Forest ecosystem services in Europe

policy and perceptions

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Forest ecosystem services in Europe – policy and perceptions

Abstract

This thesis explores policy concerning, and perceptions of, forest ecosystem services, which illustrates the multiple uses and societal benefits provided by forested landscapes, including their roles in climate change mitigation, adaptation, and biodiversity conservation. This is done through a policy analysis investigating how forest ecosystem services are addressed within the European policy landscape, and an international survey-study that examines public perceptions and prioritizations related to forest ecosystem services. Five European regions were selected as case studies—Grisons (Switzerland), Estonia, Sweden, Catalonia (Spain), and the German states of Hesse and Thuringia—representing a range of forest types, governance systems, and cultural contexts. The findings indicate that relevant policy sectors are increasingly acknowledging both synergies and trade-offs related to forest ecosystem services, and they tend to be aligned in their overarching objectives. Furthermore, survey results show that the public consistently places the highest value on the regulating services of clean air and water, irrespective of regional differences in forest cover or associated economic benefits.

Keywords: policy evaluation, policy integration, forest, public perception,

Skogliga ekosystemtjänster i Europa – policy och preferenser

Sammanfattning

Denna avhandling undersöker policy och preferenser kopplade till skogens ekosystemtjänster, vilket omfattar de många användningsområden och samhällsnyttor som skogsmiljöer erbjuder, inklusive deras betydelse för klimatanpassning, klimatpåverkan och bevarandet av biologisk mångfald. En policyanalys undersöker hur skogliga ekosystemtjänster behandlas inom olika europeiska policy-kontexter, medan en omfattande internationell enkätstudie fokuserar på allmänhetens uppfattningar och preferenser kopplade till skogliga ekosystemtjänster. Fem europeiska regioner valdes som fallstudier – Graubünden (Schweiz), Estland, Sverige, Katalonien (Spanien) samt de tyska delstaterna Hessen och Thüringen – vilka är representativa för den europeiska mångfalden av skogstyper, institutionella strukturer och kulturella kontexter. Resultaten visar att de policyområden som påverkar skogliga ekosystemtjänster i allt högre grad erkänner både synergier och målkonflikter, och tenderar att vara samordnade i sina övergripande målsättningar. Vidare visar enkätsvaren att allmänheten konsekvent värdesätter reglerande tjänster såsom ren luft och rent vatten högst, oberoende av regionala skillnader i skogsareal och ekonomiska nyttor.

Nyckelord**:** policy utvärdering, policy integration, skog, allmänna preferenser

Preface

Politicians' desire to appear proactive can sometimes be poor guidance for long-term, functional initiatives in the policy landscape. Especially in matters that stir up emotions, like climate change and environmental concern. Policy should only be initiated to solve problems and be helpful in building a society that gets better every day. When policy is formed just to impress fellow policy makers, or aimed at controlling people just for the sake of it, it should be caught and dismantled before irrecoverable damage is done – this is my firm belief.

This thesis is written in a time of rapidly changing notions and policy contexts, so you better read fast.

Stockholm, Maj 2025
Ester

Dedication

I thank Edvin, my solid rock, for love and support, and our two finest little ecosystem services of Gunnar and Amadeus for inspiration.

Contents

List of publications

This thesis is based on the work contained in the following papers, referred to by Roman numerals in the text:

I. Hertegård, E. and Widmark, C. (2025). Policy integration of forest ecosystem services-Cases of Catalonia, Estonia, Grisons, and Hesse & Thuringia. Land Use Policy, vol (151). https://doi.org/10.1016/j.landusepol.2025.107478

II. Hertegård, E. (2025). Forest ecosystem services: Public and stakeholder perceptions and prioritization across five European regions. (Manuscript)

All published papers are reproduced with the permission of the publisher or published open access.

The contribution of Ester Hertegård to the papers included in this thesis was as follows:

I. Corresponding author, developing framework for analysis, co-producing the results.

II. Single author

1. Introduction and theory

1.1 Forest ecosystem services - concept and theory

The concept of ecosystem services refers to the benefits that humans derive from ecosystems. The term "ecosystem services" was first introduced in the early 1980s. One of the earliest documented uses was by Ehrlich and Ehrlich (1981), who described how ecosystems contribute to human well-being. However, the concept gained significant traction with the publication of Daily (1997), who formalized and expanded the idea in the influential book "Nature's Services: Societal Dependence on Natural Ecosystems". A major turning point came with the Millennium Ecosystem Assessment (MEA, 2005), commissioned by the United Nations, which widely popularized the framework by categorizing ecosystem services into four widely used categories. This assessment significantly influenced policy, economics, and environmental science. Since then, the concept has become a cornerstone of sustainability science and environmental economics, linking ecological function with human welfare and informing policy instruments like payments for ecosystem services, natural capital accounting, and ecosystem-based management.

The term "forest ecosystem services" gained prominence as scholars and policymakers sought to recognize the multiple non-market functions of forests beyond timber production. The concept was strongly promoted in the wake of the Millennium Ecosystem Assessment (2005) and was further emphasized in European forest policy and research programs, such as the EU Forest Strategy (EC, 2021), FOREST EUROPE process (Forest Europe, 2020), and the Mapping and Assessment of Ecosystems and their Services (MAES, 2013) initiative. In scientific literature, early applications of the term often appear in studies assessing multifunctional forest management, ecosystem valuation, and PES in forest contexts. The work by de Groot et al. (2010) also played a key role in operationalizing ecosystem service classification, with forest-specific examples. In European contexts, forest ecosystem services are now a cornerstone in discussions on policy integration (e.g., forest, biodiversity, climate), and trade-offs between timber production and other societal benefits. Forests are seen not only as economic resources but also as providers of crucial ecological and social values.

To make any classification system for ecosystem services relevant, it needs to consider both the particular form of the ecosystem of interest and the context of decision for which the concept of ecosystem services is being used for (Fisher et al., 2009).

The evaluation of services and values provided by nature, in this case forests, are completely dependent on people's view of nature. This view is a dynamic, experience-based re-evaluation and exploration of the human-nature relationship. Moreover, how people use nature and how nature responds to this use is likely to be subject to change over time. Therefore, it is highly relevant to constantly update knowledge about people's perceptions and prioritizations to be able to sustain the vital functions of ecosystems for future use and well-being (Costanza, 2008).

Socio-economic factors are both affecting and being affected by ecosystems. Humans part of nature is a relationship in need of careful consideration to ensure both people's well-being and nature's capacity to continue to provide the services needed in the long-term perspective (MA, 2005). Generated estimates of total value of ecosystem services (e.g., Costanza et al., 1997) do not incorporate the changing socio-economic factors that to a large extent affects the efficacy of policy (Olander et al., 2017).

Individual choices and preferences are, to some extent, shaped by spatial experience (Aguilar et al., 2017). Proximity to various land types influences how people perceive, associate with, and prioritize the services provided by local ecosystems. These spatial associations are particularly relevant in policymaking and in the selection of appropriate indicators for evaluating ecosystem service outcomes. For this reason, both Paper I and Paper II in this thesis include multiple regional policy contexts, representing the diverse forest landscapes across Europe, to enable a comparative analysis of how forest ecosystem services are perceived by the public and incorporated into policy. An ecosystem service, including those provided by forests, only becomes an actual service when it yields a tangible human benefit (Fisher et al., 2009). The ecosystem services framework, grounded in an anthropocentric perspective, aims to improve the strategic orientation of environmental policy by emphasizing benefits to people (Grunewald and Bastian, 2015). Ecosystem-related decisions are not shaped solely by formal policymaking; they emerge from a dynamic interplay of socio-cultural influences. To capture these, the survey conducted in Paper II elicits what is

“top-of-mind” regarding forest ecosystem services among a representative sample of residents in a selection of areas in Europe. The large sample size further allows for the identification and exploration of subgroups with particular socio-cultural relevance, offering deeper insights into the varied ways people relate to and value forest ecosystems.

The feedback loop between value perception and policy development must be continuously updated to ensure policy relevance and target alignment. It is the expression of human needs or demands that transforms an ecosystem's potential into an actual service (Grunewald and Bastian, 2015). Policy plays a critical role in safeguarding the continued provision of ecosystem services by managing trade-offs and promoting synergies. The policy analysis study investigates the extent to which such trade-offs and synergies among forest ecosystem services are recognized within policy frameworks across the case study regions. Ecosystem services are inherently spatio-temporal in nature, varying across both geographical contexts and over time (Fisher et al., 2009). A failure to account for this dynamic character limits the ability to meaningfully integrate ecosystems into political decision-making processes (Grunewald and Bastian, 2015). This thesis offers an update of how forest ecosystem services are currently perceived and addressed within European policy contexts and public opinion.

There are different classifications discussed on dividing ecosystem services in groups based on how they create value. The Millennium Assessment divides the ecosystem services into four different groups: provisioning, regulating, cultural and supporting services (MA, 2005). The supporting services are the base of existence for the other three groups, like nutrient cycles and soil formation, while the providing services consists of withdrawable resources such as food and wood. The cultural services are for example values provided by aesthetics and recreational activities and the regulating services contribute with water purification and services that regulate the functions of the ecosystem services. However, the MA assessment has been revisited and the classification has been developed further since its publication. Two other classifications, the TEEB (The Economics of Ecosystems and Biodiversity) (TEEB, 2010) and CICES (Common International Classification of Ecosystem Services) (CICES, 2018), are also commonly used. TEEB is similar to MA but omits the supporting services, arguing that the supportive services are a subset of the ecology. The TEEB groups are provisioning services, regulating services,

habitat (including biodiversity support) services, and cultural and amenity services. CICES however, organizes the services into three groups instead of four: provisioning, regulating/maintenance, and cultural services. For this thesis, the regulation group is integrated with the supporting, since it can be difficult to distinguish between these when analysing how ecosystem services affect the recipients. This has similarities to both CICES classification and TEEB but the ecosystem services chosen are closer in line with the original MA classification, with the alteration of integrating regulating and supporting services in the same group.

1.2 Aim of thesis

The aim of this thesis is to increase understanding of the policy context, and public perception of forest ecosystem services in Europe.

1.3 Delimitations

This thesis draws on data from selected case study regions and while the findings are strictly representative of those specific regions, the cases were deliberately chosen to reflect the diversity of forest contexts across Europe.

The composition of regions differs slightly between the papers. The policy analysis is based on documents from Hesse and Thuringia (Germany), Estonia, Catalonia (Spain), and the canton of Grisons (or Graubünden) (Switzerland). However, the public perception study, which relies on survey data, Grisons, with its fewer than 200,000 inhabitants, was replaced by Switzerland as a whole in order to obtain a big enough sample to be representative.

The survey also adds Sweden as a fifth case study region, for two reasons. First, the goal was to capture the full range of European forest types, and the boreal forests of northern Europe play a central role that cannot be fully captured by Estonia alone. Second, Sweden provides an opportunity to explore public perceptions in so-called “forest-rich” countries. Along with Finland, Sweden is often grouped under a shared set of forest-related policy interests. The survey data allow us to examine whether public views in Sweden and Estonia truly align or whether these assumed similarities are more institutional than perceptual.

2. Case study regions

2.1 Catalonia

Catalonia is a 32,108 km² region in northeastern Spain, in which Barcelona is the largest city and capital. 63 percent of the land area is forested, which is higher than the country ratio of 37 percent. The landscape is shifting from the elevated Pyrenees Mountain range along the French border, and several national parks are located in both the north and south of the region. The Catalonian forests are dominated by different pine species. Conifer represents about 40 percent of the total tree composition (Ministerio de Agricultura y Pesca, 2017). Catalonia has the second largest tree volume among Spain's autonomous communities, surpassed only by Castilla y Léon, which despite being nearly three times larger. The region also ranks among those with the highest tree density. Across Spain, holm oak (*Quercus ilex*) is the most common species, accounting for 19.12 percent of all trees; in Catalonia, the share is slightly higher at 24.4 percent (Universitat Autónoma de Barcelona, n.d.). Clearcutting as a forest management procedure is only practiced on small areas of less than one hectare. The Catalonian forests are mainly privately owned and the public right of access builds on the owners' goodwill. The largest revenue from forest ecosystem services comes from timber and mushrooms, Spain being the fourth largest exporter of processed mushrooms in the world. Hunting is also popular and the common game is wild boars and rabbits. Taxes and fishing licenses provide some income for the state. Small-scale recreational berry and mushroom picking is also common.

2.2 Estonia

The country of Estonia, with a total geographic area of 45,339 km², has forests covering 54 percent of the land. Forest resources constitute an important part of the country's industry, since Estonia is an exporter of both wood fuel and pellets (NFI, 2022). Wood biomass provides 32 percent of the primary energy consumption in Estonia, as of 2018. The Estonian state is the largest forest owner in the country and controls almost half of the forested land. Private ownership of forest is at 28 percent, while juridical entities own approximately 20 percent. Wood-based products are an important

commodity group for Estonia balancing the foreign trade (Forestry and Wood Industry 2020, 2020). The export of wood products exceeds imports almost three times and this foreign trade balance is also historically positive. In 2020, the forest wood sector employed approximately 31,000 workers and is an important employer especially in rural areas (Forestry and Wood Industry 2020, 2020). Hiking and hunting in the forest are popular activities for both Estonians and international tourists. The main game is elk, wild boar, roe deer, red deer, beaver, bear and wolf. Hunting is regulated on a national level and besides providing a recreational activity, it is also important to diminish forest damages from browsing (Estonian Environment Agency, 2022).

2.3 Grisons

Grisons (also called Graubünden) is the largest canton (administrative division) of Switzerland in terms of area, covering 7,105 km². It is located in the eastern parts of Switzerland and is diverse in terms of natural and cultural geography, as it encompasses both sides of the Alps and several natural and cultural regions. The canton lies completely in the mountain area and elevations above sea level range from 260 to 4,049 meters. A third of the land area is covered with forests, mainly conifers (82 percent). Spruce is common at all altitudes, while larch (*Larix sp.)* and Swiss stone pine (*Pinus cembra*) are mainly found at higher altitudes. Most of the forest is owned by the public, and only about nine percent of the forest area is privately owned (Office, 2021). The public right of access to the forest stated in the Swiss Civil Law Art. 699, and hiking, skiing, and other recreational activities are popular. Tourism is important for the Grisons economy (Kronthaler and Cartwright, 2008).

The protective function of the forests against natural hazards like avalanches, rockfall and landslides is, by the authorities, prioritized as the most important ecosystem service from the forests and about 60 percent of the forest area are specifically designated to provide these functions. Timber harvesting is difficult due to the topography and is subsidized for the sake of regenerating the protective function as the forests grows older (Swiss Forest Law Art. 20.5) (Bühler et al., 2022).

2.4 Hesse & Thuringia

Hesse and Thuringia are two federal states located in the central part of Germany. In this study, they are jointly considered as one case study region. Hesse holds the populous cities of Frankfurt am Main, Wiesbaden, Darmstadt, Offenbach, Hanau, Giessen, Wetzlar, and Rüsselsheim am Main in the southwest. The region has a forest coverage of 42 percent of the 21,115 km² land area. In Thuringia, the corresponding share is 34 percent of the 16,171 km². This is to be compared with the national German average of 33 percent (Third National Forest Inventory, 2022). The Hessian landscape is hilly but the topography is not extreme in comparison with mountain areas. In Hesse, there are more broadleaves than conifers, while in Thuringia the conifers dominate. The Thuringian forests are dense, and a well-known hiking trail, the Rennstieg, is located within. Most forest in Hesse are held by public forest owners, such as the federal state or local municipalities, while in Thuringia privately owned forests are more common. Several towns in Thuringia are popular winter resorts. Public right of access to the forests is statutory for temporary recreational activities in Germany regardless of type of ownership. Sawn wood is an important commodity, and there are over 40 local sawmills producing 5.16 million cubic meters of sawn wood. Residual biomass is used for energy production (Third National Forest Inventory, 2022).

2.5 Sweden

This case study region is only present in paper II, due to its relevance for public opinion in the forest rich northern part of Europe.

Sweden, with a total area of approximately 410, 000 km², is predominantly covered by forests, which constitute about 69 percent of its land area. These extensive forest resources play a crucial role in Sweden's economy, particularly in the forestry sector.

The ownership of Sweden's productive forest land is diverse. Approximately 50 percent of the forest land is owned by around 313,000 small-scale private forest owners, while about 24 percent is owned by private companies. The remaining 26 percent is owned by the state and other public entities.

The forest-based industry significantly contributes to Sweden's economy - forest-based products account for approximately 10 percent of Sweden's total goods exports, amounting to a gross value of €16.5 billion. The sector provides around 60,000 direct jobs and supports an additional 140,000 indirect jobs, highlighting its importance, especially in rural areas. Biomass is a vital component of Sweden's energy mix - bioenergy accounts for more than one-third of all energy used in Sweden, with biomass providing about 60 percent of the fuel for district heating.

Hunting is a popular activity, with common game including European moose, roe deer, and wild boar. The hunting rights entail an obligation to manage wildlife, contributing to both recreation and ecological balance.

3. Methods and Data

3.1 Paper I - Policy integration of forest ecosystem services

For the policy analysis, the theoretical framework of policy integration, environmental policy integration and the Doern continuum are used to describe the results. The goal of policy integration and environmental policy integration is to explore how policy objectives are integrated between different policy sectors (horizontal integration), and how these are implemented and whether they are coherent (vertical integration).

To further explore the differences in vertical integration between the regions, the illustrative tool of the Doern continuum is applied, which emphasizes the level of coercion used to implement policy. Policy-documents were gathered by local experts, analysed with standardized criteria and summarized for comparability.

Four Case Study Regions were chosen. Each region represents a unique combination of ecological features, forest ownership pattern, and governance structures. Chosen, as a group of regions, to be representative of the European forest contexts:

- Catalonia (Spain): Mediterranean forests, pine-dominated, high private ownership, bioeconomy focus, regional government.
- Estonia: Hemiboreal forests, state-dominated ownership, biomass for energy, economic emphasis, national government.
- Grisons (Switzerland): Alpine forests, predominantly public ownership, strong protective functions, regional government.
- Hesse and Thuringia (Germany): Continental forests, mixed ownership, focus on multifunctionality, regional government.

These regions span EU and non-EU countries, enabling insights into supranational policy influence. 34 policy documents were selected based on their relevance to forest ecosystem services in the policy sectors of bioeconomy, energy, forestry, climate change and biodiversity. They were then analysed using questions on goal alignment, synergies, conflicts, and prioritization of forest ecosystem services. The comparative approach across regions allows identification of integration patterns and implementation

styles. The study avoids outcome evaluation, focusing instead on policy design and coordination.

3.1.1 Limitations

A limitation related to the methodology: local experts in each region, fluent in the native language and knowledgeable about forest policy, were responsible for selecting and interpreting policy documents. While this approach ensured contextual understanding, it also introduced the potential for bias, especially given the linguistic, cultural, and institutional differences between regions. These risks were mitigated by careful expert selection and clear communication of the study's objectives and methods during the data collection process.

3.2 Paper II - Forest ecosystem services: Public and stakeholder perceptions and prioritization across five European regions

A web-panel survey is used, targeting 5,000 respondents equally distributed across five case study regions representing diverse forest types and socio-political contexts:

- Estonia (hemiboreal)
- Sweden (boreal/hemiboreal)
- Hesse and Thuringia, Germany (continental)
- Switzerland (Alpine)
- Catalonia, Spain (Mediterranean)

Each case reflects unique ecological, institutional, and economic profiles, allowing to probe for variation in perceptions of forest ecosystem services. The survey includes 24 questions split into four categories: demographics, forest ecosystem service perception and prioritization, forest management practices, and personal forest interaction. Responses were collected in April 2023.

Methodological strengths of this study include multilingual translation, soft-launch piloting, and randomization to avoid biases. Besides inter-regional comparisons, the stakeholder groups of respondents owning forests or work in forestry/agriculture were identified and compared.

The respondents were asked to pick out five forest ecosystem services from a list of 14, and rank these 1-5 in accordance with how much importance they hold for the respondent personally. The core of the empirical analysis is based on binary outcome models, suited for this two-step ranking procedure, where the dependent variable indicates whether a respondent selected a particular forest ecosystem service (e.g., clean air and water, timber, public recreation) as the most important or among the top five. Two econometric models are employed, linear probability model (LPM) and logistic regression model. The LPM allows for direct interpretation of the marginal effects, a clear way of describing the results. To ensure predicted probabilities lie within the [0,1] interval and to correct for heteroskedasticity, the logit model was also employed. Both models are used in parallel, with the logit model serving as a robustness check for the LPM results.

3.2.1 Limitations

Since the survey is based on non-probability sampling, results reflect the views of respondents rather than the general population. While web-panels were carefully managed to ensure representativeness in terms of gender, age, and income, unknown biases such as the likelihood of joining web-panels among people with certain views on forest ecosystem services cannot be ruled out. Nonetheless, the results are broadly indicative due to thoughtful design and execution.

Response rates varied across regions, with Estonia showing the lowest participation.

There are also limitations tied to survey-based data: respondents might misinterpret questions or base answers on general ecosystem services rather than forest-specific ones. Additionally, answers may reflect top-of-mind associations more than carefully considered preferences.

Methodologically, the study uses both linear probability and logistic regression models. The linear probability model offers clarity but has technical limitations such as heteroskedasticity. Logistic regression provides better statistical properties, though its results require interpretation via odds ratios.

4. Summaries of the papers

4.1 Paper I - Policy integration of forest ecosystem services - Cases of Catalonia, Estonia, Grisons, and Hesse & Thuringia

4.1.1 Background and aims

This study explores how forest ecosystem services are integrated into policy across four European regions with diverse ecological and institutional contexts: Catalonia (Spain), Estonia, Grisons (Switzerland), and Hesse & Thuringia (Germany). As forests become central to climate change mitigation and biodiversity conservation, conflicting and overlapping policy objectives have emerged. The integration and coherence of these policies—particularly how they acknowledge synergies and trade-offs between forest ecosystem services —are crucial for efficient forest governance.

For analysis, the frameworks of policy integration, environmental policy integration, and vertical/horizontal coherence are used. 34 regional and national policy documents are analysed, covering the policy sectors of biodiversity, bioeconomy, climate, energy, and forestry, to determine the alignment of objectives, coherence of implementation tools, and levels of government coercion used.

The primary aims of this study are fourfold. First, it seeks to assess how various forest ecosystem services, such as timber production and biodiversity conservation, are integrated into policy frameworks across different regions. Second, it aims to identify the conflicts and synergies that emerge between forest ecosystem services. Third, the study analyses how environmental concerns are prioritized in relation to economic objectives within forest-related policies. Finally, it evaluates the level of policy implementation and coerciveness by applying the Doern continuum, which provides a framework for assessing the strength and enforcement of policy instruments.

Policy integration describes alignment and comprehensiveness across policy sectors. Environmental policy integration focuses on whether environmental objectives are prioritized or subordinated. Vertical integration assesses internal policy coherence and implementation tools, from soft (e.g., guidelines) to hard (e.g., legal mandates). The Doern continuum offers a spectrum to illustrate coercion in implementation.

4.1.2 Results and conclusion

Across the four regions examined, biodiversity and climate change policies demonstrate a high degree of environmental policy integration. These sectors frequently reference and promote synergies with forest-related policies, reflecting a deliberate effort to coordinate objectives. In contrast, policies related to the bioeconomy and energy tend to display weak integration, often subordinating environmental goals to economic imperatives. Forest policies, for their part, generally adopt a multifunctional approach, balancing economic, ecological, and social objectives, though rarely with a clear prioritization of one over the others. Recurring policy conflicts emerge in predictable but critical areas: timber production frequently clashes with biodiversity goals; biomass energy production can come at the expense of conservation; and recreational use is often in tension with commercial forestry, particularly in ecologically sensitive zones.

To assess how policy is implemented in practice, the study applies the Doern continuum, which categorizes instruments by their degree of coerciveness. In this context, hard instruments such as sanctions and licensing requirements are most prevalent in biodiversity, forest, and climate-related policy areas. Softer tools like strategic plans, guidelines, and voluntary standards dominate in the realms of energy and bioeconomy. All regions exhibit a mix of both, yet notable regional distinctions arise. Catalonia, for instance, employs hard instruments in its climate strategy via a dedicated climate fund. Grisons enforces emissions standards with financial penalties. Estonia and Germany, meanwhile, rely more heavily on licensing schemes and subsidies in their approach to forest management. Region-specific policy tendencies further illustrate the variation in integration. Catalonia places a strong emphasis on bioeconomy innovation, particularly around biomass, and acknowledges the trade-offs this entails with biodiversity protection. It applies both hard and soft policy tools, and exhibits high coherence in forest and climate policy sectors. Estonia, by contrast, prioritizes economic productivity in forest management, especially for energy purposes, placing timber and biomass at the centre of its strategy, while biodiversity and other ecosystem services remain secondary. Grisons focuses on the protective function of forests, facilitated by a high degree of public ownership, which eases implementation. Although environmental policy integration is strong in biodiversity policy, it is weaker in energy and forestry. In Hesse and Thuringia, forest policy reflects a multifunctional

approach, seeking synergies among biodiversity, recreation, and climate objectives. Mixed ownership structures necessitate a combination of policy instruments. EU policy is playing an increasingly prominent role in shaping national and regional governance, especially in areas like biodiversity and climate where the EU has long been active. In contrast, newer or more nationally governed areas such as forest management and bioeconomy remain under stronger local control, though signs of harmonization are emerging. This gradual convergence brings both opportunities and challenges. Where coherence between forest and climate policy is strong, mutual support and shared goals are evident. However, this is less true in the relationship between energy, bioeconomy, and biodiversity policy domains. The lack of alignment here risks missing synergies and exacerbating underlying tensions among forest ecosystem services. Taken together, the findings suggest that while forest-related policies are increasingly aware of trade-offs and synergies among ecosystem services, integration remains uneven both across sectors and among regions. Biodiversity and climate tend to enjoy greater policy priority, but economic and energy-related considerations still dominate in several contexts. EU influence provides a valuable framework for policy alignment, yet implementation remains shaped by regional ecological conditions and institutional traditions. The challenge ahead lies in reinforcing local synergies while bridging integration gaps between policy areas, particularly in the bioeconomy and energy sectors. Forest ecosystem service policy is moving toward greater coherence, but maintaining the right balance between environmental and economic aims, and between EU standardization and local responsiveness, will be critical to its long-term success.

4.2 Paper II - Forest Ecosystem Services: Public perceptions Across Five European Regions

4.2.1 Background, aims and policy context

The governance of forests in Europe is becoming increasingly complex, particularly under the influence of climate change. This paper situates itself in a timely policy debate: how can forest ecosystem services be effectively governed in a fragmented and sometimes contradictory institutional landscape? On one hand, the pressure to extract more biomass to reduce

reliance on fossil fuels grows, while on the other, biodiversity preservation and conservation initiatives demand stronger environmental protections. This dichotomy plays out differently in each European country depending on their forest resources and policy traditions. An emergent concern is how EU forest-related regulation can balance stakeholder interests, particularly under frameworks like the EU Deforestation Regulation (EUDR). In this context, policy design and implementation hinge on an accurate understanding of public and stakeholder preferences. The study investigates whether people living in different forest-rich regions of Europe perceive and prioritize ecosystem services differently.

It asks: - Do Forest owners have a different perception of forest ecosystem services than non-owners? - Are perceptions influenced by working in forestry or agriculture?

The concept of ecosystem services connects ecological processes with human well-being and is therefore suitable for perception evaluation. Spatial dynamics play a crucial role in ecosystem services valuation. Costanza's (2008) fivefold spatial classification is used to highlight how the proximity of ecosystems affects perceptions and prioritization. Notably, local-proximal services (e.g., recreation) differ from global non-proximal ones (e.g., carbon sequestration), challenging uniform valuation approaches and motivates more than one case study area. A fundamental insight is that service providing areas and service benefiting areas often do not overlap, especially in urbanized Europe. This separation of benefit and origin underscores the importance of understanding public perception as it relates not only to spatial proximity but also to lived experience and psychological closeness. The study emphasizes the anthropocentric origin of the ecosystem services framework, namely that ecosystems are valued because of their benefits to people. People's valuation is shaped by spatial, cultural, and economic proximities, with implications for how forest land is managed. The paper builds on Aguilar et al. (2017) to argue that human-nature relationships are continuously reshaped by experience, and therefore, policy must adapt to changing public preferences.

4.2.2 Results

The results of the study show a strong and consistent public prioritization on clean air and water as the most important forest ecosystem services across five case study regions: Catalonia (Spain), Estonia, Switzerland, Sweden, and the German states of Hesse and Thuringia. This finding holds regardless of differences in forest abundance, income levels, or the economic importance of the forestry sector. The prioritization of these regulating services indicates a widespread recognition of forests' role in providing essential public goods, suggesting a strong foundation for policy that emphasizes environmental benefits. While there is overall agreement between stakeholder groups, the study identifies a modest but notable distinction between forest owners and non-owners. Forest owners are slightly more inclined to prioritize provisioning services, such as timber production, than the general public. However, the divergence is small, and both groups place a high value on non-market services like clean air, clean water, and recreational opportunities. This overlap in perceptions and prioritizations suggests that policy efforts to promote multifunctional forestry, those that balance economic, ecological, and social goals, are likely to find support among a broad range of stakeholders. Differences across regions reflect underlying forest contexts and institutional settings. In forest-rich countries like Sweden and Estonia, timber production is ranked higher, and more frequently thought of as a forest ecosystem services, than in more conservation-focused regions such as Catalonia. Nonetheless, the shared emphasis on clean air and water across all case study regions reinforces the idea that certain forest ecosystem services are regarded as universally valuable. These findings offer important implications for forest governance. They point to areas of convergence where policy can build consensus, while also highlighting where stakeholder-specific interests may need to be balanced.

4.2.3 Conclusions

These findings have important implications for forest policy. First, if responses could be interpreted as the demand side of forest ecosystem services, then the policy implication must be to maintain the forests capability to provide clean air and water. Second, they suggest that policies that emphasize the protective and regulating functions of forests are likely to

enjoy broad public support. Third, the alignment of younger forest owners with the general public points to an opportunity for more cohesive, future-proof forest strategies. Finally, the study illustrates the value of regionally disaggregated data for understanding the socio-spatial distribution of perception of forest ecosystem services, an essential input for tailoring policies to local realities while still aligning with broader European objectives. If forest governance is to be legitimate and effective, it must respond to this complex mosaic of values and perceptions. Incorporating such perceptions into policy design can strengthen support, reduce conflict, and ensure that ecosystem services are safeguarded in a way that reflects their social relevance.

5. Discussion

This section discusses the findings from the two studies in relation to forest ecosystem services governance and policy development. The policy integration study investigates the degree of policy integration across regions and sectors and the public perception part examines how different stakeholder groups and citizens in Europe perceive and prioritize forest ecosystem services. Together, the papers offer complementary perspectives on the institutional supply and public demand sides of forest-related policy.

5.1 Policy integration and institutional coordination

Analysis shows that policy integration related to forest ecosystem services remains fragmented across sectors and regions. Climate and forest policies are relatively well-integrated, especially around multifunctionality and carbon sequestration. This signals a growing capacity among institutions to recognize and manage trade-offs across sectors. However, the integration of bioeconomy and energy policies with biodiversity and broader ecosystem concerns remains weak. This lack of cross-sectoral coherence can limit the effectiveness of forest sustainability goals, especially where biomass extraction is emphasized.

A key insight is that most regions use a mix of soft and hard instruments to implement policy, yet the relative weight of environmental objectives differs across policy sectors. Furthermore, supranational EU influence is strongest in climate and biodiversity policies, while forest and energy sectors remain largely governed by national or regional authorities.

5.2 Public perception and prioritization of ecosystem services

Addressing the demand side of forest ecosystem services survey data is from five European regions with diverse forest types and policy contexts. A core finding is that regulating services, particularly clean air and water, are consistently prioritized by respondents across all regions. This finding challenges the commonly held assumption that spatial proximity to forests is a dominant driver of public valuation. Instead, respondents appear to value

environmental services with broad societal benefits, even when they are not directly experienced in terms of livelihood or ownership.

The survey results indicate that forest owners and those working in forestry or agriculture do not significantly prioritize provisioning services (such as timber) over other types of forest ecosystem services. This is notable because it challenges the notion that stakeholders act primarily in accordance with their economic self-interest.

These results suggest a nuanced public landscape, where both demographic and regional factors influence perceptions of forest ecosystem services. They also highlight the presence of emerging value shifts among key stakeholders, such as younger forest owners, which may reshape the future of forest governance.

5.3 Regional dynamics and the interaction between policy and perception

Altogether, the findings from the two papers reveal important regional dynamics. Catalonia and Estonia differ in how their policy documents frame biodiversity and timber production, with Catalonia incorporating biodiversity more prominently. Similar regional contrasts are evident in public prioritisation, yet a shared rank of regulating services persists across contexts.

This suggests that while institutional approaches to, and geographical prerequisites for, forest ecosystem services vary widely, public concern for environmental and cultural values may offer a unifying basis for future policy development in relevant areas.

6. Concluding remarks

Together the results illuminate the need for responsive forest governance and caution in terms of expanding coercive policies on a supranational level. The relatively high valuation of regulating and cultural services among the public in the survey stands in contrast to the weaker integration of these services in key policy domains according to the policy analysis, especially in bioeconomy and energy strategies. Bridging this gap will be essential for maintaining legitimacy and effectiveness in forest governance.

Improving stakeholder engagement, particularly with underrepresented groups and younger forest owners, could strengthen the alignment between governance and societal demand. Additionally, better integration of cultural values into policy frameworks would reflect the actual perceptions revealed by the survey.

Both perspectives emphasize the importance of ongoing adaptation. Forests are dynamic systems, and so are the social values and institutions that govern them. The survey study provides a replicable model for tracking changing public perceptions, while the policy analysis offers an evaluative framework for institutional coherence. Together, they offer an updated understanding of ecosystems-human-relationship in Europe.

6.1 Future studies

Future research could examine how gender influences the prioritization of forest ecosystem services and the potential implications for policy implementation. Differences in environmental values between women and men may shape demand for specific services, such as recreation, timber production, or biodiversity conservation. A deeper understanding of these patterns could support the design of more inclusive and effective forest policies.

Further studies should also explore public perceptions of power dynamics in forest governance. While formal structures are well known, less attention has been paid to how citizens view the distribution of influence among state actors, private landowners, industry, and civil society. Addressing these perceptions could help bridge gaps between governance frameworks and public expectations, and strengthen participatory approaches to sustainable forest management.

References

Aggestam, F., Giurca, A., 2021. The art of the "green" deal: policy pathways for the EU Forest Strategy. *Forest Policy and Economics*, 128, 102456.

Aggestam, F., Pülzl, H., 2018. Coordinating the uncoordinated: the EU forest strategy. *Forests*, 9 (3), 125.

Aguilar, F. X., Cai, Z., and Butler, B., 2017. Proximal association of land management preferences: Evidence from family forest owners, *PLoS One*, 12 (1), e0169667.

Alliance for Freedom, Justice and Sustainability., 2021. *Daring to make more progress - Coalition treaty 2021–2025*, Germany.

Bali, A.S., Howlett, M., Lewis, J.M., Ramesh, M, M., 2021. Procedural policy tools in theory and practice. *Policy and Society*, 2021, 295–311.

Beland Lindahl, K., Söderberg, C., Lukina, N., Tebenkova, D., Pecurul, M., Pülzl, H., Widmark, C., 2023. Clash or concert in European forests? Integration and coherence of forest ecosystem service–related national policies. *Land Use Policy*, 129, 106617.

Berning, L., and Sotirov, M., 2024. The coalitional politics of the European Union regulation on deforestation-free products, *Forest Policy and Economics*, 158, 103102.

Bühler, Y., Bebi, P., Christen, M., Margreth, S., Stoffel, L., Stoffel, A., Bartelt, P., 2022. Automated avalanche hazard indication mapping on a statewide scale. *Natural Hazards and Earth System Sciences*, 22 (6), 1825–1843.

Carlsson, F., and Martinsson, P., 2001. Do hypothetical and actual marginal willingness to pay differ in choice experiments?: Application to the valuation of the environment, *Journal of Environmental Economics and Management*, 41 (2), 179–192.

Catalan Government., 2020. *Bioeconomy strategy of Catalonia (2021–2030)*, EBC.

Cornesse, C., Blom, A. G., Dutwin, D., Krosnick, J. A., De Leeuw, E. D., Legleye, S., Pasek, J., Pennay, D., Phillips, B., Sakshaug, J. W., 2020. A review of conceptual approaches and empirical evidence on probability and nonprobability sample survey research, *Journal of Survey Statistics and Methodology*, 8 (1), 4–36.

Costanza, R., d'Arge, R., De Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R. V., Paruelo, J., Raskin, R. G., Sutton, P., van den Belt, M., 1997. The value of the world's ecosystem services and natural capital, *Nature*, 387 (6630), 253–260.

Costanza, R., Ecosystem Services: Multiple Classification Systems Are Needed, *Biological Conservation - BIOL CONSERV*, 02 2008, 141, 350–352.

Daily, G.C., 1997. Nature's Services: Societal Dependence on Natural Ecosystems. Island Press, Washington, D.C.

Danley, B., and Widmark, C., 2016. Evaluating conceptual definitions of ecosystem services and their implications, *Ecological Economics*, 126, 132–138.

de Groot, R.S., Alkemade, R., Braat, L., Hein, L., Willemen, L., 2010. Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making. Ecological Complexity, 7(3), 260–272.

de Leeuw, E. D., Suzer-Gurtekin, Z. T., and Hox, J. J., 2018. The design and implementation of mixed-mode surveys, *Advances in comparative survey methods: Multinational, multiregional, and multicultural contexts (3MC)*, pp. 387–409.

Doern, G.B., Phidd, R.W., 1983a. *Canadian public policy: Ideas, Structure, Process*.

Doern, G.B. & Phidd, R.W., 1983b. *Canadian Public Policy: Ideas, Structure, Process* (Vol. 1983) (No. 2). Methuen.

EC., 2011. *Biodiversity Strategy*. Retrieved from https://ec.europa.eu/

EC, 2013. Mapping and Assessment of Ecosystems and their Services (MAES). Technical Report 2013–067. doi:10.2779/12398.

EC., 2018. *Bioeconomy strategy*. Retrieved from https://ec.europa

EC., 2021. *Forest strategy*. Retrieved from https://ec.europa.eu/environment/

EC., 2023. *Guidance on the development of public and private payment schemes for forest ecosystem services*.

Elomina, J. & Pülzl, H., 2021. How are forests framed? An analysis of EU forest policy. *Forest Policy and Economics*, 127, 102448.

Ehrlich, P.R., Ehrlich, A.H., 1981. Extinction: The Causes and Consequences of the Disappearance of Species. Random House, New York.

Estonian Environment Agency., 2022. *Yearbook Forest 2020*. Tallinn.

European Environment Agency., 2023. *CICES23*.

European Union., 2016. *Principle of subsidiarity*. Retrieved from https://eur-lex.europa.eu/

Eurostat., 2022. *Share of forest area - Products Datasets - Eurostat*.

Federal Forest Act., 1975. *Law on the Conservation of Forests and the Promotion of Forestry*. Germany.

Federal Office for the Environment., 2005. *Sustainability and success control in protection forests (NaIS)*.

Forestry and wood industry 2020., 2020. *Statistics*. Retrieved from https://empl.ee/

FOREST EUROPE., 2020. State of Europe's Forests 2020. Ministerial Conference on the Protection of Forests in Europe. Available at: https://foresteurope.org/wp-content/uploads/2016/08/SoEF_2020.pdf

Haines-Young, R. & Potschin, M., 2018. Common International Classification of Ecosystem Services (CICES) V5.1 and Guidance on the Application of the Revised Structure. Fabis Consulting Ltd., Nottingham. Available at: https://cices.eu/content/uploads/sites/8/2018/01/Guidance-V51-01012018.pdf

Johansson, J., 2018. Collaborative governance for sustainable forestry in the emerging bio-based economy in Europe. *Current Opinion in Environmental Sustainability*, 32, 9–16.

Johnston, C.M.T., Radeloff, V.C., 2019. Global mitigation potential of carbon stored in harvested wood products. *PNAS*, 116 (29).

Jordan, A. & Schout, A., 2006. *The coordination of the European Union: exploring the capacities of networked governance*. Oxford University Press.

Kleinschmit, D., Arts, B., Giurca, A., Mustalahti, I., Sergent, A., Pülzl, H., 2017. Environmental concerns in political bioeconomy discourses. *International Forestry Review*, 19 (1), 41–55.

Kliimaministeerium., 2005. *Estonian Environmental Strategy 2030*.

MA, Ecosystems and human well-being: synthesis, Washington, DC: Island Press, 2005. OCLC: ocm59279709.

Soderberg, C., 2011. Institutional conditions for multi-sector environmental policy integration in Swedish bioenergy policy. *Environmental Politics*, 20(4), 528–546.

Sotirov, M., Azevedo-Ramos, C., Rattis, L., Berning, L., 2022. Policy options to regulate timber and agricultural supply-chains for legality and sustainability: the case of the EU and Brazil. *Forest Policy and Economics*, 144, 102818.

Sotirov, M., Storch, S., 2018. Resilience through policy integration in Europe? *Land Use Policy*, 79, 977–989.

Steurer, R., 2013. Disentangling governance: a synoptic view of regulation by government, business and civil society. *Policy Sciences*, 46 (4), 387–410.

Swiss Federal Statistical Office., 2021. *Schweizerische Forststatistik 202*.

The Federal Assembly of the Swiss Confederation., 2011. *Federal law on the reduction of CO2 emissions (CO2 Act)*.

The Federal Council., 2020. *Adaptation to Climate Change in Switzerland - Action Plan 2020–2025*.

Third National Forest Inventory., 2022. Retrieved from https://bwi.info

Underdal, A., 1980. Integrated marine policy. *Marine Policy*, 4(3), 159–169.

Winkel, G., 2017. *Towards a sustainable European forest-based bioeconomy – assessment and the way forward*. European Forest Institute.

Winkel, G., Sotirov, M., 2016. Whose integration is this? European forest policy between the gospel of coordination, institutional competition, and a new spirit of integration. *Environment and Planning C: Government and Policy*, 34(3), 496–514.

Wolfslehner, B., Pülzl, H., Kleinschmit, D., Aggestam, F., Winkel, G., Candel, J., Eckerberg, K., Feindt, P. McDermott, C., Secco, L., Sotirov, M., Lackner, M., Roux, J-L., 2020. *European forest governance post-2020*. European Forest Institute.

Popular science summary

Forests are at the heart of some of the most pressing issues of our time – climate change, biodiversity loss, and cultural identity. Behind the diverse ways in which forests are used lie a wide range of consumers and stakeholders, each with their own perspectives and interests. The values that forests provide to humans can be understood through the concept of forest ecosystem services. As a theoretical framework, ecosystem services require continuous reflection on humanity's relationship with nature, our values, and our ways of perceiving the benefits derived from natural resources.

This thesis explores the human–forest relationship in two ways:

- by analysing the policy contexts for forest ecosystem services across different European regions,
- and by investigating how members of the public perceive and value the benefits that forests provide, through a cross-country survey.

Mapping the policy contexts for forest ecosystem services and identifying both conflicts and synergies is one way to capture societal preferences in representative democracies.

In **Paper I**, the degree of integration between forest ecosystem services - related policies is analysed across sectors, regions, and based on environmental prioritisation. The findings show that productive values – such as timber and biomass for energy – are frequently mentioned as being in conflict with biodiversity and conservation goals in national and regional policy. That these conflicts are acknowledged is a positive sign from a policy integration perspective. The analysis further shows that all studied policy sectors are striving towards a common overarching goal: sustainable and multifunctional forest use that supports a range of values simultaneously. A parallel analysis finds that these goals align with the European Union's overarching policy objectives. However, the EU's binding influence over forest-related policy remains limited, though it is expanding. This implies that decision-making power over forest ecosystem services is gradually shifting from national to international levels – a development that this thesis argues may not be the most effective or appropriate. The diverse ecological and institutional conditions that shape forest ecosystem services across Europe suggest a need for a variety of policy tools at the national and local levels. Accordingly, international policy should continue to focus on non-

binding instruments and sustainability targets that national and regional actors can adopt and build upon.

Paper II supports similar conclusions by showing that, while respondents across European regions share some common prioritizations, there are also meaningful differences. Clean air and water are universally highly ranked ecosystem services, but for example, Sweden stands out in its strong prioritization for non-commercial recreation – a reflection of country-specific traditions and access rights. Importantly, the study also shows that proximity to forests does not necessarily shape people's perceptions in predictable ways – a key insight for discussions on local involvement and benefit perceptions.

Taken together, the thesis highlights a rich variation in both policy context and public prioritization for forest ecosystem services across Europe. At the same time, it reveals a strong foundation of shared sustainability goals and points to several areas where international policy initiatives could build consensus. These results support the idea that future forest governance should be developed from the bottom up – with local anchoring.

Populärvetenskaplig sammanfattning

Skogen står i centrum för flera av vår tids mest avgörande frågor – klimatförändringar, biologisk mångfald och kulturell identitet. Bakom skogens många användningsområden finns en mångfald av konsumenter och intressenter med olika perspektiv och behov. De värden som skogen tillhandahåller för människan kan förstås genom begreppet skogliga ekosystemtjänster. Som koncept förutsätter ekosystemtjänster en ständig omprövning av människans relation till naturen, våra värderingar och hur vi uppfattar nyttan av naturresurser.

Denna avhandling undersöker människans relation till skogen på två sätt:

- genom att analysera policykontexter för skogliga ekosystemtjänster i olika delar av Europa,
- och genom att med hjälp av en enkätstudie undersöka hur allmänheten uppfattar och prioriterar nyttor från skogen.

Att kartlägga policykontexter för skogliga ekosystemtjänster och identifiera konflikter såväl som synergier är ett sätt att fånga preferenser inom ramen för representativa demokratier. I **papper I** undersöks hur relevanta policyområden är integrerade med varandra, mellan regioner och utifrån graden av miljöprioritering. Resultaten visar att produktionsvärden – såsom timmer och biomassa för energi – ofta nämns som i konflikt med bevarandemål och biologisk mångfald i regional och nationell policy. Att dessa konflikter erkänns är i sig positivt ur ett integrationsperspektiv. Analysen visar också att samtliga studerade policyområden strävar efter ett gemensamt övergripande mål: ett hållbart och uthålligt skogsbruk som främjar flera värden samtidigt. En kompletterande analys visar att detta mål är i linje med EU:s övergripande policyambitioner inom de berörda områdena. Samtidigt konstateras att EU:s ”tvingande” policyverktyg inom skogsområdet fortfarande är begränsade, men håller på att stärkas. Detta innebär att politisk makt över skogliga ekosystemtjänster i Europa i ökande grad förskjuts från nationell till internationell nivå – något som avhandlingen bedömer inte nödvändigtvis är den mest ändamålsenliga lösningen. De skilda geografiska och institutionella förutsättningarna för skogliga ekosystemtjänster i Europa talar snarare för ett behov av en mångfald av policyverktyg på nationell och lokal nivå. Därför bör internationell policy även framöver fokusera på icke-bindande styrmedel med hållbarhetsmål som nationella och regionala aktörer kan använda som utgångspunkt.

Papper II pekar mot liknande slutsatser genom att visa hur invånare i olika regioner uttrycker både gemensamma och särskiljande preferenser. Ren luft och rent vatten är exempel på skogliga ekosystemtjänster som värderas högt i alla regioner, men att exempelvis Sverige särskiljer sig genom högt värderad icke-kommersiell rekreation återspeglar de landspecifika förutsättningarna. Att bo nära skog innebär dock inte nödvändigtvis att man värderar skogen annorlunda – en viktig slutsats för hur vi tänker kring lokal förankring och nyttoperspektiv.

Sammanfattningsvis visar avhandlingen på en variation både i policykontext och i invånares personliga preferenser för skogliga ekosystemtjänster i Europa. Samtidigt framträder en tydlig förankring i gemensamma hållbarhetsmål. Det ger stöd för att framtidens skogspolitik bör byggas både nerifrån och upp, med lokal förankring, och uppifrån och ner, med gemensamma riktlinjer för hållbar utveckling.

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Appendix

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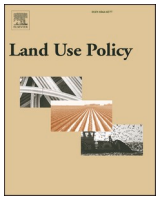

Policy integration of forest ecosystem services-Cases of Catalonia, Estonia, Grisons, and Hesse & Thuringia☆

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ABSTRACT

To ensure the long-term utilization of various services provided by forest ecosystems (FES), it is crucial that policy governing different FES are sustainable. To achieve this, policy coherence and choice of policy implementation is fundamental. This case study provides an insight in policy contexts for FES across Europe, illustrates how policies are targeting the same objectives, and identifies the synergies and conflicts in important nexuses. The aim is to use the measures of policy integration and implementation to highlight how forest ecosystem services are integrated in policy, to potentially increase the synergies and determine the suitable level of governing for future policymaking. The case study regions included are Catalonia (Spain), Estonia, Grisons (Switzerland), and Hesse & Thuringia (Germany), which represent a wide geographical span of European forests. The results indicate that the active policies governing FES are to a high degree adjusted to the region-specific forests, and showcase integration of environmental priorities, in accordance with EU-targets concerning forests and forestry. The findings of this study can help guide EU forest-related policy and broaden the perspective compared to earlier studies by including a unique composition of EU- and non-EU-member countries.

1. Introduction

The ecosystems of forests have for millennia supplied several different types of products and services important to human life and well-being (EC, 2021). Forest ecosystem services (FES) range from timber production to clean air and recreation (Reid et al., 2005). Despite increasing pressures on forests, the increasingly important role of forests in mitigating climate change has increased their value both as standing carbon sinks and as sources of renewable materials (Johnston and Radeloff, 2019). This is a global challenge in which the European Union (EU) has stated its desire to lead the way forward (EC, 2018). However, managing forests to maximize specific ecosystem services can affect the forest's ability to provide other services, potentially creating both conflicts and synergies(Aggestam and Pülzl, 2018). This is a source of tension between and within groups of stakeholders and policy makers, both regional, national, and supranational, with different views on forest management (Sotirov and Storch, 2018). The development of current and future use of FES is significantly guided by policy, where there is room for improvement in terms of efficiency (Larsson et al., 2016; Primmer et al., 2021).

In this case study, four different sites in Europe are in focus, with the aim of improving our understanding of how policy in different geographical and cultural contexts in Europe internalizes the present challenges of conflicting uses of FES but also how they acknowledge the synergies. This can be interpreted as an indication of efficiency for the policies concerned, since the recognition of how well different policy works together as a package is an integral part of creating prerequisites for effectuating policy goals (Aggestam and Giurca, 2021; Winkel, 2017). The descriptive results are then connected to the supranational level on EU to suggest caution in terms of level of coercion when formulating future policy in different policy subject areas. The policy governing forests across the different geographical types of Europe has a history of being diverse (Sotirov and Storch, 2018). The case study regions (CSRs) are chosen on the basis of their representative value of the dissimilar geographical and institutional contexts present in Europe. The included CSRs are Catalonia in Spain, the country of Estonia, the canton

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of Grisons in Switzerland, and the two German regions of Hesse and Thuringia (jointly analyzed as one CSR).

Forest products and services are an integrated element of multiple sectors, e.g., energy and biodiversity (Wolfslehner et al., 2020). This creates an increasing demand for multi-use of forests, which emphasizes the importance of acknowledging synergies and conflicts between uses of different FES in policy, since policy has a great impact on forest management (Larsson et al., 2016). For example, does the outtake of the provisioning services such as timber and mushrooms affect the recreational services negatively? If so, then policy should acknowledge it to be able to regulate a balance. Acknowledgement is a prerequisite for further development (Aggestam and Giurca, 2021). Therefore, it is of great importance to gain insight into the policy contexts that currently govern biodiversity and FES in Europe, where several policy areas need to be evaluated to see how well they work with or against each other. In this study, the policy analysed belonged to the subject areas of bioeconomy, biodiversity, climate, energy, and forest (forestry). Coherence between the subject areas[1] that are governing FES provides an indicator of their success in implementation. Measuring this can be referred to as horizontal integration (Beland Lindahl et al., 2023).[2] The steps that have been taken in analysing horizontal integration are comparing the main goals, identifying similarities and differences, and summarizing what synergies and conflicts that the policies acknowledge.

Apart from policy objectives and their integration, the toolbox used for policy implementation is also of importance in this context. The level of coercion a government (on the national or supra-national level) chooses to use for implementation gives insight into the urgency of the policy subject area, but also indicates what is left in the toolbox for future policy development (Doern and Phidd, 1983b). As forest-related policy on the EU level is moving towards being implemented with more hard[3] policy instruments (Lier et al., 2021), this study evaluates the already existing vertical integration of the regional and national policies present in the case study regions. While the analysis of horizontal integration focuses on the relationship between policy areas, the vertical integration revolves around the coherence within the policy subject areas, which also encompasses the implementation.

Analysing policy integration in the context of FES makes a valuable contribution to existing literature of illustrating the current state of policy contexts for policymakers to improve future policy's efficiency. Policy integration is not just a technical problem of formulating interdependence between different sectoral objectives, but it also reflects the values that are being pinned to the services (Beland Lindahl et al., 2023). Coordinating these different policy areas will enhance the benefits of cross-sectoral cooperation. This can lead to higher policy integration, which creates an evidence-based way of taking advantage of the existing synergies between the different usages of FES (Johansson, 2018; Winkel, 2017).

The subsequent sections are organized in the following way: The background section briefly describes the concept of FES and the CSRs. After that, the theory of the analysis follows together with a description of the method used in this paper. Then, the results of the analysis are presented, which is followed by a discussion of the result implications. Finally, the paper ends by concluding comments.

2. Background

This section explains the spatial contexts in which the policies are active, the different characteristics of the case study regions to which the analysed data pertain, and institutional setting governing their forest policy.

2.1. Forest ecosystem services

Forest ecosystem services (FES) include all products and services provided by forest ecosystems (European Environment Agency, 2023; Reid et al., 2005). These services benefit humans directly and indirectly. For example, "beautiful scenery," "biomass production," and "avalanche protection" offer clear, tangible societal benefits. Other services, like "biodiversity," "nutrient cycling," and "pollination," indirectly support human welfare by sustaining other ecosystem functions (Maes et al., 2016). Direct services from forests vary by location, reflecting local environmental conditions. In this study, all FES as formulated in the local policy contexts, but based on the wide definition as products and services provided by the ecosystems, has been taken into consideration[4]

2.2. Case study regions

The study is based upon four case study regions (CSRs) within three EU member countries and one non-EU member country. A representative sample of areas to study the diversity embedded both spatially in the European forests but also institutionally in forest governance structures. The location of the regions range from northern hemiboreal forests to central and southern European forests, and include Alpine regions as well as Mediterranean forests. The CSRs are demarcated to the country of Estonia, the region of Catalonia in Spain, the Grisons canton in Switzerland, and the federal states of Hesse and Thuringia in Germany (see Table 1). The areas are characterized by differences in forested area, geographic typology, and governance structure. All regions but one (Estonia) are federal, and hence the regions are self-governed implementing national regulation in combination with regional policy. Of the case study regions (here on country level), Estonia has the highest share of forestland, followed by Spain while Germany and Switzerland have

Table 1
Summarized characteristics of case study regions.

	Catalonia (ES)	Estonia	Grisons (CH)	Hesse and Thuringia (DE)
Geography & forest type	Southern Europe Mediterranean forests	Northern Europe Boreal/ Hemiboreal forests	Central European Alpine forests	Central European Continental forests
ha forest area CSR (% country level)*	2060,173 (41.2)	2217,000 (58.3)	201,240 (31.0)	1.443.268 (32.4)
Forest ownership	Private and state	Private and state	Public and private	Private, corporate, and state
Population in region	7.56 million	1.33 million	198,400	6.27 million and 2.14 million
Government	Federal monarchy	Republic	Federal (canton) republic	Federal republic
EU membership (EC, 2022)	Member since 1986	Member since 2004	Not member	Member since 1958

* Eurostat definition: (Forest is defined as land with tree crown cover (meaning all parts of the tree above ground level including its leaves, branches etc.), or equivalent stocking level, of more than 10 percent and with an area of more than 0.5 ha (ha). The trees should be able to reach a minimum height of 5 m at maturity in site (Eurostat, 2022))

[1] i.e. how harmonized their respective goals are.
[2] Integration can be measured on a regional, national or supranational level.
[3] Hard policy being enforced as laws or other legally binding documents, while soft policy has a more guiding power.
[4] Various classification systems, such as CICES, MA, TEEB, and IPBES, have been developed to categorize the complex web of ecosystem services.

approximately the same share of forestland.

The regions vary in size and population density. Catalonia has a high population concentration in Barcelona, with low density in rural areas. Grisons is the smallest CSR, with about 200,000 inhabitants. Estonia and the German regions Hesse and Thuringia have populations ranging from 1.33–6.27 million.

2.3. Geographical and silviculture context in case study regions

Forest types and uses vary across regions. In Estonia's northern hemiboreal forests, management focuses largely on biomass production, as in Germany's Hesse and Thuringia, though at different scales. In contrast, Switzerland's Grisons canton prioritizes forest protection, while Catalonia emphasizes mushroom production. The regions also vary in forest structures of age, species and biodiversity. The extensively managed forests are often characterized by having younger uniform trees, whilst wooded areas resembling primary forests display a wider age span and in many cases constitute habitat for more species.

2.3.1. Catalonia

Catalonia, a 32,108 km^2 region in northeastern Spain, contains Barcelona as its largest city and capital. The landscape is including the elevated Pyrenees mountain range along the French border, to several national parks in both the north and south. The Catalonian forests, which cover 60 percent of the land area, are characterized by pine species. Conifer represents about 40 percent of the total tree composition (Ministerio de Agricultura and Pesca, 2017).

Clearcutting is limited to areas smaller than one hectare. Most forests are privately owned, with public access often dependent on owner goodwill. Major forest products include timber and mushrooms; Spain ranks fourth globally in processed mushroom exports. Hunting is popular, with wild boars and rabbits as common game. Taxes and licenses generate some state revenue, and locals also gather berries and mushrooms recreationally.

2.3.2. Estonia

Forests cover 54 percent of Estonia's 45,339 km^2, contributing significantly to the national economy (NFI, 2022). Wood biomass supplies 32 percent of Estonia's primary energy (as of 2018), with the state as the largest forest owner, controlling nearly half of all forested land. About 28 percent is privately owned, and 20 percent is owned by companies. Estonia's wood product exports are nearly triple its imports, helping to balance foreign trade. In 2020, forestry employed around 31,000 people, mainly in rural areas (Forestry and wood industry, 2020, 2020). Hiking and hunting are popular among locals and tourists, with elk, wild boar, deer, and bears as common game. Hunting, regulated nationally, also helps limit forest damage from browsing pressure by herbivores (Estonian Environment Agency, 2022).

2.3.3. Grisons

Grisons is the largest canton[5] of Switzerland, covering 7105 km^2. It is located in the eastern parts of Switzerland and is diverse in terms of natural and cultural geography, as it encompasses both sides of the Alps as well as natural and cultural regions. The canton lies fully in the mountain area and elevations above sea level range from 260 to 4049 m. A third of the land area is covered with forests, mainly conifers (82 percent). Norway spruce is common at all altitudes, while European larch and Swiss stone pine are mainly found at higher altitudes. Most of the forest is owned by the public, and only about nine percent of the forest area is privately owned (Swiss Federal Statistical Office, 2021). The public right of access to the forest stated in the Swiss Civil Law Art. 699, and hiking, skiing, and other recreational activities are popular. Tourism is important for the Grisons economy (Kronthaler and Cartwright, 2008).

The protective function of the forests against natural hazards like avalanches, rockfall and landslides is, by the authorities, prioritized as the most important ecosystem service from the forests and about 60 percent of the forest area are specifically designated to provide these functions. Timber harvesting is difficult due to the topography and is subsidized for the sake of regenerating the protective function as the forests grow older (Swiss Forest Law Art. 20.5) (Bühler et al., 2022).

2.3.4. Hesse and Thuringia

Hesse and Thuringia are two federal states located in the central part of Germany. In this study, they are jointly considered as one CSR. Hesse holds the populous cities of Frankfurt am Main, Wiesbaden, Darmstadt, Offenbach, Hanau, Giessen, Wetzlar, and Rüsselsheim am Main in the southwest. The region has a forest coverage of 42 percent of the 21,115 km^2 land area. In Thuringia, the corresponding share is 34 percent of the 16,171 km^2. This is to be compared with the national German average of 33 percent (Third National Forest Inventory, 2022). The Hessian landscape is hilly but the topography is not extreme in comparison with mountain areas.

In Hesse, there are more broadleaves than conifers, while in Thuringia the conifers dominate. The Thuringian forests are dense, and a well known hiking trail, the Rennstieg, is located within. Most forest in Hesse are held by public forest owners, such as the federal state or local municipalities, while in Thuringia privately owned forests are more common. Several towns in Thuringia are popular winter resorts. Public right of access to the forests is statutory for temporary recreational activities in Germany regardless of type of ownership. Sawn wood is an important commodity, and the CSR is producing 5.16 million cubic meters of sawn wood. Residual biomass is used for energy production (Third National Forest Inventory, 2022).

2.3.5. EU influence

The EU has a long history of policies both indirect and directly affecting FES. The currently active policies affecting FES, divided into the five different subject areas chosen for this paper, are summarized below.

The European Green Deal is one of the most extensive policy packages affecting forestry on EU level. It includes a target for the union to become climate neutral, which means no net emissions by 2050, for which it uses a variety of policy instruments, soft and hard (EC, 2019). The Green Deal is closely connected to the bioeconomy strategy, which focuses on sustainable use of natural resources while harmonizing social, ecological, and economic values. The biodiversity strategy also affects FES directly with objectives especially targeting forests (EC, 2011). Within the EU biodiversity policy area, there are a number of different policy instruments at work, both soft and hard. Some examples are the Birds directive (hard), Habitats directive (hard), Natura 2000 network (hard by extension), Nature restoration (not yet mandatory as of 2024), and Green infrastructure (soft).

The policy most focused on FES on a European level is the forest strategy that sets out targets for bioenergy, climate change mitigation and adaptation, as well as sustainable forest management. The Forest strategy is attempting to integrate several objectives and international trade agreements (such as REDD+) to make a coherent forest policy framework and vision for the future of forests within the EU. The strategy was adopted at the same time as the data collection of this paper, and thus it is assumed to have had limited influence on the regional or national policies (EC, 2021). Connected to the forest strategy, the Commission has published a framework for market based instruments such as the possibility of using payment schemes for ecosystem services (EC, 2023).

The current European regulatory framework for energy is built on the EU's substantial "Fit For 55" package, which was initially aimed at aligning all climate and energy targets. The framework consists of a web of different policies aiming to promote energy provision and renewable

[5] administrative division

energy. Some examples are Governance and electricity interconnectivity (hard) (EU Regulation 2018/1999), Energy efficiency directive (hard), Governance and electricity interconnectivity regulation (hard),

Electricity market design (hard), Energy performance of buildings (soft), and Energy taxation Directive (hard). Under the current framework, member countries of the EU are obliged to integrate a 10-year plan for climate and energy (NECP) spanning from 2021 to 2030, combined with submitting progress reports continuously.

Policies which affect forests and forestry on a semi-indirect level are the Common Agricultural Policy, regulation of trade with logged wood (e.g. EUTR and FLEGT), regulations on production, protection of human health, packaging, and construction. All policies concerning climate are in some way referring to FES, including energy and emission trading packages and LULUCF (Elomina and Pülzl, 2021; Aggestam and Pülzl, 2018). Policies concerning the environment are affecting forests in both direct and indirect ways. EU regulations, like 7th Environment Action Programme, Natura 2000, and phytosanitary regulations (e.g., disease control), influence forest and forestry directly. It can be expected that regulating sulphur content of marine fuels and trans-boundary shipments will influence forests and forest industry through affecting transportation of forest products (Aggestam and Pülzl, 2018). This is also relevant for the trade defence and tariff policies.

3. Theory and method

3.1. Theoretical framework and data

Analyzing on what level different policy-areas are integrated with each other, how they are implemented, and in what way environmental issues are portrayed, provides useful insight into the relationship between different policy areas; how synergies are realized and how conflicts or trade-offs are being decided upon.This policy analysis study is based on a comparative approach to understand the similarities and the differences of FES related policies in four CSRs within three EU member and one non- EU member countries. Specifically, we target policies that are relevant for FES. Being able to shape future integration, priorities, and policy implementation is vital for upcoming policy making, since it ensures that policy goals are on target and minimizes the risk of policy failures.

We use the frameworks of policy integration (PI) and environmental policy integration (EPI) in order to see how different policy objectives in the four CSRs take FES into account. The goal of PI and EPI is to explore how policy objectives are integrated between different policy sectors (horizontal integration), and how these are implemented and whether they are coherent (vertical integration). To further explore the differences in vertical integration between the regions, we also apply the illustrative tool of the Doern continuum, which emphasizes the level of coercion used to implement policy. The analysis is limited to the policies specifically related to FES, and thus is based on documents that directly mention FES within the following sectors: biodiversity, bioeconomy, climate, energy, and forest. These policies are widely recognized as primary influences on FES, comparable with other policy studies on FES such as Beland Lindahl et al. (2023).

3.1.1. Policy integration and environmental policy integration

The PI framework, developed by Underdal (1980), evaluates how policy objectives align with comprehensiveness and consistency throughout the policy process. Comprehensiveness spans four dimensions: time, space, actors, and issues. Policies that account for long-term consequences (time) and diverse geographical areas (space) while integrating perspectives from varied actors and issues are deemed comprehensive. Even when conflicting objectives or interdependencies arise, policy can achieve integration by addressing these factors.

High PI signifies diverse perspectives and interdependencies in policy documents, which are identified by examining objectives for synergies, conflicts, or neutrality, together with perspectives addressing, e.g., challenges, risks, and justifications of policy. The PI framework is well recognized and developed, however not specifically considering environmental contexts in policy, dealing with the need for making trade-offs particularly relevant in policy targeting FES (e.g. Kleinschmit et al., 2017; Lafferty and Hovden, 2003; Lenschow, 2002; Söderberg, 2011).

The EPI framework recognizes the trade-offs between e.g., environmental and economic objectives in sectors dealing with natural resource management (Lafferty and Hovden, 2003; Lenschow, 2002). The aim is to understand the priorities and impacts on sustainability and how multifunctionality is addressed in policy (Sotirov et al., 2022; Winkel and Sotirov, 2016). EPI may be divided into strong or weak EPI, measuring how well environmental issues are integrated in policy objectives in comparison with economic issues. In a weak EPI, environmental issues are subordinate, while strong EPI refers to situations where environmental objectives are prioritized over economic objectives

(Jordan and Schout, 2006; Söderberg, 2011). To measure EPI, the prioritization of objectives and its justification of priority are analysed across policy sectors. The goals of the policies are divided into main-objectives and sub-objectives, retracting all hierarchical tendencies that are attached to the mentioning of FES.

To analyse PI and EPI, each of the policy sectors in which a connection to FES (biodiversity, bioeconomy, climate, energy, and forest) are evaluated and compared in order to understand integration of objectives and how well environmental objectives are prioritized. The analysis investigates integration between each of the policy sectors, however, specifically targeting the integration between forest policy in the other sectors.

The vertical integration analysis focuses on understanding how well policy is coherent (i.e. supporting objectives within and across policies), how conflicts are approached, and how synergies are promoted (Nilsson et al., 2012; Nilsson and Eckerberg, 2007; Nordbeck and Steurer, 2016). The vertical integration also takes into account in what way the policy is implemented; which policy instruments are being used to make sure that the policy is active in its intended way.

Policy coherence analysis may be performed by studying how policy objectives, instruments, and implementation interact (Nilsson et al., 2012). In this study, the focus is on the interaction between objectives and policy instruments used for implementation. We focus on this to understand the mechanism pushing for fulfilling the policy targets. The analysis does not include the actual outcome or the responsible actors. Coherence is measured, as Steurer (2013) outlined, into hard or soft regulations, i.e. with or without explicit sanctions. Additionally, interactions within and across levels are analysed to understand how well instruments are assisting others to achieve the same goal (synergy), or if instruments are competing causing conflicts (Nilsson et al., 2012). High levels of coherence point at synergetic policy objective where policy instruments interact within and across policy sectors, while low levels of coherence point at conflicting policy implementation.

3.1.2. The Doern continuum, instrument choice, and implications

The Doern continuum originates from Bruce Doerns' theory on long-term patterns of government preferences. Doern aimed at creating understanding on the policy processes within the state and how ideas, interests and institutions interact to form new public policy (Doern and Phidd, 1983a). The policy tools or instruments that governments use to achieve goals are dynamically linked to characteristics of the policy area regulated (Bali et al., 2021). The choice of instrument used can be described as moving along a continuum of policy instruments that range from a low to high level of coercion. See Fig. 1 for an illustration of implications from movements across the Doern continuum.

On the left hand side of the continuum, minimal governmental coercion is used to implement policy, using soft instruments like public education on the issue or voluntary agreements or endorsements. If this type of policy is not complied with by the targeted actors, there are no

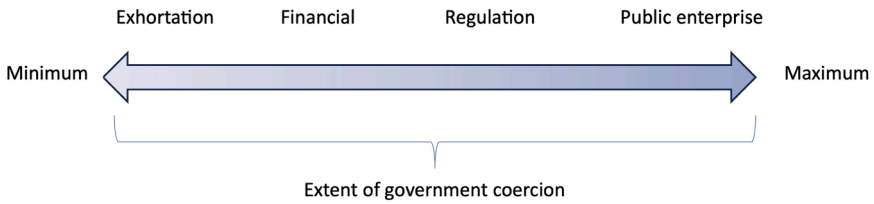

Fig. 1. The Doern continuum. Source: Adopted from Doern and Phidd (1983a).

firm consequences imposed by the government. On the opposite side of the continuum, the government uses maximal coercion to enforce the policy and create a business organization entirely or partly owned by the state to control the sector completely through public authority. Between these extreme points are intermediate levels of governmental coercion where the measures such as financial and regulatory measures are being used to implement policy. This can be in terms of licences, permits, or legislative regulation that would imply a sanction if not complied with.

Doern identified patterns in the decision makers tendency to choose high or low coercion in order to achieve their political goals. Governments often "move up" the continuum (moving from left to right in Fig. 1) using instruments with more coercion over time, as pressure increases to reach the goals and overcome opposition (Bali et al., 2021). If a particular policy sector in a governmental context can be identified to be somewhere along the Doern continuum, then conclusions can be drawn concerning the urgency and future possible level of governmental coercion. e.g. for a policy sector gaining more urgency, it is possible to move further right on the continuum only if there is still capacity to do so.

3.2. Data

This comparative study uses policy documents as its primary data. The policy sectors chosen for analysis are biodiversity, bioeconomy, climate change (both adaption and mitigation), energy, and forest policies. These policy areas were selected on the basis of being present in all regions, enabling comparability.

Cultural FES services, such as recreation and scenery, were excluded due to inconsistent regional policy coverage.

A total of 34 policy documents are included in the analysis. The documents are collected by locally knowledgeable researchers in the regions during late autumn of the year 2021. The policy documents, two to five per policy sector, met all of our conditioning requirements: 1) addresses important policy area for delivering FES; 2) are the most recent available; and 3) having a level of authority (e.g., law, bill, strategy adopted by government). Keywords guided the selection process, ensuring relevance. Local researchers, familiar with regional conditions and international FES definitions, translated keywords and selected relevant documents, which they analyzed using a standardized set of questions on goals, synergies, conflicts, and FES prioritization. Appendix B provides further detail on document structure. Policy documents were originally collected in national languages and translated into English, with quotes provided in English and the original text as footnotes. Appendix A lists the included documents.

The researchers answers on the standardized questions, strengthened with quotes from the policy documents, constituted the base on which we assessed PI and EPI. Using the same questions for all regions, and through extensive dialogue making sure that the questions are understood in the same manner, the input were deemed reliant and comparable throughout all of the CSR.

The policy documents collected are applicable either on national level, or on regional level (in the case of Catalonia (ES), Grisons (CH) and Hesse and Thuringia (DE)). The results of the report are derived using very little distinction between regional and national policy, although as Tables 2 and 3 states, the documents have mixed levels of authority. Table 2 summarizes the number of national and regional policy documents included in the analysis.

Table 2
Number of policy documents analysed, divided into case study regions.

Regions	Laws	Strategy/other	Total
Catalonia (ES)	- (4)	- (4)	- (8)
Estonia	1 (-)	3 (-)	4 (-)
Grisons (CH)	3 (1)	6 (1)	9 (2)
Hesse and Thuringia (DE)	4 (2)	5 (-)	9 (2)

Note: Number of policies on regional level are presented in parenthesis.

Table 3
Number of policy documents analysed, divided into subject areas.

Policy sectors	Laws	Strategy/other	Total
Biodiversity	2 (3)	5 (2)	7 (5)
Bioeconomy	2 (-)	4 (2)	6 (2)
Climate change	4 (1)	6 (-)	10 (1)
Energy	1 (-)	3 (1)	4 (1)
Forestry	2 (1)	9 (1)	13 (2)

Note: Number of policies on national level are presented in parenthesis. Some of the analyzed documents may belong to several policy sectors

The number of strategies referencing to FES is higher than the number of laws in most of the CSRs. The number of policy documents in the forest policy sector are highest, followed by biodiversity and climate change/bioeconomy. See Table 3. For the regions of Catalonia (ES), Grisons (CH) and Hesse and Thuringia (DE), there is a mix of policy documents applicable on national level, and regional policy in the specific region. Table 3 further illustrates that the analysed documents are mainly national (regional policies provided in parenthesis in Table 3).

The policy documents in each CSR were collected in the respective national languages and were subsequently translated into English. Quotes from policy documents presented in this study are presented in English, with the original national language text being presented in adjoining footnotes. The full list of policy documents included from the CSRs can be found in Appendix A.

4. Results

4.1. Horizontal integration

The main goals of the policy areas of bioeconomy, biodiversity, climate, energy, and forest in the analysed CSRs are all connected to the development of FES, however formulated differently, as illustrated in Table 4.

Developing strategies for sustainable forest management, while recognizing potential conflicts between FES priorities, is crucial in all regions. Although the recommended sustainable management practices vary by region, a common conflict highlighted in policy documents involves balancing the demand for increased biomass production with the need to conserve more forested areas for biodiversity and environmental protection (e.g., groundwater preservation).

In Estonia, biodiversity policies focus on protecting forests to support diverse ecosystems. In Grisons (CH), the emphasis is on enhancing biodiversity through well-structured, low-density forests, designated

Table 4
Summarized main goals related to FES in each region per subject area.

Main goals	Catalonia	Estonia	Grisons	Hesse and Thuringia
Biodiversity	Regulate forest management to be more sustainable	Protection, productivity and adapting to climate change	Promotion of biodiversity	Sustainable management
Bioeconomy	Connect growth with preserving environment	Adapting to climate change and preserve environment	Safeguard multiple interests in the forests	Connect growth with preserving environment
Climate change	Decrease greenhouse gas emissions	Decreasing greenhouse gas emissions and adapting to climate change	Decrease greenhouse gas emissions	Use forests for climate change mitigation and adaptation
Energy	Promote use of bio-energy	Adapting to climate change	Increase use of biomass and mitigate climate change	Sustainable production of biomass and mitigation of climate change
Forest	Regulate forest management balancing economic values and preservation	Regulate forest management balancing economic values and preservation	Safeguard multiple interests in forests	Enforce silviculture management balancing FES

reserves, old-growth areas, and increased deadwood. Catalonia (ES) and Hesse and Thuringia (DE) target forest management practices that explicitly encourage biodiversity.

The primary objective within energy-related policies is to support biomass production capacity while prioritizing sustainable practices. In all regions, energy policy strongly connects the use of biomass with climate change mitigation. Bioeconomy policies vary most widely in their goals, as shown in Table 4, but generally focus on promoting growth with respect for the environment.

The main goals of the forest-related policies are focused on creating sustainable forest management. The definition of sustainability in this context is not clearly defined in all of these documents. It is, however, clear that the views on what sustainability entails vary between regions.

Lastly, in climate change-related policies, the main target is to adapt both society and forests to changing climatic circumstances while trying to mitigate climate changes. In the Hessian & Thuringian (DE) policies, reaching the targets set by the EU are explicitly mentioned, but the EU targets may also have indirectly influenced the other EU member regions' policies.

To summarize this section of policy integration, i.e. how well the policy documents are acknowledging each other's objectives, or horizontal policy integration, and specifically how well FES are integrated in the different policy sectors, the results show that there is a high level of policy integration in each of the analysed CSRs.

4.1.1. *EU influence*

Both the subject areas of biodiversity and energy on the EU level have, through amendments and revisions, developed into using more coercive instruments than when first launched. Some examples are: the Revised Energy Performance of Buildings (Directive (EU) 2018/844), the Energy Efficiency Directive (EU/2023/1791), the Habitats Directive (Council Directive 92/43/EEC), and the Birds Directive (Directive 79/409/EEC). Another aspect that biodiversity and energy have in common is that they have a longer history of being on EU agenda than the other three subject areas chosen for this paper, namely forest policy, climate, and bioeconomy. The extent of coercion used currently to regulate FES in the EU varies, see Fig. 2.

Parallell to these policies, as a base for all EU policy, the principle of subsidiarity states that the desirable level of policy decisions is as close to the European citizens as possible, while still being expedient. As explained in EUR-Lex (European Union, 2016):

Specifically, it is the principle whereby the EU does not take action (except in the areas that fall within its exclusive jurisdiction), unless it is more effective than action taken at the national, regional or local level."

Policy areas historically being developed on a local level should therefore need to be deemed inefficient before being brought up to EU level.

4.1.2. *Policy coherence, integration between subject areas*

Biodiversity policy. The value of biodiversity is well incorporated in regulations concerning forest management in all CSRs and frequently stated in other areas. In the policy documents relating to biodiversity, protection and conservation is in focus in the laws, while sustainable forest management is more of a focus in the strategy documents. In the subgoals of the biodiversity documents, there is attention devoted to the multifunctional value of forests where several FES are referred to. In the German National Conservation Act, it is explained that:

"[d]ue to their intrinsic value and as the basis for human life and health, nature and the landscape must be protected in such a way, also in responsibility for future generations […], that 1. biological diversity, 2. the performance and functional capacity of the ecosystems, including the regenerative capacity and sustainable usability of the natural assets, as well as, 3. the diversity, character and beauty as well as the recreational value of nature and the landscape are safeguarded in the long term" (Federal Forest Act, 1975) § 1.[6]

However, there is a large variety of challenges that the biodiversity-related documents are aiming to solve. Some examples are harmonizing the different dimensions of sustainability (economic, ecological, and social) in Grisons (CH), exceeding renewal capability of the forests in Estonia and a facing a decrease in biodiversity in Catalonia (ES). This is indicative of the dissimilar starting points of both biogeography and politics in the regions studied. Although, policymakers from all regions mention a synergy between biodiversity and climate change mitigation. In Grisons (CH) for example, policy states that:

"The adaptation strategy aims to integrate the adaptation to climate change into the various sectoral policies and to coordinate activities (…) In forestry, adaptation to climate change is integrated into the forest law. In addition, it is part of the implemenatation work on the forest and climate change research program" (The Federal Council, 2020).[7] The main conflict between FES that is mentioned in the biodiversity policies is combining economic values with protecting more forest area. The policies have in general made measures mandatory; however few sanctions are in place if the measures are not met.

Bioeconomy. For Hesse and Thuringia (DE), a national bioeconomy strategy is in place, and Catalonia (ES) has specific strategies addressing

[6] "Natur und Landschaft sind auf Grund ihres eigenen Wertes und als Grundlage für Leben und Gesundheit des Menschen auch in Verantwortung für die künftigen Generationen (…) so zu schützen, dass 1. die biologische Vielfalt, 2. die Leistungs- und Funktionsfähigkeit des Naturhaushaltes einschließlich der Regenerationsfähigkeit und nachhaltigen Nutzungsfähigkeit der Naturgüter sowie, 3. die Vielfalt, Eigenart, und Schönheit sowie der Erholungswert von Natur und Landschaft auf Dauer gesichert sind." (§ 1 BNatSchG)

[7] "Die Anpassungsstrategie hat zum Ziel, die Anpassung an den Klimawandel in die verschiedenen Sektorpolitiken zu integrieren und die Aktivitäten zu koordinieren. […] In der Waldwirtschaft ist die Anpassung an den Klimawandel integriert in das Waldgesetz. Zudem ist sie Teil der Umsetzungsarbeiten zum Forschungsprogramm."

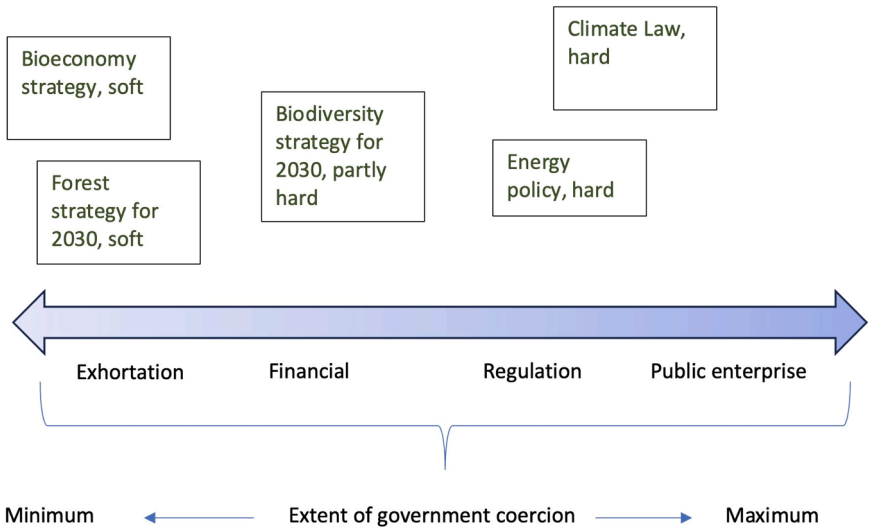

Fig. 2. Level of EU coercion in the policy subject areas.

bioeconomy. These are focused on connecting the values of nature with the overall economy, promoting economic growth in a way that does not deprive the environment on general and forests in particular. In Catalonia (ES), the strategy aims to promote the technological transformation of biomass resources of forestry, agricultural, livestock and fisheries origin into bioproducts, biomaterials and bioenergy through the use of renewable and local biomass, the reduction of waste generation in the supply chain and of the change in consumption patterns (demand and use of bioproducts)" (Catalan Government, 2020) p.2.[8]

A secondary focus in Hessian and Thuringian (DE), as well as in Catalonian (ES) bioeconomy policies is innovation. Research and knowledge sharing is pointed out to have intrinsic value on how to achieve the bioeconomy goals. Estonia and Grisons (CH) have policies that only address bioeconomy indirectly (Switzerland has a bioeconomy strategy not yet implemented when this analysis was conducted), mainly focusing on either forestry, climate change or timber production. In these documents, bioeconomy is referred to as an end goal of increasing productivity in forests while preserving the natural forest ecosystems. The Estonian Climate change adaption development plan states that:

"[…] in order to ensure the preservation of use of timber and the quality of timber and to thereby increase carbon sequestration"[9] (Kliimaministeerium, 2017) p.20.

Productivity in the forests is defined in this document in terms of timber production. Climate change is being targeted as the biggest challenge in these policies. Again, the synergy between climate change mitigation and biodiversity is referred to in policies in most regions. At the same time, Catalonia (ES) describes, in their bioeconomy strategy, biomass production and conservation of biodiversity as an example of a potential conflict between FES.

Climate change policy. The overall challenge identified by climate change-related policy documents is its negative impact on society and the environment. In the Catalan (ES) Law of Climate Change it is clearly stated that:

"[g]lobal warming is not only an environmental problem; it affects to biodiversity, economy model, mobility, trade, food security, access to water and to natural resources, infrastructures and health"[10] (Parlament de Catalunya, 2017) p.12.

The climate change-related policies are mandatory to fulfil, with sanctions for the targeted stakeholders that do not meet the stated requirements. In all regions analysed, there seems to be a priority on collaboration between different stakeholders to get the best results and impacts from the policy aims. Climate change-related policies are well integrated with biodiversity in all regions. For instance, there are synergies mentioned between biodiversity and both climate change mitigation as well as climate change adaptation. One of the objectives in the Catalan (ES) climate law makes it clear to prioritize conservation:

"[t]he conservation of biodiversity and the improvement of the vitality of forest ecosystems, their ability to adapt to available water resources and their regulatory function of the hydrological cycle and protection against erosion and other adverse effects of heavy rains"[11] (Parlament de Catalunya, 2017) Art. 2, p.5.

Grisons (CH) which is governed by the highest number of climate related policies compared to the other regions, is explicit on the synergy between timber production and carbon sequestration. A federal climate law from 2011 states that:

"[t]he effect of the sinks in construction wood can be credited"[12] (The Federal Assembly of the Swiss Confederation, 2011) Chapter 3, Art. 14.

This is mentioned in documents from the other regions as well. A prioritized FES in terms of climate adaptation for mountain regions in Switzerland is the forests protective function against avalanches and other gravitational hazards. This seems to be a unique feature from Grisons (CH) in the compared regions, although Catalonia (ES) mentions a similar local FES in terms of forests helping with erosion control and being a hydro-regulator. Water system vitality is an important goal for Grisons (CH), Estonia and Catalonia (ES) in the policy documents relating to climate change. The analysed documents for Estonia and Hesse and Thuringia (DE) mention no conflicts.

Energy. In the area of energy-related policies, there are more

[8] "Promoure la transformacío tecnol`ogica de recursos de biomassa d'origen forestal, agr´ıcola, ramader i pesquer en bioproductes, biomaterials i bioenergia a través de l'aprofitament de biomassa renovable i local, de la reducció de la generació de residus en la cadena de subministrament i del canvi en els patrons de consum (demanda i ús de bioproductes)."

[9] "[…], et tagada puidukasutuse säilimine ja puidu kvaliteet ning suurendada sel teel süsiniku sidumist."

[10] "L'escalfament global no és només un problema ambiental; afecta la biodiversitat, el model econo`mic, la mobilitat, el comer¸c, la seguretat alimenta`ria, l'accés a l'aigua i als recursos naturals, les infraestructures i la salut."

[11] "La conservació de la biodiversitat i el millorament de la vitalitat dels ecosistemes forestals, llur capacitat d'adaptació´ als recursos h´ıdrics disponibles i llur funció´ reguladora del cicle hidrolo`gic i de protecció´ contra l'erosió´ i altres efectes adversos de les pluges intenses."

[12] "Die Leistung der Senken von verbautem Holz ist anrechenbar"

strategy documents rather than laws referring to FES from the regions. FES in the focus of energy is biomass production. One of the main goals of the Estonian Forestry Development Plan concludes that:

"The use of wood as a renewable raw material and a renewable energy resource is favoured instead of products and non-renewable energy sources with larger CO2 emissions."[13](Ministry of the Environment, 2011) p.21.

Hesse and Thuringia (DE) policies state that biomass is the preferred source of fuel for electricity production. However, there are conflicts between biodiversity and biomass production which are acknowledged in energy-related policies. Furthermore, in the case of energy-related policies, the regions address different challenges regarding trade-offs. Catalonia (ES) concludes that a local challenge is that the current power plants fuelled with biomass are not economically feasible, while Grisons (CH) addresses the issue of climate change as one of the main challenges.

Forest. The policy area with the largest number of policies relating to FES is forest policy. Out of 34 documents analysed, 13 belong to this category with main focus on forest management. Catalonia (ES) mentions hydro-regulation as the overall challenge to which the policies are responding, Grisons (CH) puts emphasis on maintaining multifunctionality (protective, economic, and social functions), while Hesse and Thuringia (DE) and Estonia mention climate change as the chief problem for forest management policies to combat and adjust to. In the subgoals, some of the current challenges of forestry are crystallized. There are trade-offs between different societal demands of forests that these documents acknowledge and, in some cases, tries to solve. The economic performance of forestry is to improve in parallel with ensuring high quality of soil, drinking water, and vitality of trees together with wildlife. Additionally, recreational use should be safeguarded. The policy documents initiate action by setting the scene, defining used vocabulary, and clarifying e.g., what sustainable management means. From here, the policy documents form a support system for forest owners in terms of economic subsidies and help with making management plans that balance the different desirable FES. An example is a Swiss Enforcement Aid:

"[the document] concretizes undefined legal terms of laws and regulations and is intended to promote uniform enforcement practice."[14] (Federal Office for the Environment, 2005) p.2.

4.1.3. Acknowledgement of synergies and conflicts

Conflicts. As stated in 4.1 and 4.3, there are many similarities in the main goals of the subject areas from different regions and the policies are also rich in cross-references to each other. However, the conflicts brought forward by each CSR are different, as Table 5 illustrates.

Acknowledging conflicts is a vital part in making sure that, while trying to solve one societal issue, the policy should not be a part of creating other issues. Conflicting policy sectors are found in each of the CSRs and a common conflict between FES is found between timber production and biodiversity, identified by all four CSRs. However, conflicts are not only between forest policy and biodiversity-related policies, but also between socioeconomic functions, i.e., cultural FES and forest-, biodiversity-, energy- and bioeconomy-related policies. Estonia particularly mentions conflicts between clearcut as a felling method and sensitive areas for hazard protection (e.g. erosion and ground water regulation), while Catalonia (ES) identifies the same conflicts, however for different reasons. In Catalonia (ES), there are tensions between private land and public land use in protecting forest land from urban exploitation. Grisons (CH) mentions tourism as a problematic conflict area.

Table 5
Main FES conflicts in the regions by subject area.

Main FES conflicts	Catalonia	Estonia	Grisons	Hesse and Thuringia
Biodiversity	Forest protection and economic values	Forest protection and economic values	Forest protection and economic values	Forest protection and economic values
Bioeconomy	Biodiversity and biomass production	Nature protection and economic values	Biodiversity and timber production	no conflicts mentioned*
Climate change	No conflicts mentioned*	No conflicts mentioned*	Timber production and forest protection	No conflicts mentioned*
Energy	Biodiversity and biomass production	Nature protection and economic values	Biodiversity and biomass production	Biodiversity and biomass production
Forest	Socioeconomic values and forest preservation	Timber production and recreational activities	Protection function, timber production and biodiversity	Biodiversity and timber provisioning

* (…in the analysed documents.)

Synergies. Common synergies in policy are found between forest management and climate change mitigation, but also on adaptation and how to increase the resilience of forests connected to forest damages (e.g. fire, storm, pests, and insect damages). In consequence, the adaptation to climate change concerns how to boost the supportive and the regulative ecosystem services. In Estonia, policy focus, in terms of synergies, is on growing forest for climate change mitigation, genetic variation, and protection against damages, targeting the provision of timber production. The Estonian climate policy for instance states that:

"[t]he goal of the Environmental strategy 2030 is to establish long-term development directions in order to maintain the good condition of the environment. Meanwhile taking the connections of environment to economy and social sector into consideration and their influence on environment and people" [15] (Kliimaministeerium, 2005) p.3.

In Hesse and Thuringia (DE), policy is targeting synergies between biodiversity and climate change adaption and climate change mitigation. In policy applicable in Hesse and Thuringia (DE), the goal is to develop synergies between nature conservation and climate protection:

"a natural climate protection action program to create synergies between nature conservation and climate protection and strengthen with nature restoration measures the resilience of our ecosystems, especially peatlands, forests […]"[16] (Alliance for Freedom, Justice and Sustainability, 2021) p.38.

However, this policy is not mandatory on a federal level. The perspectives of Catalonia (ES) and Grisons (CH) are similar, identifying synergies between forest management and climate change mitigation, and identifying functions of forests for protection against hazards (e.g. erosion, avalanches, landslides as well as fire prevention). Federal forest law in Grisons (CH) states that:

[13] "Puidu kui taastuva tooraine ja taastuvenergia allika kasutamine on eelistatud suurema CO2 emissiooniga toodete ning taastumatute energiaallikate asemel."

[14] "[Diese Publikation] konkretisiert unbestimmte Rechtsbegriffe von Gesetzen und Verordnungen und soll eine einheitliche Vollzugspraxis fördern."

[15] "Eesti keskkonnastrateegia aastani 2030 eesmärgiks on määratleda pikaajalised arengusuunad looduskeskkonna hea seisundi hoidmiseks, lähtudes samas keskkonna valdkonna seostest majandus- ja sotsiaalvaldkonnaga ning nende mõjudest ümbritsevale looduskeskkonnale ja inimesele"

[16] "natürlicher Klimaschutz, mit dem wir Synergien zwischen Natur- und Klimaschutz schaffen und stärken mitRenaturierungsmaßnahmen die Resilienz unserer Okosysteme, insbesondere Moore, Wälder […]"

"[p]rotection from natural hazards. Where the protection of people or significant property requires it, the cantons secure the avalanche, landslide, erosion and rockfall areas and ensure the protection of streams via forestry."[17]; (Bundesgesetz uber den Wald (Waldgesetz WaG), 1991, Chapter 3, Art.19).

4.2. Integration of environmental issues

In connection with how well the policies in the CSRs are prioritizing environmental aspect, environmental policy integration (EPI) helps reveal policy integration. The PI analysis shows that even though biodiversity and climate change are common challenges for each of the CSRs, environmental priorities are not necessarily high. For each of the CSRs, biodiversity is showing high EPI together with climate change policies, Grisons being the exception (only showing strong EPI in biodiversity policy). However, forest-, energy-, and bioeconomy-related policies show weak EPI. Common for the CSRs are that environmental targets are typically mentioned as a subordinate goal, or subgoal.

In Catalonia (ES), for instance:

"[…] the elements of multifunctionality of forest lands in their aspects of production of environmental and socio- cultural goods and services […], guarantee the production of raw materials and make adequate use of renewable natural resources."[18] (Ministry for the Ecological Transition and the Demographic Challenge, 2013) p. 3, art. 4.

Concluding the horizontal policy integration analysis, a high level of policy integration is found in general in the four CSRs, however it is only biodiversity- and climate-related policies that show a relatively strong or strong environmental policy integration. All CSRs recognize the benefit of forests in climate change mitigation. Catalonia (ES), Hesse and Thuringia (DE), and Grisons (CH) policies acknowledge competing objectives, where multiple use of forests are recognized and synergies and trade-offs between forest FES are realized in sustainable forest management, however not prioritizing environmental policy objectives. Estonian policies are characterized by a sectoral objective, where timber production is highly prioritized, giving less priority to other FES, climate change mitigation as an exemption.

4.3. Vertical integration

To understand policy implementation and policy coherence, the vertical policy integration includes comparing policy instruments as well as policy coherence. In the comparisons of the policy sectors, the analysis must consider the historical development of the policy areas. Biodiversity-related and forest policies have been in place for a long period, while bioeconomy, energy (particularly bioenergy) and climate-related policies are more recent, affecting the policy instruments' development and implementation.

The ownership structure is also a factor affecting the instruments and coercion needed. A high share of public owned forest would decrease the need for far-reaching coercion, since policy could be implemented directly. However, in the CSR where this study is conducted, the share of state owned forests are not at such a high level to which this can be discarded.

As Table 6 illustrates, all CSRs are using a combination of policy instruments, hard and soft policy. The CSRs have in common that compliance to forest law is followed by sanctions or a fine, i.e. hard policy instruments, combined with soft policy of strategies. Catalonia (ES) and Grisons (CH) both show examples of hard policy instruments in relation to climate policy, where Catalonia (ES) has set up a financial fund for climate change mitigation measures, and Grisons (CH) has sanctions for those who exceed individual emission targets.

To summarize the policy integration analysis on the vertical level, policy coherence (measured in high or low), displays conflicts and synergies across policy objectives (as analysed in PI and EPI), together with policy implementation. The results indicate that there is, in general, high level of policy coherence across forest and climate policies in all CSRs, illustrated by the synergies of sustainable forest management and climate change mitigation. Moreover, there are also the acknowledged conflicts between biodiversity and forest as well as climate-related policies, thus high PI in combination with hard policy instruments. Consequently, low policy coherence is found between bioeconomy, energy, and biodiversity-related policies. Few hard policy instruments are also found within these policy sectors.

5. Discussion

This policy integration analysis does not assess whether policies succeed or fail but shows how well they align on objectives, synergies, and conflicts. The results of this study can be utilized to a) understand policy and how well it is integrated in each case, b) potentially increase the integration of policies related to FES. Especially those policies that are not well integrated targeting FES, thus bioeconomy-, energy-, and forest and their relationship with biodiversity-, and climate policies and c) to reflect on the current level of policy-initiative and coercion in light of the principle of subsidiarity.

The results indicate that the already active national and regional policies (as per 2021) governing FES across Europe are to a great extent specific in policy formulation targeting the issues of the region-specific forests. This heterogeneity emphasizes earlier research on the subject, e.g. (Sotirov and Storch, 2018). Analyzing EPI, where integration of environmental issues into policy are evaluated, biodiversity policy, as expected, has high EPI. Additionally, climate change policies show relatively high to high EPI for all regions. Environmental questions are not mentioned as frequently in most regions within the policy areas of bioeconomy- and energy-related policies, while in forest-related policies, most regions mention that economic, environmental, and social goals of FES are equally important. This may be a sign of the geopolitical context, in which forest policy has a clearer role in solving stakeholder conflicts in direct forest governance. As three out of the four analysed regions are EU members, EU policies related to FES are explicitly referred to within their national policies, but also likely indirectly influencing policy in all regions. The current level of supranational coercion on EU-level is low but increasing. On a transnational level, EU policies related to forests and FES are in place within all the chosen policy sectors. The EU policies are of overarching type and provides framing for local policies, leaving detailed regulations for national policy in most cases. This is exemplified by the more recent pushes for market based instruments such as payments for ecosystem services. The intention of the EU policy framework is thus to provide direction for e.g. climate change mitigation, bioeconomy development, and natural resource management within the union.

The development of forest related EU-policy being more coercive in their implementation, thus moving "up" on the Doern continuum leaves less space to further increase coercion. This is especially true for policy that has been present on EU level for longer, like the policy subject areas of climate and energy. Indicating a positive correlation with time and level of coercion. The FES-related policy also shows a high environmental policy integration in the areas of Biodiversity and Climate, which are also areas where EU-policy is implemented with more coercive instruments. An exception is the Energy-related policies, which exhibit lower prioritization of environmental issues in the stated main- and sub-objectives. A possible explanation for this may be that this is an inclination of the different regional view-points on bio-energy. The

[17] "Schutz vor Naturereignissen. Wo es der Schutz von Menschen oder erheblichen Sachwerten erfordert, sichern die Kantone die Lawinen-, Rutsch-, Erosions- und Steinschlaggebiete und sorgen für den forstlichen Bachverbau."

[18] "[…] els elements de multifuncionalitat dels terrenys forestals en les seves vessants de produccio´ de be`ns i serveis ambientals i socioculturals, […], garantir la produccio de mat`eries primeres i aprofitar adequadament els recursos naturals renovables."

Table 6
Vertical policy integration and governmental coercion in the regions.

	Catalonia (ES)	Estonia	Grisons (CH)	Hesse and Thuringia (DE)
Policy instruments **Hard/Soft**	Combination of **H/S** instruments **Hard** in FO,CC,BIO Sanctions, Financial mechanism **Soft** in EN, BEC Strategies	Combination of **H/S** instruments **Hard** in FO,EN,BIO Sanctions, Licences **Soft** in BEC, CC License, subsidy without sanctions	Combination of **H/S** instruments **Hard** in FO Sanction **Soft** in EN, BEC, BIO, CC Obligations but no sanctions	Combination of **H/S** instruments **Hard** in FO Sanctions, Fines, Monitoring and enforcement systems **Soft** in CC, EN, BIO Obligations with controls
Policy coherence **High/Low**	**High** across FO/CC/BIO **Low** across EN/BEC	**High** across FO/CC **Low** across EN/BEC/BIO	**High** across & BIO/EN CC/FO **Low** across BIO/EN	**High** across FO/CC **Low** across BIO/EN

Note: BIO=Biodiversity, BEC=Bioeconomy, CC=Climate, EN=Energy, FO=Forest

differences in whether using biomass as a source for energy is viewed as environmental friendly or not has historically made the EU-policies on the subject reluctant to incorporate environmental objectives.

Policy developing into using more coercive implementation is however not a mandatory path, but decided upon by publicly elected policymakers. The policy areas of forestry and bioeconomy for example, which do not have as long history on EU-level as energy policy, are not necessarily determined to be implemented using more coercion from the EU.

Based on the 34 policy documents included in the analysis, the results indicate that, even though the analysed regions have different forest types, hence the regions are typically characterized by different challenges and prerequisites, their priorities are rather similar. All regions are characterized by integrated forest management; thus, all four groups of FES[19] are integrated and included in policy formulation. Furthermore, the regions, regardless of being a member of EU or not, acknowledge climate change and climate change mitigation as a major challenge. This focus could be a reflection of their respective memberships in the United Nations (UN) and the UN priority of sustainable development in which climate is an overarching denoted challenge. All regions highlight strong synergies between forests and climate change mitigation, though with varied effects on FES. Catalonia (ES) and Grisons (CH) stress forests' role in mitigating hazards like erosion and fires, while Hesse and Thuringia (DE) focus on biodiversity and recreation alongside climate benefits. Estonia emphasizes forest growth for carbon storage, genetic diversity, and resilience against fires, storms, pests, and insects. This analysis shows high policy integration, indicating that policies recognize synergies and conflicts across FES and frequently cross-reference each other.

Following high levels of policy integration in the coherence of policy, illustrating how well synergies are promoted and conflicts solved, both biodiversity- and climate policy show high levels of coherence in all regions, while bioeconomy, biodiversity, energy, and forest are not as highly integrated, risking to neglect potential synergies or increasing conflicts over FES.

5.1. Limitations

Basing the study on the four case study regions of Estonia, Catalonia, Hesse & Thuringia, and Grisons is a somewhat arbitrary choice. There are several other possible combinations of regions that would similarly showcase the diversity of European forests and institutional settings of governance. Choosing other case study areas would potentially manifest different results. However, the conclusion of the diversity of FES present demands a diversity of governing policy would not be overthrown until proving that all regions are in fact very similar in the aspects that policy is based upon.

An option, and remedy to above mentioned limitation, would have been to include all regions of Europe, an endeavor too comprehensive for this study.

A limitation of a different kind is embedded in the method of having several local experts reading and interpreting the policy documents in the different regions. Native speaking researchers knowledgeable in forest and forest related issues were trusted to choose, read and interpret the policy documents based on the same list of criteria for all regions. When including documents written, not only in different languages but also cultural and institutional contexts, there is a risk of biases that are hard to discover and account for. This has been improved by choosing experts with good knowledge of the inherent differences amongst European forests and definition of forest ecosystem services. But also communicating clearly about the method and aim of the study, picking up potential biases already in the process of collecting documents.

6. Conclusion

This study aims to highlight how FES-regulating policies vary across geographic and institutional contexts in their approach to biodiversity, bioeconomy, climate, energy, and forest policies. Using frameworks for policy integration, the Doern continuum, and environmental policy integration, we analyze both horizontal and vertical integration.

The priorities, visible in the goals and subgoals of the policies, are similar in the regions. This could be a possible effect of EU and UN influence. A notion which is also illustrated by the fact that, according to our analysis, the high environmental integration in all regions and several policy sectors, is similar to the way the environmental awareness has been high in most FES related EU-policies to date.

Even though the policies recognize the same objectives, the design and formulation of the policies active in the CSRs vary greatly. The variation in policy design is a good representation of the geographical and governing differences that are present in the regions. The results of this study suggests that in light of the subsidiarity principle, the level of decision-making (as of 2021 when data was collected) in the chosen policy areas was efficient when evaluated on coherence and coordination. Moving further towards using policy instruments containing more coercion also diminishes the toolbox for future policy changes.

Recognizing conflicts and addressing low coherence among policy sectors that manage different FES, while fostering local-level synergies, would strengthen future policy development based on our findings.

CRediT authorship contribution statement

Widmark Camilla: Writing – review & editing, Supervision, Methodology, Funding acquisition, Formal analysis. **Hertegård Ester:** Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Formal analysis, Conceptualization.

[19] groups of FES in accordance with MEA-definition: supporting, provisioning, regulating and cultural

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: None

Appendix A. List of Policy documents

Policies Estonia:

- Forest Act (Metsaseadus)
- Forestry Development Plan 2011–2020 (Metsanduse Arengukava 2011–2020)
- Climate Change Adaptation Development Plan until 2030 (Kliimamuutustega kohanemise arengukava aastani 2030)
- Estonian Environmental strategy 2030 (Eesti Keskkonnastrateegia aastani 2030)

Policies Catalonia:

- Forestry Law of Catalonia (last modified 2015) original from 1988 (Ley 6/1988, de 30 de marzo, Forestal de Cataluña. Reference: BOE-A-1988–10913)
- Regulation on forest management plans (ORDRE AAM/246/2013, de 14 d'octubre, per la
- qual es regulen els instruments d'ordenació forestal.)
- Decree 328/1992, of 14 December, approving the Natural Interest Plan (Decret 328/1992, de 14 de desembre, pel qual s'aprova el Pla d'interès natural)
- Strategy of natural heritage and biobiversity in Catalonia (Estratègia del patrimoni natural i biodiversitat catalana)
- Catalan Strategy to promote forest and agrarian biomass energy use (2021–27)(Estratègia per promoure l'aprofitament energètic de la biomassa forestal i agrícola (2021–2017))
- Law 16/2017, 1st August of Climate Change (Llei 16/2017, de l'1 d'agost del canvi climatic)
- Strategy to promote green and circular economy (ACORD GOV/73/2015, de 26 de maig, pel qual s'aprova l'Estratègia d'impuls a l'economia verda i a l'economia circular.)
- Bioeconomy strategy of Catalonia (2021–2030)(Acord de Govern GOV/23/2020, es van aprovar els objectius i el contingut de l'Estratègia de la Bioeconomia de Catalunya 2021–2030)

Policies Hesse and Thuringia:

- Daring to make more progress - coalition treaty 2021–2025 between Social Democrats (SPD), Green Party (Bündnis 90/Die Grünen) and Free Democratic Party (FDP) (Mehr Fortschritt wagen. Bündnis für Freiheit, Gerechtigkeit und Nachhaltigkeit. Koalitionsvertrag 2021–2025 zwischen SPD, Bündnis 90/Die Grünen und FDP)
- Law on the Conservation of Forests and the Promotion of Forestry (National Forest Act) (Gesetz zur Erhaltung des Waldes und zur Förderung der Forstwirtschaft (Bundeswaldgesetz))
- Forest Strategy 2050 (Waldstrategie 2050)
- Act on the Conservation, Protection and Management of Forests and the Promotion of Forestry (Gesetz zur Erhaltung, zum Schutz und zur Bewirtschaftung des Waldes und zur Förderung der Forstwirtschaft (Thüringer Waldgesetz))
- Forest act of Hesse (Hessissches Waldgeetz (HWaldG))
- Federal climate protection act (Bundes Klima Schutzgesetz (KSG) 2019 zuletzt geändert
- 18.08.2021)
- National Nature Conservation Act (Gesetz über Naturschutz und Landschaftspflege (Bundesnaturschutzgesetz))
- National Bioeconomy Strategy (Nationale Bioökonomiestrategie)
- National biodiversity strategy (Nationale Strategie zur biologischen Vielfalt (2007))

Policies Grisons:

- Federal forest law (from 1991, status 2017) (Bundesgesetz über den Wald (Waldgesetz WaG) (von 1991, Stand 2017))
- Cantonal forest law of Grisons (Jan.2021) (Kantonales Waldgesetz (KWaG) Graubünden,
- Stand Jan.2021)
- Forest developmental plan 2018 + for Grisons (Waldentwicklungsplan 2018 + Graubünden)
- Strategy Biodiversity Switzerland (Federal Office for the Environment, FOEN 2017)(Strategie
- Biodiversität Schweiz (Bundesamt für Umwelt, BAFU 2017))
- Federal law on the reduction of CO2 emissions (CO2 Act) from Dec. 2011, last status 2021 (Bundesgesetz über die Reduktion der CO2-Emissionen (CO2-Gesetz) from Dec. 2011, last status 2021)
- Adaptation to Climate Change in Switzerland - Action Plan 2020 – 2025 (Anpassung an den Klimawandel in der Schweiz - Aktionsplan 2020 - 2025 (BAFU 2020))
- Strategy for leisure and recreation in the forest (FOEN, 2018) (Strategie Freizeit und Erholung im Wald (BAFU, 2018))
- Resource policy timber 2030 (FOEN 2021) (Ressourcenpolitik Holz 2030 (BAFU 2021))
- Forest policy: Goal and measures 2021–2024 (FOEN 2021) (Waldpolitik: Ziele und Massnahmen 2021–2024 (BAFU 2021))
- Sustainability and success control in protection forests (NaIS) - Guidelines for maintenance measures in forests with a protective function (Nachhaltigkeit und Erfolgskontrolle im Schutzwald

(NaIS) - Wegleitung für Pflegemassnahmen in Wäldern mit Schutzfunktion (BUWAL, 2005)) • Manual on program agreements in the environmental sector 2020–2024: Notification of the FOEN as enforcement authority to applicants (FOEN 2018) (Handbuch Programmvereinbarungen im Umweltbereich 2020 – 2024: Mitteilung des BAFU als Vollzugsbehörde an
Gesuchsteller (BAFU 2018))

Appendix B. Structure of policy document collection

Document information

- Title of document (original language)
- Title in English
- Type of document
- Policy area

Objectives

- What are the main goal(s)/objective(s) that the document indicates?
- What are the sub-objectives - if any - that is indicated in the document?
- What are the overall challenge(s) that the document directly identifies?
- Are there objective(s) or sub-objective(s) that direclty refere to forest ecosystem services?
- Are there priorities among the goals? Are there one or several goals that has higher priority than others in the document?
- Are there obligations or sanctions mentioned in the document?
- What geographical area is recognized by the policy document?
- What is the timeframe indicated in the document?

Synergies and conflicts

- Are there any synergies between different FES indicated in the document?
- Are there any conflicts between different FES indicated in the document?
- Are there particular policy instruments or measures mentioned synergies and or trade-offs
- (conflicts)
- Are there particular risks indicated in the document?

FES relation

- How are forests and the forest ecosystem services addressed in the policy document?
- Main objectives provided in column F (main goal(s)/objective(s)), please categorize to which FES they are related.
- Sub-objectives offered in column H (overall challenges), please categorize to which FES they are related.
- Are there any priority between the different FES from column T (address of forests and the forest ecosystem services) and U(main objectives categorization to FES)? Please explain in what way, and why this priority has been stated.

Data availability

Data will be made available on request.

References

Aggestam, F., Giurca, A., 2021. The art of the "green" deal: policy pathways for the EU Forest Strategy. Retrieved 2023-11-17, from For. Policy Econ. 128, 102456. https://doi.org/10.1016/j.forpol.2021.102456. ⟨https://www.sciencedirect.com/science/article/pii/S1389934121000629⟩. Retrieved 2023-11-17, from.

Aggestam, F., Pülzl, H., 2018. Coordinating the uncoordinated: the EU forest strategy. Forests 9 (3), 125.

Alliance for Freedom, Justice and Sustainability. 2021. Daring to make more progress - Coalition treaty 2021 – 2025, Germany.

Bali, A.S., Howlett, M., Lewis, J.M., Ramesh, M, M., 2021. Procedural policy tools in theory and practice. Policy Soc. 2021, 295–311. https://doi.org/10.1080/14494035.2021.1965379.

Beland Lindahl, K., Söderberg, C., Lukina, N., Tebenkova, D., Pecurul, M., Pülzl, H., Widmark, C., 2023. Clash or concert in European forests? Integration and coherence of forest ecosystem service–related national policies. Land Use Policy 129, 106617. https://doi.org/10.1016/j.landusepol.2023.106617. ⟨https://www.sciencedirect.com/science/article/pii/S0264837723000832⟩.

Bühler, Y., Bebi, P., Christen, M., Margreth, S., Stoffel, L., Stoffel, A., Bartelt, P., 2022. Automated avalanche hazard indication mapping on a statewide scale. Nat. Hazards Earth Syst. Sci. 22 (6), 1825–1843, 10.5194/ nhess-22-1825-2022.

Catalan Government. 2020. Bioeconomy strategy of Catalonia (2021–2030), EBC.

Doern, G.B., Phidd, R.W., 1983a. Canadian public policy: Ideas. Struct., Process 57.

Doern, G.B. & Phidd, R.W. 1983b. Canadian Public Policy: Ideas, Structure, Process (Vol. 1983) (No. 2). Methuen.

EC. 2011. Biodiversity Strategy. Retrieved 2022-01-18, from ⟨https://ec.europa.eu/⟩ environment/nature/biodiversity/strategy 2020/index en.htm.

EC. 2018. Bioeconomy strategy [Text]. Retrieved 2022-01-18, from https:// ec.europa.eu/info/research-and-innovation/research-area/environment/bioeconomy/bioeconomy-strategy _en.

EC. 2021. Forest strategy. Retrieved 2022-01-03, from ⟨https://ec.europa.eu/environment/⟩ strategy/forest-strategy en.

EC. 2023. Guidance on the development of public and private payment schemes for forest ecosystem services. Retrieved 2024-10-18, from ⟨https://agriculture.ec.europa.eu/system/⟩ files/2023-07/guidance-dev-public-private-payment-schemes-forest en.pdf.

Elomina, J. & Pülzl, H. 2021. How are forests framed? An analysis of EU forest policy. Forest Policy and Economics, 127, 102448. Retrieved 2022-01-03, from https://www.sciencedirect.com/science/article/pii/S138993412100054X doi: ⟨10.1016/j.forpol.2021.102448⟩.

Estonian Environment Agency. 2022. Yearbook Forest 2020. Tallinn.

European Environment Agency. 2023. Cices23 [Website]. Retrieved 2024-10-27, from https:// cices.eu/.

European Union. 2016. Principle of subsidiarity. Retrieved 2024-10-18, from ⟨https://eur-lex⟩.europa.eu/EN/legal-content/glossary/principle-of-subsidiarity.html.

Eurostat. 2022. Share of forest area - Products Datasets - Eurostat. Retrieved 2022-02-22, from ⟨https://ec.europa.eu/eurostat/web/products-datasets/-/sdg⟩ _15 10.

Federal Forest Act. 1975. Law on the Conservation of Forests and the Promotion of Forestry. (National Forest Act), Germany. (Altered last 2021.).

Federal Office for the Environment. 2005. Sustainability and success control in protection forests (NaIS) - Guidelines for maintenance measures in forests with a protective function, Switzerland.

Forestry and wood industry 2020. 2020. Retrieved from ⟨https://empl.ee/wp-content/uploads/⟩ 2021/04/2020-metsa-ja-puidutoostus-numbrites-esialgne.pdf.

Johansson, J. 2018. Collaborative governance for sustainable forestry in the emerging bio-based economy in Europe. , , 9–16. Retrieved 2022-02-23, from Current Opinion in Environmental Sustainability32⟨https://www.sciencedirect.com/science/article/pii/⟩S1877343517301744 doi: 10.1016/j.cosust.2018.01.009.

Johnston, C.M.T., Radeloff, V.C., 2019. Global mitigation potential of carbon stored in harvested wood products. PNAS 116 (29). https://doi.org/10.1073/pnas.1904231116. Retrieved from.

Jordan, A. & Schout, A. 2006. The coordination of the European Union: exploring the capacities of networked governance. Oxford University Press.

Kleinschmit, D., Arts, B., Giurca, A., Mustalahti, I., Sergent, A., Pülzl, H., 2017. Environmental concerns in political bioeconomy discourses. Int. For. Rev. 19 (1), 41–55. https://doi.org/10.1505/146554817822407420. ⟨http://www.ingentaconnect.com/content/10.1505/⟩.

Kliimaministeerium. 2005. Estonian Environmental strategy 2030, Estonia. Retrieved 2022-02-02, from (⟨https://old.envir.ee/sites/default/files/elfinder/article⟩ files/ ks _loplil riigikokku _pdf.pdf).

Kliimaministeerium. 2017. Climate Change Adaptation Development Plan until 2030, Estonia.

Kronthaler, F. & Cartwright, J. 2008. Wertschöpfung des Tourismus in den Regionen Graubünden – Stand und Entwicklung (Tech. Rep.). Retrieved from ⟨https://www.gr.ch/DE/institutionen/⟩ verwaltung/dvs/awt/Dokumente/Graubuenden HTW08. pdf.

Lafferty, W. & Hovden, E. 2003. Environmental policy integration: towards an analytical framework. Environmental Politics, 12(3), 1–22. Retrieved 2022-02-14, from https://doi.org/10.1080/09644010412331308254 (Publisher: Routledge eprint: https://doi.org/10.1080/09644010412331308254) doi: 10.1080/09644010412331308254.

Larsson, M., Stendahl, M., Roos, A., 2016. Supply chain management in the Swedish wood products industry - a need analysis. Scand. J. For. Res. 31 (8), 777–787. https://doi.org/10.1080/02827581.2016.1170874.

Lenschow, A., 2002. New regulatory approaches in 'Greening' EU policies. Eur. Law J. 8 (1), 19–37. https://doi.org/10.1111/1468-0386.00140. ⟨https://onlinelibrary.wiley.com/⟩.

Lier, M., Köhl, M., Korhonen, K.T., Linser, S., Prins, K., 2021. Forest relevant targets in EU policy instruments - can progress be measured by the pan-European criteria and indicators for sustainable forest management? For. Policy Econ. 128, 102481. https://doi.org/10.1016/j.forpol.2021.102481. ⟨https://www.sciencedirect.com/science/article/pii/S1389934121000873⟩.

Maes, J., Liquete, C., Teller, A., Erhard, M., Paracchini, M.L., Barredo, J.I., Lavalle, C., 2016. An indicator framework for assessing ecosystem services in support of the EU Biodiversity Strategy to 2020. Ecosyst. Serv. 17, 14–23. https://doi.org/10.1016/j.ecoser.2015.10.023. ⟨https://www.sciencedirect.com/science/article/pii/S2212041615300504⟩.

Ministerio de Agricultura Y., Pesca, A.Y.M.A. 2017. Cuarto Inventario Forestal Nacional de Cataluña. IFN4 (2017th ed., Vol. 2017).

Ministry for the Ecological Transition and the Demographic Challenge. 2013. Regulation on forest management plans, Spain.

Ministry of the Environment. 2011. Forestry Development Plan 2011–2020, Estonia.

NFI. 2022. Retrieved from ⟨https://keskkonnaportaal.ee/et/teemad/mets/⟩ eesti-statistiline-metsainventuur-smior⟨https://keskkonnaportaal.ee/sites/⟩ default/files/Teemad/Mets/SMI2021 _tulemused 0.pdf.

Nilsson, M., Eckerberg, K., 2007. Environmental Policy Integration in Practices: Shaping Institutions for Learning. In Environmental Policy Integration in Practice: Shaping institutions for Learning. Earth Scan. Retrieved, London. ⟨https://www.routledge.com/Environmental-Policy-Integration-in-Practice⟩. Shaping-Institutions-for-Learning/Nilsson-Eckerberg/p/book/9781844078158.

Nilsson, M., Zamparutti, T., Petersen, J.E., Nykvist, B., Rudberg, P., McGuinn, J., 2012. Understanding policy coherence: analytical framework and examples of sector-environment policy interactions in the EU: understanding policy coherence. Env. Pol. Gov. 22 (6), 395–423. https://doi.org/10.1002/eet.1589. ⟨https://onlinelibrary.wiley.com/doi/10.1002/eet.1589⟩.

Nordbeck, R., Steurer, R., 2016. Multi-sectoral strategies as dead ends of policy integration: lessons to be learned from sustainable development. Environ. Plann C. Gov. Policy 34 (4), 737–755. https://doi.org/10.1177/0263774X15614696. ⟨http://journals.sagepub.com/doi/10.1177/0263774X15614696⟩.

Parlament de Catalunya. 2017. Law 16/2017, 1st August of Climate Change, Spain.

Primmer, E., Varumo, L., Krause, T., Orsi, F., Geneletti, D., Brogaard, S., Mann, C., 2021. Mapping Europe's institutional landscape for forest ecosystem service provision, innovations and governance. Ecosyst. Serv. 47. https://doi.org/10.1016/j.ecoser.2020.101225 stitutional landscape for forest ecosystem se. ⟨https://www.sciencedirect.com/⟩.

Reid, W.V., Mooney, H.A., Cropper, A., Capistrano, D., Carpenter, S.R., Chopra, K., Zurekv, M.B., 2005. Ecosystems and human well-being: Synthesis. Island Press, Washington, DC. Retrieved from. ⟨https://www.millenniumassessment.org/documents/document.356⟩.

Söderberg, C. 2011. Institutional conditions for multi-sector environmental policy integration in Swedish bioenergy policy. Environmental Politics, 20(4), 528–546. Retrieved 2022-02-22, from https://doi.org/10.1080/09644016.2011.589625 (Publisher: Routledge eprint: https://doi.org/10.1080/09644016.2011.589625) doi: 10.1080/09644016.2011.589625.

Sotirov, M., Azevedo-Ramos, C., Rattis, L., Berning, L., 2022. Policy options to regulate timber and agricultural supply-chains for legality and sustainability: the case of the EU and Brazil. For. Policy Econ. 144, 102818. https://doi.org/10.1016/j.forpol.2022.102818. ⟨https://www.sciencedirect.com/science/article/pii/S1389934122001319⟩.

Sotirov, M., Storch, S., 2018. Resilience through policy integration in Europe? Domestic forest policy changes as response to absorb pressure to integrate biodiversity conservation, bioenergy use and climate protection in France, Germany, the Netherlands and Sweden. Land Use Policy 79, 977–989. https://doi.org/10.1016/j.landusepol.2017.04.034. ⟨https://linkinghub.elsevier.com/⟩.

Steurer, R., 2013. Disentangling governance: a synoptic view of regulation by government, business and civil society. Policy Sci. 46 (4), 387–410. ⟨www.jstor.org/stable/42637288⟩.

Swiss Federal Statistical Office. 2021. Schweizerische Forststatistik 202, Forstflachen nach Eigentümertyp und Kantonen,. Retrieved from ⟨https://www.bfs.admin.ch/bfs/de/⟩ home/statistiken/land-forstwirtschaft/forstwirtschaft/strukturen.assetdetail.22926976.html.

The Federal Assembly of the Swiss Confederation. 2011. Federal law on the reduction of CO2 emissions (CO2 Act) from Dec. 2011, last status 2021, Switzerland. Retrieved 2022-02-02, from ⟨https://www.fedlex.admin.ch/eli/cc/2012/855/de⟩.

The Federal Council. 2020. Adaptation to Climate Change in Switzerland - Action Plan 2020–2025, Switzerland.

Third National Forest Inventory. 2022. Retrieved from ⟨https://bwi.info⟩.

Underdal, A. 1980. Integrated marine policy. Marine Policy, 4(3), 159–169. Retrieved 2022-02-22, from ⟨https://linkinghub.elsevier.com/retrieve/pii/0308597X80900512⟩ doi: 10.1016/0308-597X(80)90051-2.

Winkel, G. 2017. Towards a sustainable European forest-based bioeconomy – assessment and the way forward | European Forest Institute (Tech. Rep. No. 8). Joensuu: European Forest Institute. Retrieved 2022-02-23, from ⟨https://efi.int/publications-bank/towards-sustainable⟩ -european-forest-based-bioeconomy-assessment-and-way-forward.

Winkel, G. & Sotirov, M. 2016. Whose integration is this? European forest policy between the gospel of coordination, institutional competition, and a new spirit of integration. Environ Plann C Gov Policy, 34(3), 496–514. Retrieved 2022-02-22, from ⟨http://journals.sagepub.com/doi/⟩ 10.1068/c1356j doi: 10.1068/c1356j.

Wolfslehner, B., Pülzl, H., Kleinschmit, D., Aggestam, F., Winkel, G., Candel, J., Roux, J.-L., 2020. European forest governance post-2020 | European Forest Institute. Sci. Policy. https://doi.org/10.36333/fs10. ⟨https://efi.int/sites/default/files/files/⟩.