Research Brief

Decision Making Support Toolbox

Policy Driver Scenarios

Can assist complex decision making under uncertainty

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Help assess policy coherence across scale and sectors

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Help anticipate owners' responses

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LEARNFORCLIMATE

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Introduction

This Research Brief summarizes key results and tools from two EU and nationally funded collaborative research projects: **LEARNFORCLIMATE** (https://www.ltu.se/en/research/research-subjects/political-science/research-projects/researchproject-in-political-science/learnforclimate) and **BIOCONSENT** (https://www.bioconsent.eu/).

LEARNFORCLIMATE supports learning to achieve multiple forest policy and management objectives while adapting to climate disturbances such as droughts, storms, and fires, with case studies in Germany, Poland, Slovenia, and Sweden.

BIOCONSENT provides decision-support to balance biodiversity conservation, sustainable timber production, climate adaptation and mitigation, and water protection, with insights from case studies in Bulgaria, Germany, Spain, Sweden, and the EU-27.

The Fact Sheets in this Brief were authored by members of the research team (see list of authors at the end), formatted with the assistance of ChatGPT, and edited by Karin Beland Lindahl, Luleå University of Technology and Adam Felton, Swedish University of Agricultural Sciences. They are popular summaries of published or forthcoming peer-reviewed scientific publications and reports. References to relevant sources are listed at the end of each Fact Sheet.

An earlier draft of this Brief was prepared to provide background information to participants in the projects' Final Conference *From Science to Policy and Practice: Forest Biodiversity Restoration and Climate Change-Related Disturbances*, held in Bonn and online, 23rd September, 2025.

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Policy Driver Scenarios for Decisions under Uncertainty

Why Policy Driver Scenarios Matter

Achieving EU biodiversity and climate goals for forests toward 2030 and 2050 is challenging. Long forest time horizons and contested short-term policy choices create uncertainty. Forest development is influenced by major drivers such as demographic change, macro-economic trends, policy shifts, technological innovations and environmental change. Current forest-related EU policy goals and targets must therefore be implemented in a context of uncertainty and complexity.

What Policy Driver Scenarios Offer

Policy driver scenarios are decision-support tools to anticipate future developments and design robust strategies. They describe alternative futures by combining different developments of key drivers, their interactions, and causal impacts. This helps decision-makers envision alternative developments, reduce complexity, and test the robustness of policy and management responses.

How Scenarios are Built

Key drivers and influencing factors are organized into Societal, Technological, Economic, Environmental and Policy (STEEP) driver categories. For each driver, alternative future developments ("manifestations") are explored based on data, projections, and creative reasoning. Mutually exclusive and alternative combinations of drivers are combined into a Futures Table, which summarizes plausible futures. From this, scenarios are developed, each describing a coherent "world" with a descriptive title and narrative explaining distinct features and conditions.

Scenarios are built on multiple sources, including policy documents, assessment reports, research, statistics, and projections. Narratives are validated through expert and stakeholder input, ensuring plausibility and relevance.

Examples from LEARNFORCLIMATE AND BIOCONSENT

Three contrasting explorative scenarios were developed for application at the EU and national levels:

Biodiversity First: strong environmental regulation and policy support for biodiversity conservation and close-to-nature forest management.

Multifunctionality First: mixed instruments supporting multiple use including biodiversity conservation, climate adaptation, timber production, cascading use of wood, and recreation.

Wood-based Bioeconomy First: reliance on markets, minimal regulation, maximum timber production and intensive biomass use, including energy production.

Key Points

- ➔ Policy driver scenarios support strategic foresight and robust response strategies
- ➔ Data, projections, and creative thinking are combined to organize uncertain drivers into STEEP categories and futures tables, forming the basis for distinct and plausible scenarios
- ➔ Expert and stakeholder validation increases credibility and practical relevance.
- ➔ Scenarios foster shared understanding, dialogue, and preparedness for future change.

Sources and further reading: Sotirov, M., Pezdevšek Malovrh, Š., Beland Lindahl, K., Haase, M., Aquilué, N., Kraxner, F., Krasovskiy, A., Schepaschenko, D., Johnstone, C., Hajtmarova, S., Niedzialkowski, K., Nieberg, M., Nilsson, J., Nordström, E.M., Paligorov, I., Pecurul, M., Renaud, P., Sorge, S. & Uhan, Z. 2025. *Policy and Driver Scenarios of Forest Biodiversity Conservation and Restoration in Europe. BIOCONSENT project report with coherent scenarios for each case study* (D.2.1.1). DOI: 10.5281/zenodo.14949872.

Pezdevšek Malovrh, Š., Uhan, Z., Krč, J. 2025. Možni scenariji gospodarjenja z gozdovi v Sloveniji. Korenina, 29, 14-16p. https://sidg.si/index.php/menu-za-download-javnost?view=download&id=3687

Policy Maps as a Tool to Assess Policy Coherence

Why Policy Coherence Matters

Achieving forest biodiversity and climate resilience goals requires coordination across sectors and levels of governance. Policy coherence means that objectives, policy instruments, and management practices reinforce each other rather than creating trade-offs. Incoherence occurs when goals contradict each other or instruments pull in different directions, for example when financial incentives for intensive forest use undermine legally binding biodiversity targets.

What Policy Maps Offer

Policy maps are a decision-support tool to assess vertical coherence across spatial scale (international, EU, national, and local levels) and horizontal coherence across sectors (forestry, biodiversity, climate, agriculture, bioenergy, rural development, etc.). They help identify trade-offs and synergies in advance(ex-ante), assess outcomes afterwards (ex-post), and thus provide decision-making support.

How Policy Maps are Created

Policy maps combine content analysis of policy documents with geographical mapping. Policy choices regarding goals, instruments, and practices are compiled for a unit of analysis (one country or group of countries) in tables based on systematic policy document analysis, and are validated through triangulation with multiple sources, such as expert consultations. Within- and cross-country comparisons identify similarities and differences, which are then summarized in clusters sharing commonalities and displayed on geographical maps. These visual summaries highlight the state of regulatory stringency on key forest biodiversity indicators and practices, which, in turn, allow for both policy coherence and divergence assessments across Europe.

Using Policy Maps in Practice

Policy maps offer easily accessible policy information, but assessment of coherence/in-coherence requires clear definitions, assessment criteria and benchmarks against which results are assessed. Applied rigorously, policy maps allow decision-makers and stakeholders to detect contradictions and gaps in national and EU forest and biodiversity policies, identify opportunities for alignment across sectors and levels, assess coherence in relation to normative benchmarks, communicate complex information in accessible visual formats, and support informed dialogue among policy makers, managers, and stakeholders.

Key Points

- ➔ Policy maps provide visually accessible, evidence-based support for assessing vertical and horizontal policy coherence.
- ➔ They combine document analysis with expert validation and allow for cross-country comparison.
- ➔ Maps help reveal policy trade-offs, synergies, and clusters of similar policy approaches across jurisdictions and support evidence-based comparisons across countries with respect to goals and benchmarks.
- ➔ When consistently applied, policy maps support informed decision making, encourage dialogue, and guide more coherent forest-related policies across sectors and political levels.

Sources and further reading: Sotirov, M., Pezdevsek Malovrh, Š. & Jonsson, R. 2024. *Chapter 3. Policy factors.* In Egger, C., Grima, N., Kleine, M. & Radosavljevic, M. (eds.). Europe's wood supply in disruptive times. An evidence-based synthesis report. IUFRO World Series Volume 42.

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Forest Owner Typologies as a Tool for Understanding Behaviour

Why Typologies Matter

Forest owners and managers are not a homogeneous group. Their values, goals, and management approaches vary widely. Typologies help capture this diversity by grouping owners into categories, making it easier to understand their behaviour and anticipate responses to policy objectives, implementation strategies, and management measures.

How Typologies are Built

Typologies are usually based on owners' and managers' values, attitudes, objectives, socio-demographic characteristics, management strategies, and decision-making rationalities. They have been used to improve forest management, analyse changes in the forest sector, and explore possible relationships between forest ownership objectives and their behaviour.

Typologies have traditionally been developed empirically in varying contexts and were therefore difficult to compare across regions. By using behavioural theories from the social sciences, comparability across geographical contexts, and explanatory power, has been improved.

Models of Decision-Making Rationalities

Three decision making models from social science theory help derive forest owner and manager typologies:

Homo economicus: owners and managers as utility maximisers, weighing costs and benefits ("the economically rational thing to do").

Homo sociologicus: emphasizing rules, traditions, and social norms ("the legally appropriate thing to do").

Homo psychologicus: highlighting decisions shaped by core beliefs, values, and professional knowledge ("the right thing to do").

In LEARNFORCLIMATE and BIOCONSENT, three to five forest owner and manager typologies, theoretically derived and empirically validated, were identified and applied to explore responses to EU policies in five European countries.

Using Typologies in Practice

Theory-based typologies help policy makers, forest authorities, extension service providers, and researchers tailor policy instruments, especially incentives, to different owner and manager types. They provide a practical tool to design interventions that can reflect owners' diverse motivations, constraints, and anticipated behaviours.

Key Points

- ➔ Forest owners and managers are different; typologies structure and explain this heterogeneity.
- ➔ Typologies are based on behavioural models describing owners' and managers' values and goals; theory-based models improve comparability and link to decision-making rationalities which can help predict behaviour.
- ➔ Case studies demonstrate how typologies can explain varied responses to EU forest policy.
- ➔ Theory-based typologies are useful tools for anticipating responses and tailoring policies, extension services, and management approaches.

Sources and further reading: Sotirov, M., Nilsson, J., Pecurul, M., Beland-Lindahl, K., Niedzialkowski, K., Aquilue, N., Nabau, J., Uhan, Z. and Pezdevšek Malovrh, Š. 2025. How and why target groups do or don't align with EU policy changes? Forest owner behavioural responses to EU biodiversity and climate policy objectives in Germany, Poland, Slovenia, Spain, and Sweden. *Land Use Policy* (submitted).

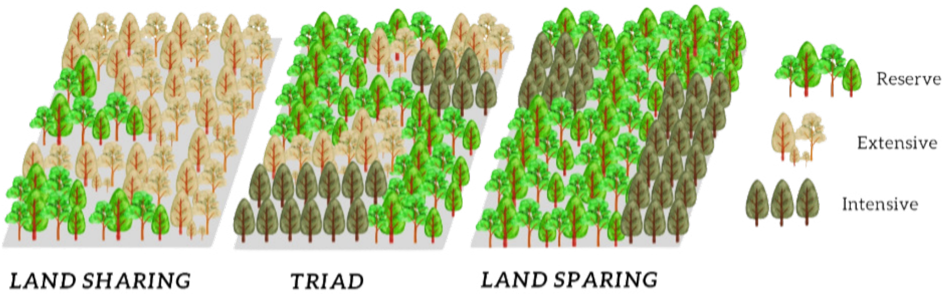
Implementation Strategies: Scale and Management Matter

Different Pathways to the Same Goal

Planning a future for Europe's forests requires not only defining the goals but also deciding how to implement them. To implement goals, we can choose different spatial and management strategies.

Spatial Implementation Strategies

Spatial options include land sharing, land sparing, and TRIAD. Each can achieve similar goals but leads to very different landscapes and outcomes. Land sharing integrates management for multiple goals in the same area. Land sparing, on the other hand, concentrates intensive management to areas that are kept separate from unmanaged reserves. In a TRIAD, areas with different management intensities and objectives are mixed, for example through zonation.



Management Approach and Intensity Options

Protecting, restoring and adapting Europe's forests require interventions which can be "active" (assisted regeneration, thinning, conservation burning) or "passive" (natural regeneration and a minimum of interventions). The choice depends on ecological conditions and management objectives. Another choice concerns management intensity, with options ranging from low to medium and high.

	LOW MANAGEMENT INTENSITY	MEDIUM MANAGEMENT INTENSITY	HIGH MANAGEMENT INTENSITY
TREE SPECIES	Native mixed species	Native and non-native	Highly productive species
REGENERATION	Natural regeneration	Natural regeneration preferred	Planting and seeding; genetically modified permitted
SITE IMPROVEMENT	Soil cultivation and fertilization only as restoration measure	Soil cultivation and fertilization permitted	Soil cultivation, fertilization, liming, draining and irrigation permitted
ROTATION LENGTH	Target diameter; high stem quality	Intermediate rotation length	Short rotation length
HARVESTING	Single tree selection	Minimise disturbance	Clearcutting and residue removal

Key Points

- ➔ Spatial strategies (land sharing, land sparing, TRIAD), management approaches (active, passive) and management intensity (low, medium, high) strongly shape forest landscapes and outcomes.
- ➔ The choice of implementation strategy affects how forests are experienced and used.
- ➔ How forest management goals are implemented is as crucial as setting the goals themselves.
- ➔ Countries differ in preferred strategies depending on ecological and socio-economic context.

Sources and further reading: Haase et al. 2026. How to achieve diverse EU forest policy objectives? Stakeholder preferences on policy implementation using land sparing or sharing approaches under different future scenarios, *Journal of Environmental Management* (in preparation).

Management Matters: Recom-mendations for Owners and Managers

Why Change Forest Management?

Climate change affects forest productivity and ecosystem service provisioning. Extreme climate events, specifically, increase frequency and, or, intensity of forest disturbances including droughts, bark beetle outbreaks or wildfires. Simultaneously, biodiversity loss threatens ecosystem functioning and the EU has established ambitious policy targets in several forest related policy areas. Consequently, climate change adaptation is urgently needed and necessitates changes in forest management measures.

How can Forest Management Support Climate Adaptation and Biodiversity?

We projected forest management under a changing climate and three alternative forest management scenarios (see “Policy Driver Scenarios”):

- under biodiversity first and multifunctional scenarios, 10% of forest areas - preferably old stands of high conservation value - were set aside from management.
- under biodiversity first, thinning intensity was decreased, and the rotation period increased on 30% of randomly selected forest areas.
- under the multifunctionality scenario, thinning intensity was increased and the rotation period reduced for the 30% highest yielding forest areas.
- under bioeconomy first scenario, productive sites with high harvest removals were managed more intensively, whereas stands with the lowest harvest removals were excluded from forest management.

We simulated forest resource management to assess the effects of climate and forest management on ecosystem service provisioning, using two different simulation models: Heureka in Sweden and 4C in Germany, Poland and Slovenia. Projections were made to the end of the century, with results compared to identify their respective climate change and management effects.

Key Points

➔ Management affects forest ecosystem service provisioning at the stand level – contrasting management decisions have a strong influence on forest characteristics and service provisioning. However, at regional to national scales, the impacts of local management choices are diluted, the changes to management are less drastic, and climate change impacts gain more importance.

➔ According to the survey results, willingness to change management was low and consequently the resulting changes in ecosystem service provisioning were quite limited. This suggests that climate change adaptation may already be considered in current BAU management decisions. An alternative interpretation is that management changes will only be triggered in response to more severe disturbances.

➔ The projected changes in service provisioning under alternative policy scenarios was obvious for some indicators, but not for all: water regulation and soil carbon uptake were hardly affected by the management changes considered.

➔ The biodiversity scenario resulted in reduced harvest and consequently increasing growing stock and carbon sinks. In Poland, there was a strong increase in broadleaved species share under this scenario with little change in growing stock, but increased carbon storage - due to higher wood density of hardwoods.

➔ Swedish scenario projections indicated that management decisions affect carbon flux quite rapidly, whereas other impacts may take several decades to create larger changes. Strong synergies were found between scenarios that benefited biodiversity indicators and carbon storage, with the multifunctionality scenario providing the most balanced outcomes for ecosystem service delivery.

Sources and further reading: Nieberg et al. (Manuscript in preparation).

Forest Simulation Models: Integrated Knowledge on Forests

What are Forest Simulation Models?

Forest simulation models describe tree growth, forest dynamics, and interactions between vegetation, soil, and atmosphere over time. They are research tools that summarize and integrate available knowledge, data, and empirical findings from observations and experiments into model systems. By necessity, models are simplified abstractions of reality.

Different Purposes, Different Paradigms

Many simulation models exist that describe European forests, each with a specific focus and purpose. Some focus on projecting accurate timber yields, while others target carbon dynamics or species interactions. The model's purpose determines the paradigm underlying its structure: which forest aspects are represented, the spatial and temporal scale, and other model characteristics. Broadly, simulation models can be classified as being *empirical*, focusing on statistical relationships between forest variables (e.g., diameter growth as a function of age, stand density, and environmental conditions). Or, they are more *mechanistic*, focusing on ecological processes that shape forest dynamics (e.g., photosynthesis or species competition).

Drivers, Scenarios and Uncertainties

Divers and scenarios are important inputs to forest simulation models. Drivers such as forest management, climate change, or disturbance regimes are often external forces that act on the modelled forest system. Scenarios provide coherent and plausible descriptions of how these drivers may evolve over time and in space, shaping model outputs. Scenarios have a strong impact on the model outputs.

As our knowledge of forests is incomplete, all model outputs come with uncertainty. Uncertainty arises from model structure (e.g., which disturbances are included), inputs (e.g., climate scenarios), and the selected parameters and conversion factors (e.g., water-use efficiency). Interpreting model results always requires awareness of these uncertainties.

Model applications

Forest simulation models can be used to answer diverse questions about forests. More empirical models are useful for projecting forest resources over years or decades, while mechanistic models typically assess long-term climate or environmental impacts. In general, simulation models help explore the consequences of different scenarios in which important drivers change. One key driver is forest management, for example reflecting how owners and managers respond to climate and policy change.

Key Points

- ➔ Forest simulation models are simplified abstractions of reality describing forest growth, forest dynamics and the interaction of vegetation, soil and atmosphere over time.
- ➔ Different forest simulation models exist for European forests, varying by modelling purpose and paradigm.
- ➔ Drivers and scenarios describing forest management, climate change and disturbance regimes are important model inputs.
- ➔ Uncertainty of forest simulation model outputs must be recognized and considered when interpreting model results.

Sources and further reading: Mäkelä and Valentine. 2022. *Models of Tree and Stand Dynamics*. https://doi.org/10.1007/978-3-030-35761-0

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Funders

LEARNFORCLIMATE is supported under the umbrella of ERA-NET Cofund ForestValue. ForestValue has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 773324, as well as the Polish National Science Centre (UMO-2021/03/Y/HS6/00035), Swedish research council Formas and innovation agency Vinnova, German Federal Ministry of Food and Agriculture via the Agency for Renewable Resources (FNR grant agreement N° 2221NR096A and 2221NR096B), Slovenian Ministry of Higher Education, Science and Innovation Innovation (Grant number C3330-21-252005).

The BIOCONSENT project was funded through the 2020-2021 Biodiversa+ and Water JPI joint call for research projects, under the BiodivRestore ERA-NET Cofund (GA N°101003777), with the EU and the funding organisations Academy of Finland (AKA, Decision number 351884), Agencia Estatal de Investigación Spain (AEI), Austrian Science Fund (FWF), Bulgarian National Science Fund (BNSF), German Federal Ministry of Education and Research (BMBF), and the Swedish Environmental Protection Agency (SEPA).