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Smart information, governance and business innovations for sustainable supply and payment mechanisms for forest ecosystem services

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D2.3. Inventory of innovation types and governance of innovation factors across European socio- economic conditions and institutions and manuscript for a scientific article

- ✓ **Part 1. The Inventory: Innovation types and governance of innovation factors across European socio-economic conditions and institutions**

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- ✓ **Part 2. The Manuscript: Mapping Europe's institutional landscape for forest ecosystem service provision, innovations and governance**

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Executive Summary

The present Deliverable entails two parts. Part 1 is an inventory listing of the biophysical and institutional data collected for the analysis carried out in Deliverable 2.1 Mapping of forest ecosystem services and institutional frameworks – Draft report and D2.2 final report of mapping (D2.1). It also includes the link to the visual database presented as maps. Part 2 is the manuscript for D2.3, mapping Europe's institutional landscape for forest ecosystem service provision, innovations and governance.

Part 1. The Inventory: Innovation types and governance of innovation factors across European socio-economic conditions and institutions

Biophysical data inventory

Knowledge on the supply of Ecosystem services (ES) is important as this supports decision-making regarding their governance which affects their delivery and/or their enjoyment. In particular, ES maps can be used to identify areas that are crucial for supply, namely the provision of a service by ecosystems; demand, namely the need for a service by society. The maps illustrate the diversity of ES and their distribution in Europe.

The biophysical data regarding forest ecosystem services were collected from diverse sources and the indicators for them were defined and computed, by following the suggestions of the EC MAES report, as well as other international initiatives on ecosystem services mapping and assessment. This resulted in the mapping of the supply of the following forest ecosystem services across the entire EU: wood, water supply, erosion control, pollination, habitat protection, soil formation, climate regulation and recreation. Out of these maps, we denoted the highest supplying pixels (i.e. top 20%) as “hotspots”, and performed correlation analysis to detect synergies and trade-offs. The data concerning the hotspots can be found in ANNEX 1 Biophysical data which is part of T.2.1: Mapping of biophysical forest ecosystem services. The Annex presents the share of forest in each country that is a hotspot for each of the selected ecosystem services.

A more detailed account of the selection of FES to map, the indicators and the hotspots can be found in D2.2. An analysis on overlaying the biophysical data with the institutional data (see below) can be found in the scientific manuscript accompanying this report.

Institutional data inventory

Institutional mapping was carried out to identify future societal demand for FES, as formalised and expressed in policy, i.e., policy demand. The institutional data, including the innovation types, governance mechanisms and actor’s rights and responsibilities related to forest ecosystem services in Europe are compiled in ANNEX 2 Database of institutional analysis. This database is the result of the policy document analysis carried out during T.2.2: Mapping of actors, governance systems, markets and forest management systems. The chosen documents were coded, i.e. grading according to the developed operationalized categories of FES, innovations, actors and governance as well as quotes and/or the excerpts of the analyst were entered into a database using an online platform (Webropol).

The methods of selecting policy documents, realising the data collection and the development of the database structure and a manual for coding are described in more detail in D2.2. ANNEX 2 is an excel extracted from webropol and re-organised for readability for the purpose of this deliverable.
ANNEX 2 is organised on five different tabs: Innovations, Governance mechanisms, Actor’s responsibilities, Actor’s right and all data.

The data in the tabs is organised by forest ecosystem services (FES), except for All data, which is organised alphabetically according to the document name. The database includes both the quantitative and qualitative responses to the database survey.

The different stages of analysis of the database content can be found in deliverables 2.1 and 2.2. and the scientific manuscript accompanying this report.

Maps as a visual inventory

Based on a selection of the data from ANNEX 1 and 2 a map was created. A more detailed description of the maps and their content can be found in D2.2. The maps should be interpreted together with D2.2.

The maps are freely accessible and the information page on the site contains the links to the metadata of the maps:
http://syke.maps.arcgis.com/apps/webappviewer/index.html?id=e27ae600fad1451fa3ed4109ae309856

The ANNEX 1 and 2 are two excel files containing all the biophysical and institutional data used in the investigation. To get access to the files, please contact the authors of this deliverable:

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Part 2: The Manuscript: Mapping Europe's institutional landscape for forest ecosystem service provision, innovations and governance

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Abstract

There has been a strong quest for mapping and assessing ecosystem services (ES) to support governance. Yet, the institutional landscape that governs ES provision across multiple contexts has received less attention. We fill this research gap by developing and operationalising a framework for the analysis of policy documents that address European forest ES provision. By coding and analysing references to forest ES as well as innovations and governance mechanisms addressing these ES in national strategies on forest, biodiversity and bio-economy, we map the institutional landscape of forest ES provision in Europe. We further analyse how biophysical supply of forest ES is connected to policies paying attention to ES and identifying innovations and governance for their provision. Identified innovations centre around value chains of wood and bioenergy as well as biodiversity conservation, while non-wood forest products, cultural heritage, and recreation receive little attention. Biophysical supply of provisioning ES is connected to strategies emphasising many innovations while little supply of regulating ES could trigger service innovations and several new governance mechanisms. As forest ecosystems have received much attention in global, European and national sustainability policies, our institutional mapping illustrates that there is room for more use of innovations in promoting ES provision.

1 Introduction

The mainstreaming of the ecosystem services (ES) concept into policies and strategies has been gradual and varied across policy areas (Bouwma et al., 2018). Although there has been a strong quest for mapping and assessing ES to support governance (De Groot et al., 2010; Maes et al., 2012; Vihervaara et al., 2018), the connection between mapping and governance has dominantly focused on spatial distribution of the expectations placed on biophysical landscapes (Burkhard et al., 2012; Hauck et al., 2013; Wolff et al., 2015) or trade-offs and synergies in ES provision and between ES in the landscape (Rodriguez 2006; Raudsepp-Hearne, 2010). Yet, the governance of ES across the landscape depends on their recognition, and will be influenced by how they are framed (Primmer and Furman, 2012; Primmer et al., 2015; Verburg et al., 2016). The ways in which governance responds to what is observed in the biophysical landscape has often been addressed through case studies (Dick et al., 2018), drawing attention to specific governance contexts. This specificity is understandable, as policies and governance mechanisms are responses to the challenges in their social-ecological and institutional setting, yet this analytical focus results in limited understanding of ES policies across multiple governance contexts. The research in this paper is motivated by the gap in empirical work on the "institutional landscape" to match that of the in-depth empirical understanding of biophysical landscape. Forests represent an important element in the European biophysical landscape, and target of governance particularly at the national level, which is why we develop our analysis for forest ES.

Forests provide a wide range of ES: wood and non-wood forest goods as provisioning ES, regulation of carbon, nutrient and water cycles as regulating ES as well as recreation and identity as cultural ES (Maes et al., 2013; Saarikoski et al., 2015; Brockerhoff, 2017; Sotirov et al., 2018). These ES have been mapped across Europe, illustrating that some areas host so-called hotspots of high supply of specific forest ES, and bundles of several ES (Orsi et al., in review). Although forest policies have addressed multiple forest ecosystem functions and sustainable management for several decades (Rammel and van den Bergh, 2003), the concept of ES has appeared in policy only recently (Bouwma et al., 2018). At the same time, forest ecosystems have become the centre of attention in global, European and national sustainability policies.

Forest ES are recognised in numerous European and global policies and assessments. These policies frame forests as providing habitat for biodiversity, protecting watersheds, reducing the risk of natural disasters and extreme weather events as well as securing livelihoods (EC, 2011; EC, 2013; UNSDG, 2015; IPBES, 2019), and Land Use and Land Use Change and Forests (LULUCF) are a target of international and European regulations to reach the new climate targets (IPCC 2000; EU, 2018). Even though policies do not always directly refer to forest ES, they address the functions of forest ecosystems, which society benefits from. The EU Forest Strategy of 2013 (EC, 2013) recognizes ES more explicitly than other strategies of its time (Bouwma et al., 2018), and seeks to ensure provision of forest ES: "balancing various forest functions, meeting demands, and delivering vital ecosystem services'' (EC, 2013: 6). The new European Green Deal of 2019 (EC, 2019: 13) commits to preparing a new EU forest strategy that will promote "the many services that forests provide".

The EU strategies addressing forest ES, namely the Forest Strategy (EC, 2013), the Biodiversity Strategy (2011), and the Bio-economy Strategy (2012), are operationalized nationally and these national strategies reflect the countries' priorities. The national strategies reflect the governance context into which possible new innovations or governance mechanisms, such as Payments for Ecosystem Services (PES), would be placed (Primmer et al., 2013). In particular, as the strategies communicate the new policy demands placed on forests and ES, and identify mechanisms for implementing them, it is relevant to analyse how the focus on ES in European strategies reflects the biophysical abundance of those same ES.

Forest policies in Europe have thus far met the demand for diversifying forest functions only at a superficial level (Winkel and Sotirov, 2016), and there is an identified need for more innovation and learning in order to address sustainability in the forest sector and related policies (Kleinschmit et al., 2014). As the contextual factors for forest ES provision, such as land-use, land-ownership, or industry structure are very slow to change, it is important to be sensitive to changes within these structures. These can include emerging or suggested new ecosystem management practices, new forms of land-owner collaboration or new business ideas departing from pre-existing operational patterns (Kubeczko et al., 2006). Indeed, with the increasing and diversifying expectations, it is helpful to identify the innovations by which change could be stimulated, accelerated, or institutionalized, and the governance mechanisms by which these expectations could potentially be implemented.

In this paper, we map the institutional landscape of forest ES provision in Europe by analysing how EU and national strategies on forest, biodiversity, and bio-economy address forest ES, as well as how their provision is promoted through innovations and governance mechanisms. In addition to describing the policy emphases quantitatively and qualitatively, the analysis is designed to answer the question: how does the institutional landscape match the supply of forest ES? By overlaying the institutional landscape with the supply of forest ES (Orsi et al., in review), our analysis shows the connections between distribution of forest ES and the policy responses with innovations and governance.

The paper is organised as follows. In the following section, we operationalise our framework, and in Section three we describe the empirical procedure of policy document analysis and summarize the ES mapping we use. In section four we report our findings. In Section five we discuss the relevance of our findings for forest ES mapping and governance and finally, in section six, we draw conclusions on innovations and governance as well as on the ways in which this kind of analysis portrays ES scarcity- and abundance-driven policy action.

2. Conceptual basis of the analytical framework

Our framework for empirically analysing policy documents, to inform institutional mapping, includes ES, innovation and governance. The literature and mapping efforts of ES generally acknowledge a range of provisioning, regulating and cultural ES (Maes et al., 2013; Saarikoski et al., 2015; Brockerhoff, 2017; Sotirov et al., 2018). Provisioning forest ES include wood for fiber and energy food. Also, other non-wood forest products can abound (Lovric et al., 2020).

Regulating forest ES include climate regulation through carbon sequestration and stock functions (and micro climate regulation), water regulation through flood and erosion protection functions. Resilience against extreme weather events can also be a regulating ES (Drever et al., 2006). Cultural ES include recreation (generating wellbeing) and identity (spiritual connection). Biodiversity conservation is often also included in ES assessments through habitat provision (Brockerhoff, 2017), and through intrinsic value it is a cultural ecosystem service as well (Saarikoski et al., 2017). Biodiversity conservation is indeed justified also with resilience functions (Drever, 2006).

Innovation theory has a long history, and although some empirical analyses focus on innovation outcomes, the bulk of literature on innovations addresses the innovation process, from emergence to the implementation of new ideas (Van de Ven, 1986). Innovation functions – or stages – that are identified in these analyses include at least visioning, development and promotion, experimentation and implementation, as well as system-level transition or upscaling (Gopalakrishnan and Damanpour, 1997; Geels and Schot, 2007; Konrad, 2012; Sengers et al., 2016). Innovation processes are often categorized by the types of innovations they produce (Carrillo-Hermosilla et al., 2010), i.e., product innovation (REFs), service innovation (Gallouj and Weinstein, 1997; Gallouj and Djellal, 2010; Visscher et al. 2019) or governance innovations (Voss and Simons, 2018). For example, product innovations emerge as a result of targeted design processes or as a response to newly emerging demands or, most commonly, as a result of these two together (Nelson and Winter, 1977). Product innovations tend to be linked to process innovations, but a process innovation might also emerge to increase efficiency (Barras, 1990). Finally, innovations can also be about market rearrangements or transformations in public and economic institutions but may also refer to cultural institutions (Davis and North, 1970; Weatherley and Lipsky, 1977; Hargrave and Van de Ven, 2006).

For forest ES, new products could include new wood-based fuels or medical or cosmetic products, while process innovation could refer to less invasive harvesting technologies or processing technologies producing less waste. With strong client orientation, the forest sector has also a fast-developing service market on forestry, bioeconomy, and nature management (Wolf and Primmer, 2009; Mattila et al., 2013; Kleinschmit et al., 2014), exceeding mere use and development of technology (e.g., Gallouj and Weinstein, 1997; Morrar, 2014). In terms of forest ES, we assume that service innovation can be related to new products, but also as broader, non-technological outcomes and practices. Forest ES related innovations can occur also in the forms of social networking (Neumeier, 2012; Kluvánková et al., 2018), and include new client and stakeholder engagement processes, forums, working groups, or platforms (Han et al., 2013; Kleinschmit et al., 2014). Although market rearrangement would require changes in formal rules, the new innovations in forest ES markets might emerge more informally, for example, as perceived changes in traditional practices of forest managers as well as prescribed behavioural changes for public servants in the governmental forestry sector.

Governance captures both government-driven hierarchical steering and broader more openly engaging policy design and implementation (Wurzel et al., 2013). While policy is seen as operating with a range of instruments resting on differing logics (Howlett, 1991), governance further emphasizes voluntary instruments and cooperative structures, implying self-regulation and collective action (Rhodes, 1997; Biermann, 2007).

Responding to the societal expectations for forest ES provision could be organised through a range of governance-mechanisms, including regulation, planning, information provision, collaboration and incentives, building on pre-existing institutional arrangements (Primmer and Furman, 2012; Primmer et al., 2015). Forest laws are the most specific and apparent governance mechanisms. They are backed up with other sector regulations, such as biodiversity conservation and water laws and broader legislative and planning systems that together address ES (Ruhl et al., 2013; Borgström and Kistenkas, 2014; Geneletti, 2011, 2015). Economic incentives for ES provision have been at the centre of ES policy analysis for long, both as government payments, and as more market-based arrangements (Vatn, 2010; Primmer et al., 2013; Börner et al., 2017). Land-use planning is another governance mechanism strongly promoted by the ES research community (Potschin and Haines-Young, 2011; von Haaren et al., 2019). To complement payments and planning, collaborative-adaptive governance mechanisms are often suggested by analysts and by practitioners (Paavola and Hubacek, 2013; Primmer et al., 2015; Dick et al., 2018).

These conceptualisations and analyses of forest ES, innovation and governance constitute the conceptual basis for the framework we operationalise for our analysis in the following section.

3. Data and methods

The core of our empirical work consisted of coding policy documents to map the institutional landscape for forest ES provision in Europe. The documents were chosen based on their relevance for forest governance and forest ES during the time of the analysis, seeking comparability. In other words, we sought to identify documents that would identify forest ES relevant governance mechanisms and innovations in a context-specific and dynamic fashion for a medium term. The consideration of relevance, comparability and dynamism led us to choosing forest, biodiversity and bio-economy strategies, which often have a 10-year time-span. These strategies exist in many EU countries and they each have an EU-level counterpart, which we also analysed. We did not include any rural or nature tourism policy documents, as there were no comparable counterparts for these as regards forest ES in many EU countries. Our dataset hence consisted of 22 national strategies and 3 EU level strategies, including 12 forest strategies, 7 biodiversity strategies, and 6 bio-economy strategies (Table 1).

Table 1. The 25 policy documents that constitute the institutional mapping data.

Forest strategies		
Europe	EU Forest Strategy	2013
Austria	Austrian Forest Strategy 2020+	2018
Czech Republic	The National Forestry Programme	2008
Denmark	Danish national forestry programme	2018
Finland	National Forest Strategy	2015
France	French Assessment of Ecosystems and Ecosystem Services – Forest Ecosystems	2018
Germany	Forest Strategy 2020	2011
Italy	Framework Programme on Forests (Programma Quadro per le Foreste)	2008
Ireland	Forests, products and people. Ireland’s forest policy – a renewed vision.	2014
Spain	State Official Newsletter	2015
Slovakia	National Forest Programme of the Slovak Republic	2007
Sweden	Strategy for Sweden's national forest program	2018
Biodiversity strategies		
Europe	EU Biodiversity Strategy	2011
Austria	Biodiversity Strategy 2020+	2014
Finland	Biodiversity Strategy	2011
Germany	National Strategy on Biological Diversity	2007
Italy	Biodiversity Strategy	2010
Netherlands	Natuurlijk verder - Rijksnatuurvisie 2014	2014
Slovakia	Updated National Biodiversity Conservation Strategy by the year 2020	2013
Bioeconomy strategies		
Europe	EU Bioeconomy Strategy	2012
Austria	Bioeconomy-Research-Technology and Innovation-Strategy for Austria	2018
Finland	Bioeconomy Strategy	2014
Germany	National Policy Strategy Bioeconomy	2014
Italy	BIT – Bioeconomy in Italy	2017
Sweden	Swedish Research and Innovation Strategy for a Bio-based Economy	2012

We operationalised the conceptual framework for the document analysis as follows. We identified forest ES that represent the spectrum of ES categories: four provisioning, four regulating, and two cultural services (Table 2). This set was chosen as a result of an iterative pre-scanning of which ES would mentioned in policy documents. Then we developed an analysis template for coding expressions of these ten ES, as well as for innovations and governance mechanisms related to them (Table 2).

Further operationalising the conceptual basis described in the previous section, we designed the following coding scheme. The weight given to each ES in the documents was coded with a grading ranging from 1 to 4 (1= mentioned indirectly, 2= mentioned directly but not an objective, 3= stated as an objective but no stated targets or measures for implementation, 4= a central objective with clear targets and measures for implementation, Table 2). Innovations were coded as Product innovation, Process innovation and technology improvements, Social and networking innovation, Service innovation, as well as Market rearrangement and Institutional innovation with a grading of 1-3 (1= promoting, 2= implementation, 3= upscaling). Governance mechanism development was coded into: Markets (direct private-to-private, private-to-private with intermediaries, market-like arrangements organised by government), Government incentives (subsidies, taxes), Regulation (laws and statutes), Collaboration (networks, cooperatives), and Information (guidelines, maps, IT and platforms, advice services), with a grading of 1-2 (1= clear mention but not clear what development is expected, 2= clear mention that will be developed).

Innovations and governance mechanisms were originally coded with more detailed grading during the coding but since they resulted in only a few entries some categories were combined for the analysis. The small number of cells left empty during the coding were corrected as no mentions (0) when analysing the data with SPSS23. In addition to the grading signalling weight in the policy documents, direct quotes or summarizing excerpts were coded for qualitative analysis of emphases.

Table 2. Analysis framework for institutional mapping with items coded from policy documents of forest ES with corresponding indicators used for ES mapping as well as innovations and governance mechanisms targeting them.

	Coded for institutional mapping	Indicator for biophysical ES
Forest ES[1]		
Provisioning ES	Wood	Growing stock volume (m^3 ha^{-1})
	Bioenergy	Potential for bioenergy production (% of forest biomass increment tons ha-1 yr-1).
	Non-wood forest products	
	Game	
Regulating ES	Biodiversity conservation	Habitat provision as forest cover in Natura 2000 sites
	Erosion and water protection	Water yield (mm yr-1)
	Climate regulation, carbon sequestration and stock	Carbon storage (tons ha-1)
	Resilience (risk control and climate change adaptation)	
Cultural ES	Cultural heritage	
	Recreation: cultural, physical and experiential interactions	Recreation opportunity (provision potential)
Innovations[2]	Product innovation	
	Process innovation and technology improvements	
	Social and networking innovation	
	Service innovation	
	Market rearrangement and institutional innovation	
Governance mechanisms[3]	Markets (direct private-to-private, private-to-private with intermediaries, market-like arrangements organised by government)	
	Government incentives (subsidies, taxes)	
	Regulation (laws and statutes)	
	Collaborative (networks, cooperatives)	
	Information (guidelines, maps, IT and platforms, advice services)	

[1] Coded as follows: 1= mentioned indirectly, 2= mentioned directly but not an objective, 3= stated as an objective but no stated targets or measures for implementation, 4= a central objective with clear targets and measures for implementation

[2] Coded as follows: 1= promoting, 2= implementation, 3= upscaling

[3] Coded as follows: 1= clear mention but not clear what development is expected, 2= clear mention that will be developed

For each document, the template was filled in 10 times, once for each ES, producing a spreadsheet with 250 rows for the 25 documents. This made the forest ES in the policy documents our unit of analysis and allowed us to analyse the innovations and governance mechanisms for each forest ES. Most of the strategies were available only in national languages. For calibrating coding, several sets of collective coding sessions were organised, and a manual with examples to support grading and extracting excerpts was supplied.

The excerpts were analysed qualitatively using thematic content analysis; all excerpts for a given item were read and categorised under descriptive labels for that theme. The themes were used in interpreting the frequencies of mentions, to add to the understanding of what mentioned innovations and governance mechanisms were referring to.

We analysed the frequencies of the coded items as graded with the 22 national strategies (Table 1; Table 2), and ran Spearman's rank correlation to analyse the coincidence of forest ES, innovations, and governance mechanisms in the 22 national documents and their biophysical abundance in the same countries. The analyses were conducted with SPSS23. The visual maps illustrating examples of coded emphases in the documents were done only with forest strategies, as these were available and comparable across the 11 countries.

The biophysical data were those reported in Orsi et al. (in review), except for habitat, bioenergy and recreation, which were computed specifically for this study. The data were converted to represent the provision of the ES proportional to total land area in each country, for example growing stock volume (Table 2, Map 1). For this, we used the vector based Corine Land Cover data (CLC) with a minimum mapping unit of 25ha to mask out the water areas. Then pixel values of the biophysical data were converted to describe the ES provision in unit per $1km^2$. Data that were expressed originally for example in unit per hectare (e.g. carbon storage tons/ha) a multiplication by 100 was executed to convert them to unit per 1 km^2 before division by the total land area. The habitat service was estimated by overlapping the forest cover extracted from the CLC and the geospatial layer of Natura 2000 sites provided by the European Environment Agency. Bioenergy was estimated as 20% of the forest biomass increment (Zambelli et al., 2012), using the forest biomass increment dataset produced by the JRC (Busetto et al., 2014). In the case of recreation, only the high recreation provision areas (classes 7-9 in Orsi et al., in review), without the proximity weighting, was used from the recreation opportunity spectrum (ROS; Paracchini et al., 2014) to describe the recreation provision potential.

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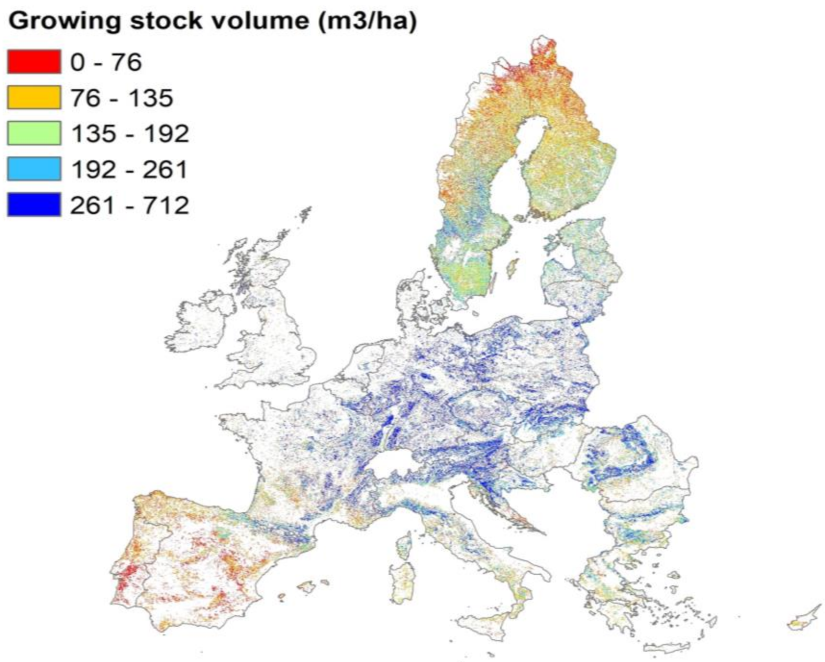


Map 1. Map of growing stock volume.

4. Results

4.1 Ecosystem services, innovations and governance in policy documents

All of the analysed strategies referred to ES or the idea of nature benefiting people in various ways. Out of the ten forest ES analysed, wood and biodiversity conservation were most frequently identified as central goals (Table 3), with biodiversity conservation being the only ES that was mentioned in all of the 25 policy documents. Although bioenergy was often mentioned as a central objective; it was not mentioned in a third of the documents. Slightly over a third of the documents did not mention non-wood forest products (game or edible plants) or cultural heritage. Out of the innovation and governance type mentions, the clearly largest number related to wood (Table 3).

Most of the innovations across the strategies related to provisioning and regulating services, while innovations related to cultural ES were mentioned least. Most innovation mentions referred to the initial stage of promoting, and only a small number addressed upscaling. The six bioeconomy strategies had more mentions of innovations compared to forest and biodiversity strategies.

Out of the innovation types analysed, process and technology innovations were most commonly mentioned in the documents and associated with a range of forest ES, foremost wood, bioenergy, and regulating ES (Table 3). According to the excerpts from the documents, process innovations included new management practices and technology development for resource efficiency and different ICT-related solutions for data collection and sharing. Product innovations were largely related to wood and bioenergy, with the exception of climate regulation. Examples included using wood to replace other building materials or refinement of biomass to make products with smaller CO_2 footprints than their traditional counterparts. Textiles, green chemicals and more resilient tree species for wood material were also mentioned. Innovations in social processes and networks were also common, and predominantly related to wood, less often to biodiversity conservation, and bioenergy. Map 2 illustrates social process and network innovation emphasis in forest strategies.

The excerpts include new forms of cooperation and partnerships between different actors and improving engagement via public participation, for example, in the planning of forest and ES use. Platforms and networks to enhance cooperation were the concrete measures mentioned for some of these partnerships. Additionally, new cooperation models for training and education and other types of educational projects were mentioned. Online platforms were mentioned as technology innovations or as service innovations. Research and training for management plans for sustainable forest management were framed as service innovations, also for biodiversity conservation.

Most service innovations were mentioned in relation to wood but biodiversity conservation, bioenergy and recreation had also service innovation mentions. Those service innovations mentioned in the strategies that related to recreation were typically about to nature and cultural tourism. Market rearrangements related to ES included greening public procurements and supporting sustainability in the markets for natural resources and developing sustainable ES business in general.

Table 3. Mentions of FES, innovations and governance mechanisms in the 25 analysed policy documents

	Wood	Bioenergy	Non-wood products	Game	Biodiversity conservation	Erosion and water protection	Climate regulation	Resilience	Cultural heritage	Recreation	Total
Ecosystem Services											
A central objective with clear targets and measures for implementation	12	12	2	3	11	6	8	3	1	7	65
Stated as an objective but no stated targets or measures for implementation	4	5	2	3	7	7	9	8	6	4	55
Mentioned directly but not an objective	5	3	8	6	5	1	4	3	4	4	43
Mentioned indirectly	2	0	2	0	2	5	2	3	3	1	20
Total of mentioned	23	20	14	12	25	19	23	17	14	16	183
No mention	2	5	11	13	0	6	2	8	11	9	67
Total	25	25	25	25	25	25	25	25	25	25	250
Innovations											
Process and technology	15	14	1	1	10	6	9	9	0	5	70
Social process and networking	17	7	1	2	9	4	3	1	2	5	51
Product	14	10	4	2	0	0	6	0	0	1	37
Service	12	6	2	0	7	0	4	4	1	6	42
Market rearrangement	10	9	2	0	8	4	4	1	0	3	41
Total of mentioned	68	46	10	5	34	14	26	15	3	20	241
No mention	47	54	60	55	91	81	89	70	67	60	674
Total coded	115	100	70	60	125	95	115	85	70	80	915
Governance Mechanisms											
Markets	15	7	2	2	8	5	2	6	4	1	52
Incentives by government	18	13	1	3	12	4	10	4	2	4	71
Regulation	14	13	4	5	15	7	11	5	2	3	79
Collaborative	17	9	3	4	10	4	5	8	2	4	66
Information	15	7	1	5	14	5	13	8	6	8	82
Total of mentioned	79	49	11	19	59	25	41	31	16	20	350
No mention	36	51	59	41	66	70	74	49	54	65	565
Total coded	115	100	70	60	125	95	115	80	70	85	915

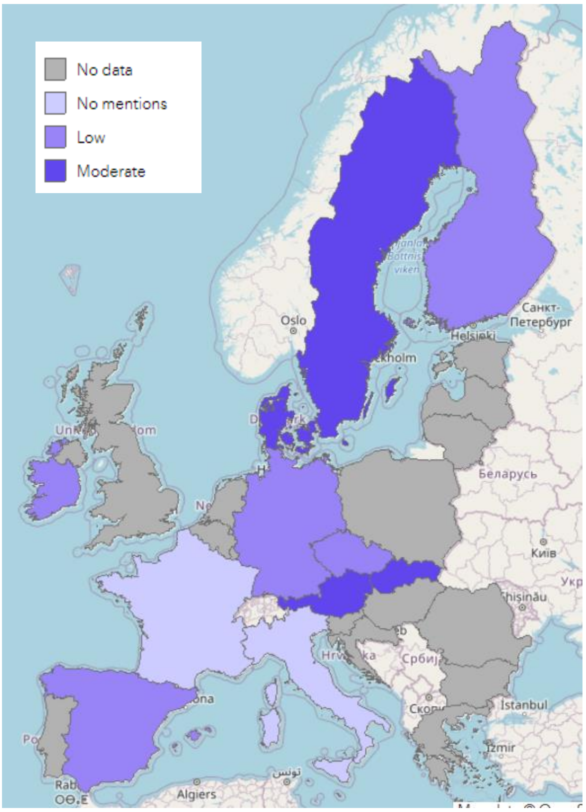
The strategies mentioned different governance mechanisms for all of the forest ES, but with varying frequency. Most frequently the mechanisms mentioned addressed wood production and biodiversity conservation, and considerable emphasis was put also onto bioenergy and climate regulation (Table 3).

Regulation and information were the most commonly mentioned governance mechanisms across the strategies (Table 3), yet bioeconomy strategies stressed collaboration and information more than regulation. Map 3 illustrates the emphasis placed on regulation in forest strategies.

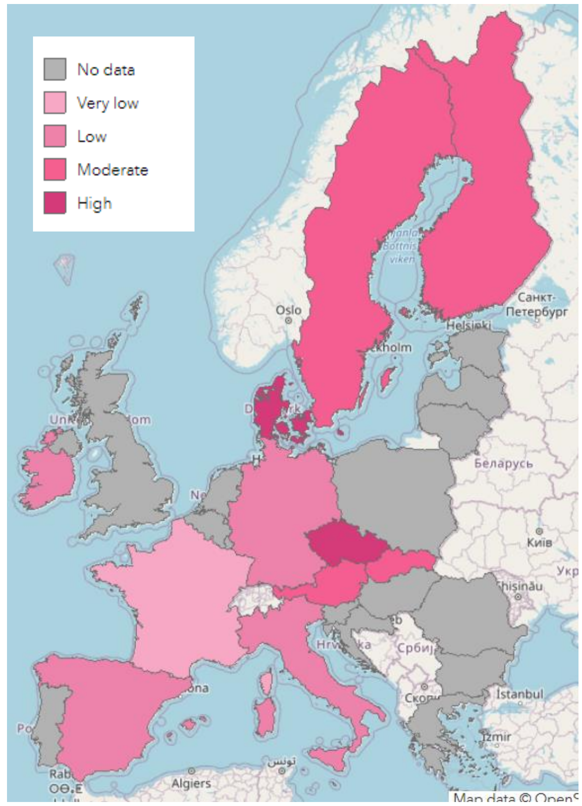
Regulation was most commonly expressed for biodiversity conservation, but also other regulating and provisioning services. Based on the excerpts, the strategies often signalled a need or a commitment to updating legislation to better reflect the current context, especially considering the need for more sustainable and climate-friendly forest management practices and innovative solutions to support these. The excerpts also signalled that allowing flexibility in management and developing guidelines and management plans in accordance with international commitments were also framed as regulation. There were occasional mentions of direct prohibitions of, for example, clear-cuts or certain hunting practices. The regulatory division between public state-owned and privately-owned forests was apparent in some of the excerpts.

According to the excerpts, information as a governance mechanism was often about generating data and developing mapping platforms with inventories and statistics, on diverse issues such as tourism, hunting, ES provision in general, or R&D investment, and training. Information governance related to climate regulation was generally connected to developing ways to measure carbon stocks and climate change impacts.

Collaborative governance excerpts referred to cross-sectoral, public-private, regional and international partnerships, and public participation in forest ES planning. Collaboration was expressed both through formal arrangements, for example, establishing boards or committees, and through informal practices. Government incentives included tax incentives, investments and financing and other incentives for the different ES and detailing the management of such incentives. The development of different types of public programmes, for example, rural development programmes or research programmes for conservation, were also framed as government incentives for the provision of certain ES. Excerpts of markets and governance, which were mainly related to wood but also to biodiversity conservation, bioenergy and recreation, included stimulating market development and growth for ES provision and the use of PES, promoting new partnerships between the public and private sectors and introducing certificates, standards, and labels to forest products.



Map 2. Policy emphasis on innovation in European national forest strategies: Social and networking innovation.



Map 3. Policy emphasis on governance mechanisms in European national forest strategies: Regulation.

4.2 Overlaying institutional and biophysical data

Overlaying the biophysical maps and the coded information on policy emphasis placed on ES resulted in no clear patterns, i.e., the correlations were mostly very low (Table 4). In this kind of qualitative analysis, however, considering also correlations at a significance level larger than P<0.05 is meaningful. With this approach, we could see that biodiversity conservation was clearly emphasised in the strategies of those countries that had high biophysical carbon storage and in those that had high volume of forest. Biodiversity conservation was indeed emphasised in all strategies from countries that had relatively high supply of ES. Cultural heritage was emphasised in the strategies of countries with a low amount of forest in Natura 2000 sites and also to a certain extent from countries with limited recreation opportunity. Resilience was recognised in those countries that had a high level of provisioning ES.

Table 4. Spearman rank correlation between supply of forest ES in 11 European countries (rows) and mentions of forest ES in 22 national policy documents from those countries (columns).

	Wood	Bioenergy	Non-wood products	Game	Biodiversity	Erosion control	Climate regulation	Recreation	Cultural heritage	Resilience
Carbon storage	-.081	-.043	-.207	.193	.443*	-.039	.136	-.088	-.188	.253
Bioenergy potential	-,036	-,049	.080	.114	.199	-.168	.051	-.018	.205	.420
Water yield	-.113	-.037	.014	.194	.263	-.193	.039	.004	.112	.316
Growing stock volume	-.143	-.008	-.051	.146	.353	-.173	.057	-.021	.009	.305
Avoided soil erosion	-.205	-.058	.000	-.147	.278	.186	.073	-.280	-.097	-.020
Soil organic carbon	-.019	.031	-.022	.263	.160	-.327	-.015	.202	.144	.280
Recreation opportunity	.061	-..020	-.179	.231	-.085	.036	.051	.075	-.378	-.056
Forest in Natura sites	-.140	.110	-.270	-.117	.129	.179	.063	-.162	-.477*	-.218

*P<0.05

The analysis of the coincidence of ES supply in a country with national strategies placing emphasis on innovations and governance showed some connections. It signalled that a relatively high supply of provisioning ES was connected to strategies emphasising process and technology innovations and social process and networking innovations as well as markets and collaborative governance (table 5). At the same time, a negative correlation indicated that a low supply of erosion control was connected to countries emphasising service innovations and several governance mechanisms. In other words, the limited provision of erosion control might trigger emphasis being placed on at least service innovation and a broad range of governance mechanisms including regulation, information, and markets. A similar but very weak signal could be detected for low coverage of Natura 2000 areas being connected to policy emphasis on both innovations and governance mechanisms, perhaps indicating that strategies consider ES innovations when areas are not set aside.

Social process and networking innovation as well as collaborative governance mechanisms were clearly connected to the supply of provisioning ES. This signals that countries with much forest were oriented in identifying collaborative network-based activities in their strategies. Finally, process innovation was emphasised in countries with high bioenergy potential, likely signalling the technological process orientation in bioenergy development.

Table 5. Spearman rank correlation of biophysical abundance of forest ES in 11 European countries (rows) and policy emphasis on innovation and governance mechanisms as coded from 22 strategies from those countries (columns).

	Innovations					Governance				
	Product	Process innovation	Social process and networking	Service innovation	Market re-arrangement	Regulation	Collaborative	Information	Markets	Incentives by government
Carbon storage	.067	.185*	.202*	.022	-.023	-.074	.230**	.016	.034	.116
Bioenergy potential	.115	.230**	.208**	.104	.009	.079	.260**	.041	.135	.043
Water yield	.125	.177*	.217**	.035	-.028	.055	.245**	-.096	.081	-.002
Growing stock volume	.116	.161*	.224**	.025	-.005	.045	.227**	-.091	.074	.036
Avoided soil erosion	-.077	-.075	-.030	-.184*	-.063	-.208**	-.001	-.310**	-.176*	-.089
Soil organic carbon	.161*	.146	.163*	.083	-.023	.125	.185*	.039	.122	-.008
Recreation opportunity	.096	-.029	-.014	-.010	-.028	-.086	.063	.144	.033	.030
Forest in Natura sites	-.009	-.106	-.069	-.116	.004	-.144	-.041	-.022	-.101	.046

*P<0.05
**P<0.01

5. Discussion

The institutional mapping, we have conducted, provides a descriptive illustration of what has been emphasised in national forest strategies at the time they have been drafted. It shows what has been envisioned as regards innovative new ways of promoting ES provision and what governance mechanisms have been identified. In this way, our mapping is a dynamic description but it should not be interpreted as an analysis of how ES policies have evolved in their specific contexts (Saarikoski et al., 2018; Angelstam et al., 2018). Neither is our analysis an evaluation of success in addressing forest ES or a ranking of the different countries' policies.

The scale of institutional mapping differs from biophysical mapping because it is bound to the administrative units at which data is available (Cash et al., 2006). Although this analysis falls short of the scale-related expectations driven by the new spatial data-driven capacities, for example for forest ES (Maes et al., 2013; Malinga et al 2015; Orsi et al., in review), a robust analysis is likely to speak to ES governance in meaningful ways and across sectors (Primmer and Furman, 2012; Ruhl, 2016).

Starting with the EU level strategies and including them in our descriptive analysis, our main dataset consists of national level forest, biodiversity and bioeconomy strategies, as they exist for many countries in relatively comparable format.

Complementing analyses of policy aiming at innovation (Smits et al, 2010; Kuhlmann, 2019), our analysis provides a reality test in sector policies that are not directly about innovation, as has been done for energy policy (Kivimaa and Kern, 2016). Our analysis of national strategies shows what EU and European national policies emphasise for forest ES and related innovations and governance. First, the analysis reveals that innovations centre around existing value chains of wood and bioenergy, and also around biodiversity conservation, which has often been positioned as challenging wood production in national forest policies (e.g., Blicharska and van Herzele, 2015; Harrinkari et al., 2017; Bonsu et al., 2019). But not all forest ES are targets of innovation - or receive much attention in policies. In particular, non-wood forest products, cultural heritage, and recreation receive little attention, which is in conflict with the ideas of operationalising the full range of forest ES and benefits for people (Saarikoski et al., 2015). For these ES, innovations developed around biodiversity conservation, which we identify – in particular those around collaboration and market arrangements – could serve as examples for policy considerations.

From our analysis, it is apparent that innovations are not systematically identified policies; they are rather niches and novelties (Geels and Schot, 2007). Yet, as innovations are an important point of emphasis in the forest sector (Kleinschmit et al., 2014) and in current European policies (EC, 2019), innovations could be a more apparent component of forest strategies. This applies even more as there is an expectation for innovations to improve sustainability (Schot and Steinmueller, 2018). Innovation may also be the result of a response to a disruption in policy (Kivimaa and Kern, 2016), or another type of external shock or stress. For example, natural disasters or pandemics can trigger local or institutional responses to increase the resilience of the forest systems at different levels. Our analysis identifies this kind of innovations related to climate change driven risks.

Second, our analysis of the institutional landscape shows that policies are more attuned to identifying governance mechanisms than innovations. Although governance mechanisms focus on the provision of wood and bioenergy as well as biodiversity conservation, some identified mechanisms also point to those ES that receive less attention across the landscape, such as game and cultural heritage. Policies function as identifiers of both goals and means (Howlett, 2019; Wurzel et al., 2013). A broad range of means is identified in the analysed strategies, confirming the recognition of instruments constituting policy mixes (Makkonen et al.,2015; Rogge and Reichardt, 2016; Barton et al., 2017). Regulation, clearly a dominant mechanism that is being further developed for those goals that are consistently identified; wood, biodiversity and bioenergy, is tuned also to steer recreational activities, for instance hunting. Important support for regulation comes from information provision and collaboration for ES governance (Loft et al., 2015; Primmer et al., 2015; Dick et al., 2018). Interestingly, the concern expressed in the literature, about policies potentially concentrating on marketisation of ES (e.g., Gómez-Baggethun et al., 2010), does not receive support from our analysis, at least not across the range of all ES. Our analysis shows that policy attention for developing market mechanisms focuses around marketable provisioning ES, and wood in particular, with only some mentions of payment arrangements for biodiversity.

Institutional landscape often refers to the institutional context and arrangements surrounding specific governance settings. Relevant for ES governance, the institutional landscape of global environmental change is often said to be too fragmented for addressing environmental challenges (Galaz et al., 2012). Rather than for merely recognising gaps, our analysis of institutional landscape generates an understanding of the geographical variation in ES governance and the ways in which it corresponds with, or responds to, the biophysical landscape of ES supply.

Our mapping shows that there is some correspondence between the biophysical landscape and the institutional landscape. An important notion for interpreting this observation is that ES are often analysed as regards their synergies and tradeoffs across the landscape (Geneletti et al., 2018; Eyvindson et al., 2019; Primmer, 2015). The study by Orsi et al. (in review), for example, shows that while ES like wood, climate regulation, and recreation are consistently supplied together, other ES like wood and pollination, erosion control and soil formation, or soil formation and climate regulation are mostly inversely related. Also our analysis shows that a high volume of forest, signalling provisioning services, is connected to biodiversity conservation. More interestingly, provisioning forest ES would trigger product and service innovations relevant for the wood value chain as well as collaboration. At the same time, scarcity of regulating ES erosion control as well as conservation seems to trigger policies to identify a range of governance mechanisms.

The framework and method we develop in this paper, is tested with a systematic document analysis. With a significant planning and calibration effort, the analysis of comparable documents produces a meaningful dataset that allows both quantitative and qualitative descriptive analysis and testing of geographical coincidence of biophysical ES supply and policy demand for forest ES. We recognise that policy documents are not detailed descriptions of ES or prescriptions for their governance (Kistenkas & Bouwma, 2018), and that they reflect the histories and legacies of each country in a limited fashion. Hence, our institutional mapping should be taken as a description of ecosystem service demand and the ways in which this demand is further mobilised as identified new innovations and governance mechanisms.

6. Conclusions

This paper bridges the gap between the significant scientific endeavour on mapping and assessing ecosystem services (ES) with an empirical understanding of the institutional landscape of ES provision across multiple governance contexts. Our analytical framework and its operationalisation for analysis with policy documents provides a methodological basis for mapping institutions. We do this by analysing how national strategies on forest, biodiversity and bio-economy address forest ES, as well as how their provision is promoted through innovations and governance mechanisms. In addition to mapping the institutional landscape of forest ES provision in Europe, the test of the framework and the method of coding comparable policy documents across countries gives important insights for systematic policy analysis and for ES governance. The institutional mapping provides a description of ES demand and the ways in which this demand is further mobilised as new innovations and governance mechanisms.

The empirical findings of our analysis show that forest ES are generally recognised in policies, but the detail in which they are addressed varies. However, identifying innovations for forest ES provision is not frequent across the different ES. Innovations centre around existing value chains of wood and bioenergy as well as biodiversity conservation, while non-wood forest products, cultural heritage, and recreation receive little attention.

Our analysis of how biophysical supply of forest ES is connected to policies paying attention to ES shows that supply of provisioning ES can result in strategies emphasising many innovations, but little supply of regulating ES could trigger service innovations and several governance mechanisms. As forest ecosystems have become the centre of attention in global, European and national sustainability policies, this institutional mapping of forest ES has also policy relevance. In the process of policy design, it is meaningful to outline the goals and the governance mechanisms that are mobilised for advancing those goals and pay attention to how the goals could be promoted through novel innovative means. For European forest policy, the provision of the entire range of ES, and in particular those ES that are scarce in the area, could be supported more systematically, and with more innovative approaches. Because policies are attuned to identifying governance mechanisms, innovations should support new ways of developing and implementing governance.

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