



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 bio-economy, biodiversity, climate, energy, and forest (forestry). Coherence between the subject areas¹ 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 hard³ 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 consideration⁴

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 km² 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 Catalanian 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 km², 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 canton⁵ of Switzerland, covering 7105 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 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) (Buhler 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 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 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; Soderberg, 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 Doern's 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

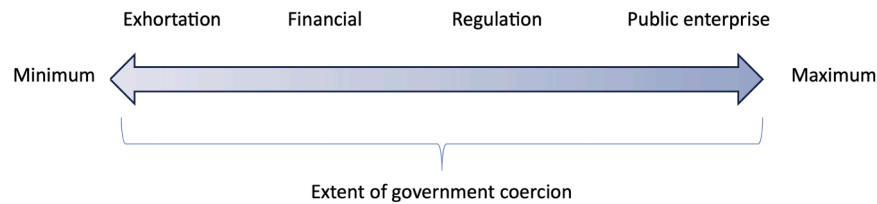


Fig. 1. The Doern continuum. Source: Adopted from Doern and Phidd (1983a).

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 reliable 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

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

policy documents included in the analysis.

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.

Parallel 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 implementation work on the forest and climate change research program" (The Federal Council, 2020).⁷The 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."

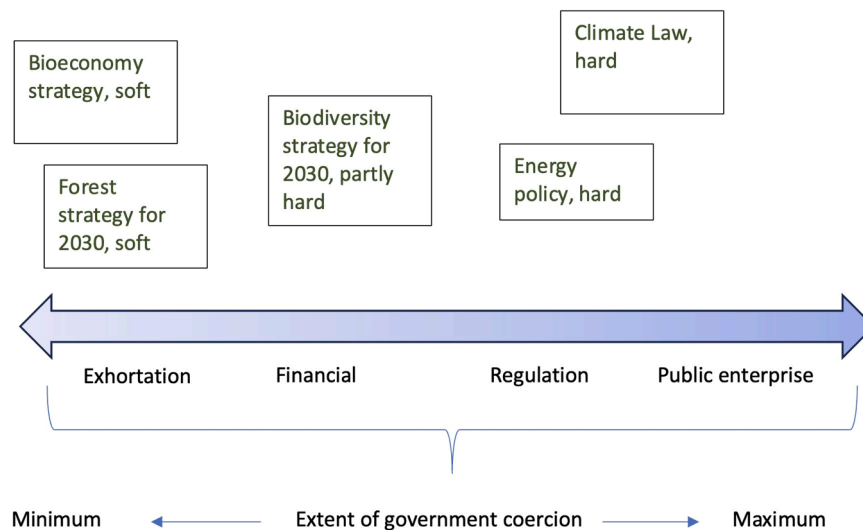


Fig. 2. Level of EU coercion in the policy subject areas.

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 Catalanian (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 adaptation 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

⁸ “Promoure la transformació tecnològica de recursos de biomassa d’origen forestal, agrícola, 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.”

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

¹⁰ “L’escalfament global no és només un problema ambiental; afecta la biodiversitat, el model econòmic, la mobilitat, el comerç, la seguretat alimentària, 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 hídrics disponibles i llur funció reguladora del cicle hidrològic 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

¹³ “Puidu kui taastuva tooraine ja taastuenergia 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.”

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
Climate change	No conflicts	No conflicts	Timber production and forest protection	No conflicts
	mentioned*	mentioned*	and forest protection	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.)

problematic conflict area.

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:

¹⁵ “Eesti keskkonnanstrateegia aastani 2030 eesmärgiks on määratleda pikaajalised arengusuunad looduskeskkonna hea seisundi hoidmiseks, lahtudes 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 mit Renaturierungsmaßnahmen die Resilienz unserer Ökosysteme, 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 über 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

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 producció de béns i serveis ambientals i socioculturals, [...], garantint la producció de matèries primeres i aprofitar adequadament els recursos naturals renovables.”

(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

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 FES¹⁹ 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

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

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.

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 biodiversity 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 climàtic)
- 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 (Hessisches Waldgesetz (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 directly refer 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.

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