The cluster focuses on forest education and experiences, biodiversity and species protection, and recreational activities. Possible services of the cluster could include forest education programs such as guided tours, workshops, children's birthday parties, adventure days, or culinary or artistic events, as well as various nature conservation activities (e.g., tree planting campaigns).

The forest areas in the ***Waakirchen*** *sub-area were designated for the Green Initiative. The forest owner has a strong personal network in the area, is active in different associations, and is committed to ecological and social issues.*

The following remuneration options are under discussion and still need to be worked out in detail:

- *Collection of membership fees*
- *Cooperation with local companies and sponsorship by these companies*
- *Participation in the regional visitor's tax (Kurtaxe)*
- *Fees for services, such as forest tours, and participation of forest owners in the profits*

There are hardly any special requirements regarding the nature of the forest areas, except that good access to the forest is advantageous.

Factores for feasibility assessment

The following chapter gives a qualitative description of opportunities, challenges and feasible options for FES maintenance (from D2.2.1) in terms of the factors technical and ecological feasibility, legal compliance, economic feasibility and operational feasibility for the business models burial forest and green initiative.

Living Lab Endlhausen

All feasibility factors relate to the independent operation of a ***burial forest****.*

Technical and ecological feasibility

In general the burial forest will require an improved network of easy accesible foot pathways, parking area and an offer of attactive burial tress. All these pre-conditions would be possible in the area Buchberg, but will need some investment.

As outlined above, a burial forest will increase cultural ecosytem services such as recreation, contemplation or spirituality in the context of an peaceful forest. Also, the management of a burial forest will require a careful and sensitive management of the forest, the individual fostering of the burial trees. This means regulating ecosystem services such as habitat function, CO2-storage, water filtration will be maintained and even improved.

Economic feasibility

From a forest economics perspective, the establishment of a burial forest represents an innovative extension of traditional forest value chains in Bavaria. It integrates cultural and spiritual ecosystem services into forest management, transforming a purely silvicultural asset into a service-oriented and emotionally valued landscape use. The business model aims at long-term, stable revenues through the allocation of burial rights, while maintaining ecological integrity and social acceptance.

The following lists a rough estimation of potential costs, financial risks, and possible revenues from the "burial forest" business model:

Expected Costs

One-time (initial) costs

- *Silvicultural preparation (e.g., selective thinning, tree safety measures)*
- *Site development and infrastructure: construction of parking areas, pathways, fencing (as legally required), and design of the central memorial or ceremony area*
- *Administrative and approval fees*
- *Expert assessments and planning studies (e.g., ecological and landscape assessments)*
- *Land registry and notarial fees, if the establishment of a servitude is required (not applicable if the church acts as a public legal entity)*
- *Initial selective tree inventory and evaluation, assessing tree vitality and future stability to determine suitability as memorial trees (influences pricing)*

Ongoing operational costs

- *Advisory and customer service*

- *Administrative costs, including:*
    - *Digital infrastructure and data management (e.g., integration into a GIS / database system for plot management)*
    - *Accounting and tax consultancy*
    - *General administrative workload*
- *Insurance costs (e.g., business interruption insurance after storm events, public liability insurance)*
- *Continuous forestry work (stand maintenance, tree inspections, safety measures – the most significant cost item)*
- *Material costs, such as:*
    - *Tree identification plaques*
    - *Biodegradable urns*
    - *Equipment and materials for the ceremony area*
    - *Seating and possibly sanitary facilities*
- *Marketing and communication expenses*

Opportunity costs

- *Loss of traditional forest income, as the area is withdrawn from regular timber production. These foregone revenues represent a substantial economic value and must be considered in the pricing of burial rights.*

Financial Risks

- *Loss or damage of memorial trees, requiring replacement or reallocation*
- *Major damage events, such as storm impacts, bark beetle infestations, or drought stress*
- *Long-term financial obligations, including maintenance, restoration, or possible extension or decommissioning costs*
- *Need for financial reserves to ensure perpetual care and risk coverage*

Potential Revenues

- *Burial rights (usage rights), depending on the duration, tree species, tree age, and location, typically categorized as:*
    - *Individual or communal trees*
    - *Partner trees*
    - *Family trees*
    - *"Shooting star trees" (for infant or symbolic burials)*
- *Interment fees (service and coordination costs for individual burials)*
- *Sales of biodegradable urns and memorial plaques*

- *Special services, such as:*
    - *Provision of pastoral support for ceremonies*
    - *Organization of musical or personalized memorial elements*
    - *Individual scheduled consultations (group information sessions usually free of charge)*
- *Secondary forestry utilization, e.g., sale of firewood resulting from safety felling operations*
- *Donations and endowments, particularly from relatives or community foundations*
- *Annual memorial events (e.g., on All Saints' Day) that may generate voluntary donations*

Operational feasibility

From a forest management perspective, the operational feasibility of a burial forest depends on the adequacy of forest infrastructure, the availability of qualified personnel, and the alignment of stakeholder interests. The successful implementation requires a balance between ecological management, visitor accessibility, and the dignified character of the burial site.

To ensure both ecological stability and public safety, specific ***forest management measures*** *are necessary throughout the planning and operational phases:*

- *Initial silvicultural preparation: selective thinning to open the stand structure, removal of hazardous trees, and establishment of safe access routes.*
- *Tree assessment and selection: regular evaluation of tree vitality and stability to ensure suitability for burial purposes.*
- *Ongoing maintenance:*
    - *Vegetation control along paths and ceremony areas.*
    - *Periodic tree safety inspections (typically every 1–2 years, or after major weather events).*
    - *Repair and renewal of infrastructure (paths, fences, seating areas, signage).*
    - *Ecological monitoring of biodiversity conservation and soil protection.*
- *Forest hygiene and safety work: removal of storm-damaged or infested trees to maintain visitor safety and visual integrity.*

The ***expected workload*** *moderate but continuous, with* ***increased intensity*** *during the establishment phase and the first years of operation, but is not completely different from ordinary forest management. Once the forest has reached a stable condition, annual maintenance requirements decrease but remain significant due to safety and visitor management obligations.*

The operation can largely be integrated into the existing forest enterprise structure, provided that ***trained forestry staff*** *is available. Key personnel requirements include:*

- *Foresters or forest technicians, responsible for tree selection, maintenance, and safety inspections.*
- *Administrative and customer service staff, for managing burial rights, GIS documentation, and coordination with families and authorities.*
- *External specialists, if needed, for legal advice, ecological monitoring, or landscape design.*

The use of digital tools (e.g., GIS- or database supported grave management system) can increase efficiency and reduce administrative work load.

In operational terms, the Burial Forest concept is ***feasible*** *within the existing framework of the Archdiocese Munich-Freising, provided that:*

- *sufficient qualified personnel and digital management systems are available,*
- *safety and ecological maintenance are prioritized, and*
- *stakeholder collaboration is institutionalized through transparent and participatory processes.*

With these conditions fulfilled, the burial forest can be managed efficiently, sustainably, and in accordance with both forest management standards and societal expectations.

Legal compliance

As a first and decisive strategic step, an ***informal preliminary inquiry*** *with the potential partner municipality and the* ***Lower Nature Conservation Authority (UNB)*** *is recommended. This serves to clarify the fundamental feasibility of the project and any potential grounds for exclusion at an early stage, before investing in costly detailed planning. As described above the burial forest is a legally considered full-fledged cemetery within the meaning of the* ***Bavarian Burial Act (BestG)****. Consequently, a burial forest is subject to the* ***compulsory use of cemeteries*** *(Friedhofszwang), requiring the area to be formally* ***dedicated*** *as a cemetery.*

*For planning and approval, various laws and ordinances must be observed. In addition to the aforementioned Burial Act and its implementing ordinance (****BestV****), these particularly include construction and planning law, nature conservation law, water law, and the Bavarian Forest Act (BayWaldG). Following approval, municipal cemetery and fee statutes will also regulate operation.*

The Sponsoring Body (Träger)

According to Article 7 of the Bavarian Burial Act, the responsibility for establishing and maintaining cemeteries lies with the municipalities. Only ***bodies under public law*** *(juristische Personen des öffentlichen Rechts) are eligible to act as the* ***sponsoring body*** *(Träger). Besides municipalities, these include* ***state-recognized churches and religious communities****. A private forest owner cannot act as the sponsoring body themselves but must enter into a cooperation with a public-law body. This means, the Catholic church, represented by the Archdiocese administration could act as a sponsoring body.*

Formal Approval Process

Once the sponsorship is clarified, the formal approval process can begin. The sponsoring body submits the application to the competent ***District Administrative Authority*** *(Kreisverwaltungsbehörde), which acts as the central point of contact and coordinates the involvement of all other relevant specialized authorities. These include the Lower Nature Conservation Authority, the Water Management Office, the Office for Food, Agriculture and Forestry, and the Public Health Office.*

Approval is granted if all legal requirements are met and no other provisions of public law conflict with the project. A crucial part of this review is the submission of a conclusive and ***comprehensive concept****. Various documents and proofs must be submitted, including:*

- *A detailed concept description*
- *A site plan and cadastral map*
- *Proof of ownership or right of use*

- *A forestry report, an expert nature conservation report, a hydrogeological report, and a traffic concept*
- *A draft of the future cemetery and fee statutes*

Specific Requirements and Prohibitions

To permanently secure the land's purpose, it is typically registered in the land register through a ***limited personal easement*** *(beschränkte persönliche Dienstbarkeit).*

Furthermore, specific structural and design regulations must be followed. In Bavaria, an ***enclosure*** *(Einfriedung) is legally required, which can be designed naturally (e.g., using a wooden railing). The establishment of infrastructure, such as a ceremonial site, requires a building permit. Any form of individual grave decoration is prohibited.*

Significant restrictions and prohibitions apply. Approval is generally excluded in designated ***nature conservation areas*** *(Naturschutzgebiete) and* ***national parks****. An absolute prohibition applies in the strictest protection zone (Zone I) of* ***water protection areas*** *(Wasserschutzgebiete). If the area is located within an FFH (Fauna-Flora-Habitat) site, a compatibility assessment is required.*

Forestry and planning law also impose formal restrictions. In Bavaria, establishing a burial forest is considered formally a ***forest conversion*** *(Waldumwandlung) as the area is not considered being a forest anymore requiring a permit under the Forest Act. The project must also be compatible with the objectives of* ***regional planning*** *(Raumordnung) and the municipality's specific* ***urban land-use planning*** *(Bauleitplanung). If the area is designated as "area for forestry" in the land-use plan or conflicts with an existing legally binding land-use plan, corresponding plan amendments are necessary, which requires the political will of the municipality.*

Living Lab Waakirchen

Technical and ecological feasibility

Technical feasibility

From a forestry viewpoint technically many features are already available in the Waakirchen area : There are interesting mixed forest stands, a good accessibility of the area and the Sigriz Alm might work as an education center for the Green Initiative.

Ecological feasibility

The Green Initiative requires per se the mainentance or even improvement of forest ecosystem services and represent with its acitivities an improvement of cultural services such as natural experience, knowledge,

Economic feasibility

The Green Initiative aims for financial sustainability through diversified income sources rather than profit maximization.

Revenues for the business model may be expected from

- *Fees for Guided Tours: A tiered pricing system: e.g., €X per student for school classes, €Y per family for public tours, and higher rates for exclusive private or corporate group bookings (e.g., team events).*

- *Fees for Workshops: Charging for specialized, longer workshops (e.g., "Wildlife Tracking", "Building an Insect Hotel").*
- *Service Agreements: A fixed annual fee from the municipality or specific schools for providing a guaranteed number of educational units per year.*
- *Small-scale sales of related products like simple guidebooks, postcards with forest motifs, or certified local wood products. This is more for brand-building than significant revenue.*
- *Initial costs ar Membership Fees: Regular income from individuals, families, and supporting clubs who become members of the "Grüne Initiative" association.*
- *Donations: One-time or recurring donations specifically to support the non-profit advocacy and public relations work. These are not payment for a service but support for the cause.*

Initial costs are relatively low, focusing on coordination, marketing, and the development of educational materials rather than infrastructure. Ongoing costs involve staff or volunteer coordination, maintenance of forest access routes, insurance, and event logistics. The model creates indirect regional value, supporting local tourism, hospitality, and environmental education. Financial risk is moderate, mainly dependent on local participation levels and stable stakeholder engagement. Overall, the business model shows high economic feasibility, particularly when embedded within municipal or regional funding frameworks and supported by existing association networks.

Operational feasibility

Implementation relies on ***collaboration among existing local associations*** *(e.g., Alpine Club, conservation groups, ecological hunting clubs) and coordination by a central entity or cluster manager. The* ***main operational activities*** *include:*

- *Organization of forest education and experience programs (guided tours, children's events, workshops).*
- *Planning and executing nature conservation campaigns (e.g., tree planting, habitat maintenance).*
- *Event coordination, communication, and promotion.*
- *Workload is moderate and can be distributed among partners and volunteers; existing forest management operations can continue without major adjustments.*
- *Forest areas need only basic accessibility and safety standards — no intensive infrastructure or forest conversion is required.*
- *Human resources: coordination and facilitation roles could be handled by the forest owner, municipal staff, or dedicated part-time project coordinators.*
- *The model benefits from strong local networks and the forest owner's engagement in ecological and social initiatives, ensuring smooth implementation and community support.*
- *Operational feasibility is therefore high, given clear role allocation, cooperative management, and adequate communication among stakeholders.*

Legal compliance

The Green Initiative operates within the framework of public forest law and environmental protection regulations of Bavaria.

- *Activities must comply with:*
    - *Forest law (BayWaldG), ensuring sustainable forest management and preservation of forest functions;*
    - *Nature conservation law (BNatSchG, BayNatSchG), especially regarding protected species, habitats, and event permissions in sensitive areas*
    - *Municipal regulations, particularly those concerning public access, event organization, and liability.*
- *Cooperation agreements between associations should clarify responsibilities, liability, and insurance coverage for participants and organizers.*
- *Educational and recreational activities should adhere to safety and accessibility standards for public forest use.*
- *If financial transactions (fees, sponsorships) are involved, compliance with tax and accounting obligations under non-profit or association law is required.*
- *The model benefits from low legal complexity, as activities remain within the scope of existing forest and community regulations, provided that stakeholder agreements and risk management are properly documented.*
- *Overall, legal compliance is achievable with transparent governance and formalized cooperation frameworks between participating actors.*

LIVING LAB ITALY

Valle Tanaro

Output 2.3

Living Lab Italy

Characteristics of the Living Lab area

Main source: Piano di Gestione Forestale - Alto, Bagnasco, Briga Alta, Caprauna, Garessio, Nucetto, Ormea, Perlo, Priola, 2010-2016; Piano Forestale Territoriale Alta Valle Tanaro, Valli Mongia, Cevetta e Langa Cebana.

Geographical location

The Italian Living Lab is located in the south of the Piedmont region, bordering the Liguria region and France. The LL's surface covers 67.264 ha, and corresponds to the Forest Area 13, which includes Langa Cebana hills, Mongia, Cevetta and Upper Tanaro valleys. Alta Valle Tanaro is the main valley of this area, in terms of surface.

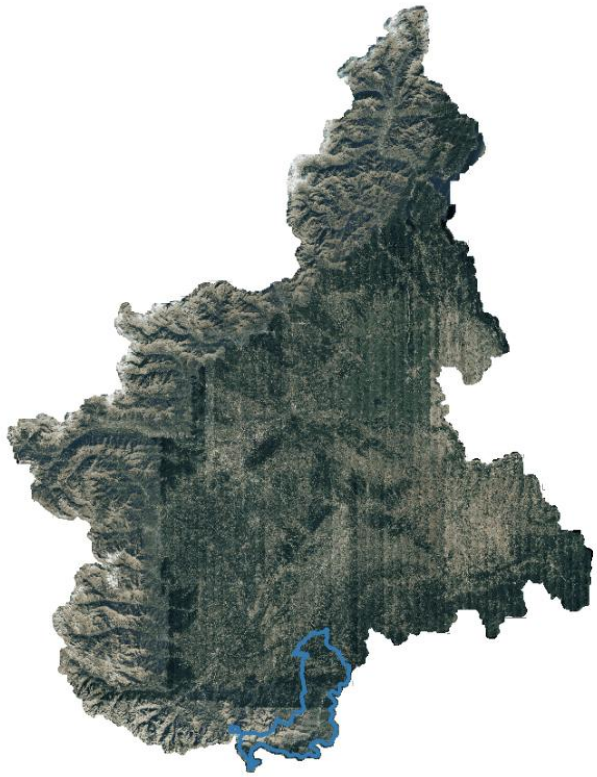

Figure 19: *Location of the Italian Living Lab.*

The LL includes 30 municipalities: Priero, Bagnasco, Marsaglia, Alto, Rocca Cigliè, Nucetto, Murazzano, Montezemolo, Briga Alta, Battifollo, Scagnello, Mombasiglio, Perlo, Ceva, Ormea, Garessio, Roascio, Viola, Castellino Tanaro, Paroldo, Cigliè, Caprauna, Sale San Giovanni, Torresina, Lesegno, Priola, Castelnuovo di Ceva, Lisio, Igliano, Sale delle Langhe.

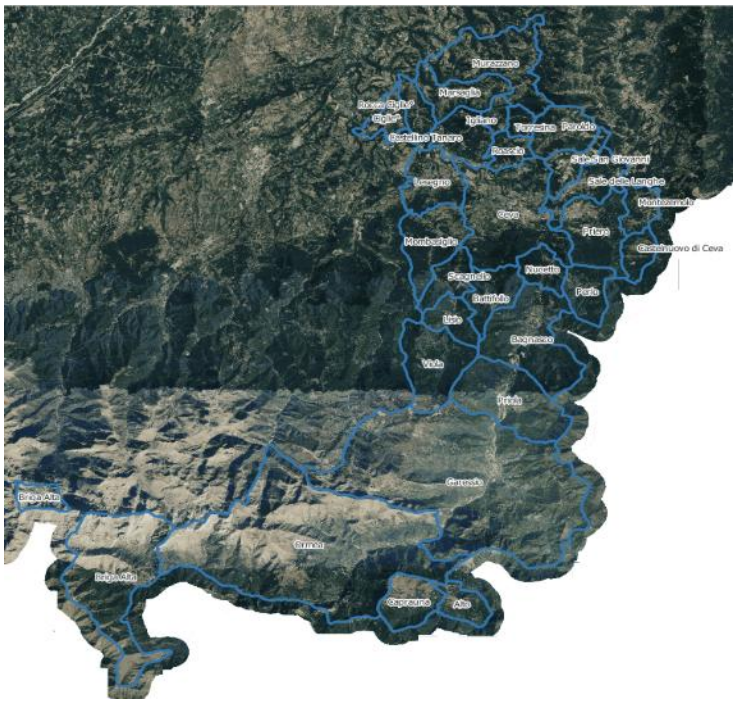

Figure 20: *30 municipalities of the Italian Living Lab region.*

Figure 21: *30 municipalities of the Italian LL region.*

Land use

The forest cover represents the majority of the total area, and it's mainly distributed in the mountain areas, while on the hillside area the land use is mostly dedicated to agriculture, especially to vineyards and hazelnut orchards.

The land use, in particular, is distributed as it follows:

- *Forest: 61 %*
- *Grassland, pastures, shrubland: 19 %*
- *Agriculture: 14 %*
- *Rockbed and glaciers: 3 %*
- *Urban areas: 2 %*
- *Water figures, shores, wetlands: <1 %*
- *Forest tree farming/arboricolture: <1 %*

Topography and climate

The area under consideration is characterized by a prevailing rainfall pattern of type Sublitoraneo, with minimum main in summer, maximum main in autumn and maximum secondary in spring. The normal Piedmont equinox regime of rainfall is therefore confirmed, even in this border area, albeit with a certain attenuation of summer lows.

There are no snow-precipitation stations within the area under consideration, so it is not possible to provide data on this. At the level of general information however the majority of solid precipitation is during the first three months of the year, between January and March, and the time of permanence of the snow cover is on average 3 - 4 months a year. One phenomenon that occurs with a certain frequency is late snowfall. In these cases, the snow has a high moisture content, in other words with an increased density, which results in an excess of overload for the plant's bushes, which become subject to crashes.

The precipitation and temperature trend were described by analyzing the time series (1996-2024) of three data collection units in the north, center and south of the LL, at different altitude levels:

- *Upega (1310 m asl, Briga Alta municipality, southern area)*
- *Monte Berlino (1765 m asl, Garessio municipality, central area)*
- *Priero (610 m asl, northern area)*

Table 11: *Maximum, Minimum, and Average Precipitation Data at Upega, Monte Berlino, and Priero.*

		N° rainy days	***Rainfall (mm)***
UPEGA (Briga Alta)	*MAX*	*24,0*	*711,4*
	MIN	*0,0*	*0,2*
	AVERAGE	*7,2*	*104,3*
MONTE BERLINO (Garessio)	*MAX*	*21,0*	*707,6*

	MIN	0,0	0,0
	AVERAGE	6,5	82,4
PRIERO	MAX	19,0	402,0
	MIN	0,0	0,0
	AVERAGE	6,4	83,2

Table 12: *Average Monthly Rainy Days and Rainfall (mm) at Upega, Monte Berlino, and Priero.*

	UPEGA (Briga Alta)		MONTE BERLINO (Garessio)		PRIERO	
	N° rainy days	**Rainfall (mm)**	**N° rainy days**	**Rainfall (mm)**	**N° rainy days**	**Rainfall (mm)**
jan	5,3	83,0	3,7	50,9	6,0	66,2
feb	4,2	58,0	2,7	20,2	5,3	63,3
mar	5,7	82,2	4,3	31,7	6,7	81,3
apr	9,5	108,6	7,8	73,3	8,2	107,3
may	10,9	118,4	9,8	103,2	8,8	106,4
jun	8,4	85,7	7,9	81,1	5,0	52,6
jul	7,1	74,4	6,1	47,3	4,2	36,6
aug	6,7	68,8	6,2	65,1	4,8	49,6
sep	6,8	78,8	6,8	82,8	5,6	77,0
oct	6,9	165,9	7,1	144,7	6,5	106,3
nov	8,6	217,2	7,5	177,4	8,8	169,0
dec	6,7	123,1	4,8	67,7	6,1	76,3

Precipitation (mm) is distributed on average in the autumn and summer months, with a maximum peak in November and a relative maximum in May, although the frequency of rainy days is usually higher in May.

Table 13: *Maximum, Minimum, and Average Values for Daily Maximum, Average, and Minimum Temperatures (Tmax, T_average, Tmin) at Upega, Monte Berlino, and Priero.*

		T max	**T average**	**T min**
UPEGA (Briga Alta)	MAX	33,7	18,3	9,1
	MIN	8,3	-3,3	-16,5
	AV.	20,2	7,1	-3,1
MONTE BERLINO (Garessio)	MAX	25,0	14,0	9,0
	MIN	8,0	-5,0	-18,0

	AV.	15,4	4,1	-1,9
PRIERO	MAX	38,2	23,7	15,6
	MIN	8,8	-1,6	-14,9
	AV.	23,2	11,1	1,6

Table 14: *Maximum, Minimum, and Average Monthly Temperature at Upega, Monte Berlino, and Priero.*

	UPEGA (Briga Alta)			MONTE BERLINO (Garessio)			PRIERO		
	T max (C°)	T average (C°)	T min (C°)	T max (C°)	T average (C°)	T min (C°)	T max (C°)	T average (C°)	T min (C°)
jan	14,5	-0,4	-10,1	11,6	-0,9	-11,3	15,7	2,1	-6,4
feb	15,3	0,5	-9,9	11,8	-0,9	-10,1	16,0	3,4	-5,4
mar	17,6	3,0	-7,8	13,4	0,7	-9,2	20,7	6,9	-3,1
apr	18,3	5,5	-4,5	13,4	3,1	-5,8	23,9	10,4	0,2
may	21,6	9,4	-0,9	17,5	7,5	-0,9	26,1	14,3	4,7
jun	26,1	13,5	2,9	21,5	12,0	3,5	30,0	18,5	8,3
jul	27,0	15,4	4,8	22,6	14,3	5,8	31,5	20,8	10,8
aug	26,9	15,0	4,6	22,6	14,0	5,8	31,8	20,4	10,2
sep	23,4	11,4	1,1	18,7	9,8	1,9	27,4	16,1	6,4
oct	21,7	8,0	-2,1	17,5	6,6	-1,8	23,4	11,6	2,3
nov	16,0	3,3	-6,2	13,3	1,9	-7,4	17,5	6,2	-2,5
dec	13,3	0,2	-8,9	11,9	0,0	-10,5	14,7	2,8	-5,4

As expected, the minimum and maximum temperatures are influenced by the elevation of the monitoring areas, but the general trend shows that the highest temperatures are detected between July and August, while the lowest ones are detected between December and January.

The elevation range of the LL is influenced by the presence of the Tanaro River, so that the lowest elevation sites are found by the riverbed and in the south-west part of the area, while the highest elevation reach 550 m asl on the northern peaks.

Geology and pedology

Geologic units

The Tanaro Valley geological units have a long history of Alpine polyphasic deformation, which has resulted in a very complex structural arrangement.

Proceeding from south to north, the valley is shaped in marble Jurassic limestone of the Marguareis-Mongioie group and, in the orographic left, in Permian porphyries; in the orographic right the slopes are formed by

marl-sandstone-calcareous alternating formations. From Garessio, Quarzosquises and Gneiss shale can be found in the initial part, then proceeding south towards Ormea there are some other units of phenocrystal porphyrinoids of k-feldspar, quartz, and biotite subordinate. Around Priola the valley crosses the Murialdo Formation: Filladi and macaceaus shale of the Upper Carboniferous period followed on the right, by the Limestones of Monte Sotta (Trias).

In Bagnasco the sedimentary sequences of the Molar Formation begin, sequence Oligocene transgressive formed by conglomerates and macroconglomerates, with arenaceous and marnose intersections. The Molar Formation includes, at Nucetto, the homonymous migmatites, Transitions to Anatessis and Granites.

Near to Nucetto the valley rests to the north-east, always in the Molar formation, then to confluence in the wide Valley of Cevetta, at the beginning of the Piedmontese Tertiary Basin, here constituted by the Monesiglio Formation (sands with sandstone nodules, conglomerates).

Soil background

Soil types that can be found in the LL vary from very shallow and undeveloped soils in the most disturbed areas to deeper and more advanced into the pedogenetic process.

- *pebbly entisols, which are typical of floodplains by rivers and streams (calcareous Typic udifluvent/ustifluvent near to the Tanaro riverbed and on the most recent floodplains) but can also be found in the most slope mountain areas, where surface erosion caused by wind and rainwater prevents soil evolution (non-calcareous Typic udorthent in disturbed mountainside areas);*
- *inceptisols, on stable and medium-depth hills (calcareous Typic dystrudept and Dystric eutrudept) and mountainside (Humic or Spodic dytrudept on mixed land use territories or former forested areas now turned into grazing areas);*
- *alfisols, usually located on low mountain areas, below natural forest stands (oak, birch, chestnut, beech), chestnut or other fruit-farming orchards, meadows or meadow-pastures (Typic hapludalf, from acidic to subalcaline).*
- *mollisols, on the highest mountainside areas, usually accommodating grazing activity where the slopeness allows it.*

Organizational structure

Responsible regional and local authorities for forest management

The Piemonte Region coordinates planning, development and management activities aimed at the protection and multifunctional exploitation of the forest cover on the regional territory, including through dissemination and training in forestry. The Forest Sector, which operated under a specific board of the Region specialized in territory and environment matters, is responsible for

- *the drafting of laws, regulations, execution norms and guidelines.*
- *coordination and management of measures for the exploitation of forests and forest enterprises, also in cooperation with the authorities in charge of European and national funds management.*
- *forestry research, communication, statistics and vocational training.*
- *management of lists and registers provided for by the forestry legislation (such as register of enterprises, operators list, register of forestry intervention plans, monumental tree list, etc).*

Local authorities that operate in the forest management field are Mountain Communities, Municipalities and Unions, representing the public administration and associations that are placed in mountain areas and manage the forest territory in order to ensure economic and social development in the most geomorphologically disadvantaged area of Piemonte.

Forest owner associations

Federforeste is a national forest owners association that aims to coordinate, protect and enhance the work of Forest Consortia and Special Companies - consortia and/or individual - in the rational management of agro-forestry assets owned by municipalities and other entities. The coordination of the forest activities and initiatives is divided into macro-territories (north-west, north-east, northern center, southern center and south Italy). Federforeste is also responsible for the representation of the single or aggregated forest owners during national forest and environmental themed panels and committees and is committed to the mitigation of the land fragmentation issue on national level.

UNCEM Piemonte represents organizations with regional level authority during the examination process of measures of mountain interest, with a view to enhancing and developing the territory and institutions. It promotes the coordination of activities of local mountain authorities.

On a more territorial scale, Forest Area n° 13 has one of the most important examples of forest owners' association, the Monte Armetta Forest Consortium (see Par. 1.6), which manages some of the public owned forests of Ormea Municipality.

In recent years, the emergence of Landowner Associations (Italian: Associazioni Fondiarie, or ASFO) has become an increasingly relevant phenomenon in the management of private land in the Italian Living Lab area. These are non-profit organizations established to promote the joint management of fragmented and often abandoned mountain properties.

The main goals of these associations are:

- *To counteract land **fragmentation**, which impedes effective forest and agricultural management.*
- *To prevent **land abandonment**, a growing issue in mountainous and marginal areas.*
- *To improve the **socio-economic viability** of rural and forest territories through shared strategies and pooled resources.*

Such organizations offer a cooperative management framework that allows landowners—often numerous and dispersed—to collectively enhance the value and productivity of their land, which would otherwise remain unmanaged due to logistical or economic constraints.

Several Landowner Associations are active in the project area, including:

- ***ASFO Carnino***
- ***ASFO del Cebano***
- ***ASFO Le Viozene***
- ***ASFO Monregalese***
- ***ASFO Pamparà***
- ***ASFO Upega***

These associations represent an innovative and locally adapted response to challenges such as ownership fragmentation, socio-demographic decline, and economic marginality of rural areas. Their model complements other forms of collective forest governance such as Forest Consortia (Consorzi Forestali) and provides a promising pathway for integrating private ownership into broader sustainable landscape and forest management strategies.

Ownership

Forest ownership can be categorized as it follows:

- *Public property (State, Region, Provinces, Municipalities Property): 16 %.*
- *Private ownership under active management: 3 %.*
- *Other Entities: Consortia, mixed ownership (ASL, Universities, ENEL, AEM, Railways, etc.): 3 %.*
- *Other private properties, including undetected private properties, which means that their size is less than that required by the technical standards: 78 %.*

Associated forms of forest management are present on the territory; these, by increasing membership, could ensure the rational use of the resource. The most extensive example on the territory is the Monte Armetta Forest Consortium, which operates by ensuring a coordinated management of more than one forest ownership under a "overall vision and homogeneous silvicultural criteria, over a reasonably long-time span" (PFA - Consorzio Forestale Monte Armetta 2021-2035). The total surface under the Consortium management sums up to 1163 ha, of which 1104.11 are owned by the Municipality of Ormea. The private ownership is represented by around 30 private partners, owning around 100 - 120 ha. The forest cover percentage of the whole land covered by the Consortium is around 41 %, while the designated use of the rest of these areas is grazing and agroforestry activities. Up until 1000 m asl, the forest cover is mainly classified as chestnut coppice.

The municipal property is encumbered by the rights of enjoyment of Civic Uses on the part of the rightsholders (defined users). By residual definition, only the municipal assets with an obvious non-state origin are not encumbered by civic use, that is to say, acquisition acts such as barters, purchases, donations, etc.

Regarding the private owners, the aim of the forest management is to ensure the production of wood and products that are derived from wood, like tannins in the chestnut coppice case.

Status of forests in the Living Lab

Characteristic of forests and their management in the LL area

The total forest cover of the LL is 41.358 ha, which represents 61 % of the total area. Deciduous species largely prevail on conifers: forest types based on conifers composition represent around 7 % of the forest cover, and around 93 % of the mountain belt reforestation areas, for a total of 3451 ha. Therefore, approximately the conifers cover around 12 % of the total forest cover, while deciduous species prevail with an 88 % forest cover.

Table 15: *Summary of surface, basal area, volume and relative-increment for the main forest categories.*

*Main forest categories***	*Surface* (ha)*	*Basal area (m2/ha)***	*Volume (m3/ha)***	*Relative increment (m3/ha/anno)***
Chestnut	*18812*	*35*	*186 (of which around 50% is dead biomass)*	*6,8*
Beech	*8723*	*28*	*166*	*5,2*
Hop hornbeam	*2744*	*15*	*65*	*3,8*
Downy oak	*3194*	*113*	*433*	*5,0*

*(*SOURCE: Geoportale Piemonte)*

*(**SOURCE: GOTTERO F., EBONE A.,TERZUOLO P.,CAMERANO P., 2007 – I boschi del Piemonte, conoscenze e indirizzi gestionali Regione Piemonte, Blu Edizioni, pp. 240)*

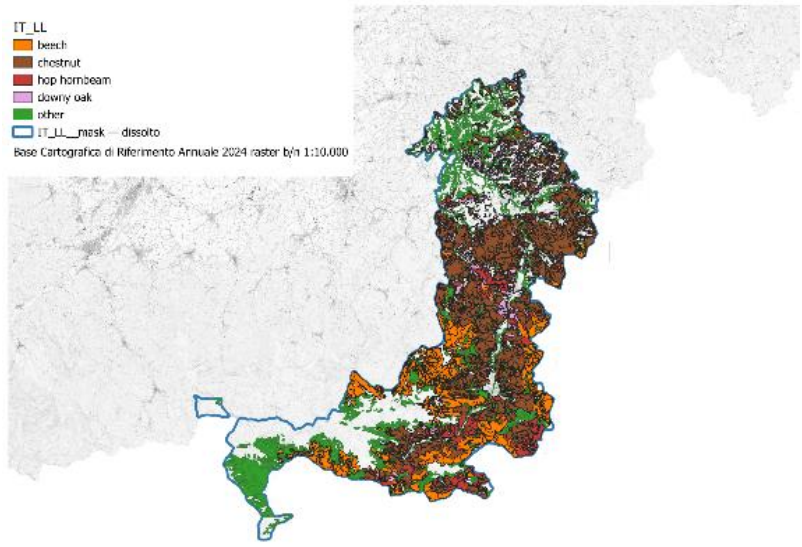

Figure 22*: Tree species distribution in Valle Tanaro.*

Forest management in the area

Management strategies are tailored to both ecological conditions and the cultural context of ownership, which varies across the region.

Forest Management Techniques

Silvicultural practices in the area include a range of interventions:

- ***Crop cuts** and **occasional thinning**, aimed at improving forest structure and removing damaged or non-productive trees.*
- ***Successive cuts** (preparatory, seeding, secondary and clearing phases), used to promote natural regeneration.*
- ***Hole cutting**, applied in small patches to simulate natural disturbances and facilitate regeneration.*
- ***Juvenile stand maintenance**, such as pruning, thinning and cleaning, particularly important in chestnut coppices to enhance growth and quality.*

Infrastructure

Forest infrastructure is well-developed in some areas, especially where forestry operations are more frequent. The average length of forest roads is approximately 1327 meters, with an estimated road network density of 50.5 meters per hectare. These roads are crucial for timber extraction and access to remote forest areas. However, in the more pastoral or less-managed sections of the territory, infrastructure remains minimal or absent.

Forest Products

*The forested area is utilized for both **wood** and **non-wood forest products (NWFPs)**:*

- *About 27 % of the forest area is classified as "productive," while another 48 % is considered "protective-productive."*
- ***Chestnut forests** dominate and are mainly used for fuelwood and production of wood chips for energetic purposes and tannin extraction. Despite their potential for producing poles or high-value timber, such uses remain underexploited.*
- ***Beech forests**, historically coppiced for firewood and charcoal, are now increasingly being converted into high forest to maintain ecological stability.*
- *NWFPs, such as **tannins**, are also relevant. The presence of companies like Huvepharma and Silvateam indicates potential value chains linked to chestnut biomass and green chemistry applications.*

Tourism and Recreation

*Forest areas in the LL are important for tourism, particularly **hiking, cycling, and agro-tourism**, leveraging both the scenic mountain landscapes and the region's cultural identity tied to chestnut and hazelnut cultivation. Existing infrastructure includes regional cycling routes and facilities such as the Garessio 2000 ski resort.*

Forest Ecosystem Services in the Living Lab area

Forest ecosystem services have been assessed on local and large-scale level. The results of forest ecosystem services assessment and the potential effects of forest management on ecosystem services supply are presented in D2.2.1 Forest Ecosystem services assessment pilot action report and are summarized here.

The forests in the Living Lab of Tanaro Valley provide multiple ecosystem services:

- *Provision of timber wood, fuel wood and fire wood*
- *Non-Wood Forest Products (NWFPs)*
- *Provision of habitats for wild animals and plants*
- *CO_2 storage and sequestration in forests*
- *Recreation and tourism*
- *Aesthetic value of the forest*

Potential effects of forest management on FES supply

This section will undergo further refinement and integration until the end of the Forest EcoValue project.

Business portfolio in place

The Valle Tanaro Living Lab hosts a range of forest-related economic activities, which can be grouped into five main thematic areas:

1. Wood and Biomass Production

*Timber harvesting plays a significant role in the local economy, particularly through the management of chestnut and beech forests. While much of the chestnut wood is currently used for firewood and biomass, a major economic driver in the area is the presence of **Silvateam**, a leading company located near the Living Lab, specialized in the extraction of **tannin from chestnut wood**. Silvateam's industrial processes require large volumes of timber, which stimulates forest management and increases the demand for raw materials, thereby creating a strong incentive for active silviculture and sustainable forest planning. Additionally, initiatives such as the Calore Verde district heating system in Ormea promote the use of local woodchips, although profitability remains a challenge due to high production costs compared to foreign competitors.*

2. Non-Wood Forest Products (NWFPs)

The area shows strong potential and growing interest in the development of NWFP-based value chains, especially in connection with mushrooms. Around the municipality of Ceva, mushroom-related activities are highly developed, thanks to the active role of the Gruppo Micologico Cebano, a mycological association that organizes educational, cultural, and food-related events. This local culture has supported the emergence of small processing enterprises specializing in mushroom transformation. Increasingly, these businesses are engaging in hybrid forms of aggregation that include private companies, public authorities, and non-profit actors, fostering innovative collaboration models.

3. Chestnut Cultivation

*Chestnut cultivation has deep historical and ecological roots in the Valle Tanaro and continues to represent a strategic economic and cultural resource. Traditional chestnut orchards are valuable both for **local food production** and **ecosystem service provision**, including soil protection, water regulation, and biodiversity conservation. Although their productivity has declined due to abandonment and low market valorization, recovery and management efforts are underway, often supported by associations of chestnut growers and Natura 2000 conservation objectives. Revitalized orchards also contribute to the diversification of income through **chestnut-based products** and **mushroom harvesting**, as well as their potential role in **tourism and educational activities**. Improved management techniques—such as pruning, replanting, and biomass reuse—could unlock further economic and environmental value.*

4. Ecotourism and Outdoor Recreation

Forests support ecotourism and outdoor recreation through a well-established network of trails and natural attractions. The presence of protected area, Natura 2000 sites, and mountain landscapes offers excellent opportunities for hiking, cycling, and nature-based experiences. These assets are increasingly leveraged for "slow tourism," connecting ecosystem services with local food heritage and biodiversity.

5. Community and Social Enterprises

Forest management is also tied to inclusive, community-driven initiatives. The La Volpe e il Mirtillo cooperative and the Nuove Radici project in Ormea exemplify social enterprises that involve local residents and migrants in forestry work, trail maintenance, and agroforestry. These projects aim to combine ecological restoration with job creation and social cohesion, especially in marginal rural areas.

Economic valuation of Forest Ecosystem Services

While full economic valuation of FES in Valle Tanaro is reported in D 2.3.1 Transnational pilot testing FES economic assessment and market frameworks in each LL, for the purpose of this feasibility assessment, we present valuation results for the ecosystem services that were in focus of the LL activities, namely timber wood, firewood and fuelwood biomass provision, non-wood forest products, carbon sequestration, and recreation. Please, refer to D 2.3.1 for further details on valuation methodology.

The results of the adjusted unit value transfer for the Italian Living Lab in Valle Tanaro are presented on Figure 23. Two sets of value estimates were produced:

- *A mix of market price (MP) valuation for timber wood, firewood and fuelwood biomass provision, Italian voluntary market carbon pricing (VMCP) for carbon sequestration and adjusted unit value transfer for other FES, hereinafter, 'Mixed-method and VMCP'.*
- *Adjusted unit value transfer for all FES, except for the carbon sequestration valuated using the upper-bound estimates of recommended carbon pricing (RCP), hereinafter, 'Value transfer and RCP'.*

Provision of timber wood biomass rounds the top five FES with the highest social value per ha. While value transfer slightly overestimates local MP valuation of timber wood provision, the difference in market price and transferred values of firewood biomass provision is more significant (+€49.55/ha), which can be explained by data scarcity and underreporting on firewood market. In case of fuelwood, value transfer underestimates value of firewood biomass provisioning service by more than a half when compared to MP valuation results. According to the pricing on the voluntary carbon market in Italy, a value of a ha of forest in terms of carbon sequestration is about €50 lower (in 2023) than value of timber wood provided by the same ha. However, when valuating carbon sequestration with the upper-bound carbon pricing (€295/ha) recommended to achieve climate mitigation compatible with the global climate targets, this FES takes its place among the four most valuable regulating services in Valle Tanaro. This difference highlights sensitivity of monetary valuation and importance of clarity about communicative goal when using results of such assessments. Finally, recreation is the top fourth or fifth most relevant FES, depending on the valuation method, while provision of non-wood forest products, including chestnuts, mushrooms and berries, has the lowest value per ha.

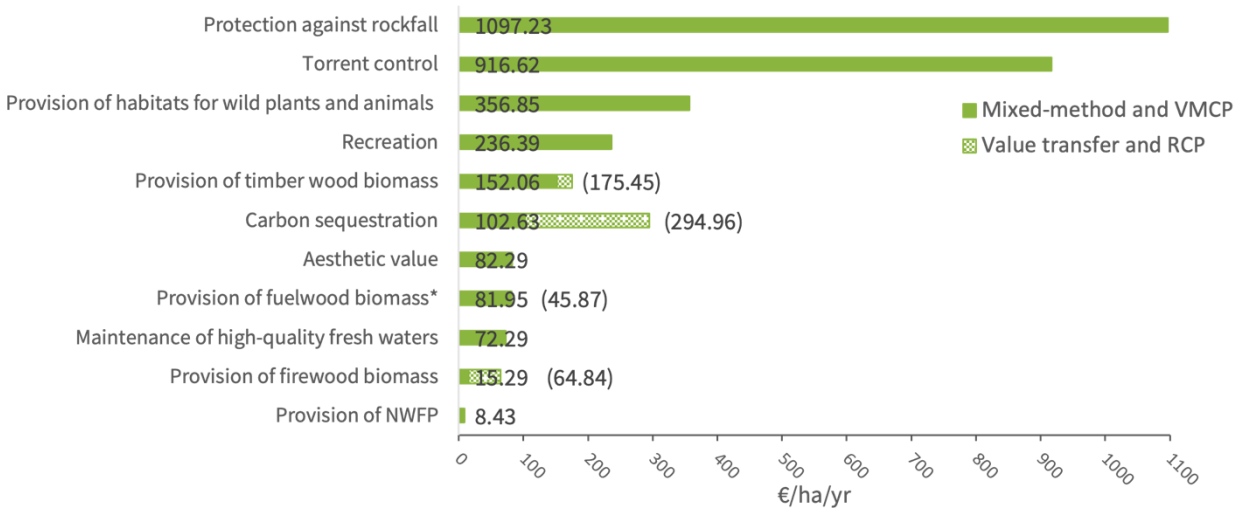

Figure 23: *Unit value estimates in 2023 euros per ha. Bold green depicts values estimated with the Mixed-method and VMCP. Patterned green depicts additional values estimated with the Value transfer and RCP, with the estimates indicated in parenthesis. NWFP stands for non-wood forest products, including chestnuts, mushrooms and berries. *As MP estimates provided a higher value for fuelwood biomass FES than adjusted unit value transfer, the patterned green part of the bar is not visible on the figure.*

Estimates of the total economic values (TEV) of forests in Valle Tanaro, using both valuation approaches, are demonstrated in Figure 24. Using pricing compliant with Paris Agreement climate change mitigation targets, CO_2 sequestration accounts for around 36% of TEV, making the principal contributors to total forest value. Otherwise, contribution of this FES is almost the same as one of recreation (13% and 14% respectively). It must be noted, that provided TEV estimates are a serious underestimation, as the number of FES included in the calculation was restricted to five. To avoid double counting and an inflated valuation of provisioning services, fire- and fuelwood biomass provisioning services were also excluded from the TEV analysis, as the forest area providing these FES fully overlaps with timber wood biomass provision (i.e., total forest area), while only a small subset of non-provisioning FES could be valued in TEV terms (i.e., high possibility of underestimation). Despite these limitations, value of timber provisioning service constitutes a relatively small share of the forest TEV, suggesting that the social importance of forests in Valle Tanaro extends well beyond timber production. At the same time, we must keep in mind that provisioning FES are provided by the same forest area as carbon sequestration and provision of habitats and partially overlaps with other FES. This hints at potentially detrimental losses in social value of forests if forest management is fully oriented at timber provision.

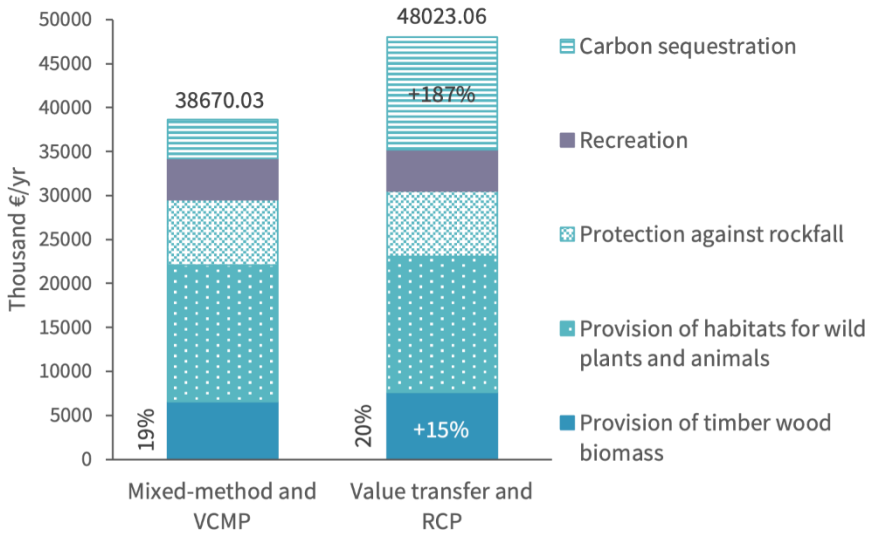

Figure 24: *Estimates of total economic value (TEV) of forests in Valle Tanaro, calculated using two different approaches. Total values per year for each FES are estimated based on the forest surface areas providing respective services. Percentages for provision of timber wood biomass placed on the left of the bars indicate a contribution of timber wood provision to the TEV. Percentages for timber wood biomass and carbon sequestration placed inside the bar indicate difference in total values of these FES between TEVs estimated using different methods. Numbers on the top of the bars indicate the TEVs.*

Spatial distribution of FES social values in Valle Tanaro further details our understanding about the FES provision in the Living Lab (s. Figure 25). Not all values are evenly distributed throughout the territory of the Living Lab. While most of the forest area provides below expected average value per ha (1167.10 €/ha/yr[10]), areas providing above expected average value per ha as well as highly valuable areas are concentrated around Ormea, Trappa, in the North/North-West of Garessio, and on the Southern border of Valle Tanaro. While further supplementation of this map with the spatial distribution of forest ownership and residential areas could shed more light into FES providers and beneficiaries dynamics in the area, already at this stage we can see a high risk of potential trade-offs when forest management plans are focused only on one ecosystem service.

[10] *As forest areas providing timber wood biomass, carbon sequestration and habitats for wild plants and animals has a 100% overlap, at least three FES are expected to be at each ha, therefore, expected average is a representative midpoint value. It was calculated as follows:* $Expected\ average = Average\ of\ all\ FES\ values\ per\ ha \times 2$

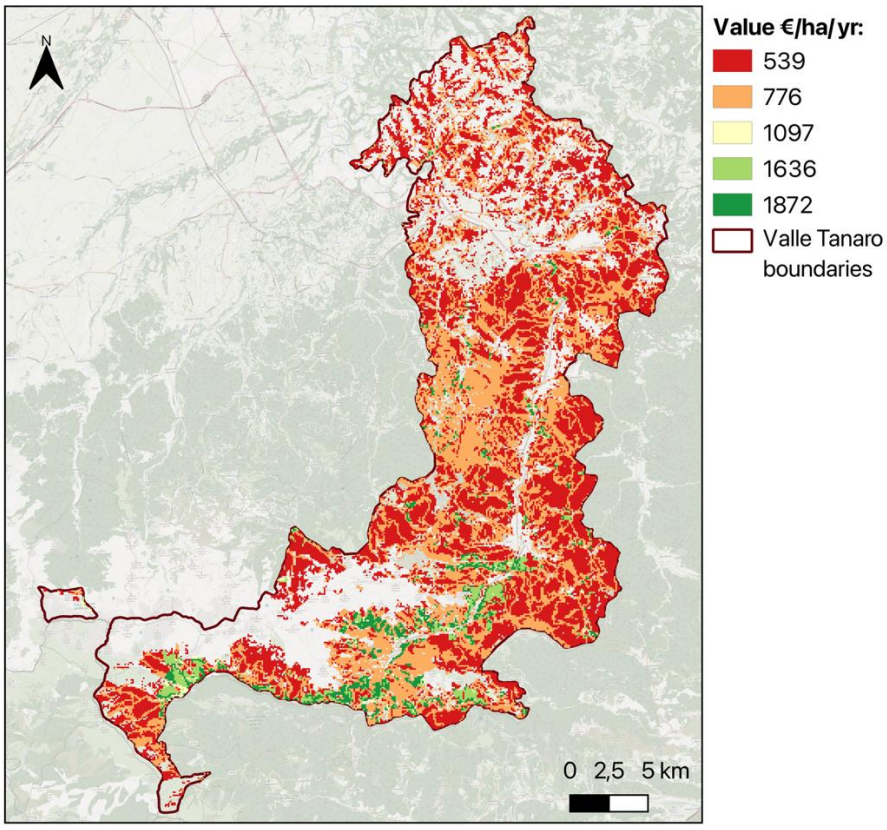

Figure 25: *Spatial distribution of unit values in Valle Tanaro. Only estimates produced with the Mixed-method and VCMP were used for mapping. Some degree of spatial under- and overdistribution is present for the unit value of carbon sequestration as unit value estimation is based on mean carbon sequestration per ha, not carbon sequestration specific to the forest unit.*

Feasibility Assessment

Development scenario

The Tanaro Valley is already experiencing the effects of climate change, particularly in the form of ***increased temperature variability*** *and* ***altered precipitation patterns****. According to local meteorological data and qualitative assessments, these changes are affecting forest dynamics and are expected to intensify in the coming decades. In particular, reduced snow cover duration, increasingly frequent alternations between drought and exceptional rainfall events, and extreme weather events (e.g., late wet snowfalls, strong windstorms) are leading to* ***greater exposure to disturbances****, such as forest blowdowns, forest declines, landslides, flooding, hydrogeological instability and pathogen outbreaks.*

As a consequence, a ***redistribution of dominant tree species*** *is anticipated, especially across elevation gradients and microclimatic zones. While a precise mapping of future scenarios across the entire Living Lab area is currently limited by data resolution and landscape complexity, qualitative projections suggest that main species may gradually shift their optimal ecological niches, either migrating upward or becoming more vulnerable at lower altitudes.*

These changes may lead to:

- ***Altered forest composition,*** *with pioneer and drought-tolerant species potentially becoming more prevalent.*

- ***Reduced productivity*** *or increased mortality in some chestnut coppices, already affected by abandonment and pathogens.*
- ***Greater risk of biodiversity loss****, especially in marginal habitats or Natura 2000 sites sensitive to climatic stressors.*

In response to these challenges, forest management strategies will need to become more adaptive and risk aware. Promoting structural and species diversity, maintaining mixed stands, and implementing ecosystem-based approaches will be essential to ***enhance forest resilience*** *and* ***secure ecosystem services*** *in the long term.*

Objectives

Ecological objectives

1. Timber Production

Ecological Objective: *To ensure a sustainable and continuous supply of wood while preserving forest health and multifunctionality.*

Sustainable timber production in Alpine forests should aim to shift from exploitative to close-to-nature silviculture, promoting uneven-aged and mixed-species stands. This enhances resilience to climatic extremes, pests and diseases, and reduces the ecological cost of harvesting. Forest operations should maintain soil stability, minimize canopy opening to reduce evapotranspiration, and apply selective thinning and small-scale harvesting systems. In chestnut coppices, ecological improvement may involve the conversion to high forest, especially in productive or sensitive areas. The use of local wood by industries like Silvateam creates a strong economic driver, but ecological thresholds must be respected to avoid overexploitation and degradation of soil and habitat conditions.

2. Carbon Sequestration and Storage

Ecological Objective: *To maximize the forest carbon sink function while maintaining ecological integrity.*

Forests play a key role in climate mitigation by sequestering and storing carbon in biomass and soils. In a climate-smart context, forest management should aim to increase standing biomass (e.g., through extended rotation cycles, reduced harvest intensity) and protect carbon stocks. The conversion of coppices into high forests and natural regeneration can significantly boost long-term carbon storage.

3. Biodiversity Conservation

Ecological Objective: *To maintain and enhance structural, compositional, and functional forest diversity.*

Biodiversity-oriented Forest management focuses on maintaining native species richness, deadwood, microhabitats, and vertical structure, all crucial for forest-dependent flora and fauna. It is especially relevant in Natura 2000 sites or areas with traditional cultivations such as chestnut orchards, which serve as biodiversity hotspots when maintained in mosaic landscapes. Actions include preserving old-growth features, leaving retention trees and snags, limiting the introduction of non-native species, and maintaining habitat continuity. Forest edges, riparian zones, and ecological corridors should be actively managed or restored to support species migration under climate change.

4. Recreation and Tourism

Ecological Objective: *To enable nature-based tourism while protecting sensitive ecosystems and ensuring long-term landscape quality.*

Forests in the Valle Tanaro are already central to slow tourism, offering scenic, educational, and cultural experiences. Ecologically sound forest planning can enhance these functions by preserving aesthetic value, maintaining trail accessibility, and protecting natural landmarks (e.g., ancient chestnut trees, panoramic ridgelines). Infrastructure for hiking, mushroom picking, and biking should be low-impact and avoid habitat fragmentation. Multifunctional management integrating tourism with ecosystem conservation (e.g., interpretive trails in Natura 2000 sites, guided foraging) can generate co-benefits while reducing pressures on core habitats.

5. Non-Wood Forest Products (NWFPs)

Ecological Objective: *To support the sustainable harvesting of NWFPs while conserving their ecological basis.*

NWFPs like mushrooms, herbs and chestnuts are deeply tied to both biodiversity and cultural heritage. Ecologically smart management involves regulating harvest intensity, maintaining understory integrity, and ensuring species regeneration. For example, sustainable mushroom collection depends on undisturbed litter layers and microclimate conditions, which require limiting soil compaction and canopy disturbance. Promoting NWFPs also incentivizes local communities to engage in land stewardship and landscape maintenance.

Economic objectives

The development of new forest value chains in the Valle Tanaro Living Lab requires economic strategies that are both place-based and multifunctional. The following objectives reflect the need to align economic viability with forest stewardship, biodiversity, cultural heritage, and social inclusion.

1. Mobilizing Blended Finance for Ecosystem-Oriented Forestry

One of the main objectives is to enable forest owners and managers to access ***blended finance instruments*** *that combine public incentives with private funding. Public support mechanisms—such as payments for ecosystem services, climate-related subsidies or fiscal incentives—can play a crucial role in reducing the financial gap of forest operations that impact positively on provision and maintenance of Ecosystem services (e.g. carbon storage, biodiversity conservation, hydrogeological protection). These tools are essential to improve the* ***economic competitiveness of sustainable forest management****, especially in marginal areas with high ecological value and low short-term returns.*

2. Supporting the Continuity of Traditional Economies

The economic valorisation of ***traditional cultural practices*** *such as chestnut orchards, mushroom foraging, and beekeeping represents both an opportunity and a necessity. These activities are rooted in the identity of the Tanaro Valley and contribute to the multifunctionality of forest landscapes. Promoting their continuity through technical support, branding, and access to local or niche markets can sustain livelihoods while preserving valuable agro-silvo-pastoral systems. They also provide important links between* ***biodiversity, gastronomy****, and* ***rural tourism****.*

3. Linking Tourism and Forest Management through Local Reinvestment

The Living Lab aims to promote ***tourism and recreational services*** *that generate direct benefits for forest ecosystems. This includes encouraging economic models in which part of the revenue from outdoor experiences (e.g. hiking, guided foraging, agroforestry visits) is* ***reinvested in landscape maintenance****, such*

as trail restoration, chestnut orchard care, or forest thinning. These models enhance ***local circularity*** *and strengthen the relationship between tourism economies and environmental responsibility.*

4. Developing Integrated Economic Models for Forest Multifunctionality

Forest management in the area should move toward ***integrated economic models****, where timber harvesting, non-wood forest products, and ecosystem service valorisation coexist. This multifunctional approach allows for income diversification and better risk management, especially in small-scale forestry contexts. Carbon and biodiversity credits, if appropriately regulated and supported, could become an additional revenue stream that complements traditional wood markets, particularly when based on low-impact and nature-based practices.*

5. Strengthening Local Networks and Micro-Enterprises

Another strategic objective is to foster ***cooperation among small-scale actors*** *through forest owner associations, consortia, cooperatives, and informal networks. The Tanaro Valley hosts a number of promising initiatives (e.g. ASFOs, Monte Armetta Consortium, La Volpe e il Mirtillo cooperative) that demonstrate the potential of aggregated models for accessing markets, sharing resources, and enhancing forest governance. Empowering* ***micro-enterprises*** *and local entrepreneurs is essential to generate employment, improve processing capacity, and scale up innovative forest-based business models.*

6. Fostering Innovation in the Bioeconomy and Green Chemistry

Lastly, the development of ***innovative value chains*** *based on forest residues and by-products—such as tannins, flavonoids, oils and polymers—represents a frontier of economic diversification. The presence of established actors like* ***Silvateam*** *and the growing interest in circular and bio-based products offer concrete opportunities to connect forest management with* ***green chemistry and sustainable industrial processes****. This innovation axis can revitalize underused resources and contribute to broader regional development strategies focused on decarbonisation and sustainable material cycles.*

Measures

The following set of measures is proposed to support climate-smart and biodiversity-oriented forest management, while fostering the emergence of viable and inclusive economic value chains in the Valle Tanaro Living Lab.

1. Promote Climate- and Biodiversity-Smart Silviculture

- *Support for the conversion of coppices to high and mixed forest, where ecologically and economically appropriate, to enhance carbon storage, structural diversity, and long-term productivity.*
- *Encourage mixed-species, uneven-aged stands through selective thinning and regeneration practices, improving resilience to drought, pests and extreme events.*
- *Prioritize ecosystem-based silviculture in sensitive areas (e.g. Natura 2000 sites), avoiding clear-cuts and maintaining vertical and horizontal heterogeneity.*
- *Implement monitoring protocols to assess changes in species composition and health due to climate shifts, guiding adaptive management.*

2. Reinforce the Value of Traditional Land-Use Systems

- *Support the rehabilitation and maintenance of chestnut orchards, integrating traditional practices with modern techniques to increase productivity and resilience.*
- *Promote technical assistance and branding for NWFPs (mushrooms, honey, herbs), linked to sustainable harvest protocols and biodiversity conservation.*
- *Develop certification schemes (e.g., organic, sustainable forest product labels) for traditional and multifunctional land uses.*

3. Support Forest-Based Circular and Bioeconomy Value Chains

- *Facilitate investments in the processing of low-grade wood and residues for energy and green chemistry applications (e.g., tannin extraction, biopolymers).*
- *Strengthen collaboration with industrial actors like Silvateam and local SMEs to anchor innovation in the region.*
- *Promote cascade use of timber and the "trash to cash" approach to valorize by-products from pruning, thinning and restoration activities.*
- *Encourage cooperative business models that combine product transformation with ecosystem service enhancement (e.g., carbon offsetting, biodiversity sponsorships).*

4. Activate Mechanisms for Ecosystem Service Monetization

- *Pilot blended finance instruments (e.g., PES, carbon credits, biodiversity credits) that reward forest owners for sustainable management.*
- *Explore voluntary contribution models in the tourism and recreation sectors (e.g., visitor levies, partnership with private sponsors) to fund forest upkeep.*
- *Promote schemes linking access to forest-based experiences (e.g., mushroom permits, foraging tours) to maintenance and conservation efforts.*

5. Stimulate Tourism and Education Linked to Forest Stewardship

- *Develop interpretive trails, thematic routes, and nature-based learning activities that highlight the ecological and cultural value of forests.*
- *Invest in low-impact and multifunctional infrastructure for forest management and hiking, biking and guided outdoor experiences, especially in connection to restored chestnut groves and Natura 2000 sites*
- *Integrate ecotourism operators into forest governance mechanisms, ensuring that their activity contributes directly to conservation goals.*

6. Strengthen Territorial Governance and Cooperation

- *Support the expansion and coordination of forest owner associations (ASFOs) and forest consortia to overcome fragmentation and enable joint planning.*
- *Provide capacity building for micro-enterprises and cooperatives, especially in forest operations, NWFP processing, and eco-tourism services.*
- *Encourage the participation of social and civic actors (e.g., community cooperatives, schools, NGOs) in landscape restoration and sustainable forest use.*

- *Promote multi-stakeholder network and initiatives, aimed at impact-economy initiatives.*

Priorities

In light of the challenges and opportunities that emerged during the participatory process, the priority for the Valle Tanaro Living Lab is to establish a resilient, multifunctional forest economy that aligns forest management with the long-term provision of ecosystem services. This vision requires not only ecological and technical innovations, but also new financial mechanisms, governance arrangements and business models adapted to the territorial context.

A central priority is to ***enhance the active management of forests****—especially in areas currently abandoned or degraded—by linking such interventions to measurable ecosystem service outcomes. Particular attention should be given to the* ***restoration and maintenance of traditional chestnut orchards*** *and the* ***conversion of old coppices to high forest****, especially in chestnut, beech and mixed species stands. These practices can support carbon storage, biodiversity, water regulation and landscape aesthetics, while also enabling the production of timber and non-wood forest products.*

To sustain these management efforts, ***blended finance solutions*** *must be promoted. These include public incentives for climate-smart and biodiversity-enhancing forestry (e.g., PES schemes or silvo-environmental payments), as well as voluntary private contributions, such as sponsorships or land stewardship agreements. One promising path is the creation of* ***multi-benefit business models*** *that bundle climate and biodiversity credits with sustainable product offerings or tourism services.*

Given the high level of ***land fragmentation*** *and the small scale of most forest owners, a second key priority is to support* ***aggregation and cooperation mechanisms****, particularly through existing forest consortia, landowner associations (ASFOs), and community cooperatives. These structures can coordinate planning and operations, pool resources, and improve access to markets, training and investment. They are also well placed to act as intermediaries in* ***hybrid public-private models****, capable of delivering both environmental and socio-economic outcomes.*

The ***integration of non-wood forest products and slow tourism*** *into local value chains is a third important priority. The cultural and economic relevance of mushrooms, chestnuts, honey and medicinal herbs—as well as the scenic and recreational value of forests—offers opportunities for developing tourism and experiential services connected to foraging, mycology, environmental education and forest wellbeing. These models can generate income while directly involving local actors, reinforcing the sense of place and stewardship.*

Finally, the area should invest in ***capacity building, innovation and communication****, especially to support new green businesses. This includes technical training (e.g., for forest operations, NWFP processing, tourism services), the activation of school-to-work pathways (e.g., via the Ormea Forestry School), and public campaigns to raise awareness around ecosystem services and the value of well-managed forests.*

In summary, the most promising business models identified by the stakeholders involve:

- *Carbon and biodiversity credit generation through improved forest management.*
- *Value chains for NWFPs such as mushrooms and chestnuts.*
- *Tourism and educational services that reinvest part of their revenue in forest care.*
- *"Adoption schemes" linking forest areas to branded agroforestry products.*
- *Circular economy models based on the reuse of forest residues (green chemistry).*

- *Private sponsorships for forest restoration and landscape improvement.*

*These business options share a common requirement: the **recognition and monetization of the ecosystem services** provided by forests. Developing this portfolio is not only economically desirable, but essential to ensure the ecological continuity and territorial cohesion of the Tanaro Valley.*

Selected business ideas

Business idea – Multifunctional Forest Economy for the Tanaro Valley

*The business idea proposed for the Valle Tanaro Living Lab emerged from a comprehensive analysis of the area's ecological complexity and socio-economic dynamics. Given the **broad spectrum of ecosystem services** present—ranging from carbon sequestration and biodiversity conservation to recreation and non-timber products—and their high degree of interdependence, a **modular and integrated approach** was deemed necessary.*

*This decision was further reinforced by the specific characteristics of the territory: a **large and diverse forest area**, **fragmented land ownership**, the presence of **multiple stakeholder types** (from private landowners to cooperatives, municipalities, and SMEs), and a **wide variability in habitats and forest types**. In this context, a mono-sectoral or product-focused model would have been too narrow. Instead, a diversified business model was designed to:*

- ***Generate positive** and **measurable impacts** on ecosystem service provision.*
- *Enable **cost optimization** by combining complementary activities.*
- *Maximize **local economic benefits**, particularly in sectors such as forestry, agriculture, nature-based tourism, training, and wellbeing.*

*The proposed business model follows a **dual-track logic**, each component supporting both ecological functions and economic sustainability:*

- ***Land stewardship and forest enhancement***

  A set of forest management and improvement interventions is implemented on selected plots through stewardship agreements with private and public landowners. These actions are designed to deliver certifiable impacts on ecosystem services (e.g. increased carbon stocks, improved biodiversity indicators, hydrological regulation) and contribute to broader socio-economic goals (e.g. employment, environmental education, access to nature). The quantifiable nature of these results enables their valorisation for marketing, Corporate Social Responsibility (CSR) or climate compensation purposes (carbon & biodiversity credits), involving companies, institutions or individuals as sponsors or offset buyers.

- ***Product and service development with forest-linked value***

  *A parallel line of activities involves the **commercialization of non-wood forest products (NWFPs)**—including mushrooms, chestnuts and honey—as well as **experiential and eco-tourism services**, such as guided walks, mycological tours and team-building events. These products and services are marketed with a **forest "adoption voucher"** embedded in the sale price. Each purchase contributes directly to the funding of concrete forest interventions, linking consumers to landscape stewardship and creating emotional engagement through storytelling and place identity.*

*Together, these components form a **resilient, multifunctional forest economy model**, capable of generating diversified revenue streams while securing the long-term supply of ecosystem services that are crucial for the well-being of the Tanaro Valley's communities and landscapes.*

Factores for feasibility assessment

*The feasibility analysis of the business model proposed for the Valle Tanaro Living Lab was based on a **15-year economic and technical modelling exercise**, aimed at evaluating both the financial sustainability and the capacity of the model to deliver quantifiable ecosystem service outcomes.*

The modelling process followed a structured sequence of steps:

- ***Definition of the core activities** included in the business model, namely:*
    - *Improved forest management (conversion of ageing beech coppices and restoration of chestnut orchards), generating carbon and biodiversity credits, and at the same time providing timber and fuelwood-*
    - *Collection and commercialization of **non-wood forest products (NWFPs)** such as chestnuts, honey, and mushrooms.*
    - *Development of tourism and experiential services, including guided hikes, mycological visits, and corporate team building.*
- ***Market analysis** of production costs and sales values for each product and service line, with special focus on the **volatility of carbon credit pricing** and its impact on revenue streams.*
- *Construction of multiple financial scenarios, based on varying:*
    - ***Baselines for forest operations**, depending on regional legislation and standard harvesting intensity.*
    - ***Silvicultural orientations** (e.g., extent of high forest conversion vs. mixed forest management).*
    - ***Public support levels**, modelled as a variable percentage of total investments and forest management costs (0 %, 20 %, 50 %, 85 %).*

*To ensure financial robustness, the model was calibrated so that product prices (wood, NWFPs, services) remain in line with real market benchmarks, while the **€/tonCO_2eq value** of carbon credits was adjusted to ensure a minimum **10 % margin**. This allowed for testing different credit price scenarios while preserving economic balance. Finally, **initial investment costs**—including certification, tourism service design, marketing, and promotion—were estimated based on comparable initiatives in similar rural contexts.*

Technical and ecological feasibility

The forest management interventions foreseen in the business model include:

- *Conversion of aged beech coppices into high forest, through preparatory thinning and progressive canopy restructuring.*
- *Restoration of traditional chestnut orchards, involving pruning, soil care, understory cleaning and periodic maintenance.*

- *Maintenance of mixed forest patches derived from abandoned chestnut groves, with selective interventions focused on biodiversity and NWFPs.*
- *Landscape and recreational infrastructure development, such as creation and maintenance of interpretive trails, signage, and access points.*
- *Monitoring systems for ecosystem service indicators (carbon stock, biodiversity, water retention).*

Economic feasibility

*As introduced in the overall feasibility assessment, the business model for the Valle Tanaro Living Lab was evaluated through a **15-year economic and technical simulation**, with the aim of assessing both the financial sustainability and the capacity to deliver measurable ecosystem service outcomes.*

Cost structure

The main cost categories included in the model are:

- ***Forest operations and landscape maintenance***
    - *Technical design and supervision*
    - *Certification*
    - *Monitoring and internal audits (€/ha)*
    - *Management plans (€/ha)*
    - *Payments to landowners:*
        - *Chestnut orchards (€ /ha/year)*
        - *Beech stands (% of timber sales)*
    - *Silvicultural activities:*
        - *Beech forest – preparatory cutting*
        - *Beech forest – conversion cutting*
        - *Chestnut orchard – restoration*
        - *Chestnut orchard – annual maintenance*
- ***Recreation and tourism infrastructure***
    - *Trail development*
    - *Trail maintenance*
- ***Support services***
    - *Design of educational and training offers*
    - *Start-up, marketing and extraordinary expenses*
    - *Personnel and machinery for product/service delivery*
    - *Overheads (15 % of other costs)*
    - *Marketing and communication (15 % of other costs)*

- *Financial and contingency costs (7 % of other costs)*

Revenue structure

The revenues are drawn from:

- ***Products***
  - *Chestnuts*
  - *Honey*
  - *Timber*
  - *Mushrooms*
- ***Services***
  - *Basic tourism activities*
  - *Mycological tours*
  - *Premium experiential packages and corporate team building activities*
- ***Carbon and biodiversity credits (€/tonCO_2eq)***

Scenario-based modelling approach

Initial simulations of the business model revealed a ***systematic lack of profitability****, or in some cases even* ***negative margins****, particularly in relation to the production of ecosystem service credits (e.g., carbon). These outcomes were mainly due to the* ***high cost of forest operations*** *in steep and fragmented terrains, coupled with the relatively low market value of traditional products such as chestnuts and honey.*

In response, the model was ***refined by introducing public incentives*** *as a structural component of the financial strategy. These incentives were applied in various sub-scenarios as a* ***percentage of total costs and investments*** *related to both forest management and the development of associated business lines (e.g., tourism, certification, marketing). The goal was to* ***enhance the economic performance of carbon and biodiversity credits****, enabling them to function as a viable income stream and support the overall viability of the model.*

The final simulation included two main scenarios and multiple sub-scenarios:

- ***Scenario 1:***

  Restoration of abandoned chestnut orchards (with quantified annual maintenance) and high forest conversion in ageing beech coppices. Outputs include timber, chestnuts, honey, mushrooms, tourism services, and ecosystem service credits.

- ***Scenario 2:***

  Mixed-forest management in chestnut orchards combined with high forest conversion. Outputs include timber, mushrooms, tourism services, and credits.

Each scenario was tested across four ***levels of public co-financing*** *(0 %, 20 %, 50 %, 85 %) and two* ***forest management baselines*** *(one regulatory, one based on business-as-usual harvesting intensity). This* ***multi-***

variable approach *was essential to assess the conditions under which the proposed products and services could be offered at* ***competitive market prices****, while maintaining positive ecological and social impacts.*

Key financial and impact indicators

From the simulation results, the following indicators were obtained:

- ***Annual managed forest surface:*** *between 25 and 40 hectares/year*
- ***Total projected revenues (15 years):*** *between* ***€ 4 and € 8 million****, depending on the scenario*
- ***Annual turnover at full maturity:*** *over* ***€ 600,000/year***
- ***Estimated employment creation:*** *at least* ***10 full-time equivalent jobs*** *in forestry, agriculture and tourism*

Operational feasibility

The forest management measures foreseen in the business model—already described in the technical and ecological analysis—have been carefully calibrated to match the ***actual availability of local workforce and forest enterprises*** *in the Valle Tanaro area. The financial modelling exercise was conducted to ensure a* ***progressive scale-up of interventions****, allowing for realistic implementation rates and minimizing operational bottlenecks.*

The estimated ***managed surface area (25 – 40 hectares/year)*** *is consistent with the current capacity of forestry contractors and technicians operating in the region. The planned interventions—such as high forest conversion in beech stands and restoration of chestnut orchards—are aligned with the* ***existing wood supply chain****, contributing to its reinforcement rather than competing with it. In fact, these operations enable the extraction of wood in line with current market practices, while simultaneously* ***enhancing the provision of less tangible ecosystem services*** *such as carbon storage, biodiversity conservation, and hydrological regulation.*

Maintenance workloads and routine operations (e.g. trail upkeep, monitoring, chestnut grove care) have been included in the model's cost structure and distributed across time to ensure feasibility. In addition, the potential activation of a ***carbon and biodiversity credit market*** *could offer a new income stream for forest managers and contractors, reducing financial exposure over time and fostering long-term investment.*

On the ***stakeholder engagement side****, the business model has been progressively validated during the participatory activities of the Living Lab. Through a series of workshops and targeted consultations, the* ***products, services, cost components and financial structure*** *of the model were discussed and adjusted. The stakeholder mapping and profiling process allowed the identification of a core group of actors—spanning public institutions, the Ormea Forestry School, chestnut producers, forest companies, ASFOs, processing enterprises, and third-sector organizations—who could be directly involved in the implementation phase.*

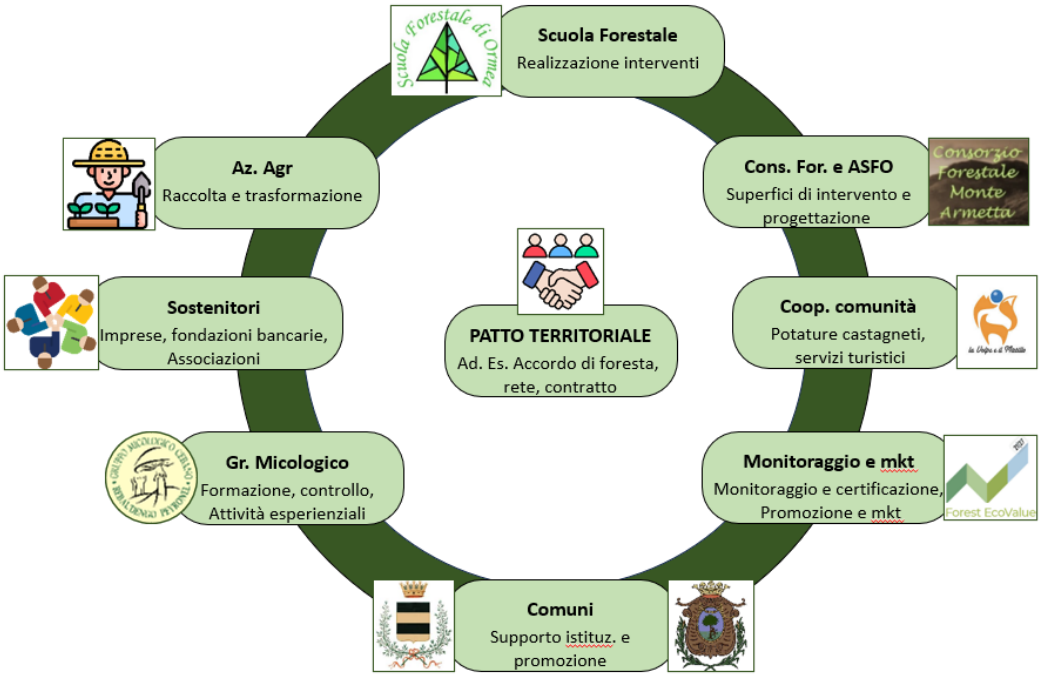

Figure 26: *BM Valle Tanaro A – advancement.*

Many of these stakeholders have already expressed ***informal interest*** *in the model and see it as a promising opportunity for future collaboration. Their existing competences, assets and territorial presence provide a solid foundation for the deployment of the proposed activities and for the* ***long-term governance of the business model****.*

Legal compliance

The proposed business model is fully compliant with the regional forestry regulations of Piemonte, including relevant territorial and municipal Forest management plans. It aligns with national forest policies promoting multifunctional and sustainable management and is consistent with Italy's commitments under the EU Forest Strategy, the European Green Deal, and the EU Biodiversity Strategy for 2030.

In particular, the model supports objectives related to climate change mitigation and adaptation, biodiversity conservation, and the enhancement of ecosystem services. It also meets the eligibility criteria for public support measures such as PES schemes and CSR 2023 – 2027 silvo-climatic payments (e.g., measure SRA 27), making it suitable for integration within existing policy and funding frameworks.

Conclusions

The development of the business model for the Valle Tanaro Living Lab was the result of a ***participatory and iterative process****, combining stakeholder engagement with technical modelling. Through workshops, interviews and joint analysis, the model was progressively refined to reflect local needs, capacities and priorities. The approach integrated* ***ecological, economic, and social dimensions****, ensuring that proposed actions were both environmentally sustainable and economically grounded, while also enhancing local value chains and community wellbeing. The Living Lab served as a* ***real-world testing and validation space****,*

enabling dialogue between institutions, private actors, and civil society, and fostering the co-design of solutions tailored to a complex and fragmented mountain territory. This process-oriented methodology provided not only a functional business model, but also a transferable framework for future implementation and policy learning.

Main Achievements and Key Feasibility Findings

Technical and Ecological Soundness of Interventions

The forestry interventions identified have been evaluated as technically viable and ecologically strategic. These actions are consistent with regional forest planning tools and contribute to ***climate change adaptation, carbon sequestration, biodiversity conservation****, and the* ***enhancement of hydrological functions****. Designed according to climate- and biodiversity-smart principles, they avoid extractive approaches and instead favour gradual, ecosystem-based silviculture that maintains habitat quality while enabling sustainable resource use.*

Potential for Diversified Value Chains and Ecosystem Service Valorisation

The business model presents opportunities for the ***simultaneous development of multiple value chains****, including timber, non-wood forest products (e.g. mushrooms, chestnuts, honey), and nature-based tourism. In parallel, it introduces an innovative mechanism for the* ***monetisation of ecosystem services****, through the generation of* ***carbon and biodiversity credits*** *linked to concrete forest management activities. This diversification strategy not only spreads financial risk but also strengthens the territorial economy by integrating ecological and experiential dimensions into marketable offers.*

Stakeholder Engagement and Territorial Alignment

One of the key achievements of the Living Lab process has been the active and structured involvement of local stakeholders—ranging from forest owners and cooperatives to municipalities, third-sector actors, educational institutions, and SMEs. Their participation has ensured that the business model reflects the ***realities, constraints and ambitions of the territory****, making it more robust and locally anchored. Many stakeholders have expressed concrete interest in contributing to the implementation phase, either through land stewardship, product development, service delivery or governance roles.*

Simulated Impacts and Economic Performance under Realistic Conditions

The 15-year financial simulation shows that, under realistic assumptions, the model could activate ***25 – 40 hectares/year of managed forest****, generate* ***€ 600,000/year*** *in turnover at full maturity, and create at least 10 full-time equivalent jobs. However, the model's economic viability is strongly influenced by the availability of public co-financing or ecosystem service payments. Without such support, the internal cost of producing climate credits ranges between* ***€ 87 and € 187 per tonCO_2eq****, far above current market averages. This underscores the need for blended finance strategies and policy frameworks that recognise the full value of ecosystem-oriented forest management.*

Critical Challenges and Systemic Barriers

Despite the promising potential of the proposed business model, the feasibility assessment also highlighted several ***structural and systemic obstacles*** *that must be addressed to ensure real-world implementation and long-term sustainability.*

High Cost of Implementation in Marginal Forest Areas

The steep slopes, poor accessibility, and fragmentation typical of mountain forests in the Valle Tanaro area significantly increase the cost of forest operations. Activities such as high forest conversion, trail restoration, or chestnut orchard recovery are ***labour-intensive and costly****, often exceeding the market value of the extracted products. Without dedicated support mechanisms, these costs represent a major barrier to widespread adoption, especially for small forest owners or undercapitalized cooperatives.*

Low Profitability of Traditional NWFPs: The Case of Chestnuts and Honey

Although chestnuts and honey are culturally and historically relevant products, the ***economic returns from their production remain limited****. In the modelled scenarios, the revenue from chestnut orchards was often lower than the associated management costs, particularly in traditional systems. Honey production showed slightly better margins but still failed to offer a stable income base. By contrast, mushrooms demonstrated higher added value and stronger potential for integration with gastronomic tourism. This imbalance calls for a* ***repositioning of NWFPs*** *within diversified, multifunctional value chains.*

Fragmentation of Ownership and the Cost of Land Mobilisation

The high degree of land fragmentation in the Living Lab area poses both operational and organisational challenges. Mobilising private forest parcels requires significant ***animation and coordination efforts****, which were not included in the financial modelling but could represent substantial overhead costs. This issue limits the scalability of interventions and highlights the need for* ***aggregation tools****, such as forest consortia or stewardship agreements, that can pool resources and streamline implementation.*

Sensitivity to Baseline Assumptions in Carbon Credit Generation

A critical variable in the business model is the ***baseline used to calculate additionality for carbon and biodiversity credits****. The feasibility analysis showed that depending on whether the baseline is defined by* ***regional forest regulations*** *or by actual average harvesting intensity (as per regional deliberations), the* ***volume of credits generated — and thus their value — can vary by up to 60 %****. This variability introduces uncertainty in revenue forecasting and raises questions about the* ***standardisation and credibility*** *of voluntary market mechanisms.*

Market Gap in Credit Pricing in the Absence of Public Support

Under scenarios without public funding, the model would require a ***carbon and biodiversity credit price between € 87 and € 187 per tonCO_2eq*** *to be financially sustainable. This is far above current global market averages — currently around* ***$ 15 per ton*** *for improved forest management projects, and even lower when compared to REDD+ or renewable energy credits (source: State of the Voluntary Carbon Market 2025, Ecosystem Marketplace). Such a gap confirms that, in the current market landscape,* ***public co-financing or alternative forms of support are essential*** *to bridge the economic viability gap and reward ecosystem service provision.*

Enabling Conditions and Strategic Levers

Addressing the structural challenges identified in the feasibility assessment requires a coordinated effort to activate key ***enabling conditions and strategic levers****. These factors are essential not only to support the implementation of the business model, but also to pave the way for broader policy innovation and territorial transformation.*

Blended Finance and Incentive Models: From PES to "Climate-Smart Timber" Premiums

To overcome the financial gap between the costs of climate-smart forest interventions and the market value of resulting products and services, ***blended financing mechanisms*** *are needed. These may include combinations of public incentives (e.g. PES schemes, silvo-climatic payments under CSR), private contributions (e.g. sponsorships, carbon offsetting), and donor support. The introduction of* ***production-linked subsidies****, similar to the approach seen in the German Living Lab—where public support is tied to timber volumes produced under specific ecological criteria—could be replicated in Piemonte. A* ***climate and biodiversity smart timber premium****, linked to certified silvicultural practices, could both reward good management and support new markets.*

Policy Innovation on Baselines, Creditability, and Eligibility

The effectiveness of ecosystem crediting schemes hinges on the definition of ***credible, fair, and transparent baselines****. In the current regulatory context, the use of different reference scenarios (e.g. legal norms vs. actual management practices) creates significant variability in the volume and value of credits. A* ***regional-level clarification and standardisation*** *of baseline assumptions could greatly improve confidence in credit markets and stimulate investment. Similarly, clearer guidance on what constitutes eligible, additional, and verifiable forest interventions would reinforce the environmental integrity and economic attractiveness of the credits.*

Aggregation Tools and Forest Governance Frameworks

To mitigate the effects of ownership fragmentation and support coordinated action, the expansion of ***aggregation mechanisms*** *is critical. These include forest owner associations (ASFOs), consortia, cooperatives and other forms of collective management. Supporting these structures with technical assistance, facilitation, and access to funding will enable them to play a key role in* ***land mobilisation, joint planning, and investment coordination****. Strengthened forest governance at the territorial level can ensure a balanced distribution of responsibilities and benefits across different actor groups.*

Capacity Building and Market Infrastructure for Ecosystem Service Monetisation

The development of ecosystem service markets — particularly for carbon and biodiversity credits—requires parallel investment in ***human capital and infrastructure****. This includes training for forest managers, technicians, and service providers; creation of new professional profiles (e.g. ecosystem service brokers); and development of user-friendly tools for project design, monitoring, certification, and sale of credits. Public institutions and research centers can play a key role in facilitating access to* ***voluntary markets****, especially for small and medium actors, ensuring that the benefits of environmental services remain within the territory and contribute to local resilience.*

Strategic Outlook and Areas for Further Development

The feasibility assessment and the participatory work carried out in the Valle Tanaro Living Lab have laid the foundation for a business model that is both locally grounded and adaptable to broader contexts. The next phase of development should focus on testing, refining, and scaling the model, while leveraging policy tools and strategic alliances to ensure long-term sustainability.

Business Model Improvement: Balancing Ecological Restoration with Profitable Forestry

The current version of the business model focuses primarily on forest interventions with ***negative economic balances****, such as chestnut orchard restoration and coppice conversion. While these are ecologically justified, future iterations should explore a* ***more balanced portfolio****, combining ecological improvement actions with*

more economically viable forestry operations *— e.g., in productive chestnut coppices or high-volume beech stands. This would enhance the model's profitability while maintaining its alignment with climate and biodiversity goals. A more selective use of forest types and treatments could help* ***reduce credit production costs*** *and increase financial resilience.*

Scaling and Transferability to other Alpine and Apennine Regions

Thanks to its ***modular structure****, the model is highly adaptable to other forested mountain areas facing similar challenges—land abandonment, ecological degradation, limited economic viability, and fragmented ownership. Regions in the Alpine and Apennine arcs could benefit from replicating the approach, adapting the mix of activities to local ecological and socio-economic contexts. The feasibility work in Valle Tanaro serves as a* ***proof of concept*** *that multifunctional forestry can serve as a driver for integrated territorial development.*

Pilot Implementation and Public–Private Partnerships

The next step is to initiate ***pilot actions****, activating land stewardship agreements and ecosystem crediting schemes in selected forest parcels. These pilots should be supported by* ***multi-actor partnerships*** *involving public authorities, ASFOs, private companies, cooperatives, and NGOs. These alliances would serve not only to coordinate implementation, but also to test governance mechanisms, validate monitoring methodologies, and attract both public and private co-financing. Pilot testing will also allow refinement of the* ***economic tools*** *developed during the modelling phase and better calibration of pricing strategies.*

Future Integration with Regional Strategies and Programming

Finally, to ensure long-term impact and institutional anchoring, the business model should be progressively integrated into ***regional development strategies****, including forestry programming, climate adaptation plans, rural development funds, and carbon/biodiversity crediting frameworks. Synergies with existing policy instruments — such as CSR measures, regional forest plans, and biodiversity action strategies—will be essential to embed the model into operational programmes. This alignment would not only facilitate funding but also position multifunctional forest management as a* ***strategic lever for sustainable mountain development****.*

LIVING LAB SLOVENIA

Tržič

Output 2.3

Living Lab Slovenia

Characteristics of the Living Lab area

Geographical location

Our Living Lab is the Municipality of Tržič in the Northern Slovenia with a total area of 15,500 hectares (s. Figure 27).

Figure 27: *Location of the Municipality of Tržič in Slovenia.*

Land use

73 % of the municipality's area is covered by forests, while agricultural land is mainly located in the southern, lowland part. Pasture is also present in the alpine meadows. The largest settlement is Tržič, with 3,000 inhabitants, while the municipality as a whole has 15,090 residents living in 35 settlements, corresponding to approximately 98 inhabitants per square kilometre.

Topography and climate

The municipality lies at the foot of the Karawanks mountain range. Its northern part is mountainous, with the highest peak reaching 2,133 m, gradually descending southward into hilly terrain and then into flat river–glacial terraces, with the lowest point at 424 m. The average elevation is 1,080 m, and the average slope is 25.3°. The climate is alpine, characterized by high precipitation — the average annual rainfall in Tržič is about 1,400 mm, and in higher areas it exceeds 1,700 mm. The topographic map in Figure 28 gives and overview of the altitude differences in the Living Lab area.

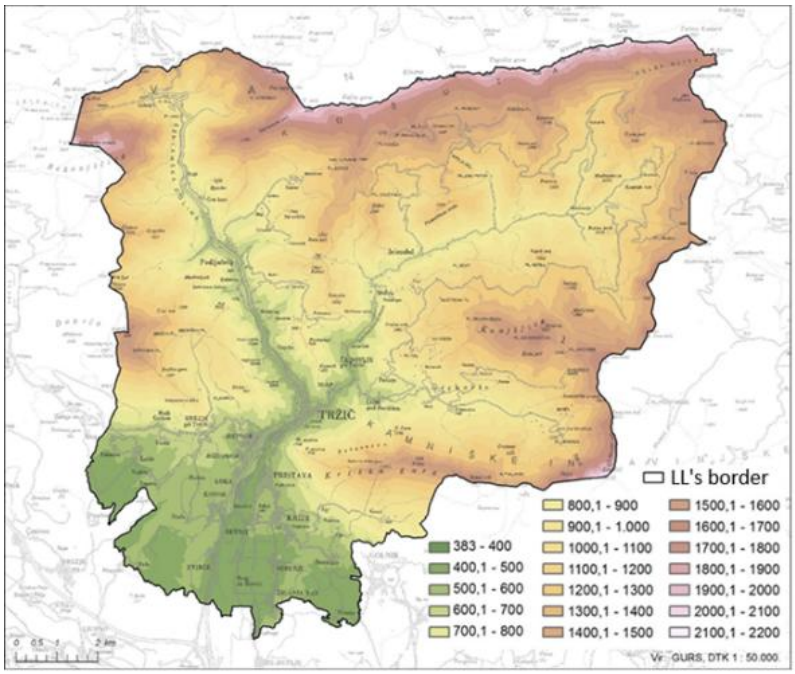

Figure 28: *Topographic map of the Municipality of Tržič with elevation data.*

Geology and pedology

The municipality has a diverse geological and soil composition. In the mountainous areas, carbonate rocks prevail, mainly Triassic limestones and dolomites. The hilly region features more varied geology, including Carboniferous, Permian, and Triassic rocks such as sandstones, shales, conglomerates, breccias, limestones, dolomites, keratophyres, and porphyries. In the lowlands, glaciofluvial sediments dominate. Soil conditions also change rapidly. The most common soils are rendzinas, followed by dystric and eutric brown soils, with occurrences of leached soils, rankers, hypogleys, and alluvial soils. The municipality is rich in watercourses, the largest being the Tržiška Bistrica, Mošenik, and Lomščica rivers. Figure 29 provides an overview of the divers terrain, based on the digital terrain model (LiDAR) of the municipality of Tržič, showing infrastructure and delineated torrents in the area.

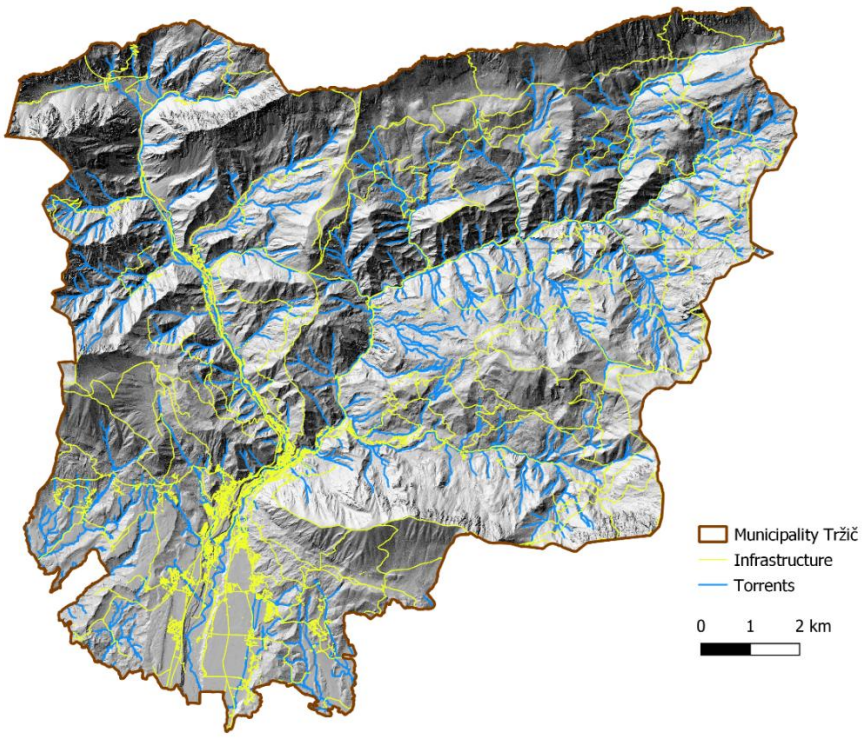

Figure 29: *LiDAR-based digital terrain model with delineated torrents and infrastructure in the Municipality of Tržič.*

Organizational structure

The entire LL area falls within a single municipality, the Municipality of Tržič.

Slovenia Forest Service (SFS, "Zavod za gozdove Slovenije") is responsible for forest management and prepares forest management plans for all forest in Slovenia, public and private. The LL area falls under SFS regional unit Kranj and SFS local unit Tržič. There are five SFS districts (Podljubelj, Košuta, Vetrih, Lom, Kovor). In each of them there is a district forester employed. There are some organizations for forest owners. For us, the most important are Forest owner association of Gorenjska and Forest owner association of Upper Gorenjska. Important organization in the field of forestry is also Slovenian state forest company (SiDG, "Slovenski državni gozdovi d.o.o."). The company's purpose is to manage the state forests according to the management plans.

Ownership

In the LL, private forests prevail, accounting for 85.5 % of the total forest area, while 9.7 % are state-owned and 4.7 % are municipal forests (s. Figure 30).

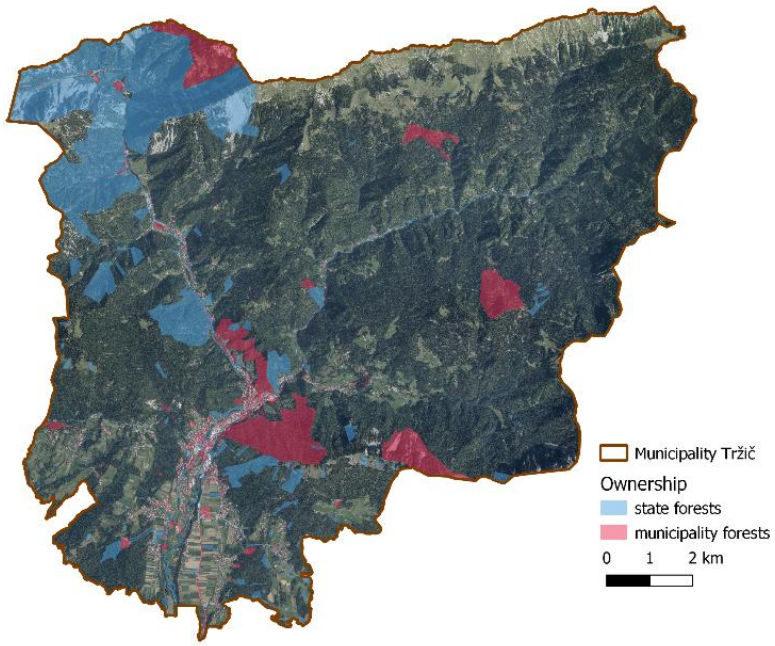

Figure 30: *Orthophoto image of the Municipality of Tržič showing location of state and municipal forests.*

Average forest property in the LL is 0.5 ha, there are more than 2000 forest (co-)owners in the LL. Despite high number of owners, there are quite some owners with large properties. The bar chart below in Figure 31 provides an overview of the number of forest owners per property category.

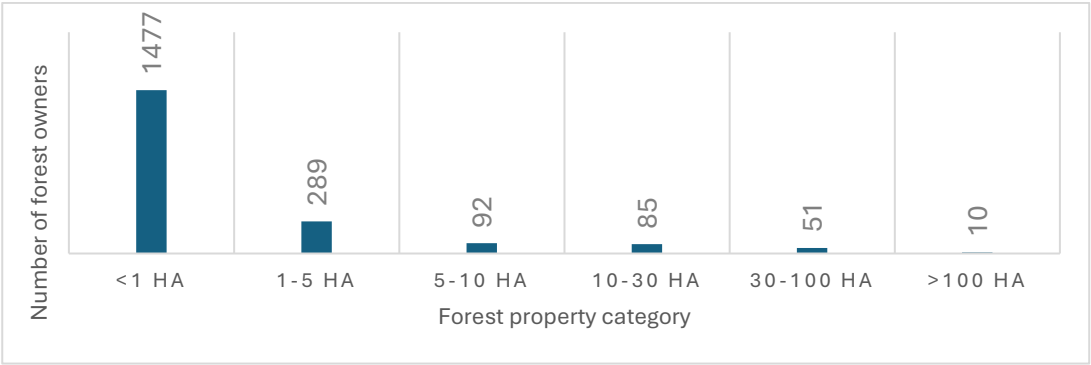

Figure 31: *Number of forest owners per property category.*

Status of forests in the Living Lab

Characteristic of forests and their management in the LL area

Forests cover approximately 73 % of the total area, corresponding to a forest surface of 11,290 ha. The average growing stock amounts to 401 m^3 / ha, while the average annual increment is 7.9 m^3 / ha. According to forest management plans, the maximum allowable cut is 7.2 m^3/ha, and the actual harvest amounts to 5.0 m^3 / ha.

The dominant tree species are Norway spruce (Picea abies) with 60.0 % of the total growing stock, European beech (Fagus sylvatica) with 21.4 %, Silver fir (Abies alba) with 8.1 %, and European larch (Larix decidua) with 3.7 %. Additional species with more than 1% of the growing stock include noble hardwoods, hard broadleaves, pines, and oaks. The prevailing forest types are montane and alpine beech forests, fir–beech forests on silicate and carbonate substrates, protective forests, and fir–beech and spruce stands. Mixed forests predominate, while pure stands, where a single species represents more than 70 % of the basal area, account for 36 % of the total forest area.

An analysis of stand development phases shows that 14.8 % of stands are in the regeneration phase, 11.3 % are pole-stage stands, 64.2 % are mature timber stands, and 9.7 % are young stands. Forests in the southern part of the municipality exhibit a relatively more natural tree species composition, whereas those in the northern part are altered to a greater degree. In total, 4.7 % of the forests are completely altered, meaning their species composition is entirely different from the potential natural one, 17.3 % are heavily altered, and 40.2 % are moderately altered.

In Slovenia, forest management is close-to-nature, multifunctional, and sustainable. Clear-cutting is prohibited, and regeneration is mostly achieved through natural regeneration, with interventions in the forest designed to mimic natural disturbance regimes. Management practices aim to enhance various forest functions and maintain their long-term sustainability. For all forests in Slovenia, SFS prepares forest management plans to ensure adherence to fundamental forest management principles. In the area, management is predominantly conducted using group selection and gradual cutting, with management objectives and guidelines adapted to site-specific conditions. Most forests in the municipality regenerate naturally, with only 226 ha of forest area supplemented with planted seedlings, primarily Norway spruce or beech saplings. Young stands are tended to improve future tree quality and species composition. The implementation of silvicultural treatments (tending of young stands and undergrowth) in the municipality is below the prescribed level. In older developmental phases, including pole-stage and mature stands, selective thinning is carried out. Trees designated for harvest are marked individually by district foresters with a red dot and a stamp on the lower part of the trunk. The rotation periods for most forest types range from 120 to 160 years.

Forestry has historically been an important activity in the Tržič area due to natural conditions. Currently, forest management faces several challenges. One challenge is the reduced intensity of management, particularly in protective forests, which are extensive in the area due to terrain. Lack of management decreases the stability and vitality of stands, leading to aging forests with limited natural regeneration. Another challenge concerns areas previously dominated by accelerated Norway spruce cultivation, which are more susceptible to windthrow and bark beetle infestations.

Forest Ecosystem Services in the Living Lab area

Forest ecosystem services have been assessed on local and large-scale level. The results of the assessment and the potential effects of forest management on ecosystem services supply are presented in D2.2.1 Forest Ecosystem services assessment pilot action report and sumarized here.

The Slovenian Living Lab provides multiple forest ecosystem services:

- *Provision of timber, fire and fuel wood biomass*
- *Protective role of forests against the damaging effects of torrential waters;*
- *Recreation and tourism.*

Potential effects of forest management on FES supply

This section will undergo further refinement and integration until the end of the Forest EcoValue project.

Business portfolio in place

The business portfolio refers to the forest ecosystem services considered, namely 'provision of wood biomass', 'protection against torrents' and 'recreation and tourism'.

Wood biomass

The use of biomass as a renewable energy source is encouraged by the EU and the state. The Municipality of Tržič is well-suited for biomass use, with significant forest coverage and a favourable ownership structure. Low-quality wood is traditionally used for heating, with part sold in Slovenia and Austria. Prices for energy wood vary by quality, supply conditions, and global market trends. For example, beech firewood costs approximately 90 €/m³, while pulpwood is around 50 €/m³. Many owners harvest less than the allowable cut, completing about 70 % of the planned harvest. A local market with stable demand for lower-quality wood could encourage more active forest management and increase forest-derived income.

Currently, there are no major consumers of lower-quality wood in the municipality, such as large wood-processing companies or municipal BDHS systems (Biomass District Heating Systems). Several small enterprises operate in logging, harvesting, and transport. Two large nearby companies also provide biomass grinding and supply services.

Torrents

Downstream watercourses are managed by the water sector, which typically does not operate in the predominantly forested upstream hinterlands. In these forested headwaters, sustainable, close to nature, and multifunctional forest management reduces the impact of damaging torrential floods. In areas with significant protective forest functions, management is adapted, and subsidies are available for silvicultural activities, such as planting, tending, and initial thinning. In the past, torrent management in Slovenia was organized by specialized company combining forestry and hydrology expertise. Funds were also allocated for the implementation of flood protection measures. In recent years, most funding has focused on post-event restoration works rather than preventive measures. In the field of forest management, funds are also available for the above-mentioned silvicultural works in torrential areas. However, due to the relatively low estimated labour costs (hourly rates), the implementation of these activities is lower than planned. Special funds are also available for protective forests, which can be used for torrent control measures (e.g. for the construction of check dams). Since the implementation of such works is extremely demanding and there is a lack of established practice for their planning and implementation, these activities are generally not planned in most parts of Slovenia. While the Slovenian Water Agency operates and plans interventions downstream, there is no dedicated service for torrent monitoring or for defining necessary forestry interventions in upstream forested areas. Communication between the forestry and water sectors is limited.

Recreation and tourism

Under Slovenia's Forest Act, forests are publicly accessible, meaning anyone can walk through them. Nevertheless, certain restrictions apply to recreational activities. Additional incentives are required for measures that provide public benefits. In areas where the social functions of forests are emphasized, management is adapted, and subsidies are available for silvicultural activities, including planting, tending, and initial thinning. If a forest is designated by municipal decree as having a special purpose due to highly

emphasized social functions, the municipality is obligated to purchase it at the request of the owners. Other forms of compensation are possible but are rarely implemented in practice. Some forest owners sell local products at forest entry points. There are several associations and providers operating in the municipality that are linked to the municipality's natural resources.

Economic valuation of Forest Ecosystem Services

While full economic valuation of FES in Tržic is reported in D 2.3.1 Transnational pilot testing FES economic assessment and market frameworks in each LL, for the purpose of this feasibility assessment, we present valuation results for the ecosystem services that were in focus of the LL activities, namely timber wood, firewood and fuelwood biomass provision, torrent control, and recreation. Please, refer to D 2.3.1 for further details on valuation methodology.

The results of the adjusted unit value transfer for the Slovenian Living Lab in Tržič are presented on Figure 32. Only values obtained through adjusted value transfer method (Alpine average) and voluntary carbon market pricing for carbon sequestration are reported as conservative estimates. Upper-bound estimates include direct market valuation for timber and firewood biomass provision and recommended carbon pricing (upper-bound) for carbon sequestration. According to both value estimates, torrent control FES has the second highest value per ha of forest, while other FES in focus of the LL are sensitive to estimate scenarios. Integration of local market prices in valuation makes timber wood provision FES more socially important in relative terms (i.e., value per ha) than recreation. This difference indicates value underestimation of Alpine average. Same observation is true for firewood biomass provisioning service, as local market prices valuation provides almost twice as high than that of Alpine average; however, this estimate adjustment to local market has a marginal effect on its social value, compared to other ecosystem services.

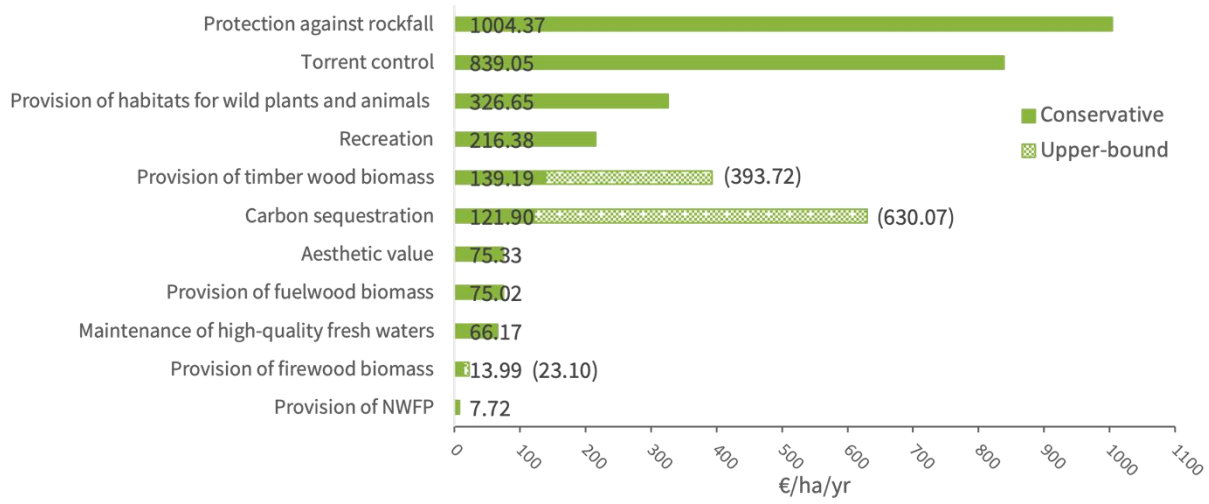

Figure 32: *Unit value estimates in 2023 euros per ha. Upper-bound value estimates are provided in parenthesis. NWFP stands non-wood forest products, including chestnuts, mushrooms and berries.*

Estimates of the total economic values (TEV) of forests in Tržič, using both conservative and upper-bound unit value estimates, are demonstrated in Figure 33. Torrent control is among the two biggest contributors to the conservative TEV (21%). In the upper-bound TEV, carbon sequestration has a leading contribution, followed by timber wood biomass (23%). Although with the moderately high value per ha, recreation has only a marginal contribution to both TEVs. This inconsistency suggests that targeted efforts on expansion of the forest area providing this FES will have a substantial effect on the TEV of forests in Tržič. It must be noted, that provided TEV estimates are a serious underestimation, as the number of FES included in the calculation was restricted to six. To avoid double counting and an inflated valuation of provisioning services, fire- and

fuelwood biomass provisioning services were also excluded from the TEV analysis, as the forest area providing these FES fully overlaps with timber wood biomass provision (i.e., total forest area), while only a small subset of non-provisioning FES could be valued in TEV terms (i.e., high possibility of underestimation). Despite these limitations, value of timber provisioning service constitutes less than a quarter of the forest TEV, suggesting that the social importance of forests in Tržič extends well beyond timber production. At the same time, we must keep in mind that the forest area providing provisioning services fully overlaps with the one providing carbon sequestration, almost fully with one providing habitats for wild plants and animals, and partially with other FES, hinting at potentially detrimental losses in social value of forests if forest management is fully oriented at timber provision.

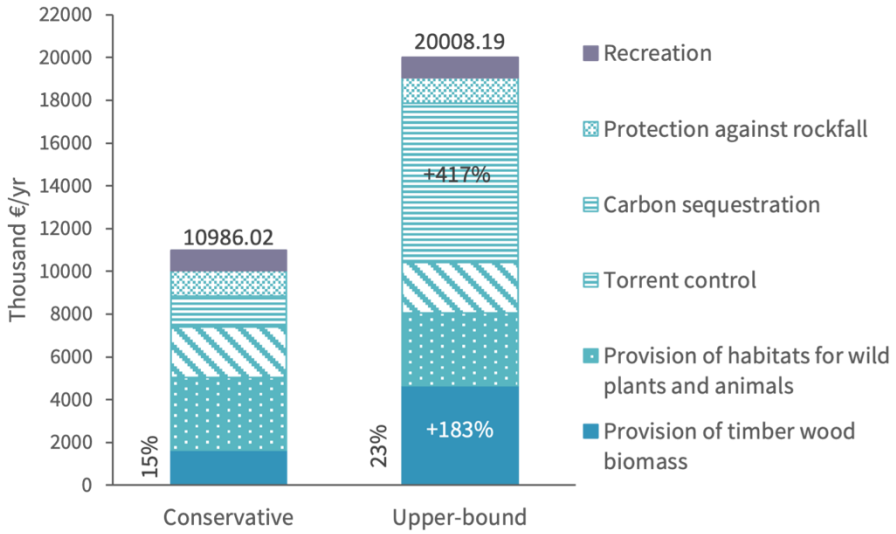

Figure 33: *Conservative and upper-bound estimates for total economic value (TEV) of forests in Tržič. Total values per year for each FES are estimated based on the forest surface areas providing respective services. Percentages for provision of timber wood biomass placed on the left of the bars indicate a contribution of timber wood provision to the TEV. Percentages placed inside the bar indicate difference in total values of FES between conservative and upper-bound TEVs, when such difference occurred. Numbers on the top of the bars indicate the TEVs.*

Spatial distribution of FES social values in Tržič further details our understanding about the FES provision in the Living Lab (s. Figure 34). Not all values are evenly distributed throughout the territory of the Living Lab. While most of the forest area provides slightly above expected average value per ha (825 €/ha/yr[11]), highly valuable area are very scares and concentrated in the north-west of the LL, in the north of Poratjie (around Dovžan gorge), and in the south-east of Tržič. Areas with the lowest relative values (only timber provision and carbon sequestration FES are concentrated in the southern part of the LL. While further supplementation of this map with the spatial distribution of forest ownership and residential areas could shed more light into FES providers and beneficiaries dynamics in the area, already at this stage we can see a high risk of potential trade-offs when forest management plans are focused only on one ecosystem service.

[11] *As forest areas providing timber wood biomass and carbon sequestration has a 100% overlap, at least two FES are expected to be at each ha, therefore, expected average is a representative midpoint value. It was calculated as follows:* $Expected\ average = Average\ of\ all\ FES\ values\ per\ ha \times 2$

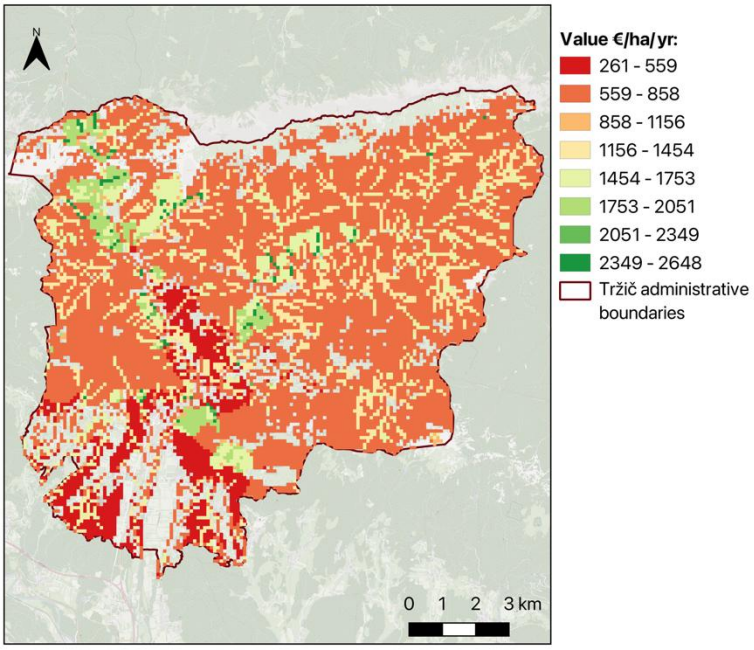

Figure 34: *Spatial distribution of conservative unit values in Tržič. Some degree of spatial under- and overdistribution is present for the unit value of carbon sequestration, as unit value estimation is based on mean carbon sequestration per ha, not carbon sequestration specific to the forest unit.*

Feasibility Assessment

Development scenario

Due to climate change, extreme weather events are becoming increasingly frequent, including in the Municipality of Tržič. As a result, forests are becoming more exposed to various natural disturbances such as droughts, floods with erosion and landslides, windthrows, ice and snow breakage, wildfires, and bark beetle outbreaks, which often follow such disturbances. The ForClim model was used to test how different forest management approaches affect the provision of FES under various climate change scenarios for the Municipality of Tržič (Fidej et al., 2023). The results showed that, due to the relatively high precipitation in the area, the impacts of climate change on FES provision are smaller compared to the other study areas. The findings indicate that close-to-nature forest management is effective in ensuring the long-term provision of FES. However, no single management approach performs equally well across all FES. Biodiversity increased under the no-intervention scenario, while the protective function of forests and timber production performed best under an adaptive close-to-nature management regime that includes planting tree species adapted to future climatic conditions. The goal is to maintain forests that are natural, site-adapted, structurally and species diverse, and therefore more resistant and adaptable to various types of disturbances. At the same time, forests play an important role in mitigating climate change and its effects — they act as carbon sinks and carbon storage, help moderate local temperature extremes, and significantly reduce the negative impacts of torrential floods and other natural hazards through their protective functions.

In addition to climate change, demographic changes must also be considered. Both in Slovenia and globally, migration from rural areas to urban centres is increasing. Despite this trend, the municipality as a whole maintains a relatively stable population. Recreational studies in Slovenia indicate growing pressure on forest areas. Similarly, in the Municipality of Tržič, indicators such as parking fees and overnight stays show an increasing number of visitors and a rise in tourism activity.

Objectives

The overall goals are :

Wood biomass

Promoting the use of wood biomass in the municipality

Torrents

Developing a system for torrent management

Recreation and tourism

Promoting sustainable recreation in forest areas

Ecological objectives

Wood biomass

- *Encouraging active management of private forests – climate change resilience*
- *Promoting renewable energy sources that reduce the CO_2 footprint (also at municipal level)*
- *Ensuring biomass supply while taking into account ecologic functions*

Torrents

- *Ensure the protective functions of forests against the impacts of torrential floods*
- *Ensure the protective functions of forests while taking into account their ecological functions*

Recreation and tourism

- *Ensure environmentally friendly recreation and tourism in forests while respecting ecological functions*
- *Increase visitor awareness of the importance of forests' ecological functions through recreational activities*

Economic objectives

Wood biomass

- *Establish a market for low-quality wood (biomass district heating systems (BDHS))*
- *Stable heating prices*
- *Create opportunities for additional income for forest owners and companies engaged in biomass production and supply*
- *Reduced import-related energy dependency of the municipality in times of uncertainty, increased self-sufficiency, and acceleration of the circular economy*
- *Encouraging active management of private forests –more quality timber*
- *Encourage the clearing of overgrown areas for (renewed) agricultural use*

Torrents

- *Reduce damage (rehabilitation and intervention costs) caused by torrential floods*
- *Improve quality of life, stability, and investment opportunities through enhanced flood safety*
- *Increase property values (buildings, land, and forests) as a result of improved flood protection measures*

Recreation and tourism

- *Assess the potential economic benefits for the local population*
- *Improve the quality of visitor experience, thereby increasing income for the local community and the municipality*
- *Identify potential PES (Payment for Ecosystem Services) schemes to promote sustainable recreation in forest areas*
- *Contribute to reducing conflicts related to recreational activities in forest areas and ensure the unhindered economic use of forests*

Measures

Note: Forest management in Slovenia is sustainable, close-to-nature, and multifunctional; these concepts are integrated into forest management plans.

Wood biomass

Special forest measures aimed at maintaining or increasing the potential of forest biomass are not necessary. In principle, forest management strives for higher-quality assortments, but there is always a share of low-quality wood present.

We also carried out other activities not directly related to forest management. We assessed the potentials and needs for woody biomass in the municipality based on records and databases of SFS. Through a survey among bigger forest owners, we sought to determine whether they were interested in selling, in what quantities, and what are the main factors influencing their decision to sell wood. We raised awareness among various stakeholders, especially the municipality, about woody biomass. We conducted an interview with a company engaged in wood biomass. Stakeholders were connected in a workshop, where we jointly developed proposals for increasing woody biomass. The activities are described in more detail in the document Regional Roadmap – Slovenian LL.

Torrents

Management aimed at improving protective functions against the harmful effects of torrential floods is largely similar to the management of protective forests. It is important to identify areas where the protective role against the harmful effects of torrential floods is (extremely) significant and where adapted management is reasonable and necessary. Measures for protection against torrents in the wider torrent area are similar to those in protective forests, while additional measures near the torrents are related to the removal of dead biomass and wood storage, stabilization of banks (e.g. planting, biotechnical measures, tending of young stands). Attention should also be given to adapted construction and maintenance of forest roads as well as the execution of felling and skidding operations.

We also carried out other activities not directly related to forest management. During the project, we analysed the situation in the field of torrent regulation, initiated employee training, and developed a system for the

inventory and inspection of torrents in the Municipality of Tržič. There, we first analysed the torrents, identified problematic ones, prepared forms and guidelines for inventory, created an application in QField, and tested the methodology. We roughly estimated personnel needs and costs at the level of SFS, as well as damage caused by floods and erosion. We cooperated and established connections with various forestry institutions. We raised awareness among both the general and forestry public. The activities are described in more detail in the document Regional Roadmap – Slovenian LL.

Recreation and tourism

In areas important for recreation, management is already adapted accordingly. These areas are usually designated as areas with an emphasized recreational function. For them, forest management plans define specific guidelines regarding felling and skidding, silviculture, protection, infrastructural measures, and additional actions necessary to strengthen the recreational function (awareness-raising, stakeholder cooperation, etc.). We also carried out other activities not directly related to forest management. During the project, we conducted and analysed a survey on forest recreation in the Municipality of Tržič. We cooperated with the municipality. We organized several workshops to gather information on various stakeholders in the fields of recreation and tourism, connected the stakeholders, and jointly developed proposals to reduce potential conflicts among different land users. We raised awareness among both the general and forestry public. The activities are described in more detail in the document Regional Roadmap – Slovenian LL.

Priorities

Wood biomass

In the field of wood biomass, it would be highly favourable for forest owners if a local market for low-quality wood were established within the municipality. Such a market would reduce transportation costs, encourage cooperation among forest owners, and enable lower costs of logging, extraction, and transport. Consequently, forest owners could achieve better purchase prices and more favourable sales conditions for biomass. The establishment of local market also represents an opportunity for companies engaged in logging, extraction, transport, chipping, and/or biomass supply. A key component of this system could be a municipal district heating system based on wood biomass (BDHS), as the municipality currently lacks a larger BDHS. In Slovenia, the amount of harvesting and the methods of forest management are determined by forest management and silvicultural plans. However, it depends on the forest owners how actively they manage their forests and how much of the planned harvesting potential is actually realised. Therefore, it is crucial that local market conditions provide additional motivation for active and sustainable forest management. Actively managed forest stands are more resilient and responsive to climate change, the quality of assortments improves, and consequently, the economic value of forests increases, while the availability of wood for biomass production also rises. The establishment of a local biomass market and a BDHS brings economic and social advantages for the local community, such as lower and more stable heating costs, increased energy self-sufficiency in uncertain times, and promotion of the circular economy and local value chains.

<u>Priority tasks</u>

- *Analysis of biomass potential (forest resources and the willingness of forest owners and wood-processing companies)*
- *Analysis of biomass demand (potential users: municipalities, companies)*

- *Review of legislation, literature, best practices, participation in meetings and conferences*
- *Analysis and cooperation with stakeholders (mainly the municipality and forest owners)*
- *Awareness-raising and education of various stakeholders*
- *Networking and cooperation among key stakeholders*
- *Integration of the BDHS into strategic plans and future municipal projects*

Torrents

Greater flood safety is in the public interest, and after the devastating floods of 2023, an increasing number of people are aware of its importance. Flood safety is strongly influenced by processes occurring in (predominantly) forested hinterland areas, where sustainable, nature-based and multifunctional management practices are already being implemented, significantly reducing the negative impacts of torrential waters. Nevertheless, with relatively small investments in the upper parts of torrents, it is still possible to further reduce the risks of flash floods and the related damages. Our business model is not a typical one; it is more of a payment scheme – a system for torrent management at the national level, whose main goal is to increase flood safety for all people and their property against the harmful effects of torrential floods. The business model would involve various stakeholders: SFS, the Water Agency, the state (relevant ministries), local communities, and forest owners, with clearly defined responsibilities and obligations. Additional funding would be required to cover new obligations and additional work. The concept is that public authorities responsible for people's safety (the state and municipalities) contribute to ensuring public benefits for society and residents (beneficiaries) by encouraging forest owners, forest managers, and water infrastructure operators (service providers) to implement measures that are crucial for flood protection. These incentives may be either financial (funding forest management measures, construction and maintenance of flood protection structures) or non-financial (volunteering, organizational support, or execution of works that may be too demanding for individual forest owners).

First and foremost, establishing an effective response system requires a good supervision mechanism. Torrent supervision is a specific task involving a comprehensive assessment of torrent conditions and the identification of necessary measures. This is a demanding work that requires technically skilled, professionally trained, and physically capable personnel. Our proposal is that SFS, with additional resources and personnel, takes responsibility for forest supervision in torrent-prone areas.

Priority tasks

This involves establishing or complementing a complex system that depends on various sectors and decision-makers at higher administrative levels. Therefore, the priority tasks include activities already implemented within the Forest EcoValue project and in cooperation with other projects and the public service of SFS, as well as those that still need to be carried out to achieve the goal of the business model / payment scheme. The main tasks are:

- *Assessment of the strengths and weaknesses of the current forest management system in torrential areas*
- *Proposal for improving forest management in torrential areas to reduce flood risk*
- *Review of the condition of selected torrents and surrounding forests, assessment of their status, identification of necessary measures, and preparation of a methodology for torrent inventory*
- *Assessment of the time, personnel, and costs required for torrent inventory within SFS*

- *Assessment of the damages caused by torrential floods*
- *Assessment of the feasibility of establishing a torrent management service within SFS, including an estimate of the required personnel and costs*
- *Stakeholder analysis in the field of torrent management and assessment of competences for specific areas*
- *Networking and cooperation with different stakeholders*
- *Awareness raising*

Priority tasks at the higher decision-making level

- *Harmonization and updating of legislation*
- *Ensuring permanent and stable funding (both for the operation of services and for flood protection measures: forest management, transport infrastructure, and water management measures)*
- *Promotion of cooperation and interdisciplinary training among all key national institutions*
- *Establishment of an integrated torrent monitoring system supported by a geographic information system*

Recreation and tourism

The area of the Municipality of Tržič offers numerous opportunities for recreation and tourism due to its natural features and relatively quick accessibility from larger cities. Recreation and tourism can bring many benefits (additional income opportunities for residents, revenue for the local community through tourist accommodation taxes and parking fees), while at the same time, the potential for disagreements increases due to a higher and more diverse number of visitors. Various business models and payment schemes are possible in the field of recreation and tourism. The concept can also involve service providers (forest owners) ensuring better conditions for recreational activities for users (the public, visitors) through adapted forest management. For forest owners in areas where the social functions of forests are particularly important, compensations are already available for silvicultural works. However, these compensations are not linked to additional activities aimed at improving the recreational function, such as maintaining trails, entry points, signage, and similar. In such cases, the local community could assist through implementation rather than financial compensation, while forest owners could receive specific earmarked funds for certain measures, which currently do not exist. In some other countries, specific agreements between municipalities and private owners are already being introduced, where forest owners develop cycling paths in their forests for the benefit of local residents.

Business models can also be related to additional income for landowners, such as arranging parking areas and earning income from parking fees, selling products, establishing agreements for trail maintenance as mentioned above, organizing or co-organizing guided tours, and similar. It is in the interest of forest owners that forest use for economic purposes is not hindered, that conflicts with other uses are addressed and resolved, and that forest visitors respect the forest code of conduct. The local community can also contribute to smooth forest management by helping with awareness-raising and informing visitors.

Priority tasks

- *Analysis of the current situation and characteristics of forest visits in the municipality*
- *Analysis of visitors' willingness to pay for parking and use public transport*
- *Identification of areas important for recreation and tourism*

- *Review of existing and potential forms of agreements between the local community and forest owners*
- *Education and networking of stakeholders*
- *Public awareness-raising and education*
- *Identification of possible PES schemes*
- *Awareness-raising*

Selected business ideas

Wood Biomass

In the Municipality of Tržič, no large-scale municipal BDHS currently exist, although the municipality has extensive forest cover, favourable settlement patterns, and a suitable ownership structure for such systems. Strategic municipal documents, including the Local Energy Concept, already reference renewable energy sources and BDHS. Decisions regarding BDHS implementation are typically gradual and based on municipal strategies related to energy self-sufficiency and the green transition. The establishment of a BDHS would create a new market for lower-quality wood in the municipality, offering potential additional income for forest owners, farmers managing overgrown areas, and companies involved in biomass production and supply. Biomass procurement can be organized either by the municipality or by specialized companies. Agreements with forest owners usually take the form of one- or multi-year contracts, defining prices based on quantity and quality, with possible adjustments for inflation. Greater flexibility from the buyer—allowing smaller delivery volumes or flexible delivery schedules—can attract a wider range of forest owners. Beyond economic benefits (additional income for owners and companies, lower heating costs), BDHS systems increase local energy self-sufficiency, reduce carbon footprints, and promote a circular economy.

Torrent management

Our business model is not typical; it is more of a payment scheme. Payment schemes linked to FES provide financial incentives to forest owners and managers to deliver not only timber but also other essential FES. These benefits are achieved through forest protection measures, silvicultural practices, restoration activities, watercourse bank stabilization measures, and higher standards of sustainable forest management, which indirectly increase forest resilience. In the context of managing torrential areas, the state and local communities contribute to public benefits—primarily enhancing the safety of people and their property from the harmful effects of torrential floods—by supporting comprehensive management of these areas. Torrent management encompasses several components, including establishing a monitoring system and service that connects key stakeholders, implementing stabilization and restoration measures, promoting resilient and vital forests within torrentential areas, and conducting specific interventions for slope and bank stabilization.

Recreation and tourism

The Municipality of Tržič offers exceptional opportunities for recreation and tourism, providing potential income for the local community and its residents. Multiple business models for recreation are possible. The first is in the form of payment schemes designed to incentivize forest owners to improve conditions for recreational use within their forests. Other business models can generate additional income for landowners, such as through parking fees, sales of local products, and related services. Indirect benefits are also possible: appropriate measures reduce conflicts and enable regular forest management by owners.

Factores for feasibility assessment

Technical and ecological feasibility

Wood biomass

*In addition to forest wood resources, ensuring sustainability is also important. In terms of sustainability, the maximum allowable annual harvest, as determined in forest management plans, amounts to approximately 81,000 m³ of wood, of which around 27,000 m³ are low-quality assortments. The ownership structure in the municipality is favourable for supplying a BDHS, as there are several owners with holdings above 30 ha, who collectively own a large share of the forests (s.**Figure 31**), which also implies a larger share of the harvest. This makes organizing the supply simpler than dealing with a large number of owners providing smaller quantities of biomass.*

The settlement pattern in Tržič is suitable (multiple residential buildings clustered together) for establishing a BDHS or replacing existing district systems. Less favourable is that the existing district systems use gas, meaning that a potential energy source switch would require not only replacing the boiler but also the piping.

There is no shortage of companies in the municipality and surrounding area engaged in felling, chipping, and transporting wood biomass. Two larger companies operate in the biomass sector in the municipality (one specialized in chipping, production, and supply, and another offering additional services such as felling, skidding, and transport), along with several independent entrepreneurs involved in felling, skidding, and/or transport.

Torrents

Information on torrents was obtained not only through modelling but also through an inventory of the torrent conditions, based on previous expert studies, professional assessments by district foresters, and field surveys.

Recreation and tourism

Additional information on more frequently visited areas was also gathered from the results of the recreation survey and through stakeholder participation in workshops.

Economic feasibility

Wood biomass

Establishing a municipal BDHS is a complex project that depends on the founder, e.g., the municipality. Simplified, the main costs involve planning, construction, and maintenance of the BDHS, as well as the input component, wood biomass.

If we focus more narrowly on the supply of the raw material, wood biomass, this can be organized in various ways. Purchases can be managed by the municipality (if it has suitable personnel and infrastructure) or by companies engaged in wood biomass. In most cases, one- or multi-year agreements are set-up between forest owners and the buyer, specifying a price, which may (but does not necessarily) depend on the quantity and quality of the biomass supplied (purchase units: dry tons, loose cubic meters, m³, heat content). Contract forms vary; in some cases, suppliers are bound to specific quantities and delivery times, while in others they have greater flexibility. Prices may be adjusted according to inflation or fuel costs, meaning that an increase in fuel prices also raises the purchase price. Greater flexibility on the buyer's side (ability to accept smaller quantities, flexible delivery times) allows inclusion of a wider range of forest owners. The agreed delivery method in contracts provides an economic safeguard for both parties, the buyer and the seller.

Torrents

The economic assessment of flood protection measures, which includes the system for torrent regulation, is complex. We roughly estimated the damages caused by floods and erosion at both the national and municipal levels. Significant damages (3 billion € for floods in 2023 for the entire Slovenia, 25 million € for the Municipality of Tržič over the last seven years) indicate that (relatively low) investment in preventive protection, including torrent regulation, is important and justified. For the case of the Municipality of Tržič, we estimated the approximate personnel needs and costs for torrent regulation within SFS. The assessment included the following additional tasks for the forestry service: identification of problematic torrents, inspection of problematic torrents, establishment and maintenance of a torrent database, employee training, and communication and awareness-raising among other stakeholders. Estimates of this additional work and tasks, as well as damage assessments, provide a basis for decision-making at higher levels.

Recreation and tourism

The economic feasibility of recreation-related objectives is connected to several aspects. Measures needed to improve conditions for recreation, including the reduction of conflicts among users, must be identified and evaluated. Costs of adapted forest management can be partially covered through subsidies for work in forests with exceptionally emphasized functions. Other incurred costs (e.g., maintenance of trails and access points) could be provided by the municipality—either through various (European) projects or through a portion of tourism fees or parking charges, which could be allocated to support recreational functions. Economic feasibility is not always directly linked to funding, it can also involve forms of assistance, volunteering, event organization, and similar activities.

When considering economic feasibility, attention must also be given to harmonization among different uses, such as aligning recreation with timber production. Measures must benefit both activities; otherwise, the overall economic outcome could be negatively affected. One way to relieve forest owners in heavily visited areas could be greater municipal involvement in road maintenance, which is important not only for forest owners but also for recreation and tourism.

Operational feasibility

Wood biomass

The results of the survey conducted among larger forest owners indicate that they are willing to sell lower-quality wood if a purchase system is established within the municipality under suitable conditions. In addition to a good price, organized and flexible logistics, allowing delivery of smaller quantities, is important to them. Many also prefer that felling, skidding, and/or transport be carried out by the buyer. The survey response rate (28 % returned) suggests that the topic is of interest to larger owners. Nevertheless, they did not respond to the invitation to the biomass workshop, which may be related to the timing of the workshop and other obligations of forest owners. Likely, interest in participation and attendance would increase with concrete projects and more locally specific measures.

In strategic plans and the Local Energy Plan, the municipality already indicates that it will implement activities to increase the use of wood biomass, mentioning BDHS. However, recent infrastructure energy projects mean that the municipality does not currently plan to replace existing district heating systems with biomass-based systems. The municipality does have some funds available for energy projects, but establishing or replacing a BHDS is a demanding project that is not currently planned. They are interested in introducing a BDHS in new constructions or public buildings. Legislation encourages the transition to renewable energy, but if the municipality uses natural gas, this transition is desirable rather than mandatory.

The municipality notes a lack of consistent guidance from the state regarding (green) energy development. Co-financing and promotion of various energy sources have changed frequently, making it difficult for a small municipality to track trends and calls for proposals if they change too quickly. Currently, the municipality is understaffed and cannot manage or lead large projects on its own. For new projects, they are open to energy solutions using wood biomass and recognize its economic and ecological advantages.

Wood-processing and energy companies have a strong interest in increasing the use of wood biomass, as this represents a business opportunity for them.

Torrents

During the project, we found that responsibilities for managing torrential areas, which are essential for organizational feasibility, are unclear, resulting in necessary measures often not being implemented in practice. We also identified that the field has been neglected at all levels over past decades; however, within the SFS, there is significant interest and engagement regarding torrents at multiple levels. We found that we lack knowledge in less forestry-specific topics, indicating a need for additional training for employees.

We collaborated with the Biotechnical Faculty and the Slovenian Forestry Institute; this collaboration is expected to continue. Cooperation among the three major forestry institutions and unified efforts is important for further development in this area. Concrete collaboration and networking with the water management sector, forest owners, and the municipality have not yet occurred but are planned for the future. Such cooperation is crucial for the implementation of activities in the field.

Recreation and tourism

Experiences from the workshops indicate that stakeholders appreciate the opportunity for communication in the fields of tourism, recreation, and forestry. Project activities enabled the confrontation of different stakeholders and the exchange of opinions. In the workshops, we jointly developed and expressed concrete proposals for harmonizing various land uses, both at the municipal level and at specific (critical) locations. There are many recreation-related stakeholders in the Municipality of Tržič, which is an advantage compared to some other areas. Well-connected stakeholders, groups, and associations can act more proactively, increasing the organizational feasibility of the set objectives. The local community—the municipality—aims to promote recreation and tourism, providing support for feasibility at the political level as well. Successful implementation of measures requires cooperation with forest owners and experts (forestry, nature conservation, etc.). A part of the measures is linked to infrastructure (parking lots, public transport, road use regulations). In this area, good organization and a clear municipal strategy are essential.

Legal compliance

Wood biomass

The use of low-quality wood, which is utilized for chipping, is generally regulated. Felling and harvesting technology are defined in forest management and silvicultural plans. Currently, in Slovenia, technologies for exploiting wood biomass are in use that do not allow for a higher proportion of green cuttings (e.g., chipped branch residues, smaller trees). In the event of increased use of technologies that also allow for higher proportions of green cuttings, exploitation of such material could increase (greater removal of branches, tops, more frequent tree-based methods). This could lead to a form of modern "littering." There are no regulations limiting the use of green chips for biomass. Several documents address the cascading use of wood, meaning the use of wood according to quality. Forest owners are encouraged to practice cascading use of wood (e.g., advice on quality and possible uses of wood, guidance for obtaining high-quality

assortments), but ultimately, it is the forest owner who decides based on their own needs and market conditions.

Torrents

Torrent control is an intersectoral topic. Forestry and water management legislation are not fully harmonized. Further work will be needed in this area to align and update the legal framework, and the division of responsibilities and obligations must be made clearer. The legislation governing torrent management should be partially updated. The proposed measures are partly consistent with the existing legislation, while in some cases, updates have been suggested. In certain situations, the measures comply with one sectoral law but may not align fully with another. Legislation should define an adequate level of funding for torrent area management and prioritize this ecosystem service in cases where human lives or critical infrastructure are at risk.

Recreation and tourism

The proposed activities related to recreation and tourism are in accordance with forest and nature conservation laws and regulations, as well as forestry policy strategies. Some legislative measures are currently ineffective; an example of this is sanctions for driving in natural environments. Legislation in this area is already undergoing changes. Since Slovenia guarantees free access to forests, some solutions regarding measures are questionable. The problem is that legislation does not address specific issues (for example, the management of mountain bikers, who is allowed to perform guiding, in which forests, and similar matters). Some measures do not yet have established legal practice; for instance, contracts between municipalities and forest owners for trail management. The proposed measures are therefore not inconsistent with legislation, but many open questions remain, which will be resolved through practical implementation.

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