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POLICY BRIEF

Based on results of ONEforest

Forests, wood value chain and multi-criteria decision making in four European countries

CONSORTIUM

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Forests support human well-being and play a key role in the ongoing societal transformation replacing fossil-based materials, hence green transition. Forests provide a multitude of services, e.g., timber- and non-timber based products, biodiversity support, water provision, protection in the landscape, recreational activities, biogeochemical element recycling, and supporting carbon storage. Simultaneously, climate change is a major challenge to forests development as forest disturbances (e.g., fire, storms, insect or microbe infestation, and drought) increase the vulnerability of forest ecosystems. These challenges together with the multitude of services causes conflicts which inherently leads to a need of complex decision-making in forest management as well as downstream wood value chain, requiring a multi-criteria decision-making support system.

Resilient forests, capable of handling the multitude of challenges and demands on Forest Ecosystem Services (FES), can only be attained through a common understanding and general agreement between all stakeholders within the forest wood value chain. This includes forest owners, forest managers, forest operations companies, managers in wood processing industries, local communities, and the wider society. The individual interests of stakeholders can conflict with each other, requiring balancing between economic, ecologic, and social goals. Developing knowledge of silviculture management, forest operations together with an understanding of the forest wood value chain, the consequences of demands and needs of different

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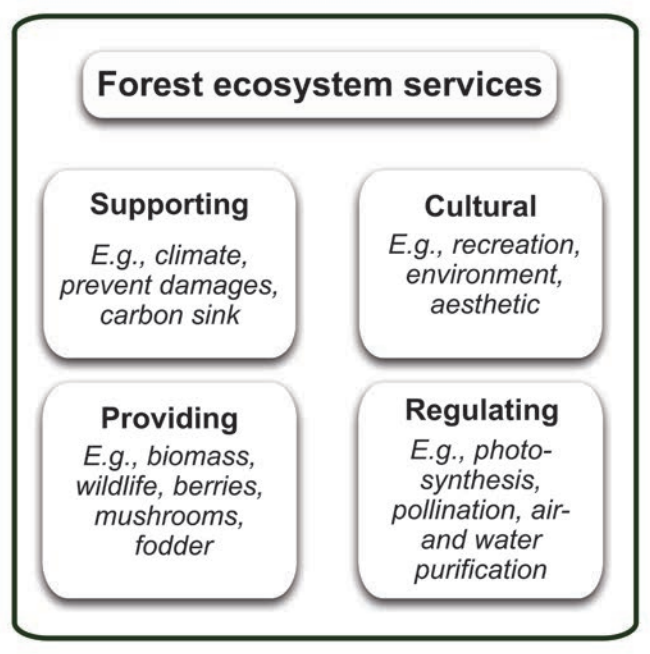
stakeholders may be realized via forest management and in the downstream wood value chain. To be able to integrate the interests of different stakeholders, support reliable forest wood value chains, considering the ecologic, economic, and social dimensions of forests and illustrating the benefits of synergies and need of necessary trade-offs between forest ecosystem services, decisions on forests need support.

The main objective of ONEforest research project (www.oneforest.eu) is to develop a multi-criteria decision-making support system (MCDSS) for decision-makers, supporting conflict management, and sustainable forest management. In the MCDSS the effects of different forest management choices may be evaluated considering the balance of forest ecosystem services. By complementing with the dynamic value chain model, possible futures including societal demands e.g., job provision, quality of different forest-based services and volume of wood supply can be evaluated.



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ONEforest research and findings in a nutshell

- Four management options were simulated in each case study region corresponding to different site-specific characteristics and the management options, based on forest models simulations over 40 years, serve as a base for the MCDSS.
- Engineered topsoil covers (TSCs) based on biopolymers and wood fibres were applied to the identified case study regions as a new method of planting and sustaining plant growth including the assessment of their effects on the soil microbiota.
- Based upon analysis of the analysis of forest stakeholders' perceptions, prevailing policies on national and regional levels and public's perceptions, four policy pathways depicting different possible future societal development were developed and included in the MCDSS.
- The ONEforest multi-criteria decision-making support system (MCDSS) intention is to support complex decision-making finding optimal assignment of management options. By considering stakeholder preferences and requirements balancing forest management options and management goals, the model provides a number-based decision. Results should be understood as suggestions for decision-making.
- A dynamic wood value chain model was developed to, in complement to the forest management decision, support comprehensive decision-making in the downstream forest wood value chain.

Case study regions

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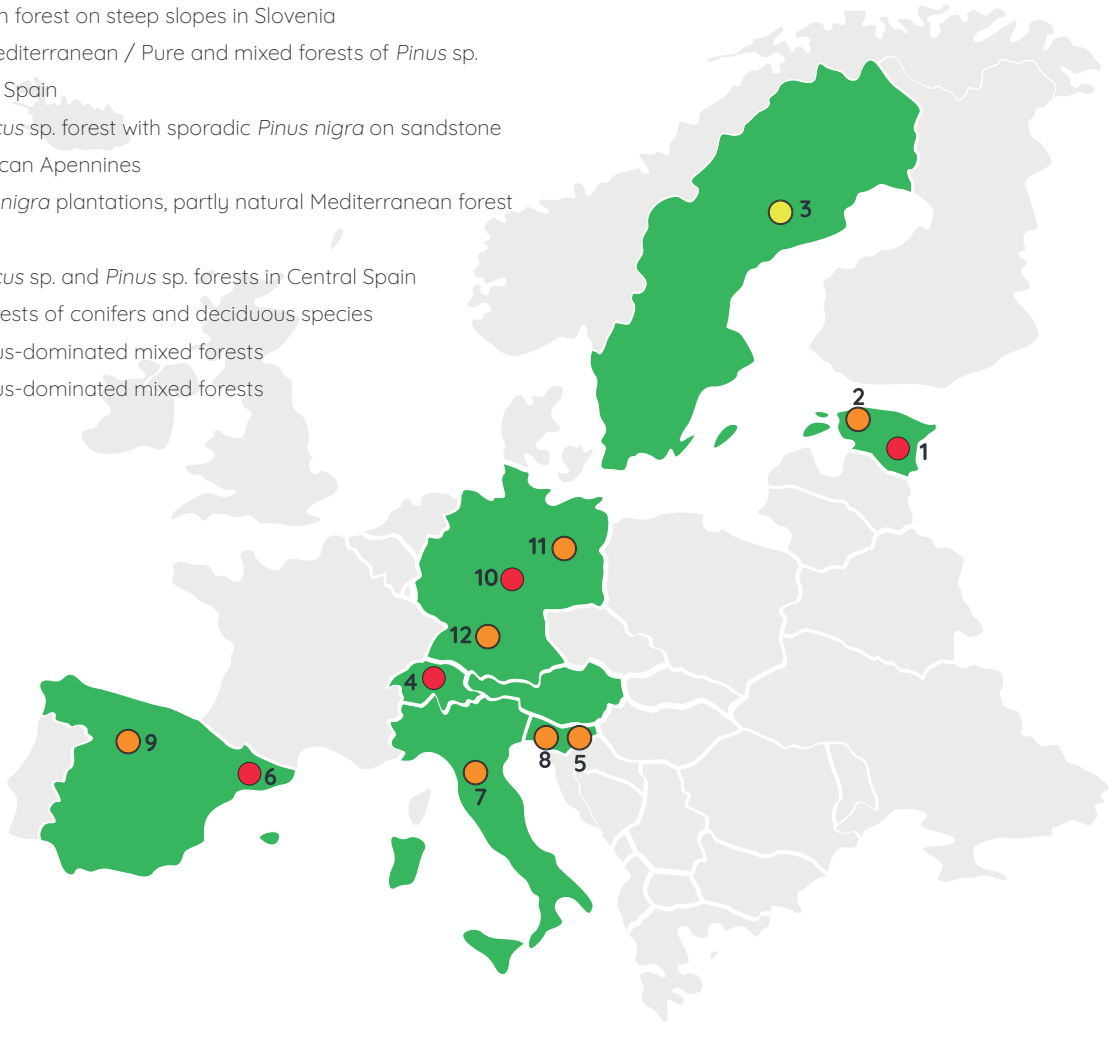
The insights and results originate from four diverse European biogeographical regions; Catalonia in Spain, the canton Grisons in Switzerland, Hesse and Thuringia in Germany and Estonia. These Case study regions (CSRs) cover a multifaceted management system with FES objectives, ensuring they play a central role in sustainable forest management and support biodiversity.

Biogeographical region / Characteristics

1. Boreal/Hemiboreal / Monoculture in Estonia
2. Boreal/Hemiboreal/ Mixed forests in Estonia
3. Boreal/Hemiboreal /Monoculture forest in Sweden
4. Alpine /Coniferous mountain forest on steep slopes in Switzerland
5. Alpine/ Mixed mountain forest on steep slopes in Slovenia
6. Mediterranean/Sub-Mediterranean / Pure and mixed forests of *Pinus* sp. and *Quercus* sp. in N-E Spain
7. Mediterranean / *Quercus* sp. forest with sporadic *Pinus nigra* on sandstone in the slopes of the Tuscan Apennines
8. Mediterranean / *Pinus nigra* plantations, partly natural Mediterranean forest on limestone
9. Mediterranean / *Quercus* sp. and *Pinus* sp. forests in Central Spain
10. Continental / Mixed forests of conifers and deciduous species
11. Continental / Coniferous-dominated mixed forests
12. Continental / Coniferous-dominated mixed forests



Case study regions

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	Catalonia	Estonia	Grisons	Hesse/Thuringia
Forest type	Mediterranean forests	Boreal/Hemi-boreal forests	Alpine forests	Continental forests
Forests area (country level)	41 %	54 % (according to FAO definition)	31 %	Hesse 42 %, Thuringia 43 %
Forest ownership	74 % Private	50 % Private	90 % Public	Hesse 75 % Public Thuringia 56 % Public
Forest management system	Multiple management	Multiple management	Multiple management	Multiple management
Certification	20 %	Major share	70 %	75 %
Population in region	Population in region	Mixed (sparsely populated rural areas)	Mixed (sparsely populated rural areas)	Mixed (sparsely populated rural areas)
EU membership	EU member since 1986	EU member since 2004	Non-EU member	EU member since 1958

Case study regions

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CATALONIA

Timber and non-wood forest products as cork, mushrooms, pine nuts contribute significantly to the region's revenue. Additionally, forests provide environmental and social services as biodiversity, soil and water protection, leisure, among others. Forest disturbances are mainly fires, pests, and storms. The Department of Climate Action, Food and Rural Agenda oversees forest governance, with the Forest Ownership Centre focused on privately owned forests, promoting sustainable practices, and supporting the development and implementation of management plans and forest management guidelines.

Catalonia-CTFC

ESTONIA

Hiking is a popular activity, while hunting serves both as recreational and forest maintenance purposes. The wood-based sector is important to Estonia's economy. For example, Estonia is one of the largest timber house exporters in Europe. The country is also a notable exporter of wood fuel and pellets which are produced from low-quality timber and logging residues. The recent R&D work and investments in the wood-based sector are focusing on chemical valorisation of wood, resulting in an increased role of wood to meet the future needs of the bioeconomy and implementation.

Estonia young spruce stand in spring-Jüri Pere

Case study regions

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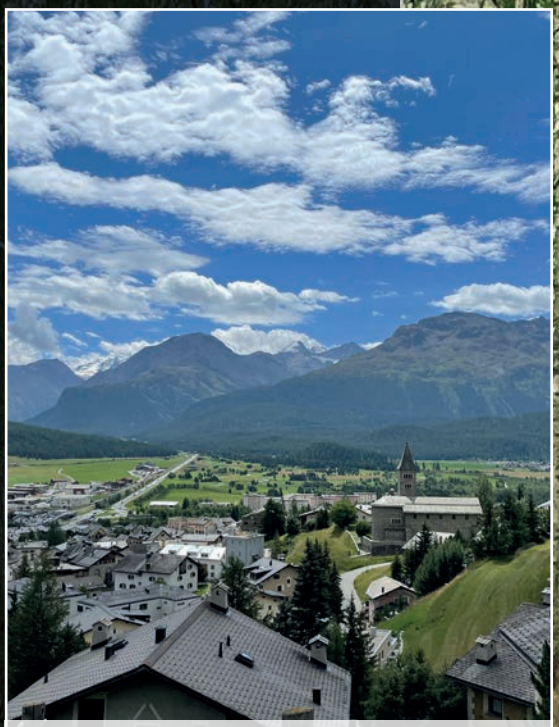
GRISONS

The canton's elevation spans from 260 to 4,049 meters, and it attracts outdoor enthusiasts for activities like hiking and skiing. Swiss law grants public access to these forests, supporting a robust tourism industry, a key economic pillar. Forest management is a joint responsibility between forest owners, the canton, and the federal government. Protection against gravitational hazards like avalanches, rockfall and landslides is an important service of forests. Protection forests (gravitational hazards mainly) requiring subsidies for timber harvesting due to the steep mountainous terrain. The canton promotes biodiversity through close-to-nature silviculture, maintaining forest reserves and nature conservation, e.g., the Swiss National Park and the UNESCO Biosphere Reserve "Biosfera Engiadina Val Müstair."



Grison (Pontresina)-Mark Werder

HESSE AND THURINGIA

German forests offer free public access for recreational purposes. Forest management differs among owners, however, generally focuses on the provision of multiple ecosystem services. Sawmills producing sawn wood as well as fuel for energy generation, is found in the two regions. The regions face climate change challenges such as droughts, high temperatures, bark beetle infestations and forest fires; storms, and browsing disturbances are also common threats, all of which impact forest growth and forest management.

Hesse Waldstruktur-Marian Mayr

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FOREST MANAGEMENT OPTIONS

Four forest management options were simulated in which the intensity and management philosophy is diversified. Intensity is varied between low and high in the management options while the management philosophy varies between continuous and rotation management. Continuous management methods are characterized by selective fellings, avoiding clearcuts, while rotation is characterized by final harvest at a specific stage of maturity and clearcuts are common.

MULTICRITERIA DECISION-MAKING SUPPORT SYSTEM (MCDSS)

The four options are adapted to local silvicultural systems in the case study regions based upon simulations using forest inventory data to be used in the MCDSS via 19 indicators (e.g., harvest timber, diameter variability, deadwood composition, carbon sequestration, visual attractiveness, species diversity, and wood revenues). The mathematical model behind the MCDSS is based upon a weighted sum of each of the criteria aiming at finding the optimal solution. Each of the policy pathway is operationalized in the model by weighting the indicators according to the narrative of each of the pathway reflecting the user's preferences.

Additionally, to the MCDSS, different types of topsoil cover were engineered and their ability to support plant growth in terms of water retention and limitation of weed growth and soil erosion were tested. Specifically, biopolymers-based

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products (xanthan gum and gelatine) reinforced by the addition of wood fibres, were developed. Their performances were evaluated through extensive laboratory analyses, greenhouse experiments, and field experiments in different case study regions.

POLICY PATHWAYS FOR FUTURE DEVELOPMENT OF THE WOOD VALUE CHAIN AND USE OF FORESTS

Apart from the forest management options, policy pathways were developed together with forest-based stakeholders in each of the case study regions. Together with the analysis of current policies, stakeholder's views of forest ecosystem services and public perceptions, key factors affecting the development of forest wood value chain and societal development were outlined. The pathways vary across two dimensions: demand of biomass from forests and strength of political decisions or political institutions. A set of four policy pathways were developed for each case study region.

MCDSS COMBINING FOREST MANAGEMENT AND POLICY PATHWAYS

The multi-criteria decision-making support system (MCDSS) aim is to support decision-making of forest management to enable evaluation of management options. MCDSS is based on the one hand on the forest management options and its 19 indicators, and on the other hand on user inputs. Forest regions in the MCDSS are represented by cells of different sizes using representative stands that differ in

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site-quality index, stand age and species code. The MCDSS returns then for each of the cells in the region a suggestion of a management option that should be used, based on the mathematical optimization including the weighting of indicators by the decision maker with the help of the policy pathways. This enables regional connection between the management options and the MCDSS model and is based upon user input.

The results suggest different management options adapted to decision-maker's preferences and policy pathways. Generally, as an example, in a policy pathway focusing on timber harvest balancing ecology and economic values, the indicators of harvest of timber and wood revenues are given higher weight. At the same time the biodiversity index and carbon sequestration are low. The results of the MCDSS suggest that the major forest management option should be rotation-based and in high intensity, while a smaller share of the area should be managed in a continuous management method. Another example shows that a policy pathway where a combination of recreation and biodiversity are main priorities, indicator weights are low of harvested timber, while indicators such as visual attractiveness, biodiversity index and number of large trees are high weighted. The MCDSS optimization simulations results in a mix of all four forest management options. Finally, in a policy pathway focusing on climate change mitigation and green transition, indicators weights are given close to equal weights, resulting in continuous management methods.

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To conclude, the results provide the decision-maker with number-based optimized suggestions of forest management options to support decision-making. Local site-specific features may be included in the weights of the MCDSS, e.g., supporting recreation in urban forests. Results are depending on the assigned weights, which means that the decision-maker's knowledge of the forest is essential to ensure high quality of the optimization. In this context, the use of the four policy pathways may further serve as support. Important to consider is that the results depend heavily on the weighting of the indicators, enabling different optimal solutions for the same region depending on the user input. However, more development of stand-level simulations is needed to develop the practical use of the MCDSS further.

THE DYNAMIC WOOD VALUE CHAIN

The weighted objectives of the decision-makers also have an impact on the regional timber supply chain in each CSR. In addition to the MCDSS, a dynamic simulation model (DVCM) provides information on the socio-economic and environmental impacts of timber supply on the wood value chain. Considering the current wood processing industry in each case study region and the weighted objectives, the DVCM models how the wood value chain develops in the future. Various indicators of the wood value chain (e.g. employment, value-added, CO_2 emissions and carbon storage) can then be used to support comprehensive decision-making in the forest wood value chain.

CONCLUSIONS AND POLICY RECOMMENDATIONS

In comparing the four case study regions, the forest and its prerequisites, and the attitude and use of forests differ. Even though difference prevail, analysis of the results indicates that in the future, the forests in the case study regions face similar challenges. Climate change mitigation is a common challenge to all and carbon storage (in forests and in products) is relevant in each of the regions. Common is also the challenges of increasing forest disturbances following climate change, however the effect may differ between regions. This is supported by the developed policy pathways in ONEforest. Additionally, the demand for woody biomass, particularly as a substitute for fossil-based materials, is a shared challenge between the case study regions. Following this is a need for technological development and innovation but also a stronger need for transporting biomass to ensure that forest industry has enough raw material.

Among the differences between the case study regions, the focus and attitude toward forest, forest products, and forest industry is strongly connected to the local forest. Focus on protection against gravitational hazards are more important in central Europe, while forest fires are a major challenge in the south. Furthermore, ownership structures are different across the case study regions affecting forest management. Finally, there are differences of the prerequisites for forest industry development across the case study regions, affected both by the geographical location but more importantly the supply of biomass. Developed in ONEforest, the MCDSS builds upon data and input of

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weights related to simulated management options and policy pathways in the future, however, the optimization needs high-quality forest data together with high-quality knowledge of the forest owner/ forest manager. A challenge of modelling is also the uncertainty that effects of climate change bring.

In sum, the ONEforest project, recognized the following policy recommendations:

1. **Addressing regional challenges and differences**

- Acknowledge regional challenges and differences across Europe recognizing climate change effects posing challenges for forests as well as raw material flows down the forest wood value chain.
- Recognize the differences in attitude and use of forest ecosystem services across Europe. Develop unified policy that addresses common challenges while allowing for regional adaptation to ensure harmonized regulations. The aim is to support sustainable forest management practices that enhance biodiversity while adapting forests to climate change impacts (e.g., fires, pests, droughts) and support providing, supportive and regulative as well as social forest ecosystem services.

2. **Ensure continued research and development and innovation transfer**

- Support research on the forest ecosystem as well as encourage technological development, digitalisation, and innovation to support the implementation of the EU Green deal, supporting research and

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innovation ensuring stable long-term funding.

- Support knowledge-transfer of research finding and innovation practices to end-users (e.g., foresters, industry stakeholders and policymakers) to support decision-making (e.g., MCDSS).

3. **Support of the forest sector and strengthening of the forest wood value chain**

- Enhance training and workforce development to equip forest sectors with well- specialized workforce for a modern forest sector.
- Encourage infrastructure for transport of biomass to ensure high-quality and steady supply while promoting efficient use of raw materials, supporting local and regional forest wood value chains.

In summary, European forests are facing **dramatic transitions under climate change,** challenging a sustainable provision of forest ecosystem services. We observe increasing socio-economic demands regarding the services forest provides. However, there is strong evidence that both forests reaction to climate change and demands of forest ecosystem services differ between biogeographic regions. **For these reasons, there is a strong need for integrating science-based tools** such as the developed **MCDSS** for decision support **in policy making** at EU, national and regional level to anticipate impacts of societal development on the long-term forest ecosystem provision to promote sustainable forest management, support biodiversity, and the green transition.

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www.oneforest.eu

Fact: The project ONEforest

The ONEforest Project (www.oneforest.eu funded by the EU's Horizon 2020 Programme, addresses the challenge of common forest management by developing a multi-criteria decision support system. This system, aimed at providing decision-making to stakeholders by assessing SFM, exploring synergies and trade-offs of Forest Ecosystem Services (FES), ensuring sustainable wood supply, improving biodiversity, and addressing stakeholder interests through indicators in social, economic, and environmental dimensions. Throughout the project, experts' and stakeholders' suggestions and needs were actively gathered to inform the development of new policy recommendations.

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Learn more: www.oneforest.eu